The arid zone of West Pakistan: geographical aspects of aridity in West Pakistan.

M. Fazal Ahmad Khan

Geographical Aspects of Aridity in West Pakistan

Volume II

Part II

Chapter 6

Plant Ecology and Cultivated Plants

In the field of plant ecology an insignificant amount of work has been done in West Pakistan, related to forestry mainly in the former Province of Punjab and to agriculture particularly in the Lower Indus Basin.

In the old province of Punjab, pure botanical work started in 1869, when Aitchison composed a "Catalogue of plants of the Punjab and Sind".(1) A descriptive account was prepared by Bamber, in the "Plants of the Punjab" in 1926. A more comprehensive work was done by Sabnis in 1940-1941, as "A contribution to the flora of the Punjab and the associated hill regions".(1) Similarly a valuable floristic literature exists on "The flora of Waziristan",(2) a territory in the north western highlands.

The most useful and comprehensive works were produced by Gorrie, R.M., "Soil and Water Conservation in the Punjab 1946",(2a) and by Glover, the "Erosion in the Punjab:* its causes and cures",(2b) in the same year. Both these studies consider erosion in the Potwar Plateau and from this lead on to ecological measures which would suit the local farmers and foresters in the reclamation of the ravined lands.

The present work now under way on soil conservation is based on the experiments carried and suggested by both Gorrie and Glover, these studies for the first time being based on an integrated ecological approach. Most work has been done in the Lower Indus Basin, since this area offers the greatest potentialities for progressive agriculture. In its pioneer stage the botanical work done in this region, was confined to the compilation of plant lists from the point of view of their medicinal utility.(3) In 1923 Sabnis compiled systematic information on "The flora of Sind".(4) In this analysis he observed two types of flora. In the western part of the Lower Indus Basin the flora is influenced by the western desert, which forms a link of the Baluchistan desert, while in the eastern part the flora is the continuation of the Rajputana desert, hence the Lower Indus Basin exhibits elements of both the eastern and western species. Sabnis forms a conclusion that in the course of time the western species will dominate the region as the area is dominated by winds blowing from the west. This work was followed by "A note on the ecology of the flora of Sind" in 1929, which forms the most fundamental work in the floristic study of the Lower Indus plain.(5) During the same year, an illustrative work was produced by the combined efforts of Blatter, McCann and Sabnis, the "Flora of the Indus Delta". The literature produced in later years is descriptive of the local vegetation, such as the "Observations on the vegetation found round about Laki and Monghapir".(6) In the field of cultivated plants, Dastur R.H. has worked on "The periodic partial failures of American cottons: their causes and remedies".(7) He concludes that Gossypium hirsutum disease in cotton could be prevented in the saline and alkaline soils of both Sind and Punjab, if more water and nitrogen are applied during the hot weather on saline soils. He has established a close correlation between the soil and climatic factors. His work examplifies ecological research of economic importance.

At the conclusion of the last century and at the turn of the present century, some botanists were attracted to Baluchistan because of its peculiar flora, inspite of its inhospitable climatic conditions, pioneer work starting in 1891.(8) In 1896 this was continued by Maynard and Prain, who prepared a "Note on the Botany of the Baluch-Afghan Boundary Commission",(9) "Contribution towards a flora of Baluchistan" was published in several series during 1919-20 by Blatter, Halberg and McCann.(10) This work is not a study of plant communities under their specified environs, but is a study of plant genera. Before this voluminous work an article on the "Flora of the Persian Baluchistan and Makran" was published as a combined effort of Blatter and Halberg in 1916.(11) These authors have indicated the affinities and similarities between its flora and that of South India, which is an inference of the past moist climate of this area. Stebbings in 1921-1926 (11a) produced three volumes on "Forest types in India", in all a very comprehensive study. After these classical studies on flora, a "Report on the forests of Baluchistan" was prepared by Glover in 1944. It is an inventory of the existing forest types. The British India Meteorological Services established a system of preparing weather calendars for main crops,like wheat, rice and cotton, for the purpose of recording the whole cultivation operation and meteorological phenomena occurring during the growth period of these plants. Such calendars were available for some districts of West Pakistan.

Besides the above literature,Champion has produced a most important account on the forests of the sub-continent of Pak-Hind,(12) recording forest types and considering the moisture content and the aridity of the area. His study was based on the study of habitat factors of both natural and anthropeic. He followed Schimper, Koppen and Thornthwaite, in his approach to the classification of climatic types and sub-types basing on the moisture conditions. Figs. 49, A indicates his divisions of forests for West Pakistan.

This work was achieved prior to the existence of Pakistan, and since then, several measures have been taken by the Government of Pakistan in the establishment of plant cover and its protection by diseases.(13) The Forest Department has attempted to check erosion by various methods as terracing (watbandi) check-damming, river training and afforestation. Under the guidance of the Forest Research Institute dry land afforestation experiments were conducted all over the country for the production of firewood crops under rainfall alone. Recently, Vahid has classified the forests as Reserved and others. Fig. 49 A.(14) In the same way advances have been made in agricultural crops, concerning diseases, new varieties, the uses of fertilisers and the provision of better seeds.

In 1950 Kapadia composed a statistical analysis of the "Sind grasses" from both the geographical and ecological points of view.(15) In 1957 a few research papers were prepared by national experts, on soil erosion control under the auspices of Unesco.(16) This symposium throws light on the type of ecological work being done in the arid and semi-arid zones of West Pakistan, referred already in Chapter 5. In the north west highland the Forest Department has carried out reclaiming devices of severely eroded lands affected by ephemeral streams. A number of projects have been embarked upon to improve the ranges and the stock carrying capacity of West Pakistan. The sand dune area at Mustang has been reclaimed by forest department,by closure to grazing and planting suitable species of trees, the wasteland is brought under cultivation and grazing.

In 1947 a conference of the Directors of the International Meteorological Organisation was held at Washington.(17) During its procedure, it was recommended that a network of phenological stations should be established by every country. Each country should prepare and submit lists of flora and fauna on a regional basis. It was further advised, by the conference, that there should be a preparation of local crop calendars, inserting the dates of emergence, flowering and maturity of major crops for the purpose of maintaining the plant-weather relationship and an advanced crop husbandry. These recommendations were acted upon in Pakistan,but that effort was not directed to the solution of plant ecology of the arid West Pakistan.

Since 1954, the Meteorological Department has focused its attention on the ecological and physiological aspects of each important plant. Such work was first started in an orchard at Quetta on fruit trees as apples, peaches, plums, almonds, pears, and vines. Each plant was regularly observed and recorded in respect of, (1) of the development of the main stem, (2) growth of circumference and diameter (3) insects, pests, diseases and yield. In addition, experiments on the regeneration of forest trees, and grasses are going on. Simultaneously a project was undertaken for the determination of an Index of Drought Resistance of Fruit Plants in Quetta Region. A sum of Rs 27,712 was granted by the government annually towards this project.

Along with this, the micro-climatic studies for the improvement of important crops, like wheat, rice, maize, toria, sugarcane, jute, cotton, tobacco and grasses was initiated in 1956 at the Government Experimental Farms at Tandojam, Lyallpur, and Tarnab. The first is located in the arid zone and the latter are situated in the semi-arid zone. This research was financed by the Food and Agriculture Council of Pakistan for 3 years with a sum of Rs 234,560. In 1959, Food and Agriculture Council of Pakistan, approved the establishment of shelter belts for the purpose of micro-climatic studies. Since then, under the Unesco technical assistance programme, experiments on the discovery of salt accumulating plants, and the production of salt resistance wheat species are in operation. (18)

The present writer has endeavoured to make an assess-ment of the ecological environments of the plants in West Pakistan (arid and semi-arid zone). Both,the natural and cultivated plants vary largely in density and species from place to place according to the present and past local natural and social environments. Hence,plant ecology is a reflector of the composite local habitat factors. Likewise,the experts think that the plants express the past and present potentialities of all time.(19) In this reference the famous plant ecologist Shantz H.L. writing on his favourite subject of "Plants as soil indicators", states "The plant cover, if properly interpreted can be used as an indicator of the climatic conditions under which it was produced, on the soil on which it grew and the practices of grazing or other uses to which it has been subjected".(20) Therefore,the mechanism of the several habitat controls whose influence is striking in producing the existing patterns of plant ecology may be touched upon briefly.

The contrasts in plant distribution covering, according to Schimper, are governed by "three factors - heat, atmospheric precipitation (including winds), soil". The role played by each,was,stated thus,"Heat determines the flora, climatic humidity the vegetation, the soil as a rule merely picks out and blends the material supplied by these two climatic factors, and on its own account adds a few details".(21) In his opinion, the flora (plant life) of a region is controlled by temperature and the vegetation (total plant aggregation) is determined by the humidity. If the moisture is adequate the plant aggregation will be thick; if the moisture is inadequate the vegetation cover will be thin. Thus Schimper, attached great importance to two factors, the thermal and aquatic, the soil being considered as an additional supplement for the plant growth.

Climate has long been recognised, as the primary control of vegetation patterns. As pointed out by Wood, "Plant distribution is primarily controlled by the distribution of climatic conditions".(22) Mason has further remarked, "and in any given region the extreme of these factors may be more significant than means". The latter axiom is of particular relevance for the climate of West Pakistan, and for the rest of the arid and semi-arid world. In the same context, Embergar too has considered climatic extremes and their frequency as decisive factors in the varigated deposition of vegetational patterns.(23) He computed their influence by means of a formula, based on the extreme values of rainfall and temperature, co-mingled with their mean values.

Livingston and Shreve, classified the most important environmental conditions determining the growth of plants and their distribution as, (a) moisture, (b) temperature, (c) light, (d) chemical and mechanical, whereas Tansley, classified the environmental controls into (a) climatic, (b) physiographic, (c) edaphic and (d) biotic.(24) Nichols, has illustrated cartographically the habitat factors advocated both by Livingston and Shreve and Tansley, with an additional two factors, anthropeic conditions and pyric conditions (the effects and results of the action of man and fire). The most important factors are examined below in the light of plants grown in West Pakistan.

The climatic controls are various and they bear inter-related influence on the plant growth. Klages, after the study of all his predecessors expressed this inter-relationship thus: "The main climatic factors are temperature, moisture and light, of less importance, are atmospheric pressure and air currents. Superimposed on these but not of less importance is periodicity".(24) The climate of West Pakistan, as has already been explained is strikingly periodic with marked extreme conditions. The interpretation of the rainfall data has revealed the periodicity of rainfall. It also indicated, that it always rains somewhere or other during the whole year. Thus, the rainfall is confined to certain months of the year and over certain parts of the country and shows unequal distribution in time and space, but the maximum amount of rain falls in the months of summer from July-September. This rain incidence is of torrential nature and sometimes yearly rainfall may come in 24 hours, with consequent decrease in effectiveness. The extreme region is confined to the south eastern, **s.western,** eastern and some portions of the north eastern part of the country, and fades out towards the west and north west, **and S.east** The months of May and June and then the months of October and November are months of drought almost throughout the country. Roughly, the drought period is never less than 30-60 days in a year. Even in the rainy months, rainfall is not equally distributed throughout the month. Throughout the country, there is a great difference between the average and extreme rainfall whether it comes in summer, winter or in the spring, but these differences are particularly high in the regions with summer rainfall, where the intensity and frequency of drought is most noticeable. The periodicity of rainfall has a lasting effect on the plants, which are restricted to seasonal or annual types. Perennial plants are a feature only of relatively uniform climates. The plants in West Pakistan grow in the wet seasons and are dormant in the dry season, except the perennial fruit trees.

The periodicity and intensity of rainfall is combined with extreme temperatures,with both year to year or succession of years fluctuation. Climatic adversity is accentuated,by wide ranges of temperature and rainfall at specific places and,by the incidence of frequent violent dust-storms during drought and constant destructive floods in rains. There is not sufficient data relating to the moisture in soil during the growth period for a complete study yet to be made. The soil and humidity relationship have been indicated in the previous chapter, according to Meyer's humidity factor. Thus,West Pakistan, according to Meyer's humidity factor,falls in the values of 65 and 144 which are values for arid and semi-arid regions respectively. Thus,we are mainly concerned with water which is the dominant factor for the plant growth in our region.

In his studies on South Africa, Thompson W.R. framed the conclusion,that,"moisture is unquestionably the dominant factor in the production of crops and animals in South Africa" and furthermore,he goes to such an extent,to show the necessity of water, as water "over-rules all other aspects of farming enterprise in the Union and is closely related to the national welfare".(25)

In his studies on "The moisture belts of North America" McDougall says,"It has long been recognised that the vegetative organs of different species were adapted to various conditions of water supply; and also that the occurrence of the larger plant formations was mainly determined by the moisture factor in the climate".(26)

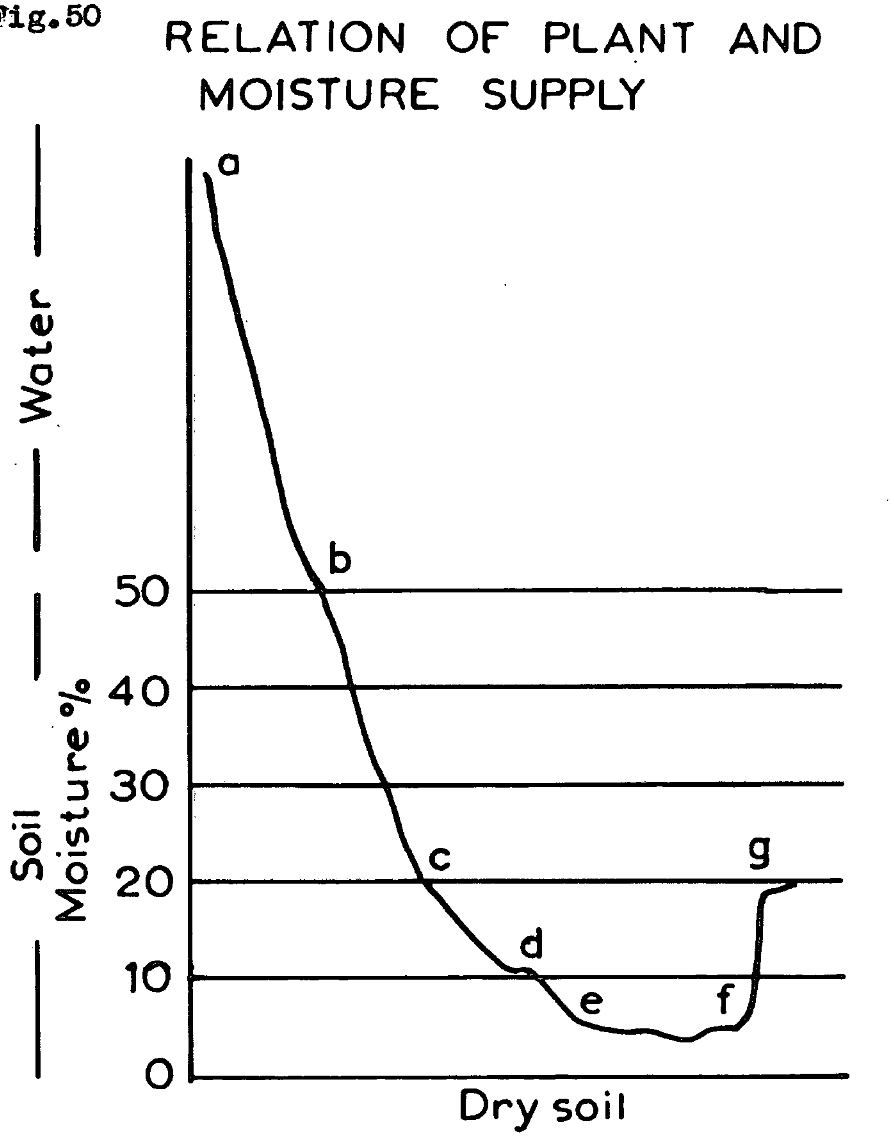
This brief selection shows, how the importance of moisture for plant growth has been realised. All these remarks are applicable to West Pakistan. The relative amount of available water is intimately related with diversified crop production and natural vegetation in any given area. Copious water encourages luxurious vegetation and a wide range of crops can be grown if thermal conditions are suitable. The scarcity of water leads to scarce plant growth and a small range of crop production. Recently Beard has classified the vegetation types of the arid zones of tropical America based on the seasonal formations, which are the result of seasonal rainfall.(23) Not only are the vegetation types based on the amount of moisture content, but basic ecological plant classification has also been based on "water relationships". Such accepted groups of plants as advocated by Schimper, are "hygrophytes", "tropophytes", and "xerophytes" to examplify the vegetation types of habitats of increasing degrees of aridity.(21) Similar types have been designated by Warming, except that the latter has termed the second group "mesophytes". The hydrophyte plants grow wholly or partly immersed in fresh water. These plants grow in a very humid environs where the loss of moisture is restricted. Plants which do not thrive under very wet or very dry conditions occupy the intermediate position between the two extreme types. All those crops which are not drought resistant are assigned to the group of mesophytes. The drought-escaping and drought evading are grown in dry areas and the ephemeral plants in the desert also belong to this class.

The formulation of a definition for the xerophytes has become controversial. Shantz H.C. in his treatise on "Drought resistance and soil moisture" has explained,that every plant responds to drought in particular ways, and he advised that one should not look for the one or two physical or physiological variations to explain every plant.(27) He has classified plants, considering their behaviour as (1) drought-escaping, (2) drought evading, (3) drought enduring and drought resisting. The drought-enduring and drought resisting are the xerophytes, as they have the ability to live under conditions of water deficiency. The desert plants are generally taken as xerophytes; but they are not confined to deserts only. These desert plants have been further differentiated into two ecological classes.

(1) xerophytes and xeromorphics.(23) According to the early views halophytes (salt tolerant) plants were also considered as a class of xerophytes. The halophytes bear resemblance to both xerophytes and xeromorphytes, but they cannot be grouped under either heading. The former definition of xerophytes was that, of plants which could live in dry situation because they transpire less than average plants (mesophytes). This definition is not in fact correct as under certain circumstances, the xerophytes transpire like other plants. Physiologically they transpire increasingly when water is plentiful. In a more practical sense xerophytes are the drought-resistant and drought enduring plants, not necessarily belonging to a desert region. Sorghum is a group of cultivated xerophyte plants and Cacti a natural form of the desert. These plants are found in all types of climate, and their presence is governed by the conditions of the sub-stratum.

These types and their adjustment under the delicate climatic conditions of the arid zones has been explained by Shantz with a help of a simple diagram (Fig. 50) which shows, "The relation of hydrophytes, mesophytes and xerophytes to moisture supply in loamy soil". The loam was chosen to obtain the exact values of the moisture. Sandy soil would have given the lower and the clay soil would have given the higher values. The figure indicates the moisture holding

Fig.50


RELATION OF PLANT AND MOISTURE SUPPLY
a
b
c
d
e
f
g
Water
Soil Moisture %
50
40
30
20
10
0
Dry soil

capacity as: (28)

Dry soil	0% (based on dry weight)
Desert dry soil under desert vegetation	5%
Hygroscopic coefficient	6.8%
Wilting coefficient	10%
Field carrying capacity	19.6%
Moisture holding capacity	50%
Saturated soil	50%
Water table at	50%

The space between (a) and (b) (Fig. 50) is free water where submerged and floating hydrophytes grow. From (b) to (c) conditions will suit only hydrophytes, where moisture percent of soil is 20. The death will occur after the point (d) The section having the moisture content 20-10 percent would grow both mesophytes and xerophytes. The mesophytes will die below (d) and xerophytes will face a partial or total dormancy; and the moisture is lost to evapotranspiration. The plant growth becomes passive or "estivation" prevails. The soil regains the moisture content when the rain falls, and its carrying capacity rises from 5% to 19.6%, and the plant life becomes active at (g).

The conditions of marsh, aridity, temperature and soil under which the specified plants grow habitually are ascertained as their habitats. Thus different topographic areas like montain, plains, valleys, deserts and marshes offer the respective habitats to different plants.

From the previous account we have concluded, that water supply is of paramount importance as a factor of habitat in the areas of arid and semi-arid. In the drought period the plants are exposed to great insolation and water is released to the atmosphere by transpiration. This transpiration has no adverse effect provided this loss is replaced from the soil moisture and the plant physiology is able to cope with the replacement rate. When evapotranspiration exceeds the soil moisture supply, the plant is subjected to a state of physiological drought, which arises under various circumstances.(24) The first, is that of insufficient amount of water in the soil, when no water is left for transpiration, a general situation in the arid and semi-arid region: the plant activity is also retarded by winter temperatures, roots becoming incapable of absorbing water. Most plants are not able to grow in the saline soils, as the salts obstruct the absorbing power of the plants and only the "salt loving" plants flourish.

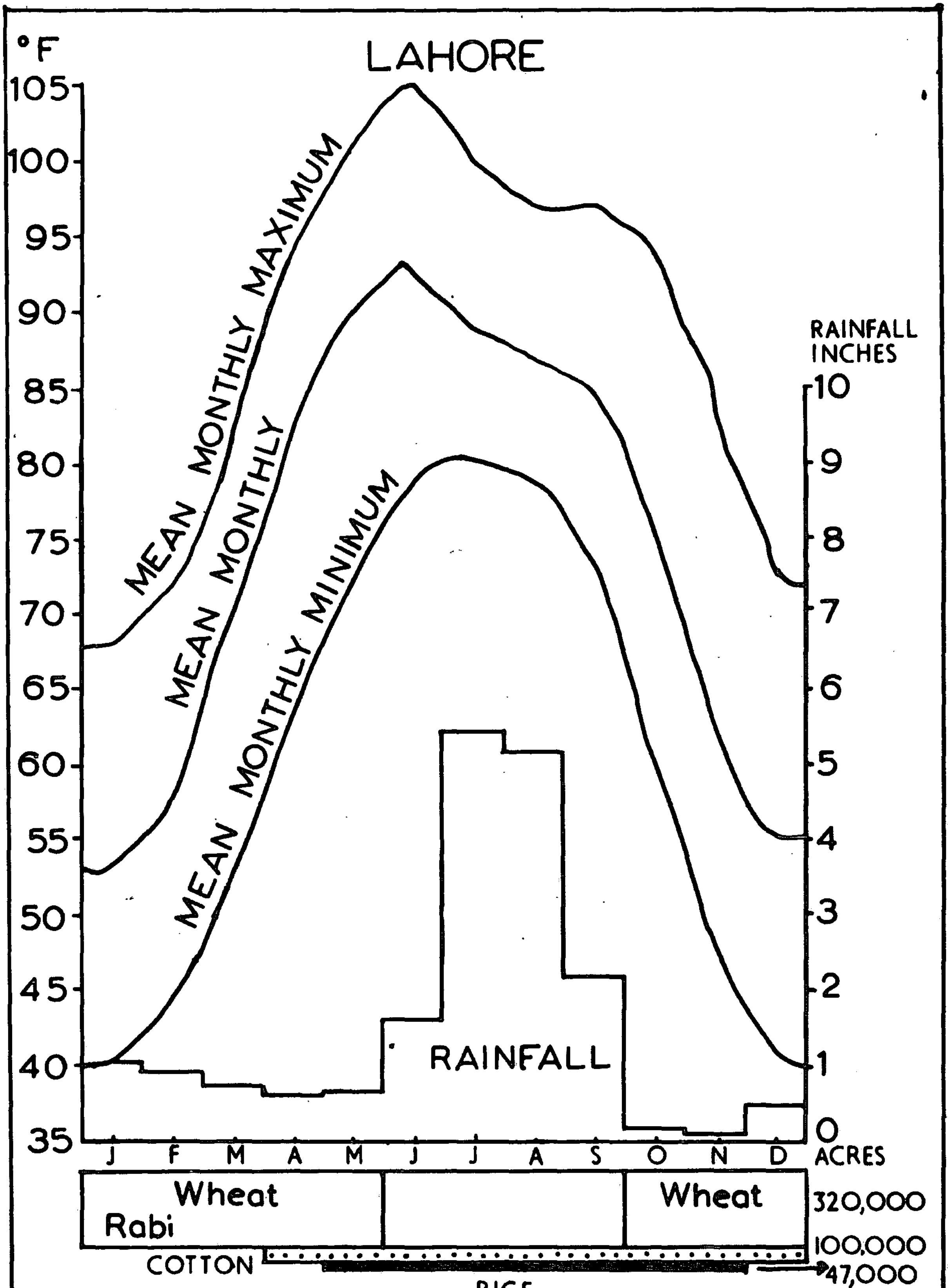
The xerophytic plants have ability to adapt themselves to the drought. Their leaves are succulent, fleshy, hairy thorny, and/or wax covered. The dry season recurs regularly hence trees are scarce, being replaced by annual herbaceous plants, which are active in the wet spell. By the end of the wet season, the herbs produce seeds, tubers, and bulbs, which are able to survive drought, the parent plant not surviving. The plant life is rejuvenated whenever the moisture is available. Grasses are the most common and important herbaceous plants. These plant types and vegetation types gradually merge into each other like the climatic types.

At four representative stations for sample study in Chapter 3 viz., Lahore, Quetta, Peshawar and Jacobabad, the dominant characteristic of the heat and moisture is a strongly rhythmic recurrence of rain and drought, which corresponds naturally to markedly rhythmic plant growth. The contrasts are extremely startling in the case of Lahore and Jacobabad, where the heat and moisture coincide and plant growth becomes seasonally vigorous. This pulsating nature is reflected in the varied types of vegetation and crops, which range from desert scrub to deciduous forest, adapted to prolonged drought, and to monsoon forest. The monsoon forest is rich in foliage and yields commercially important trees.

~~The further impact of moisture and heat are brought out by constructing ergographs for Quetta, Peshawar and Lahore.~~

The impact of climatic factors of rainfall and temperature on the cultivation of major crops in the arid and semi-arid sections of West Pakistan,are analysed in the account which follows,first,by constructing Ergographs Fig. 51 A-C for three representative stations, Quetta, Lahore and Peshawar. The crops chosen are wheat, rice and cotton for Lahore and Peshawar, but for Quetta wheat, maize and barley have been chosen as the main crops. The basic data about these crops is based on an average of 5 years from 1954-1955 to 1958-1959.(29) These ergographs show,how crops are adapted to the seasonal rhythm in relation to mean maximum, minimum and mean temperatures and rainfall. More cultivated acreage occurs in the Lahore District, hence the difference in scale acreage,between Lahore and Peshawar and Quetta is noticeable.

Secondly,the yearly regime of maximum and minimum temperatures and rainfall, along with the total cultivated area at the said 3 stations are illustrated in Figs. 52 A, B and C, to show the climatic risks and hazards for years 1947-1957. The data illustrated,is for the crop years 1947-1948 to 1956-1957.



°F
LAHORE
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
MEAN MONTHLY MAXIMUM
MEAN MONTHLY
MEAN MONTHLY MINIMUM
RAINFALL
RAINFALL INCHES
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
ACRES
Wheat
Rabi
Wheat
320,000
100,000
COTTON
RICE
47,000

Fig. 51A

Thirdly, to show the vital importance of water for the increase of acreage as well as for the increase of production, yearly fluctuation of irrigated area, production and rainfall have been demonstrated in Fig. 53 A-B, for years 1947-48 to 1955-56. (Again note the difference in scale of the two figures).

Fourthly, moisture and thermal conditions for wheat, the Rabi crop and for rice, the Kharif crop are explained, with the help of the dot maps illustrating the data for 1958-59 Fig. 54 A-B.

Fifthly the Fig. 55 illustrating the land-use status of the arid and semi-arid zones provides further evidence of the limitations imposed by the lack of moisture.

Finally, showing the percentage of total cultivated area, Fig. 56A, percentage of forested, area relative to the total geographical area, Fig 49B, and the distribution of forests, Fig. 49A, the range map Fig. 56B, and the climatic and edaphic controls in Appendix 16, further reveal, that water is the prime control of agriculture as well as seri-culture and pasturage in West Pakistan.

Meteorologically the arid and semi-arid areas in West Pakistan, constitute 3 broad sections, namely the (1) north western highland or the region of spring rainfall maxima. (2) The Indus plain forming the summer rainfall maxima, and (3) the region of Quetta Kalat experience the winter rainfall maxima. Besides these, there is a neutral section forming a corridor between the winter and summer rainfall zones, which obtains rainfall almost well distributed throughout the year (see Fig. 13, Chapter 3). The plant growth in these; precipitation zones is decided primarily by local moisture conditions, especially atmospheric moisture, such as rainfall, snowfall, air humidity and dew, along with the thermal conditions.

The meteorological regime, in the whole sub-continent of Pakistan and Bharat is so dominant, that the agricultural caldendar corresponds to this rainfall incidence; and from the time immemorial cultivation has naturally been regarded as having a twin-season character, based on the Rabi or winter rainfall crop and the Kharif or the summer rainfall crop. We shall see in the proceeding accounts, that inspite of the introduction of modern canal irrigation, both acreage and production of the crops still tend to vary with the increase and decrease of the rainfall.

As already explained, our region experiences 4 climatic seasons in a year, and cultivation routine more or less approximates to these climatic seasons. For instance, Kharif crops are sown as the south west monsoon sets in, in mid-June, and sowing continues till mid-July. These crops are harvested from September to November. The main Kharif crops are Rice, Bajra, Maize and Jowar. The sowing of the second main crop, the Rabi, starts in October and continues to November, and it is reaped during March to May. The Rabi harvest consists of Wheat, Gram, and Barley. These require a relatively less amount of water, their growth is especially benefitted by dew and these crops are suited to the coldness of winter. The occasional wet spells in winter are very much suited to Rabi, but for increased and safe production irrigation is necessary as rainfall is not reliable.

The details of the cropping programme vary considerably from place to place, depending on the local geographical and social conditions of the farmer and this is very well expressed in the following words, "Throughout, the soil, the season, the local conditions and agricultural practices vary in an extraordinary degree. The variety of ordinary field and garden crops is greater than in any other country in the world. Crops are normally sown and harvested in various parts in every month of the year, and generally speaking the inherited experience of generations enables the ryots to cultivate their small holdings very skilfully".(30)

Bearing in mind,this general pattern,we may examine the 3 ergographs which present the respective actions of rainfall and temperature on the plant growth throughout the year, at the 3 stations of Lahore, Peshawar and Quetta, representing summer, spring and winter rainfall maxima respectively. Figs. 51, A-C. The troughs and crests of moisture and heat symbolising wet and drought conditions, are not simultaneous in their occurrence all over West Pakistan,but they correspond to growth conditions in general in the whole country. Plant growth coincides with the march of precipitation and temperature.

At Lahore, heat and abundant water occur together, thus conditions are very suitable for a prolific natural annual plant growth, and for cultivated crops like rice and maize. Even the deserts bloom with the spells of summer rainfall. It is said that, "The scorched grass and trees respond to the change by putting forth young shoots, and with only an inch of rainfall the whole country looks for a time quite green and fresh".(31)

The high temperature favours evapotranspiration, which is of utmost importance for the well-being of the plant. In such cases only high precipitation will replace the water lost by evapotranspiration. Unfortunately in this climate heavy precipitation usually means periodic downpours, and torrential rainfall results in run-off and therefore does not effectively neutralise high evapotranspiration. Particularly, in the unprotected upland and steep slopes of West Pakistan run off is very rapid. In the plain areas evapotranspiration loss in the rainy season is generally reduced by the atmospheric humidity. At the same time direct insolation is also reduced by the frequent cloudy spells, and these activities vary from plant to plant and from soil to soil. Conditions are obviously different from these in the British Isles where ~~the chief~~ an important causative factor of evapotranspiration is wind, especially during autumn and winter, when thermal activity is reduced to nil.

As the ergograph **for Lahore shows** temperature never falls below $40^{\circ}F$ in January and it rises to nearly $100^{\circ}F$ in June. These extreme temperatures are not in themselves obstructive to plant growth. The hot weather landscape results from the lack of and loss of moisture in the soil. Thus, during the autumn drought the trees shed their leaves and plants become dormant rapidly, and in the June drought the whole country appears brown and burnt under the blazing heat. Only isolated local spots support greenery whereever moisture is available. The chief reasons for plant dormancy in the British Isles are low temperatures.

As a rule, the soil moisture is never lacking as the rainfall is well scattered both in time and space. It is the winter temperature to which the plants succumb; here temperature rules the plant growth in the British Isles. Whereas rain over rules temperature in the arid and semi-arid zones of West Pakistan.

The rainfall curve exhibits extreme fluctuations. The highest amount of rainfall comes during the 3 summer months from July-September. The ergograph demonstrates, that most of the area is allotted to winter wheat based on soil moisture recharge during the summer rain. It is sown in October after the monsoon rain and it is ready for harvesting by the middle of March, and continues up till May, the drought period. The ergograph shows, that wheat is in the fields from October to May, and from this we can estimate the climatic requirements of this crop. During its germination small spells of rainfall visit the country. From the end of November till the mid January the crop has to experience the hazards of winter, which are occasionally accompanied by strong gales, cold waves and hailstorms. These phenomena leave their mark both in yield and acreage. With the turn of February weather conditions appear very conducive to growth. Wheat requires occasional wet spells and moderate temperatures, which determine the quality of the grain. For a high yield and fine quality, a well distributed but not excessive rainfall with alternate sunshine periods are required throughout its growth period. In the Lahore district, the winter rainfall is less than at Peshawar and Quetta, but more acreage is brought under wheat cultivation at Lahore with the help of canal irrigation: 320,000 acres.

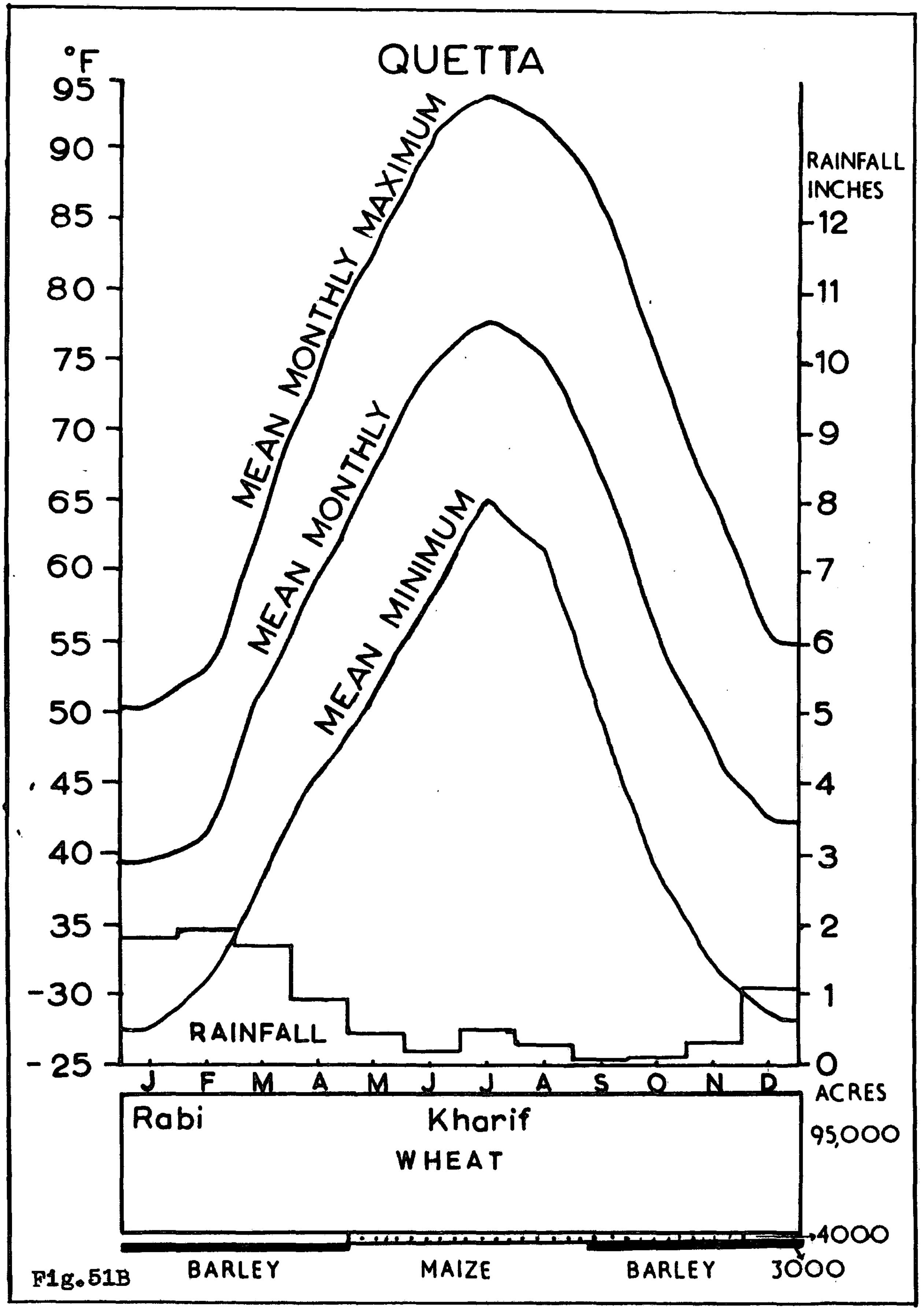
The second crop as shown in the figure is cotton, which is a Kharif crop; 100,000 acres are given over to it. Unlike wheat, cotton is a pre-monsoon sown crop. As illustrated in the figure, its sowing starts during the hot days of May and depends on the application of irrigation.

The plant develops fully during the summer monsoon and its yield is at the mercy of the timely arrival of the monsoon rains. Picking starts at the departure of monsoon and again depends on the timeliness of the cessation of rain. Cotton and rice are almost contemporary crops. They are grown during the period of plentiful rainfall, the irrigation water thus being conserved for the Rabi crop of wheat on which depends the food situation of West Pakistan.

The area under rice, 47,000 acres, is less than that under cotton. Increased production depends on the introduction of early ripening varieties of both rice and cotton to utilise the surplus water of summer monsoon and irrigation water for winter wheat. Profitable agriculture depends, however, on the adequacy and efficiency of rainfall in its distribution in terms of space and time. The monsoon rains of the Kharif crop come in irregular downpours, which are less effective for the plant growth and most of which is lost in rapid run off. In addition, these heavy downpours are powerful agents of erosion. Thus, the summer monsoon is not suitable for full direct utilization and only with adequate provision of storage can it be used.

Thus, we have a situation in which the figures of precipitation even for the wet season give a misleading picture of moisture availability for plants. During monsoon maxima, only a fraction of precipitation can be immediately used, the remainder either running waste in a damaging fashion or for cultivation having to be stored for use in other seasons. Thus the first obvious picture of ooincidence of high temperatures and rainfall maximum as favourable to plant growth is not strictly accurate.

Quetta, Fig. 51B. It presents a reverse picture of cultivation procedure. The highest amplitudes of rainfall and temperature do not coincide as at Lahore. The rain maximum occurs in the month of February. In this region of winter rainfall as clear in the Fig, the most


QUETTA
°F
95
90
85
80
75
70
65
60
55
50
45
40
35
-30
-25
MEAN MONTHLY MAXIMUM
MEAN MONTHLY
MEAN MINIMUM
RAINFALL INCHES
12
11
10
9
8
7
6
5
4
3
2
1
0
RAINFALL
J F M A M J J A S O N D
ACRES
Rabi
Kharif
WHEAT
95,000
4000
BARLEY
MAIZE
BARLEY
3000
Fig.51B

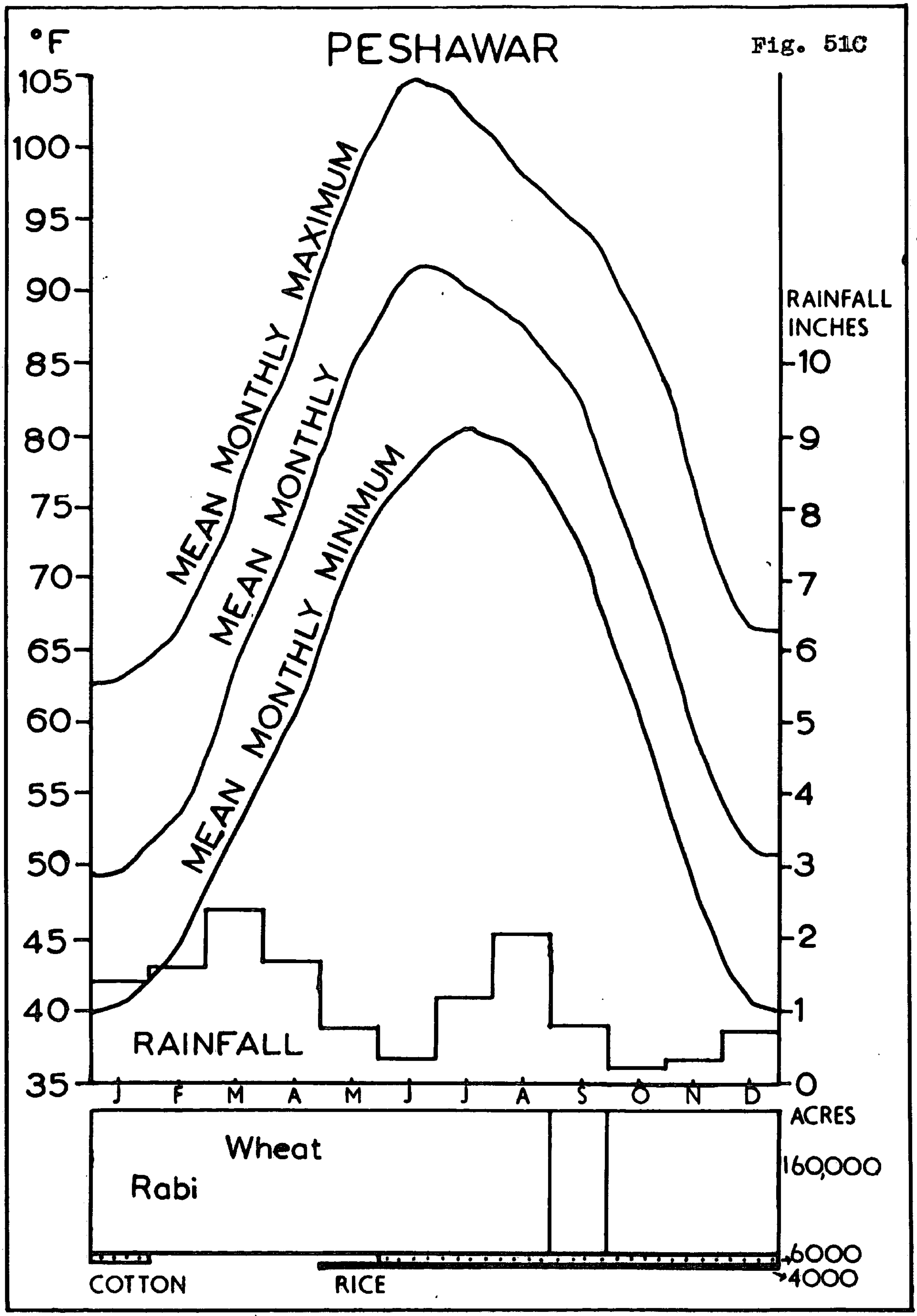
striking phenomena is that, there are two crops of wheat, winter and the spring, which cover the fields the whole of the year, most of the rainwater being put at the disposal of wheat. The other striking point is the absence of cotton cultivation in this region, the chief reason being the lower summer rainfall. A small harvest of rice is obtained with the available meagre amount of summer rainfall. The area occupies by this crop is too small to be illustrated on this ergograph.

In the region of winter rainfall the wheat crop in the plains is sown during October-December. In the upland areas its sowing is early, from September and continues till December. The crop which depends entirely on the winter rains or the crop of "Khushkaba" (dry crop) lands is sown during January-February. The main winter crop of wheat is harvested during the relatively dry period from late April to the middle of May. The spring crop is harvested during July-August. It is seen that the sowing period varies from plain to uplands. The early sowing starts on the high elevations and plains activities starting a full month later, the need for an early start in the high-lands resulting from the early onset of autumn cold and rain. The total area given to wheat as plotted in the ergograph is 95,000 acres. The second largest crop is maize. This is a Kharif crop, depending on summer rainfall, and its cultivation is confined to the hilly tracts, because plains are given to the cultivation of more valuable wheat and rice. Barley follows more or less the routine of winter wheat, but its cultivation occupies more marginal areas, and it does not compete with its companion wheat crop. The impact of rainfall,which governs the cultivation rhythm are well illustrated in this region. The poor maize crop is obtained from the summer moisture minima and the winter and spring copious moisture produce two Rabi crops, wheat and barley.

At Quetta Region,the rainy season coincides with the thermal minima below 30°F. The snowfall and cold waves are recurring phenomena during winter. ~~The~~ Plant growth is clearly not severely inhibited since wheat and barley are found in the fields. The curve of rainfall regime sinks lowest in the months of September-October, while at Lahore and Peshawar, September is a wet month. The temperature crest at Quetta,responds with the moisture trough so the summers are dry and hot. The autumn drought is conspicuous. The plants survival depends on their ability to withstand such seasonal stresses.

The plant growth during these critical periods,is maintained by local supplies of underground water, which is the basis of irrigation in the Divisions of Quetta and Kalat. The summer rainfall is small and even that is lost to a vigorous evapotranspiration, under high temperature, few cloudy spells, and low atmospheric humidity. Thus, the climatic habitat has limited the number of crops and the limiting factors are both rainfall and temperature.

Peshawar is a representative district of the spring rainfall maxima. The figure shows, the correspondence between summer rainfall and good thermal conditions. This region bears a similarity to both Lahore and Quetta, as it receives rainfall both in summer and winter. The dry phases occur during the months of June and October. It exhibits two well defined rainfall maxima, in spring and summer, of a dry temperate type. It is evident from the figure, that there are two physiological growing seasons, one during the months of February to April and the other during July-September. The cultivation procedure of winter wheat and rice is similar to Lahore but cotton is sown in June and its picking continues till January. Moreover, there are two crops of wheat, winter and spring and as evident from the ergograph wheat is in the fields throughout the year except for the month of September. The acreage under wheat is 160,000 acres. Spring wheat is of minor importance and its sowing

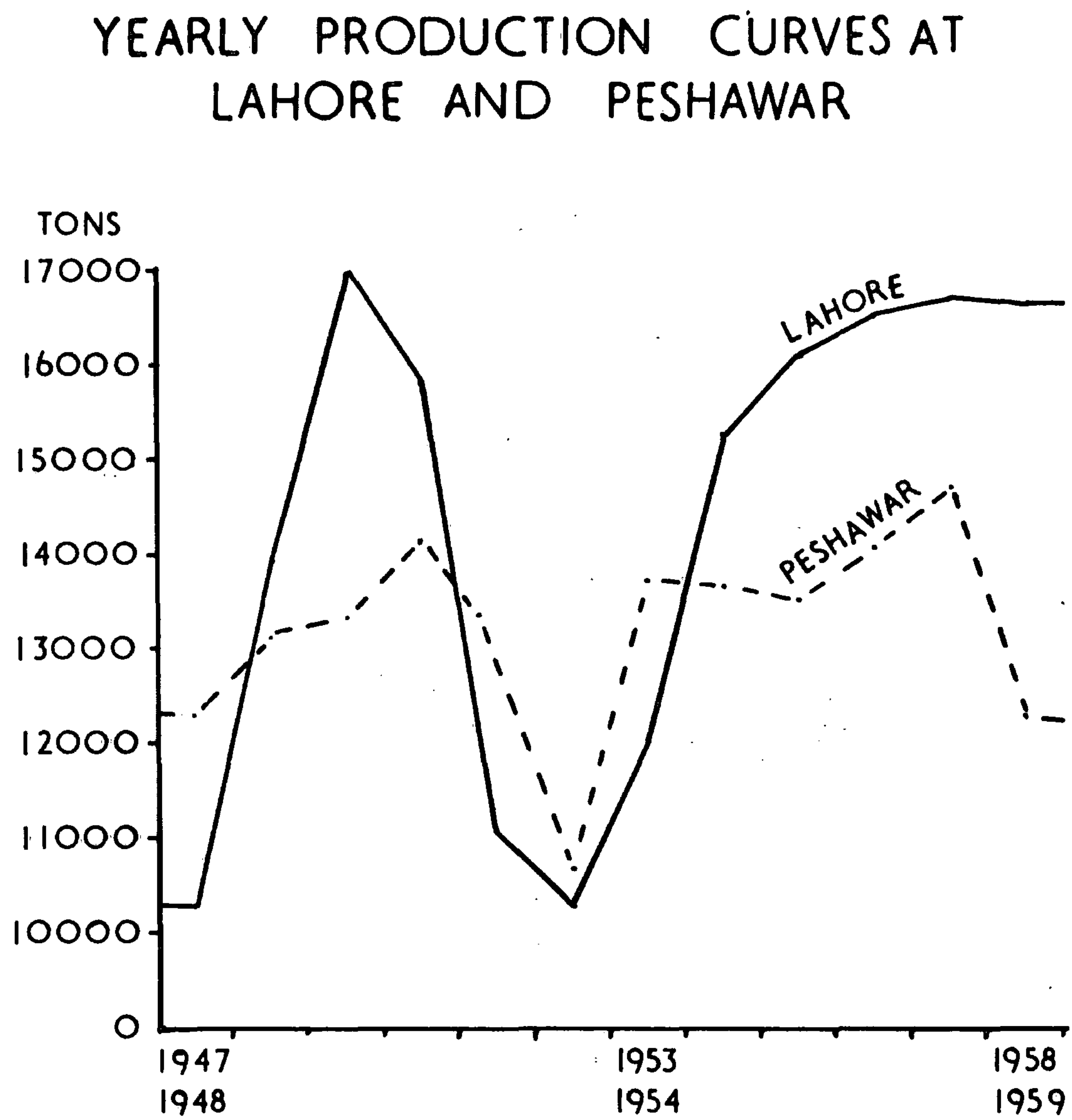

°F
PESHAWAR
Fig. 51C
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
MEAN MONTHLY MAXIMUM
MEAN MONTHLY
MEAN MONTHLY MINIMUM
RAINFALL
RAINFALL INCHES
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
ACRES
Wheat
Rabi
160,000
6000
4000
COTTON
RICE

programme coincides with the spring wheat at Quetta. The rain water is fully utilised for the wheat crops. Cotton and rice are summer monsoon crops. Their sowing is done in the pre--monsoon period and harvesting is done in the post monsoon period. These crops go through both dry and wet phases.

The most important point that emerges from the ergographs, is that, the coincidence or otherwise of the moisture and temperature cycles mainly govern cultivation. From these ergographs and from our study of climate, it is clear that the length of both dry and rainy season in the arid and semi-arid areas varies according to local factors, for instance relief, and direction of winds. The pulsating nature is reflected in the different types of crops grown and the acreage given to them. The crops grown, range from the hydrophytes such as rice, cotton and maize to barley and wheat as xerophytes and mesophytes.

Though, the annual rainfall is highest at Lahore, well distributed rainfall is more characteristic of Peshawar, (Figs. 15,19) where there are greater possibilities of increasing crop production, by introducing suitable crop rotation, by sowing better seeds and fast growing varieties. In this respect, if water is saved during the wet summer phase for the Rabi crops, both the acreage and yield of wheat can be increased. Wheat is the staple cereal of West Pakistan, and its demand is increasing in east Pakistan also because of the interchange of the armed and other services between the two wings. Early ripening varieties of rice and cotton may be introduced to utilise the surplus water of the summer monsoon as the extreme heat and abundance of water occurs simultaneously.

To indicate the further vagaries of climatic conditions, the yearly regime of maximum and minimum temperatures and rainfall along with the curve of total cultivated area at selected places have been graphically illustrated in Figs. 52 A-C. The acreages ascertained are for the crops of rice, wheat, cotton, maize and barley for Lahore and Peshawar, while for Quetta, wheat, barley and maize are included (the climatic limitations which deter the cultivation of cotton and rice, have already been considered). These may be studied with further reference to Figs. 57, A-B. The rainfall as appeared in the histogram is extremely variable. There was only 11.99 inches of rainfall during 1947 at Lahore, which is 7 inches below normal. The histogram also shows 4 alternative years of below normal rainfall and 7 years of above normal rainfall and no year with a normal rainfall. In and before 1952/53, alternating wet and dry years were accompanied by little variation in wheat acreage, but since that year, relatively good rainfall years and the development of irrigation has produced a steady increase


YEARLY PRODUCTION CURVES AT LAHORE AND PESHAWAR
TONS
17000
16000
15000
14000
13000
12000
11000
10000
0
LAHORE
PESHAWAR
1947
1948
1953
1954
1958
1959
Fig. 57A

in acreage . The effect of climatic variability on yields was much greater but of the same basic pattern, as is shown in Fig. 57 A-B. The production of rice, wheat, cotton, maize and barley rose rapidly from 100,000 tons in 1947-48 to almost 140,000 tons in 1948-1949. The agriculture year 1949-50 was the year of highest prosperity curve even though rainfall was deficient and when even minimum temperatures were exceptionally high; this prosperity may be related to increasing availability of irrigation water and the absence of flood produced disaster. Positive and negative aspects of economic success are thus revealed. During more recent years both acreage and production tend to rise. This may be attributed to the Grow More Food Campaign, under which an increased area was brought under the plough, and more emphasis laid on the use of better seeds, better varieties, improved methods, more use of commercial fertilizers, and increased irrigation. The yearly regime of rainfall is extremely variable, the regime of temperature is less fluctuating, but acreage is not affected as agriculture becomes more sophisticated. All these variables however are still important - see the strikingly fluctuating curve of production. Fig. 57A.

At Peshawar, rainfall is less variable and temperatures especially mean maxima have been steady, but acreage has not been constant, and the production curve is very irregular. Figs. 52 B, 57 A. Both at Lahore and at Peshawar, year 1952-53 was a year of reduced rainfall, low acreage and the lowest production. The most marked variations in the curves of both production and acreage are exhibited at Peshawar, the reason being the great dependence of agriculture on rainfall, while fluctuations in the Lahore region are more or less controlled by artificial irrigation. Drastic changes in production are visible. Acreage (Peshawar) has been steady from 1954-55, but production tends to increase, booming during 1957-58, 147,214 tons, when yearly rainfall was abnormally high, 20.0". In the following year 1958-59 production was reduced drastically even when the rainfall was above average 18". Under such wet conditions the decrease in production of these crops resulted from a combination of other factors.

At Quetta most of the cultivation depends on the underground water replenished both by snow and rainfall. There are the spectacular fluctuations both in the acreage and in the production. The yearly increase in acreage corresponds with yearly increase in production and rainfall and vice versa.

Crops were in nominal surplus in 1947-48 in the whole of

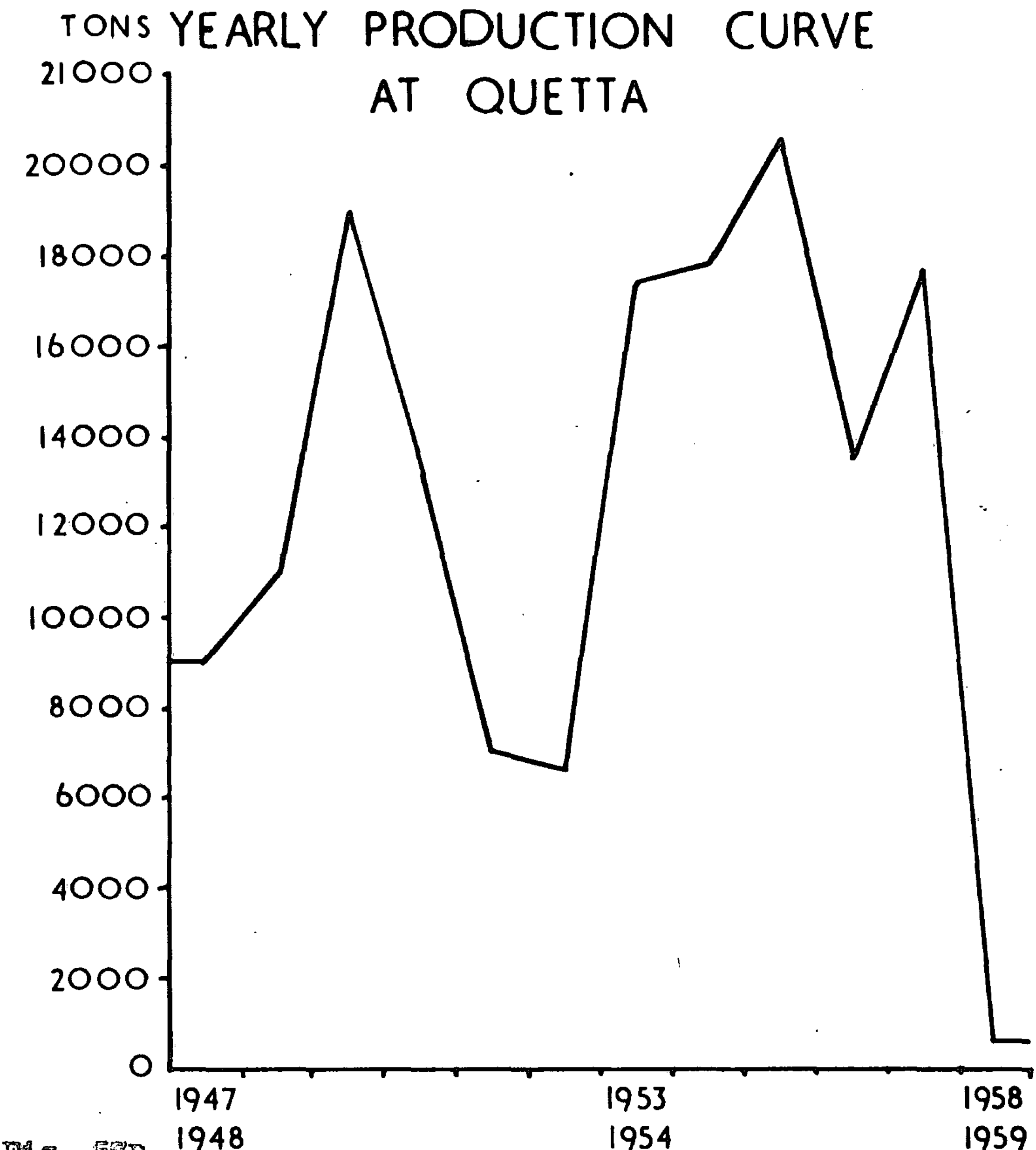

TONS
YEARLY PRODUCTION CURVE
AT QUETTA
21000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1947
1948
1953
1954
1958
1959

Fig. 57B

West Pakistan. The crops were badly affected during the mass migration of population, food stocks left in Indian territory and the canal supplies reduced by India. By 1949-50,the situation in food had improved as the influx of refugees was subsided and they were settled in spite of floods in 1950. Production decreased sharply in 1951, partly because of monsoon failure. The Kharif crops were affected even in the irrigated areas as less rainfall reduced the canals flow also. The Kharif crops contribute 25% of the food grain in West Pakistan, and their decline was followed by a wheat shortage in 1951 owing to the failure of the pre-sowing rain. Soil moisture in the rainfed areas was almost nil.(32) The rain at the sowing time of wheat was also low and as a result the whole rainfed area was not sown. The low rainfall affected the rivers flow also and their level remained below the level of inundation. The areas which normally depend on the inundation cultivation remained uncropped. The low production of wheat during 1952-53 is related to the canal water held up by the Indian authorities. Thus the drought was enhanced by the human efforts also.

The production of Kharif crop was recovered by short term immediate measures affecting fertilizers, pest and disease control introduced by the provincial governments. Unfortunately this was partially offset by the locust swarm.

Water shortage in the canals owing to withdrawal by India again adversely affected wheat production. The wheat production fell from 2,972,000 tons to 2,390,000 tons in 1952-53. Besides these factors,wheat also suffered by the turning over of wheat land to oil seeds, rice being replaced by cotton for the same reason-attractive prices. These circumstances show how the production declined with the dwindling availability of water.(32)

By the end of 1952 the imports were sharply curtailed and 1953-54 produced a bumper crop, and wheat prices fell so low, that it could be given to the cattle even. In the Lower Indus plain cattle were actually fed on wheat because of a decline in Bajra and Jowar crops.

The weather in the year 1953-1954 remained suitable for both Rabi and Kharif crops. This increase is shown in the cultivated area as compared with the former year. The favourable trend produced a succession of good crops but it was changed to disaster by floods in 1954-1955, and the 11 districts of Upper Indus plain which is the major agricultural zone were badly affected by torrential summer monsoon rains, immediately after the floods receded. By these rains a very heavy Kharif crop was produced in the areas unaffected by the floods and rice was declared surplus. The same type of wheat crop was also obtained and it was also declared surplus. Wheat supplies of 3,590,000 tons were in such a happy condition that an emergency food reserve of 500,000 tons of wheat and 100,000 tons of rice was built up. The shortage of food products emerged again in 1955-56 by recurring floods which brought no incidental benefits combined with the damage of rice crop by pests.

According to the official report July 1959, the wheat crop in Pakistan for 1958-1959 has been estimated at 3,865 lakh tons which is the best over the past six years. It shows a rise of about 15 lakh tons over the poorest crop of 23.90 during 1952-1953. This increase is attributed to the "Grow More Food Campaign" but the high output is mainly due to favourable weather, improved farming conditions.(33)

This account of crop production reveals the dependence of crops on water availability both in time and quantity. It is estimated, that a good year of rainfall may yield a grain crop 2-4 percent in surplus and a bad year may bring a deficit of 10 percent or more.(32) The situation of food in Pakistan has been very serious during 1947-1952. The natural causes may be combined with the effect of refugee influx to the peasant population of canal colonies of West Pakistan. The majority of the refugees were agriculturalists or small craftsmen, but most of them were not familiar with the type of irrigation farming practised in West Pakistan. They were confronted with the problems of husbandry on irrigated land in their new surroundings. Their miseries were increased by the recurring alarming floods, and waterlogging and salinity increased with the handling of land and canals by ignorant farmers.(32) The damage to crops by the floods in West Pakistan is expressed by Darling.(34) "Nowhere is this improvidence more marked than in the riverain tracts of the province and nowhere is farming more of a gamble. Whether it is Ravi, the Beas, or the Sutlej or the harlot Sind as the Indus is popularly called, it is always the same. Ek sal amir, ek sal faqir - Rich today a beggar tomorrow, is the way it is put by local wit, and this exactly expresses the case. If the river behaves itself there is "God's Plenty", but if a big flood comes, it is goodbye to crops, cattle and home. Thus one proverb says that 'he who neighbours a river is neither hungry nor thirsty' (Darya da Lamsaya, na bhukha na trihaya)." (Chapter 4).

It is evident from the above that the different types of ecological crop hazards are encountered in various years and localities. The main fluctuation and variabilities are generally accounted for by the dry and abnormal wet phases and also diseases. The acreage at Lahore is fairly uniform as a result of efficient irrigation but there are startling fluctuations particularly in production at the other two stations.

As wheat is the staple cereal in West Pakistan, its cultivation occupies nearly 77% of the Rabi crop in the Upper Indus canal colonies,(32) and no other cereal is grown with such concentration as wheat, as is evident from Fig. 54A. This map and Figs. 53 A and B may be studied together in order to get a true picture of the water control of this crop. Wheat in West Pakistan is grown in the main, on seasonal precipitation which is considered (on average) to be "ideal" for its cultivation, particularly for the growth of high protein wheat. By the study of the ergographs,we have seen,that the wheat has a wide adaptability and is being sown or reaped,in every part of West Pakistan, throughout the year. The meteoric water limit for wheat cultivation has been considered as less than 30" annually. Wheat can be grown in the areas of 10" of efficient rainfall particularly where alternate fallowing and cropping are practised.(24) The other condition suited to the wheat growth is high rainfall when it is not combined with high temperatures. This is an indication of its being a cereal of warm temperate zone or winter rainfall not a crop of monsoon rains, when both humidity and temperature occur combined. The crop is harvested before the excessive atmospheric humidity sets in to which the crop is susceptible.

In West Pakistan the winter crop is the most important

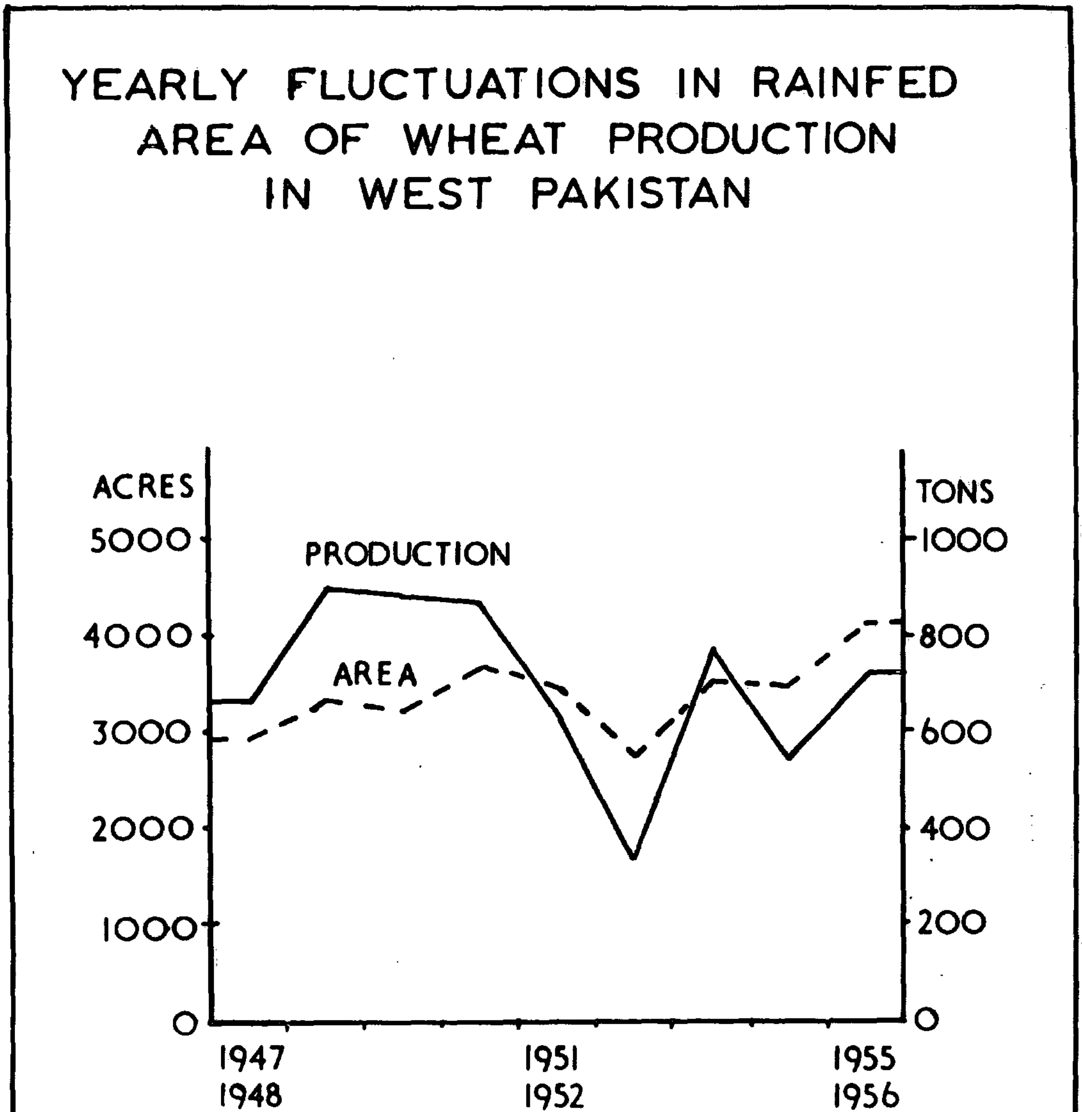
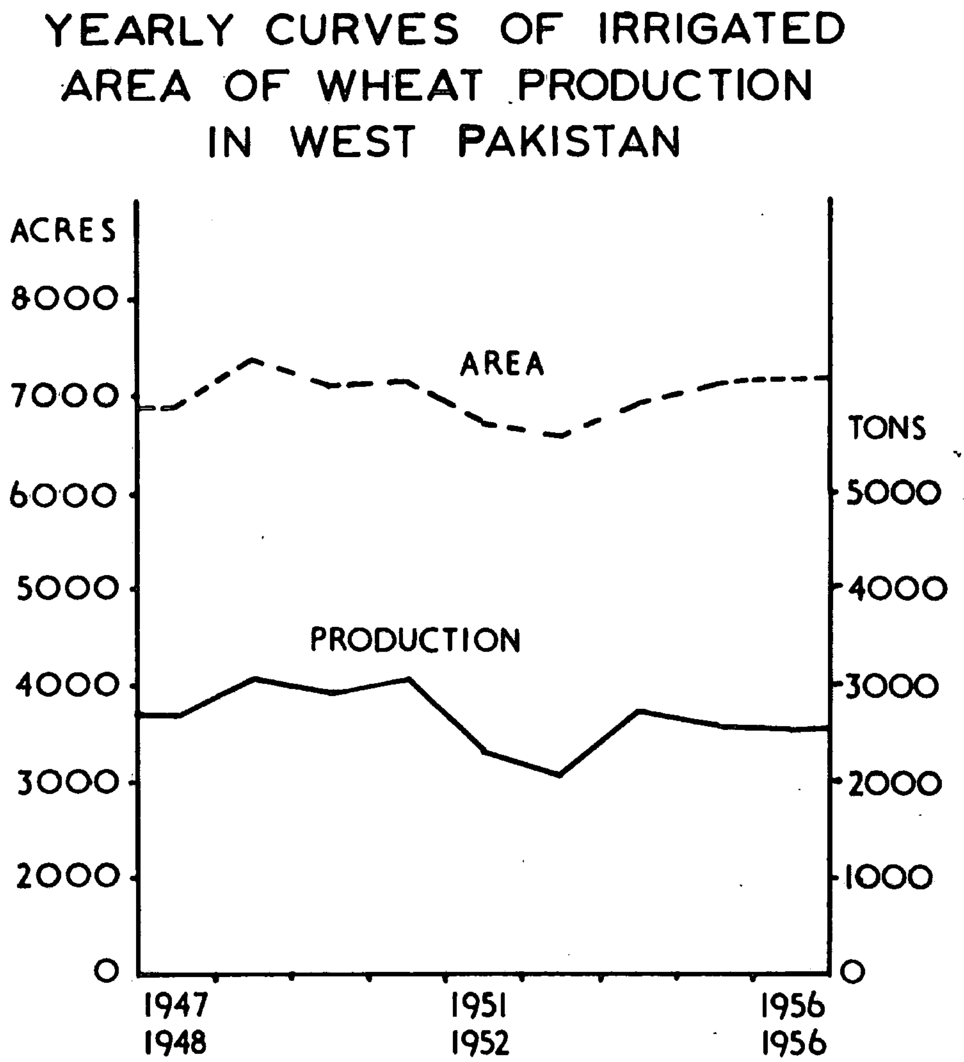

YEARLY FLUCTUATIONS IN RAINFED AREA OF WHEAT PRODUCTION IN WEST PAKISTAN
ACRES
TONS
5000
4000
3000
2000
1000
0
1000
800
600
400
200
0
PRODUCTION
AREA
1947
1948
1951
1952
1955
1956

Fig. 53A



YEARLY CURVES OF IRRIGATED AREA OF WHEAT PRODUCTION IN WEST PAKISTAN
ACRES
8000
7000
6000
5000
4000
3000
2000
0
AREA
PRODUCTION
TONS
5000
4000
3000
2000
1000
0
1947
1948
1951
1952
1956
1956

Fig. 53B

and spring wheat forms the minor crop. The winter or the Rabi crop of wheat grows best, when there are favourable moisture conditions during autumn when the plant gets established and it is, then able to endure the enforced dormancy imposed, by the low winter temperature. If there is no rainfall during the winter months a critical period occurs, and the application of irrigation water becomes compulsory. As stated in the chapter on hydrography, during winter the river courses are very much shrunken, leading naturally to the shortage of water in the diversion canals also. Hence, even irrigation water becomes inadequate which augments the critical situation of the wheat crop. In turn, both acreage and production are severely affected.

The study of the distribution map shows that the natural boundary for wheat growth as limited by rainfall is marked by the isohyetal lines 30"-15", has been extended towards the south in the arid areas with 10"-5" rainfall, with the application of irrigation water supplies. If this map is compared with both rainfall and irrigation maps, we can demarcate from north-south two zones of wheat cultivation lying each side of the 15" isohyet.

Where rainfall is more than 15" then dependence on precipitation is greatest although irrigation water is utilised even when total rainfall reaches 20". When rainfall is less than 15" we find the 'cultural zone' of wheat cultivation dependent on irrigation. In the central doabs irrigation and rainfall maintain yields at about 10.0 maunds per acre, while at Quetta dependence ultimately on scanty rainfall brings yields down to 4.9. Rain fed wheat in the trans-Indus plains produce c. 6 maunds, while in the lower Indus low rainfall and irrigation gives 6.9.(35) It would seem that below 15" wheat culture is only possible with irrigation and the factors affecting its importance,are economic and technical rather than climatic.

It is advocated by the experts,that,"all cultivated land with less than about 12" must be irrigated. But where more than 20" occur there is a tendency to rely on rainfall, a proceeding which is only really justified by a rainfall, of about 50".(36) This view needs comment. The irrigation requirements are not strictly a question of amount of rainfall but rather a question of rainfall regime and incidence. Whereever the rainfall is seasonal, no matter if it is 80" as in east Pakistan, irrigation is necessary during the dry season. This point is further illustrated in Fig. 54A. Wheat acreage tends to concentrate near the natural water lines, and in the canal colonies. By the comparison of the 3 maps, rainfall, irrigation and wheat cultivation we can conclude, that, the modern irrigation works have resulted in the extension of wheat cultivation on relatively unleached soils, which otherwise would have been mere wastes. It also reflects the inherent chemical fertility but lack of water. With the provision of water, wheat is cultivated on 130,000 acres with a yield of 39,918 tons in one of the hottest and driest places in the world, the district of Jacobabad. (Figures for 1959).

The effect of irrigation and rainfall on the wheat acreage and production is well conveyed by Figs. 53 A-B, during years 1947-48 - 1955-56. Appendix 15. Both the acreage and production obtained from the irrigation is less fluctuating than the acreage and production which relied on mere rainfall. The fluctuations in the acreage in both figures is less than that of the production. The failure of rains not only results in acreage not being worked, but in even more in decline, in yield.

It is proved in some experiments at Lyallpur that quantity of water applied to the crop is a major factor affecting the yields. The results obtained from these experiments are reproduced here. (37)

Effect of water on crop yields

Crops	Total water applied Acre inches	Yield per acre in maunds	
		Grain	Straw
Wheat	8.6	24.0	52
	14.6	29.0	60
	17.6	30.5	68
	20.6	31.5	72
		Kapas	
Cotton	22.7	14.00	
	28.7	18.00	
	34.7	20.48	
	37.7	20.48	
		Cane	
Sugar cane	49.30	871.0	
	62.80	1081.5	
	70.55	1159.5	
	77.30	1207.9	
	85.05	1264.0	

These results indicate,the effects of water on the yields of wheat, cotton and sugarcane. In the case of wheat, in the first instance,8.6 inches of water was applied to an acre which gave a return of 24.0maunds of grain, and 52 maunds of straw. As the amount of water increased both yields of grain and straw increased. The same results are shown by cotton and sugar crops.

It is clear that diminishing returns had been met at the end of the experiment with cotton, that the rate of return was decreasing in the case of wheat, while continued water application would have been profitable with sugarcane. What is required for a safe and efficient use of both irrigation and precipitation, is more research into the water requirements of different crops. In the United States of America at Colby, Kansas, on the basis of such experiments, a formula was established, indicating the field water requirements of wheat:-(24)

$$\text{Yield} = \frac{\text{Water used} - 7.13}{0.53}$$

In absolute quantity this meant that 7.13" of water were required before any grain was produced, and "Each additional 0.53" of water resulted in a bushel of increased yield". On the basis of this formula, the experts have been able to estimate the exact water needs of wheat crop. Both the Appendix 15 and Figs. 53 A-B illustrate, that the fluctuations both in acre and production are higher in the rainfed areas, than those in the irrigated areas. The yield per acre in rainfed areas is also low. In the irrigated areas the average yield per acre for the last 7 years has been 844 lbs and in the rainfed 443 lbs.- the difference is startling.

The fluctuations in the wheat production occur mainly, by the vagaries of weather which lead to a serious food condition in West Pakistan. The rainfed areas are the main sufferers when rain is insufficient or late. This deficiency is made up by the irrigation supplies where possible. The curves of production as well as acreage went down during 1951-52 and 1952-53 both in Figs. 53 A-B. This decrease is related to the prolonged drought. The acreage was reduced to 6,553,000 acres in 1952-53 from 7,163,000 in 1950-1951. This was the lowest return since 1947. Production was also reduced drastically, falling from 3,057,000 tons in 1950-51 to 2,020,000 tons in 1952-53.

As the irrigation map demonstrates clearly, the rivers are naturally spaced very well. The diversion dams and canals have been constructed to provide water to the interfluves and perched valleys. Still the total amount of water available for use is very limited. Though the water is applied on a large scale, it is still not used in the most effective ways. In particular, applications are too small in quantity in terms of known plant needs as compared to other countries. In Pakistan, on average, 340-375 acres are irrigated with one cusec of water, each fortnight.(37)

The resulting soil moisture status is not optimum to continuous plant growth, and there is encouragement of salinity and waterlogged conditions. (See Chapters 4 and 5) In the areas of concentrated population, irrigation water becomes even more scarce as "every block of 25 acres receives irrigation water for only nineteen acres"(37) but the crops are grown on the 25 acres, hence the water applied is inadequate, and the yields are bound to be low. In the western U.S.A. generally 1 cusec of water is applied to 100 acres only, and the same duty is practised in Egypt. In the irrigated areas of the United States and Egypt irrigation water is applied frequently in small quantities, which keeps the soil moisture status almost to the optimum during the whole period of growth. In consequence the yields are high.

In recent years, the economics of agriculture has been well realised by the government and national scientists, particularly. The small quantity of irrigation water applied to the crops has been held to be the chief reason of prevailing salinity and one of the main causes of the low crop yields. It is surmised, that proper manuring may increase the crop yields, while at the same time more manuring needs more water in order that it should enter the soil. On such considerations, Asghar has suggested, a proper water delta for the main crops grown in the Upper Indus Plain.(38)

He has given the list of crops irrigated with the present water amounts and proposed water amounts as follows:-

Name of the crop	Water delta practised	Water delta proposed
Cicer arietinum(gram)	10"	13"
Leus Esculenta (Lentils)	10"	13"
Pennisetum typhoideum (Bajra)	10"	13"
Brassica Campestris (Toria)	13"	16"
Triticum sativum (Wheat)	13"	16"
Horcleum vulgare (Barley)	13"	16"
Avena satina (Oats)	13"	16"
Audropogen soryhum (Chari)	13"	16"
Cyamposis psoralioides (Guara)	13"	16"
Trifolium resupinatum (Shaftal)	19"	16"
Brassica rapa (Turnips)	19"	24"
Gossypium spp. (Cotton)	22"	28"
Melilotus parviflora (Senji)	25"	32"
Zea mays (Maize)	25"	32"
Trifolium alexandrium (Berseem)	43"	54"
Medicago sativa (Lucerne)	49"	61"
Oryza sativa (Rice)	55"	69"
Saccharum officinarum (sugarcane)	64"	80"

Two Staple Crops:-

Over 3 million tons of wheat is produced annually in

Pakistan which comes to 99 lbs. per capita.(32) In West Pakistan the production of wheat in 1958-1959 has been 3,760,504 tons, and it comes to .01 tons per person calculated from the population estimates of July 1960. Pakistan ranks fourth in Asia for the production of wheat; still her yields are below the world average as clear in the table below.(39)

Table

Average yield per acre of wheat and rice in lbs.

Country	Wheat	Rice
Egypt	1,968	3,486
Japan	1,926	3,889
Italy	1,560	4,552
United States	1,106	2,643
China	954	2,275
Turkey	894	3,033
Brazil	774	1,304
Pakistan	702	1,192
India	690	1,154

(Average of 1953-55)

The rice crop in distribution and cultivation techniques is a significant indicator of moisture conditions. In West Pakistan as shown by Fig. 54B the highest concentration of rice cultivation is found in two sections; the Lower

Indus Basin corresponding to intensive irrigation and in the Upper Indus Basin its concentration is confined to the districts of Guhjranwala and Sialkot in association with high summer monsoon rainfall and supplementary irrigation. Rice is also grown in isolated pockets in West Pakistan depending on seasonal flood inundations. As noted earlier, the variability and torrential character of monsoon rainfall brings its own particular problems. Rice cultivation no less than that of dry season wheat, still demands water storage and erosion control schemes.

Wheat yields are below the world average; and are higher only than India. In West Pakistan the average yield is 702 lb per acre. Higher yields being obtained from the canal colonies up to 10.5 mounds per acre. In Japan and Egypt the yields per acre are more than double of that in Pakistan. In respect of paddy, the yield per acre in Pakistan is 1,192 lbs, in Japan with intensive cultivation paddy is produced as 3,889 lbs per acre. The low yield is accounted for, by a poor or no rotation, consequently fertility declines and yields also. As a result not directly of aridity but of poor husbandry.

From a consideration of crops and their needs we turn to an examination of regional land use. Fig. 55 and

Appendix 16. The land use pattern predominantly reflects the moisture conditions and presents water availability. The total geographical area of the western division of Pakistan is 198 million acres, and out of that the use of 88,088,000 acres is not reported. The non-reporting areas are in the high mountains, inaccessible forests or rugged uninhabitable rocky slopes, sandy wastes and the tribal areas. The largest non-reporting area in the Division of Kalat is 47,498 thousand acres. The Divisions of Rawalpindi and Multan are wholly reported for land use assessments.

Forest occupies at least 4,975,000 acres of the total area of West Pakistan, at least this is the area about which information is available. It may be stated here that forest data varies considerably from source to source, and the reliance has been placed here on the source stated here.(37) The percentage of forested area to the total geographical area may be noted in Fig. 49B. With the formulation of forest and soil conservation schemes, it is officially estimated, that the percentage of the forest area in West Pakistan has increased by 2-3 percent since 1947. This accounts for an increase of 1,425,000 acres in terms of area. Of these, 517,000 acres were added during 1958-59. The West Pakistan Government have allocated an additional sum of Rs 3,310,000 to the Forest Department in

1959. In 1959, the total forest coverage was 5,141,000 acres, of which the afforested and re-afforested area is c. 317,000 acres. Within the next 3 years an area of 1,482,000 acres comprising of the area along the coastal belt in Karachi, in the zones of Gulam Mohammad and Tanusa Barrages, in the district of Khairpur, the belt on either side of the Indus river and the Frontier zone, will be developed.(40) All these sections are in the vicinity of water points, hence, their selection for tree growth. Afforestation is of vital importance not only as a preventive measure for erosion and to control floods but also ultimately to meet the acute shortage of timber and fuel. In the agriculturally important canal colonies trees are required to serve as windbreaks. The existing forested acreage should be preserved primarily as a means of protecting the catchment and course of the rivers. A controlled rotational grazing may necessitate the protection of the forests. Quick growing species as poplar may be grown in the irrigation tracts which will furnish the growing demand.

The land which is not available for cultivation amounts to 49,620,000 acres. This includes land which are absolutely useless for cultivation as bare wasteland, built up areas, communication lines, water courses and land used for other than agricultural purposes. It also includes saline lands (appearance of efflorescence on the surface resulting in failure of crops on 20 p.c. or more of the areas), and waterlogged lands (fields unable to raise crop on 20 p.c. or more of its area due to excessive moisture in root zone of crops).(41) The maximum amount of this land lies in the Division of Quetta, 18,308,000 acres, which is the result of the inhospitable climate and eroded terrain of the area. This land is unproductive from the point of view both of agriculture and silviculture.

The type of land which is reckoned as the "uncultivated land excluding current fallow or cultivable waste" covers 22,992,000 acres in West Pakistan. It consists of, grazing lands, groves which have not been reported either under "forest" or under "area sown". Though, technically waste, this land is cultivable. The causative factors for the non-cultivation of these areas are several. In the light of the preceding account, we can conclude, that, the main reason for non-cultivation is scarcity of water. Appendix 16 shows that most land of this type lies in the arid regions outside the compass of irrigation. In Hyderabad, where irrigation is on an extensive scale, there are still 3,951,000 acres lying waste for want of water, and for the same reason 1,053,000, 2,273,000 and 4,496,000 acres are lying useless in the Divisions of Lahore, Multan and Bahawalpur respectively.

The following data gives an impression of the scarcity of water in the areas of perennial canal irrigations. The intensity of cropping is 57 percent in the Lower Indus Basin, 65 percent in the former State of Bahawalpur and 75% in Upper Indus canal colonies.(32) The cultivation of Rabi crops are limited owing to low winter rainfall as well as low river discharges. Thus,the percentage of the area cropped by Rabi is 25-30 and by Kharif 34-45. The amount of cultivable waste in the non-irrigated arid and semi-arid areas are of great magnitude. The arid Divisions of Kalat and Quetta possess 3,520,000 and 961,000 acres respectively, and the semi arid areas where irrigation is on a small scale the cultureable waste land amounts to 1,390,000 and 2,867,000 acres in the Divisions of Peshawar and Dera Ismail Khan respectively.

The other category of land use is the current fallow. This comprises land,not cultivated during the specified year but cultivated for at least one harvest during the preceding four harvests. Land left uncultivated for four or more harvests is included in "cultivable waste". The practice of fallowing in West Pakistan is not effective in improving the fertility of the land. In the arid areas frequent dust storms remove its fertile cover. On fields, which are left to fallow on the fringes of the desert, the desert encroaches upon them, and they lose their fertility. Apart from these,the land suffers utterly from the sheer negligence on the part of man. As no attention is paid to this land, weeds grow in great profusion depriving the soil of much of its fertility and moisture. Productivity gain is always small and often now turns into loss.

The type forming the "net area sown" is the total cropped area during the year, minus the "area sown more than once". The greatest amount of such land sown lies in Division of Multan which relies on the canal irrigation. In the Indus plain the sown area is under canal irrigation, (see Fig. 56 A also Figs. 28,30, irrigation). In the Divisions of Kalat, Quetta and Dera Ismail Khan and Peshawar away from the river plains, the amount of sown area dwindles with the dwindling rainfall. (see rainfall Fig. 21B). Thus the present land use patterns are fully governed by the (1) availability of artificial perennial irrigation water, and (2) by the amount of rainfall received by the area. Fig. 56A shows,the proportion of the cultivated area in each Division of the arid and semi-arid zones in West Pakistan. It forms a key to the water availability for the cultivation of crops. This map, when compared with the irrigation map reveals,that,the largest proportion of cultivated area is confined to the Multan Division, where intensity of irrigation is the greatest. The Division of

Hyderabad ranks 2nd in cultivated area. The magnitude of cultivated area decreases with the decreasing intensity of irrigation. Hence, agriculture is essentially irrigational not rainfed, with the ecological consequences already noted and obvious economic and cultural results.

Further points of land use are illustrated by sample studies of crop production, (Appendix 17) at five stations, Peshawar, Lahore, Multan, Jacobabad and Quetta. The first two belong to our dry-steppes region, Quetta belongs to the semi-arid region, and the remaining two fall in the Desert region. Peshawar is situated in the sub-montane plain, Lahore and Multan are located in a true plain. Jacobabad is situated in a desert area, and Quetta is surrounded by highlands.

The two main crops Rabi and Kharif are grown at all stations, but their degree of importance depends on the water availability. These crops are tabulated according to the acreage they occupied during 1958-59.

Among the Rabi crops, wheat ranks high in the areas of Peshawar and Lahore districts. It is predominant also in the districts of Multan and Quetta, but the Rabi crop is of second importance at Jacobabad. There is an adequate amount of winter and spring rainfall both at Peshawar and Quetta, which is also supplemented by canals in the first case and by Karez at Quetta. At Lahore and Multan, wheat cultivation entirely depends on the canal water and it is the major crop in these areas. At Jacobabad, though, it depends on the canal water, it ranks second in its acreage. Most of the Indus water is utilised in its upper reaches before it reaches the Jacobabad canals, hence, wheat is replaced by gram which is able to stand the drought conditions. Only, those areas are able to allot large acreage to wheat, which can rely on an abundance of canal water or rain water. Where ever these moisture supplies are precarious, wheat is replaced by gram, which thus occupies marginal unirrigated land. The other crop in the Rabi sequence is barley. Barley and gram are supplementary rather than competitive with wheat, as their requirements of water and soil are not so high as demanded by wheat, therefore the areas of comparative inferiority of soil and climate are occupied by gram and barley. Gram requires a naturally drained sandy loam, which is common throughout the country. Thus, it is a crop of second order at Lahore, Multan and Quetta. It is also a drought resistant crop and its production may be extended to the drier and sandier parts both as a fodder and food crop. It becomes the staple food in the dry highland and desert regions.

Barley also yields relatively well in inferior habitats.

It is the second crop at Peshawar and 3rd at the rest of the stations. Thus wheat has no competition, on the fertile soils and water supplied areas, and inferior areas are sown to gram and barley.

According to the crop record of 1958-59, rice occupies the first place among the Kharif crops at Lahore, Jacobabad and Quetta. Most years rice is grown on a very small acreage at Quetta but during 1958-59 it abnormally occupied the first place, among the Kharif crops. The large acreages at Lahore, is mainly due to summer monsoon supplemented by canal water and at Jacobabad, mainly due to plentiful canal water during the heavy rains. Rice faces competition from maize, which also requires much water and good soils. Maize is the popular Kharif crop in the Trans Indus plain of Peshawar. At Multan maize is the 2nd important crop. In the main safe irrigated areas rice is always preferred for its higher market value.

The other Kharif crops are bajra and jowar. These crops give yields even under poor climatic conditions and on a variety of soils poor and unirrigated. Hence, they do not compete with rice. There is always a competition between bajra and jowar; as is shown by the Appendix 17 jowar is over ridden by bajra at all places except at Quetta again exceptionally in 1958-59.

In the preceding account, we have seen how water puts a limitation to the cultivation of both Rabi and Kharif crops. It also illustrates, how the yearly amount of rainfall affects the total acreage and total production. We have also compared the fluctuations of acreage and production in the rainfed and irrigated areas. The moisture impact is visible in the delineation of land use patterns; and it is even more graphically and simply expressed by the figures, showing how the magnitude of acreage reduces with dwindling water supplies. Except wheat, rice and maize, all the coarse grains, as bajra, barley, gram, jowar are more or less "barani" - hence their acreage fluctuates with fluctuation in rainfall.

We may now consider crop yields and the food situation. Wheat is the staple food in West Pakistan with rice as a lesser but still important food crop. In the whole of Pakistan these two crops "cover over two-thirds of the total cultivated acreage and permit an uneasy self-sufficiency of cereal supply in years of normal crop. In years of drought or flood, not uncommon occurrences, failure of crops leads to contraction of real incomes and places heavy strain on foreign exchange resources". (32) Another observer reckoned "Agriculture is the one occupation of the people.

Their daily lives are concerned with the rainfall or irrigation supply from wells and canals, the prices of grain and cloth, the payment of rent or land revenue, and the health of their flocks. The ordinary cultivator is a man of few resources with small means for meeting his limited needs".(42)

Crop yields are generally low in Pakistan as compared with those obtained in other countries. The causative factors may be taken both as physical and cultural. The physical are related to the climatic and soil conditions, which concerned the inherent fertility of an area. Rain-fall variable in its incidence and amount, is the vital factor in determining the crop yields. Rainfed cultivation is so critically poised,that the slightest downward variation in precipitation brings catastrophic drops in yield. "The 'dry' crop areas vary considerably from season to season,depending upon the character of the late rainfall, deep alluvial loam. It is grown as a single crop or mixed with gram and barley, successful and favourite crop".(42)

Though in West Pakistan crops depend dominantly on the application of irrigation water, this vast irrigation system is still not sufficient to produce the high yields because of the very high water duty noted earlier. In West

Pakistan application of irrigation water is not sufficiently frequent and the soil moisture level varies very considerably, and plants are thus subjected to alternative drought and moisture conditions and plant growth is obstructed. It now becomes necessary, to ascertain that how much water actually reaches the crop roots? It has been determined for the whole upper Indus Region, that the water applied to the crops is dissipated in several ways. On the whole 17% of the water is lost in the main and branch canals and that in the distributaries about 28%. An amount of 30% goes to recharge underground water through minors and water courses. "So even where main canals and branches are lined (as they are in Thal), if 100 cubic feet are taken from the river into the canal hardly 43 cubic feet will be utilised by the crops, the rest, 57 cubic feet, will go to increase the water table".(43) In addition to the problem of plant variability of needs in frequency of watering, the penetration of water in the soil varies from crop to crop and soil to soil. This phenomenon is illustrated in Figs. 58 and 59. Fig. 58 demonstrates the profile of a bajra field in the Thal area. The area of water penetration from the natural surface downward is 6½", this zone is followed by a space of dry soil 2.5 feet;

Fig. 58

THAL

(Well) Irrigation Penetration in Bajra Field Thal

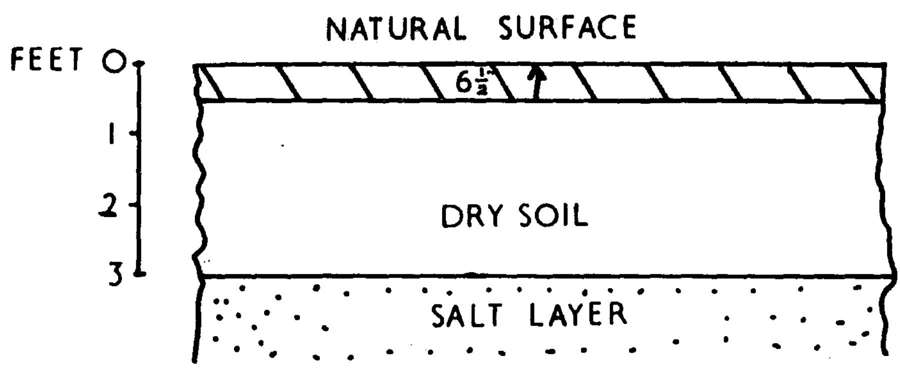
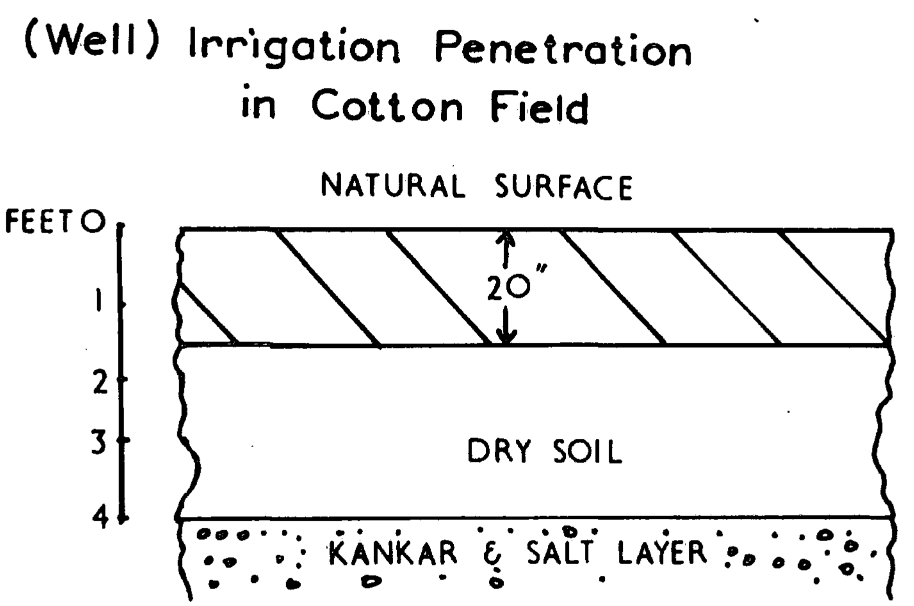


Fig. 59


(Well) Irrigation Penetration
in Cotton Field
NATURAL SURFACE
FEET 0
1
2
3
4
20"
DRY SOIL
KANKAR & SALT LAYER

and finally it is replaced by a salt layer further below; the bajra plant only requires a shallow soil penetration of water, hence it makes meagre demands on water. In the same area the penetration of irrigation water in a cotton field is 20" from the natural surface. Cotton requires over three times the amount of water required by bajra. Below this moisture zone, exists the zone of dry soil, which is followed by Kankar and salt layer. The two figures further illustrate the difference in the soil profile. The zone of dry salt and salty layer is a common feature in both profiles, but there is an occurrence of Kankar in profile. Fig. 59.

As far as the irrigation practice is concerned, the circumstances are very complicated. If water is applied too superficially, evaporation from the surface overrides the transpiration and water is wasted. At the same time excessive water is injurious to the plants and raises the water table. It is suggested by the Agricultural Ministry, that "irrigation water must be applied when 60% of the available water in the root zone is depleted".(37) This type of regularity seems impossible at present, as it must be based on advanced research on the moisture consumption by each plant, in its various growth phases. Even more important such knowledge must finally be applied by the individual cultivator. As far as the application of water is concerned, generally the best method to obtain optimum plant growth,is to have an interval of 7-10 days between successive light irrigations. The recognition of soil moisture prior to seeding is of vital importance, as that stored moisture will be an effective guidance for further applications.

Sustained efforts are required,to be made in the research of national water resources to increase the existing water resources substantially, otherwise no real headway can be achieved. The downward trend of the food grains results from competition with the commercial crops, and the farmers allot better land and more water to these crops. The government control on the prices of the cereals also has deterred the farmers from their cultivation in the years passed.

The low yields also result from the high incidence of pests and diseases. The estimated annual losses by pests and diseases range from 5-10% of the whole agricultural crops. These losses can periodically rise to 100% with the incidence of locusts, rust epidemics, and swarming caterpillars.(37) Food production could be increased rapidly by adoption of effective plant protection measures and throughout West Pakistan, measures are being taken in this direction.

Appendix 18, shows the schemes undertaken in the control of plant diseases throughout West Pakistan.

Crude and ancient methods and implements of cultivation are also responsible for the present low yields. Mechanization has been suggested as another means of increasing crop yields, by the Agricultural Inquiry Committee, with an emphasis on tractors and their attachments.(44)

Mechanical power is a replacement of man power, and is estimated that complete mechanization could displace 2 out of every 3 farmers. On social grounds alone, its use for cultivation operations is restricted, since under present circumstances industry is not developing rapidly enough to offer employment to displaced farmers, as well as to absorb the increasing millions. This suggests that the use of tractors will on normal land be confined to the newly opened canal colonies, where there is no danger of displacing the labours because of the small population of the new areas. As "Colonization by ordinary methods will be slow and costly, use of tractors would enable the cultivable area to come into production in less than half the time required in the case of bullock cultivation".(44)

Tractors have hitherto been in use only on the large holdings like the estate farms. Before the implementation of the present Land Reform, the small size of the holdings limited the scope of mechanization.

Under special circumstances, the use of tractor becomes indispensible and justified. For instance, in the arid areas, and in particular in the rainfed areas tractorisation enables quick ploughing immediately after the rains, for the rapid destruction of infestation by weeds and for deep cultivation, to break up hard pans and for the cultivation of saline soils. To achieve these purposes, the farmers of large holdings rent the tractors by the Government.

The number of tractors in West Pakistan are 3,263 and in East Pakistan 543, in the United States 5,200,000 and in the world 7,100,000 (1955), excluding U.S.S.R.

In the light of the present agrarian situation, and the increasing population, the most economical farm equipment policy is to improve the existing cultivation implements and methods, and to allow tractors to be introduced when ever the danger of unemployment is absent. The general and slavish imitation of advanced countries, in the way of farm mechanization could theoretically bring a general unemployment of incomparable magnitude. Moreover, there remain the ecological problems which have hardly yet been examined in West Pakistan. Improvements in mechanical efficiency may in regions, such as West Pakistan make possible cultivation at crucially correct times, yet it is in these same regions that the ecological balance in the soils is most unstable.

It is essential,that before more power is put in the hands of the cultivator,that he knows how to use it correctly. Ignorance here could be disastrous.

The Village Aid Training centres are being proved a great step forward in giving instructions,so that the farmers can improve their existing implements and practices. The cultural factors partly responsible for low yields at present,reinforce the importance of this point.

Everything is taken out of the soil, as food, fodder, fibre and fuel,but only,a small fraction is returned to the soil in the form of manure or fertilisers. The basic reason for the small application of manures is the lack of fuel, which enforces not only farmers or villagers but even the city dweller to use farmyard manure, cotton-sticks, straw and sugarcane trash in their hearths. The organic matter in the soil depleted, its structure destroyed and its moisture holding capacity is reduced.

The cultivation has become exploitive in the absence of good rotations, alternative systems of land use and husbandry. Monocultivation is a common practice.

In Sudan the introduction of legumes in the Gezira scheme,has strivingly increased the cotton yields.(45) The legumes in the agriculture play a vital role in the maintenance of soil fertility. Legumes have been introduced,in the irrigation farming in Australia, South Africa and Israel, often as pioneer crops, before the establishment of a fixed rotation. In West Pakistan, the reclamation of Thal desert was started by growing the legumes, and as fodder crops, legumes are already grown extensively in Pakistan. The following rotation has been suggested by the Agriculture Department, as an effective step towards the increase of crop output.

Comparison of Different Rotations at Lyallpur

Rotations	Cropping intensity percent.	Average yield in maunds per acre.	
		Cotton	Wheat
		(Nine years' average)	
Set "A".			
1. Wheat, fallow, cotton	66	16.9	23.71
2. Wheat, gram, cotton	100	12.58	24.00
3. Guara(a) (Green manure), Cotton Toria(b).	133	13.77	25.12
4. Wheat, Chari Guara(c), gram, cotton, Senji(d).	166	15.47	25.91
		(Eight years' average)	
Set "B".			
1. Wheat, Toria, Cotton	100	10.99	24.26

2. Wheat, Toria, Cotton, Senji	133	11.39	26.94
3. Wheat, Gram, cotton	100	16.29	25.85
4. Wheat, cotton, sugarcane	100	11.73	26.53

(a) Cynopsis psoralioides.
(b) Brassica napus.
(c) Sorghum vulgare.
(d) Meliotus parviflora.

Source:- Seasonal Notes. Punjab Department of Agriculture.

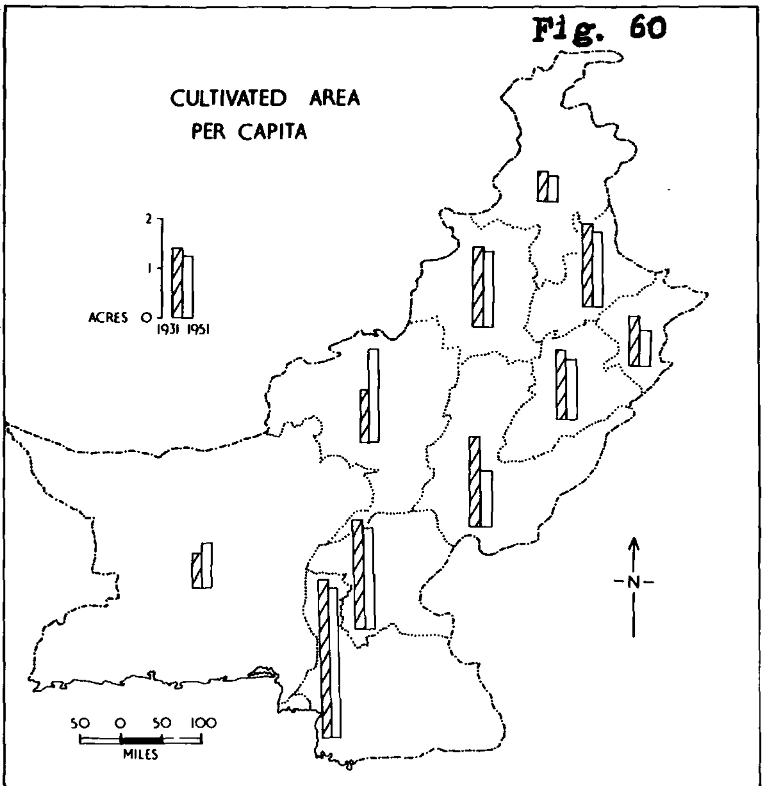
In this chapter, leading from the ecological foundations, we have again moved towards an examination of the many inter-related factors connected with the given situation of aridity. We may conclude by expanding our consideration still further.

The total cultivated area of Pakistan is nearly 60 million acres. Out of that 36% lies in East Pakistan, 0.52 acres per capita. In arid and semi-arid West Pakistan the per capita acreage is 0.9. (See Fig. 60). The poverty of land resources is striking when we compare these figures with those of other countries - Table below. (46)

Cultivated land per capita of Total and Agricultural Population

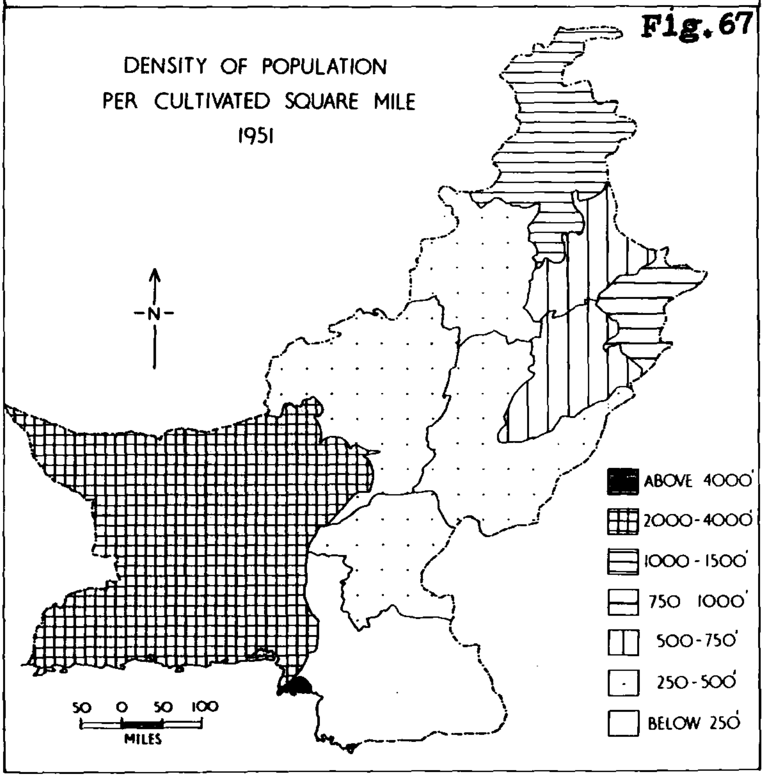
Country (a)	Acres Per capita of Population: Total	Agricultural
Canada *	5.3	28.5

Fig. 60



CULTIVATED AREA
PER CAPITA
2
1
ACRES 0
1931 1951
N
50 0 50 100
MILES

Fig. 67



DENSITY OF POPULATION
PER CULTIVATED SQUARE MILE
1951
N
ABOVE 4000
2000-4000
1000-1500
750 1000
500-750
250-500
BELOW 250
50 0 50 100
MILES

U.S.A. *	3.1	16.5
France	1.2	5.5
Denmark	1.7	6.5
Netherlands	0.3	3.4
Belgium	0.3	3.4
U.K.	0.4	12.0
Japan	0.20	0.8
U.S.S.R.	3.26	5.73
Pakistan *	0.69	
India *	0.89	

(a) Continents: data for 1947-49

Single countries:- data for pre-war years except for those with asterisks.

In East Pakistan 29% of the cultivation is double cropping. On the other hand, in the arid West Pakistan, cultivation on extensive areas, depends dominantly for only a fraction of each holding in any given year. Therefore, "The shortage of water enforces upon West Pakistan cultivator roughly the same amount of under-employment as the scarcity of land does in East Pakistan". It is also "related to the economic holding, the out-turn of the crops grown minimises the differences in pressure of population on cultivated area".(32)

In West Pakistan, the chief economic and social limiting factor is limited water; "The scarce factor is likely to be the number of acre-inches of water that will keep a cultivator fully employed in agriculture. It is frequently if not generally the case in West Pakistan that only a part of each holding can be cultivated in any year, for lack of water".(32)

The man and work hour ratio for West Pakistan has been estimated by Colin Clark.(32) 250 inches of water are required for the provision of 2,500 man hours of work, on average quality land of the canal colonies. His estimates of water consumption comes to 156 acre-inches. In his calculation of the ratio of total supply of irrigation water in West Pakistan against population, the cultivator in the canal colonies remains unemployed almost for a period of 6 months in each year. The shortage of water has not only limited the cultivated acreage but it also imposes unemployment for a long time, in spite of relative low density of population and large tracts of potentially cultivable land.

Colin Clark has also estimated a, "theoretical" limit of exploitation of water resources in the Indus "at another 200,000 cusecs from the canals and wells combined, sufficient, all things considered to provide an additional 2,520 million acre inches of water. Reducing this theoretical estimate to something more likely to be realisable, 1,520 million acre inches might actually be available for cultivation in West Pakistan". Yet vast tracts of fertile soils are going out of plough every year due to erosion, salinity and water-logging. The main cause of all these calamities is variability of rainfall in its incidence and amount, along with meagre amount of irrigation water and the dust storms which remove the dry soil particles.

In West Pakistan, any such increase in the cultivated areas depends on improved irrigation methods and extension in the irrigation works, along with the provision of effective drainage systems, to prevent the twin menace of waterlogging and salinity, as well as the improvement in soil fertility by reclaiming the sick soils. By, in other words, total ecological improvement, measures are also taken to reclaim the eroded land to check the run off in summer monsoon. A number of schemes have been proposed and executed under the first and second five year plans to achieve these objective. (See Chapters 4 and 5). Storage dams are completed at Warsak on Kabul river and, at Rawal, and work on the largest, Mangla dam, is started. The multipurpose schemes are Thal, Taunsa and Guddu projects in the upper Indus and Kotri Barrage in the Lower Indus Basin. Under these schemes, water flow will be controlled and regulated, and its use will be economised and the present cultivated area will be both extended and cultivated more extensively.

Besides, canal irrigation schemes, the cultivation may be extended by the pumping of stagnant water from the depressions in the dry season from October-November. To plough the land quickly after rainfall, is another means to conserve the moisture. Water supply may be increased, by tapping the underground water for, which Tube well schemes are being executed in Bahawalpur. These schemes are implemented under the technical assistance of U.S.A. In the long run a net work of 300-500 tube-wells will be completed. The details of the schemes may be visualised in Table A, Chapter 4. In the arid Divisions of Quetta and Kalat, small irrigation schemes are sponsored by the Agriculture Department since 1948. An area of 0.9 million acres have been provided with the irrigation facilities uptill 1959. For the same region, it has been estimated, that an additional c. 6,000,000 acres can be cultivated, if coastal and desert streams are harnessed for irrigation.(47).

In April 1959, a short term irrigation scheme was approved under which, over 40,000 acres of barren land, mostly in the Cholistan area will be brought under bajra cultivation. The scheme comprises the provision of water to certain areas in the Cholistan desert through Khakra and Desert branches of the Bahawal canal during July and August.(48) This will enable the local farmers to extend the cultivation of Bajra which constitues their staple food.

The irrigation system will be made more stable and efficient following the final solution of the Indus Basin dispute. These reservoirs will stand a security for agriculture during the critical periods.

The basic problem is,that,under conditions of environmental difficulty and hazard as in arid and semi-arid regions, individual peasant farmer cannot easily develop sophisticated approaches to land management. A restricted crop range, in the absence of irrigation,hampers the development,even of traditional, rule of thumb staple crop sequences and rotations. Illiteracy,and village isolation,prevent the cultivator from benefiting from the experience of others. Traditional irrigation developments in West Pakistan conditions, as in Iraq brought only short-lived benefits, because local soil deterioration was accompanied,by the destructive effects of regional ecological damage,beyond the control of village irrigators. Recent political misrule and social instability further restricted progress. By the late eighteenth century quiet poverty was safer than the accumulation of wealth,which only became the target for extortion. All cultivation became a matter of seeking subsistence security. During the period of irrigation development from 1880 onward the full needs of change were not realised.(49)

"The whole agricultural system of the province has in fact been adapted to meet the predominant feature of the climatic conditions viz; the uncertainty of rainfall. This has led the agriculturalist to aim at security rather than high results".(50)

"Irrigation and drainage work on the placement of colonists is only the first step to increased production. After irrigation, for instance, the farmer has to learn not only to use water but also to change the whole range of his farming practices ..... left to himself the farmer will adjust slowly to new possibilities".(51) Only during the last years of British rule and in the period of independence, has the complex gravity of the situation been realised. In the new nation-state, as appears in the priorities given in the Five Year Development Plans,under the Colombo Plan auspices, a national agricultural policy has had to be formulated. The realisation of the importance of agriculture has led to,not only technical appraisals of environmental possibilities,but also to the improvement of husbandry, and farming practice by the people. Ultimately it is the farmer who forms the link between land and wealth.

In this thesis the approach has been deliberately restricted to a study of the more or less direct implications of aridity viz, climate, hydrography, water use and ecology.

The full consequences of aridity do in fact spread into all parts of life in West Pakistan,but an examination of the mainly human social and economic elements would require a second thesis. All we can do here,is to use some aspects of human reaction to environment,to help us to understand the environment more fully. In the concluding chapters are briefly examined some of the evidence of this last kind.

Part II

Settlement Patterns

Chapter 7

Early Cultures

In order to appreciate the human appraisal of the West Pakistan region, it is helpful to note the changing historical character of Indus culture in the pre-historic and historic periods.

Pre-historic Settlements

There are many instances from which one can conclude, that Stone Age people went through cultural transformations locally, achieving a mode of life to which the name "Civilization" has been given by modern archaeologists. Hence, the Sukkur and Rohri Stone people may be considered as the true ancestors of Mohenjo-Daro and Harappa, and in adjacent areas, have emphasized the facts that the Indus civilization developed locally, having individual characteristics, as well as close contacts with other contemporary civilisations of South-Western Asia.

The Stone Age Settlements:-

It is now generally held, that the earliest abodes of mankind in West Pakistan were along the banks of Indus river. The earliest settlements were scattered along the river course, from Attock down to Sukkur and Rohri. By the Pleistocene period, dominant features of the relief of Pak-Hind Sub-Continent had been formed, except that, the lowland Indus trough still formed a great collecting basin for highland detritus, complementary and parallel to isostatically rising mountains. The beginnings of the cultural geography goes back to the remote period. All the phases of cultural geography, whether related to primitive man or modern man, are in considerable measure, shaped by physical environment. It is well illustrated in Fig. 61 how the expansion of settlement was shaped and directed by the physiographic features of the land. (The greatest concentration of the dwellings is seen on the northern bank of the river Soan, south of Rawalpindi, see below).

It is still obscure, whether the earliest inhabitants entered the region from outside or emerged here by evolution. In any case, evidence has been left by them consisting of artifacts of various types. Fig. 61 suggests that Man's gradual growth as a sentient being, can only be dimly discerned, amid the geological and physical environments which he first confronted. Primitive man was essentially a part of the plant and animal life surrounding him and he remained enslaved to these natural environments. With his physical evolution, he gained consciousness of these powers and

Fig. 61

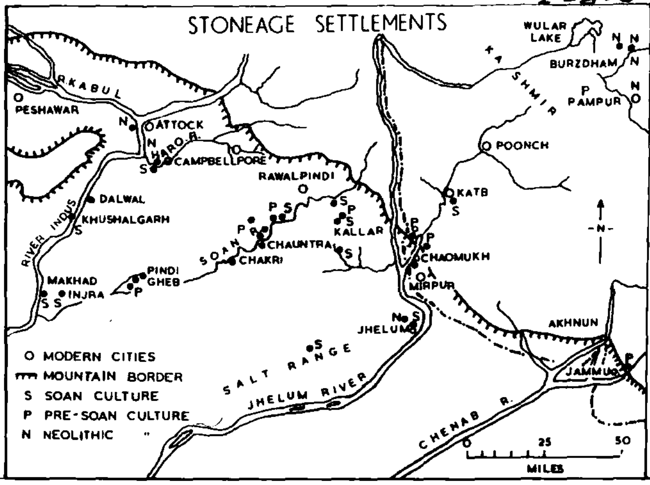
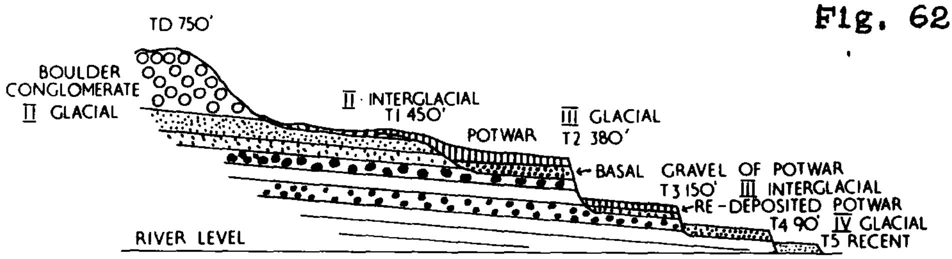


Fig. 62



TRANSVERSE SECTION THROUGH INDUS TERRACES (TD. T 1. ETC.)
NEAR CONFLUENCE WITH SOAN RIVER

Fig. 63

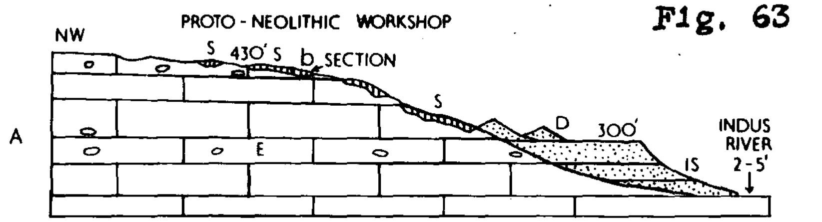
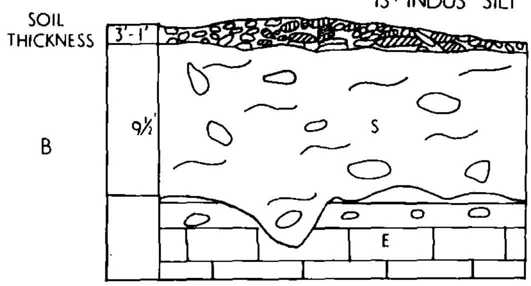


FIG. A SECTION NEAR SUKKUR & ROHRI

S: SOIL D: SAND DUNES
IS: INDUS SILT E: EOCENE LIMESTONE



DETAILED SECTION AT POINT b INDICATED IN FIG. A potentialities which distinguished him from other animals. He was then enabled to free himself from simple direct control of natural environment.

As explained in Chapter Two the drift deposits consisting of boulders, gravel, sand, clay and silt, accumulated under the action of glacial, pluvial and acolian agencies, in river valleys, in the shape of terraces, deltas, lake-basins deserts and plains. In these deposits are preserved the traces of human existence and of relief and climatic conditions of the Pleistocene period.

The idea that the Indus Valley is the first human abode in West Pakistan has been confirmed by the De-Terra Scientific Expedition to Kashmir, north-west Punjab, Sukkur and Rohri in 1939.(1) Its purpose was to study the effects of the Ice-Age in these areas. In the course of their research,expedition brought to light important primitive human encampments in the area situated between rivers Indus and Jhelum, and also an area in the proximity of Sukkur and Rohri. The study was based on finds and evidences provided by the presence of "artifacts" embedded in successive terraces of rivers Indus and Soan. In West Pakistan,the whole study was extended to the following territories:-(1)

1. The Soan Basin.

2. The Indus river from Attock to the junction with the Soan.

3. The Lower Indus Basin in the vicinity of Sukkur and Rohri.

The reason why the first settlers chose these quarters, has been explained concisely by De-Terra himself. "It was noted that the sites were congregated close to the river on terraces, suggesting that the river valleys afforded better hunting and habitable ground or more easy routes for travel". It indicates, that even during his early development, man was capable of selecting and adopting easily accessible means of livelihood.

Researches in districts 1 and 2 were limited to five terraces at three places Dalwal, Kushalgarh and Makkad, located, along the left bank of Indus from North to South. (Fig. 61) A succession of glacial periods has been traced, which in turn related to the river valleys, where the rivers have deposited their sediments in terraces and later cut into them. These terraces are the outcome of glacial as well as the pluvial action, under the processes of aggradation and degradation. The terraces are explained here in the order as demarcated in Fig. 62 which is a transverse section through the Indus terraces near confluence with Soan River.

Terrace D,was composed of coarse boulder conglomerate and it was formed during the Second Glacial period. Its present elevation is 750 feet from level of the river.

Terrace 1,contained cemented boulder conglomerate formed by the processes of erosion, in the Second Inter-Glacial period. Its height is 450 feet.

Terrace 2,constituted of "weathered deep brown purple boulders", and it was covered by a thick layer of Potwar loess and silt. This can be dated to the Third Glacial period. It lies at 380 feet.

Terrace 3,was built up at the height of 150 feet, in the duration of Third Inter-Glacial age, and consists a long eroded base of gravel. Plate 19 and Fig. 62.

Terrace 4,was formed during the Fourth Glacial period under the deposition process, it contained gravel and sand and rises to 90 feet.

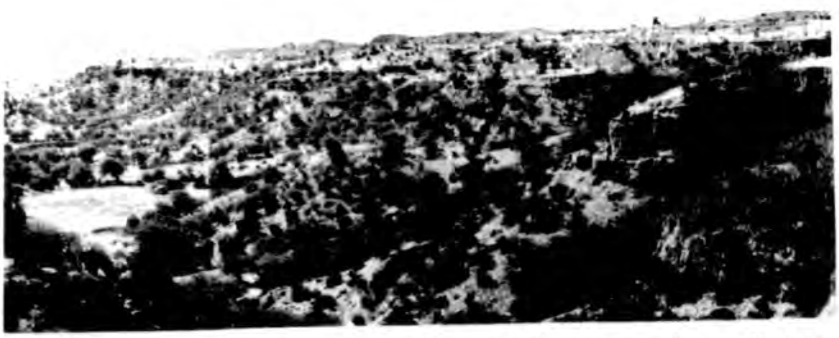
Terrace 5,was recent, rising to 30-40 feet and was flooded by river water frequently. The normal cycle of river sedimentation, boulder→gravel→sand→silt is illustrated in Fig. 62.

These terraces are indication of climatic changes as well as a suitable habitats for early man. They are a natural treasury for fossil remains and artifacts and are the key to the quaternary formations. The terraces mentioned

Plate 19

T1

2. **Right slope of Soan Valley near Bandhar.** Terraced Boulder conglomerate ridge (T1) in left background. T, terrace.



1. Right slope of Soan Valley above Chauntra. Terraces 2 and 3 on Boulder conglomerate.

above are both aggradational and erosional.

A transverse section was drawn by De-Terra through these terraces and specimens were collected from the successive terraces. After an examination and comparison of artifacts belonging to each terrace, different names were assigned to the various industries. The typological sequence was thus ascertained (see Figs. 61, and 62 for the account follows).(1)

1. Pre-Soan Settlements:-

These are related to the highest terraces D and 1. This culture belonged to the first phase of the second Inter-Glacial period. The tools surviving from these sites, were deeply "patinated" crude and "rolled pebbles", which suggested that they were made during the process of deposition. These implements were mainly of quartzite and were barely distinguishable from natural pebbles.(2) Thus during the period of temporary climatic amelioration in the second Inter-Glacial period, these abundant tools indicate the presence of Paleolithic man whose culture has been designated by the archaeologists as "Pre-Soan" or Early-Soan. The following sequence, based on the differences in the formation of "pebble flakes" may thereafter be utilised.

Early Soan Sequence

A	B	C
pebbles heavily worn and patinated	unworn pebbles patinated	pebble tools less patinated, not worn.

Fig. 61 shows, that the Pre-Soan culture was concentrated in the neighbourhood of Rawalpindi, Kallar, Chauntra, Chakri and Pindigdheb, mostly on the right bank of river Soan. Plate. 19. This culture has been reckoned as contemporary to South African paleolithic settlement.(3)

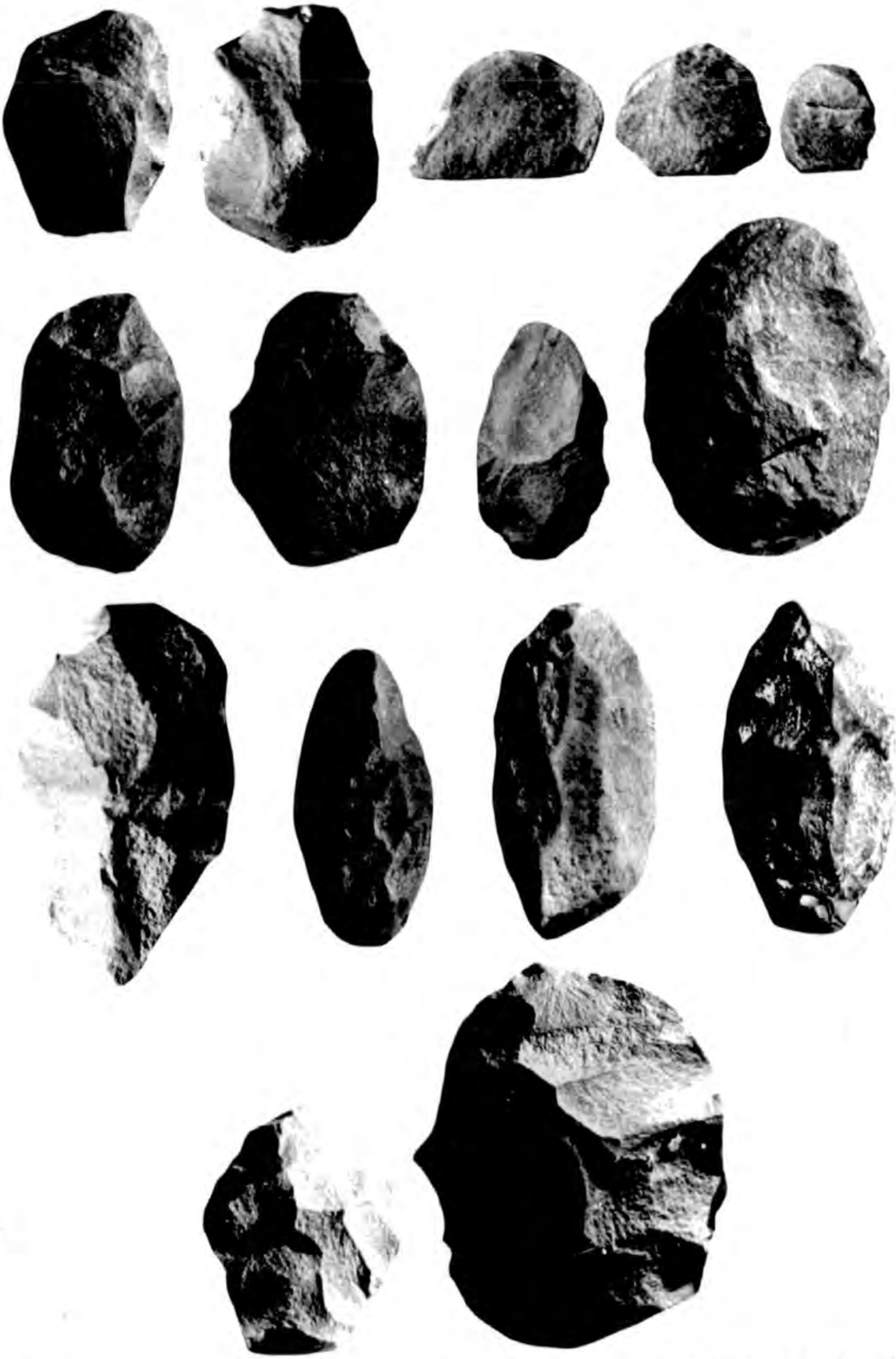
2. Soan-Culture:-

Between 400,000 to 200,000, the pre-Soan culture(2) succeeded by the Soan Culture associated with terrace 1. Actually this culture is a local advancement of the Pre-Soan culture. Geologically the terrace is assignable to the last phase of Inter-Glacial II. The boulder conglomerates of this terrace have yielded tools, showing considerable progress in the formation technique, marking a transitional period, between the Early Soan Culture and the Late-Soan cultures. The salient features of this industry were the Chopper and pebble tools.(2) See Plate 20. This culture has also been discovered near the Indus river at Kushalgarh, Injira, Makhad, and near Campbellpure. The local technique of this culture continued to the fourth Inter-Glacial period, A

B

C

D



[illegible] Abbevillan hand axes from Chauntra
[illegible]

terrace 4. Cultural similarities with South East Asia are apparent.

3. Late-Soan Culture:-

Between the Early and Late Soan cultures, intervened the third Ice-Age and the next culture in the sequence is assigned to this period is called by De-Terra "neolithic". The following sequence may be observed.

Late Soan

A	B
Flat pebbles tools and cores.	Fresh and unworn tools, core and flakes in potwar silt.

Probably these manufactured with the aid of wooden striking implements.(2) The mode of tool manufacturing was distinctly improved, as implements were trimmed, smoothed, grooved and polished and were highly finished on the whole. Plates 20-D, 21,22,23 and Fig. 61 indicate sites of this neolithic cultures.

The outstanding features appearing in Fig. 61 are, firstly, the predominantly stream side distribution of the cultures implied by stone "factories", - chipping of stone might have been made easy by the use of water. Secondly, in the Potwar region the primary or pre-Soan sites were lodged in the central part. During its secondary and tertiary phases the culture spread dominantly over to the West, and to a lesser extent to the East on the banks of Jhelum

Plate 21

4. Soan workshop level (S) between Potwar loess and Soan gravel.

2. Potwar loess (Ps) over Boulder conglomerate with Soan workshop (W) on terrace ledge above Chauntra.

Plate 22

4. Late Soan workshop (crosses) at base of Potwar loess at Pir Abdul, near Gila Kalan, Soan.

5. Old (second glacial?) conglomerate over Dhok Pathan beds and upper edge of T_3 at hand-ax site near Chauntra.

Plate 23

Soan workshop above Adial, with redeposited (fourth glacial?) loam in foreground. (See fig. [illegible].)

1. Human skull of neolithic(?) age in postglacial loessic soil southeast of Rawalpindi.

river. The reason of expansion and the progress in their artifacts may be the growth in population in the first place and better type of raw material available on the Indus banks. The raw material in the Soan valley is either of erratic blocks or sandstones and limestones of the Kalachitta ranges. The raw material available on the Indus banks is mostly the Attock Slate which is more suitable for chipping and flaking techniques. Thirdly, the improvement may be owing to their long practice and tradition. See Plate 20, which indicates the stages in the advancement of cultures of implements. The location of stone huts suggests a dispersed type of settlements.

Thus, the earliest human artifacts appear in boulder fans at the close of the Second Glacial period. An abundance of Paleolithic and Neolithic tools found in the terraces of the Indus and Soan rivers. Fig. 61 also suggests that the cultures spread outwards from the Soan valley, but does not indicate signs of inward movements, suggesting that the Soan culture is indigenous in its origin. Man's emergence was coincident and contemporaneous probably with the two later glacial advances. Research has shown the ubiquity of pebble tools and of cores made of small pebbles in all phases of the Soan cultures, suggesting that pebbles were the only raw material available. The study also suggests that the man was at a fairly advanced stage of hunting, for which stone was the first pre-requisite.

The above notes illustrate the evolution of a stone age culture in a limited area.

As a result of ~~these~~ glaciological investigations made in the Indus Valley south of Attock, there appeared obvious incentives to carry on research in the rest of the areas of the Indus Plain(1) in order to find out whether the above mentioned culture had links with the delta region, or with the Indus plain in Sind. Plate 24.

Ample evidence became available on the Stone Culture in the Lower Indus Basin, in the proximity of Sukkur and Rohri by the presentation of "core-tool family" implements. These series are supposed to furnish an example of "Proto-neolithic workshops", and appeared as well-defined human industries belonging to two primary groups; the Sukkur and Rohri.

The typological analysis of this area has been rendered impossible owing to the absence of systematic stratified deposits. A conclusion relating to dating has been drawn from the fact, that the formation of "terra-rossa" is possible only under moister circumstances than now prevail.(1) Therefore, their date of origin goes back to a time of heavier

Plate 24

4. Factory site near Rohri, Sind

rainfall, and this infers a moist climate in the stone age. There is no doubt concerning the moist climate of the Inter-Glacials, aridity setting in with the final retreat of ice sheet to the North. The "terra-rossa" soils along with the "factory" sites were buried under yellow-grey silt on the valley sides near Sukkur and "varnished" with sand dunes.(1)

The proto-neolithic sites were located on a hill West-North-West of Sukkur and to the South East of Robri, at an elevation of 130'-160' above the stream bed, on the surface of Eocene limestone containing flint. The hill top was covered with ferruginous soil, mixed with residual limestone breccia and had a thickness of 1-3 feet. Figs. 63 A and B.

1. Sukkur:-

The collection of tools obtained from the site in the continuity of Sukkur were patinated like the Pre-Soan industry. The tools discovered, were exposed in the foot of the hill were large "axelike" tools, which enabled the Stone Age humanity to dig, scrap and cut. The top implements were constituted of cores, waste flakes and larger scrapers, mixed with blades and scrapes. The manufactory at Sukkur was classifed into three groups, based on the degree of patination rendered by each group and the raw material used was flint. The most recent artifacts bear a resemblance to the earliest tools found at Mohenjo-Daro.

2. Rohri Sites:-

The occupied sites in the environs of Rohri, were located on the dissected hill-top. The ravines on the hillsides were filled in with a fine grey sand silt mixed with planorbis shells, and this sediment was deposited at the height of 60 feet above the river. The slope sites were coated by silt and ultimately the silt was covered with shifting dunes. The factories are concentrated around two hills of limestone, and thus were differentiated as Rohri 1 and Rohri 2. They depended on flint for their chief raw material.

Rohri 1:-

The types of blade core sorted out were mainly conical in form, with few flat blades and irregular, early type of crude and waste flakes co-existed with them. The reflection of this mixed phase of the industry and a high degree of skill suggested, that the refined articles might have produced for the purpose of export and rough were used locally. The archaeologists fancy, that the trading relations were established among the stone cultures also.

Rohri 2:-

The occurrence of blades, became rare and the flakes were mostly flat and thin in conformation. A great quantity of waste flakes and small chips were very distimct. On the whole the industry was highly specialised. On the basis of evidence from these cultures, one can make a brief comparison between the Upper Indus and the Lower Indus cultures.

		Soan or Upper Indus Culture	Lower Indus Culture
1.	Location	On the banks of rivers Indus and Soan.	On the banks of the Indus.
2.	Material	Quartzite.	Flint.
	Implements	Patinated pebbles in the early stages. Worn pebbles in the first phase, and fresh unworn core tools and flakes make the later aspect. Absence of blades and concave-convex shapes. Hand axe occurred rarely. Non-specialised.	Patinated blades and flakes in the early stages. Worn blades, flakes in the first and concave-convex core implements, core flat and flakes make the final aspects. Existed almost all phases. Axelike and pick-like tools but negligible. Specialised and commercially important for blades and flakes.

The early man finally produced a most useful implement the "hand axe". It was the earliest widely used human device while man remained as a hunter using stone instruments. No sign of stock farming or cultivation appear contemporaneously.

Various points of contrast indicate, that the two cultures had flourished as separate and individual entities, bearing no relation to one another. The Lower Indus Cultures were more advanced than the Soan cultures, but both were of hunters. The industries which appeared in the Lower Indus Valley also represented an indiginous growth from which a more continuous urban civilization emerged. Archaeologists also believe, that the Lower Indus valley's settlements belong to the earliest period of the Chalcolithic civilisation of the Indus valley and preserved in this region are the remains of continuous occupation of sites.

The climate during the Stone Age culture was probably pluvial. The rivers flooded and spread more and more debris in the foot hills and built fans and terraces. These accumulations of fans provided the early man a great source of raw material for their implements. The men lived in the hilly country among the river terraces, where their primary needs of water and raw material for the tools were satisfied. As the pluvial conditions prevailed over the country, extensive forests must have been thriving in the present treeless area.

Bronze Age Culture:-

Until 1922 Pakistan had few known pre-historic remains to offer to the world, except for the famous Taxila ruins which belong to the early historic period. The antiquity and consistency of human settlements as gleaned from the discoveries in the Indus Valley, now suggest, arid West Pakistan can lay claim to the honour of being a pioneer of civilization along with Sumer, Babylon, Egypt and Assyria. Here a continuous history of civilization started circa. 5,000 B.C., when the arts of agriculture and crafts flourished to a high degree of efficiency, and the land supported a relatively dense population as demonstrated by archaeological remains. There is already copious evidences of pre-historic cultures, based on different types of sites; food production, pottery, textile fibres, building materials, seals, implements, paintings, carvings, graves, bones, and utensils. These relics have been excavated from the divisions of Hyderabad, Khairpur, Quetta, Kalat, Bahawalpur and Multan. The data offered by such extensively excavated sites is abundant. The main settlement sites are the cities of Mohenjo-Daro and Harappa, and some villages in the Quetta-Kalat divisions. Many other sites have been unearthed superficially, located, but not excavated on a large scale. Their interpretation is as yet tentative. These sites are scattered over the whole Lower Indus basin, and Quetta Kalat divisions.

These areas are now climatically dry and physically consist of desert, bad lands, mountains and dry dissected plateaus; which are traversed by large and small rivers.

The divisions of Kalat and Quetta generally form a mountainous terrain, more especially towards the north; where latitudinal-trending branches of the Sulaiman range rise to the height of over 12,000 feet. The southern mountain ranges run longitudinally and parallel to the coast. A central plateau and desert are enclosed by these ranges. The rivers flowing here are inconsiderable in volume except after heavy rainfall. Climatically the area experiences extreme climatic conditions with a snowing winter. Rainfall is both capricious and precarious, hence desertic conditions are universal. The soil in the areas of water supply is productive and fruits and grains are grown commercially. The chief sources of water are underground water supplies; and the water has been tapped since the Middle Ages by means of "Karez".(2) The climate of this region has changed considerably since 5,000 B.C. as noted already more fully in the section on climate.

Below the hilly terrain, the Indus and its major tributaries drain a vast plain of alluvium deposited by the rivers themselves. In its final stage, the Indus now passes through the desert where the evidence of pre-historic culture is prolific. In fact both climatically and archaeologically the arid zone of West Pakistan forms the eastern component of the immense dry zone of south west Asia as already considered under climate.

As a whole it is assumed by the geologists, archaeologists, historians and climatologists that both the former province of Baluchistan and the Indus plain must have been experienced a pluvial phase in the Pleistocene during about 5,000 B.C.

The archaeological records have afforded considerable evidence on the climatology of this zone, but nothing has been proved conclusively. The work of Sir Aurel Stein concerning the ruins of south Baluchistan as well as Central Asia introduced the idea of proceeding dessication.(4) Before assessing the arguments about progressive dessication it is logical, to note the distribution of pre-historic villages, towns and cities and examine the reasons for such patterns. The pre-historic cultures examined here are delt with, with the following chronology.

1. Early pre-historic hill villages and town cultures are antecedent to the Indus city culture, presumably dating to and beyond the 4th millennium B.C.
2. Middle pre-historic period, the Indus city culture, estimated from 2,300 B.C.-1,500 B.C.
3. The post-Indus culture probably post 1,500 B.C.

Early pre-historic or the hill village cultures:-

It was early discovered by the archaeologists, that settlements were associated with artificial mounds to which Arabs give the name of "tell" the equivalent of the Sindhi "daro", the north-west Frontier "dheri", the Baluchi "dhamb", or the Iranian "tepe".(2) The "tell" is a small hillock which came into existence by the repeated process of erection of city, town or village, in the succeeding centuries. Every time a new "structure" was built, it rose on top of the ruins of the preceeding settlements.

A classification of these "tells" in our region has been proposed by Professor Stuart Piggot, was based on the painted pottery, the scheme of grouping following the bases of classification of pre-historic Persian Cultures.(3) In Persia "Buff-wares" were related to the south, and "Red-wares" were associated with the north. In the same way Buff-cultures are found in south Baluchistan and the Red-wares were located in the North. The following sequence has been observed by Piggot, which corresponds to the Persian sequence of cultures.

Table

A. Buff Cultures.

1. The Quetta Culture (from sites in the Bolan Pass).
2. The Amri-Nal culture (from two sites, the first in Sind the second at the head of the Nal Valley in Baluchistan).

3. The Kulli Culture (from site in Kolwa in South Baluchistan).

B. Red-ware Cultures.

4. The Zhob Cultures (from sites in Zhob Valley of North Baluchistan).

The Geographical Patterns of Settlements:-

The most striking feature, as is obvious from Fig. 64A and reflected in the nomenclature of each settlement, is their location on the riversides. The isolated hill-separated basins, the valleys, which dissect the mountains of Baluchistan and the alluvial fans at the torrent mouths, were studded with tells. These cultures stretched out along the present seasonal routes of migration. In the hills and fans, particularly those which are priviliged with water, settlements are still present, where people could and can cultivate crops by age old methods of "Sailaba" or "Khushkaba". Each valley, oasis like, seems to have been nearly an independent economic unit, which suggests that the environment was favourable to development of peasant cultures which did not require political unification for their survival. The cultures were stamped with local peculiarities, and inter communication was probably not frequent.(5) In spite of these marked individualities, these cultures also exhibited common traits which might have been due partly to the common element in the environment, such as the stone from the local mountains for the building purposes, and the clay from the adjoining stream beds for pottery, and partly to the common cultural background of peasantry.

The underlying unity may thus be related to migration. There are multiple causes relating to the migration phenomenon, but the most probable cause was climatic variation, especially the climatic changes in contemporary central and western Asia, where the recurrence of relatively dry years gave rise to the wave after wave of migration. It also tended to force the earlier settlers still farther towards the east.

The streams and valleys clearly provided the routes of penetration from north to south and east to west and they facilitated the use of routes through the hills to the Indus Plain. The concentration of finds indicates penetrations to and from Baluchistan to Iran and Sind. Sea movement was borne along the Makran coast, as is proved by the archaeological evidence.(3) The north Baluchistan communities made and "decorated their pottery in the same distinctive manner as the inhabitants of northern Iran".(3) These and other affinities indicate the land routes along the watercourses. "The southern Baluchistan is comparable to south Iran or Iraq and presumably they are sea-borne relations".(3) These similarities establish that, though the villages were isolated units perched in different valleys and on hills, yet they pursued similar crafts and maintained trading relations over considerable areas.

Perhaps it was the combined effects of climatic changes and migration, that checked human evolution along the earlier and simpler lines, and produced complications in the primary settlements. This is suggested by contemporary events in the modern dry zones of West Pakistan where nomadism prevails.

A few specific cultures have been selected in order to give a brief survey of conspectus, of the range of antiquity, as visible in the remains of early pre-historic sites.

Speaking broadly, the sites fall into 4 groups. Fig. 64A and Plate 25.

A. The Quetta, Pishin concentration.

B. Sites in the valleys of Rakhshan, Nal Mashkai, Gaj-Kulachi, and the northern reaches of Porali river, with chief concentration in Nal.

C. The sites in the valley of Kej and Kolwa in south Baluchistan.

D. The cultures in the Zhob valley.

The first three cultures are typically "Buff-ware" while the Zhob valley yields "Red-wares".

A. The Quetta Culture:-(3)

A large amount of archaeological work has been carried

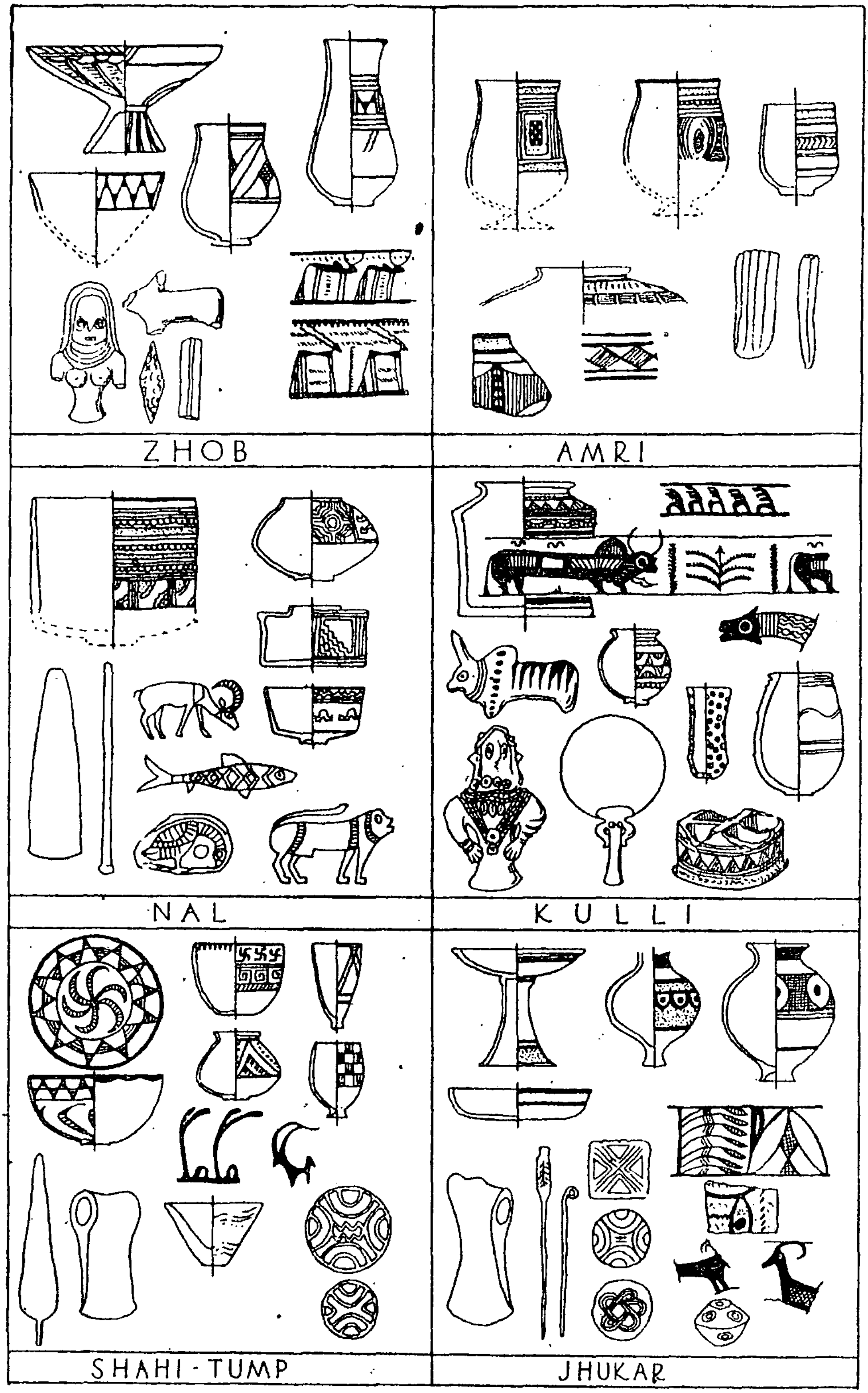


FIG. 3.—PREHISTORIC CULTURES OF WEST PAKISTAN

Not to scale. (From Stuart Piggott in *Ancient India*, No. 1) out in Bolan pass. In the light of the archaeological facts, these cultures were closely allied to the local culture of Quetta. Quetta stands at the head of the natural passage between the two mountain regions, and it has had a commanding position throughout the human history, because of its location on a natural routeway. The sites are threaded along the stream banks. Very little detailed information has been ammassed about the Quetta culture. The archaeologists have located only 5 "tells", the highest among these being 45-60 feet high, with a base diameter of 600 feet, the dimensions showing that they were very small agricultural villages. The ruins of the houses indicate that they were built of mud bricks. Finds of buff pottery painted in purple brown with geometric patterns were unearthed. This pottery is regarded as contemporary with the pottery at Tal-i-Bakun in the Fars and Susa regions of Persia.(2)

The second group has two chief centres of culture at Nal and Amri. Amri is located on the right bank of the Indus at the foot of the Kirthar range, these two similar cultures jointly known under the name of Amri-Nal culture. Related groups were found in the valleys of Mashkai, Gaj-Kulachi, Rakhshan and northern Porali. The location of Nal-Amri settlements, demonstrates the early use of the classical trade routes from the Indus bank to Baluchistan. The most important routes even today, are from Baluchistan through the Mula pass, along the river course, and along the foot hills to Johi and then to the terminus made by Lake Manchar. Gaj gorge has been used as a traffic line since the pre-historic village age. Another route starts from the Maskai and Nal valleys over the Lak Phusi and the Lak Rohel, at Pandri enters Sind. These river valleys have always been the connecting links of the different villages, towns, cities and nationalities.(5)

The settlements have formed tells with heights varying from 10 to 40 feet. The average size of the settlements is generally less than two acres ..... "about the size of the area enclosed by the lowest contours at Tepe Gawra" a famous parallel culture in Mesopotamia.(3)

A distinctive feature of some of the Amri occupation was the defensive wall, for instance Kohtras Buthi was situated on a hill-spur, and had a double defensive wall.(3) The remains of such fortifications have been traced at Dhillanijo-Kot also.

Throughout the areas of the pre-historic village phase archaeological excavation has been very limited and most of our knowledge is tentative. Extremely inadequate data exist about the layout of the village and houses. The plan of Nundara indicates, that buildings situated in the south east part of the settlement bear a common orientation of south-east. The groups of rooms at Naudara form blocks of 40 sq. feet. Door and windowless cellars were also found.(3)

The hill fortress of Kohtras Buthi exhibited the surface indications of "the outlines of countless rooms, both large and small, grouping themselves into blocks separated from one another by alleys inside the cyclopean defensive wall, but apparently separated from it by an open space. This wall of large, roughly coarsed blocks has at least four exterior bastions and the remains of an entrance, while the ruins of a slighter outer defence wall lie about 100 feet away".(3)

The pottery, both at Nal and Amri, was parallel. The most distinctive features of these districts was the presence of "very thin and fine" wares covered with a fine "white slip". In addition to this the paintings on pots included "occasional touches" of blue, yellow and green as well as red.(2) The patterns contain items derived from animals such as lion, caprids, birds and fish, as well as the geometric figures. The chief speciality of Nal was the pottery animal design, a feature absent at Amri.

The presence of particular qualities of copper and nickel-rich metals suggest importations from Aman, Rajputana or Afghanistan. Some metals might have been worked locally. Among these metal objects, primitive forms of axe were also discovered, suggesting that these sites might have evolved from the local stone-age settlements. The other evidences of international intercourse are the ornaments and beads, for instance, of lapis lazuli and carnelian, products of north-east Afghanistan.(3) It emphasises the maintenance of inter-regional connection and commerce, exchange of ideas and practices.

The Nal-Amri culture is essentially, then an assemblage of small village settlements on the river banks in the valleys and on the hill spurs, occupying otherwise hetrogeneous locations. The houses were constructed both of stone and mud bricks, and fired bricks were used very infrequently unlike the Harappa people. Stratigraphically Amri, Ghazi Shah, Lohri and Pandi Wahi, were in occupation in the middle pre-historic period.(3) Nundara may be contemporary to the Harappa cultures. Evidence of contacts with Mesopotamia and Persia are not precise. Some parallel has been drawn between the Nal and Nundara and early dynastic Sumer, based on drawings of animals.

C. The Kej-Kolwa or Kulli culture:-

This is named after the type site in the valley of the river Kulli in south Baluchistan. This culture was dispersed throughout the Kolwa district with a few parallels at Mashkai, Mehi and Shahi along the stream courses. The area occupied by the settlement as estimated by the ruins of the typesite of Kulli was 200 square yards. The tell of Shahi-tump occupied a space of only 80-90 square yards. Like the Nal-Amri cultures,the sites belonging to the Kulli culture were not more than 2 acres. The Kulli culture was less widely spread than Nal.(3)

Normally,the material employed for the constructional purposes was consisted of a wide range; from crude masonry set in mud mortar to skilfully angular slates of shale and stone decorated with ashlar blocks,obtained from a distance of 2 miles from the typesite. At Mehi mud bricks were employed. At Shai-tump the foundation of the occupational level was of stone; and mud bricks were applied for the superstructures; the size of bricks was 19 x 10 x 3 inches. The excavations at these sites has not been comprehensively carried out, therefore,the information about the size of the houses and apartments is very conjuctural. The space covered by rooms at Kulli was 12 by 8 feet, with door and windowless cellars like Nundara. The staircases in the houses evidence the use of multi-storeyed houses. Defensive walls again are noted.

The pottery discovered from the sites belonging to

Kulli culture shows many traditional strains which is an inference of a more complicated culture. The pottery was of Buff-ware series. The sites offered a great variety of pottery as well as new designs and shapes among them, such as the bottle shaped vases, beakers, and vessels. The bottle-shaped objects probably used to hold medicines or cosmetics. The pots were decorated and painted by animals like cattle, figures and trees. Unlike the previous cultures the findings obtained from the Kulli sites, were chiefly clay figurines of women and animals. A considerable attention was attracted by the objects of ornaments like bangles, necklaces, and head-dress. Specimens of Kulli pottery have been discovered in Baghdad and South Persia, further extending the range of cultural contact. The superb painted pottery at Kulli was significant and imposing in character, and seemed to have been manufactured on the spot (plate 25).

The Kulli culture bears strong parallels to the cultures of Elam and Mesopotamia,in the execution of landscape of trees and animals on their pottery. The links between the Syrian culture and the Kulli culture have been maintained, on the bases of similar stone vessels present at two sites. From these evidences the archaeologists suggest,that the

Baluchi traders might have migrated to Sumer and they observed their own cultural rites. The Makran coast has been thought to be the main passage way between Sumer and South Baluchistan. It would therefore seem, that only, South Baluchistan had trading contacts with great cities of Elam and Sumer in early dynastic times.

D. Zhob Valley Cultures:-(3)

Its chief peculiarity is that, it is related to Red-ware pottery and belongs to the land through which flows the Zhob river, north of the prehistoric Baluchistan zone (Fig. 64A) and Plate 25. The area is braided by many channels. The sides of channels, especially both banks of the river Zhob, were occupied by the pre-historic settlements, allied to the Zhob cultures. The river flows southward in an incised valley through a mountainous region of complex grain and rugged terrain. Among these natural elevations, there are numerous lowly heights which are the "tells" representing the pre-historic settlements. As the map shows the Zhob culture bears great similarities to three cultures, already described but Zhob cultures have sufficiently different aspects for it to be accepted a separate culture. The chief distinction is the Red-ware pottery resembling that of Persia, rather than that of South Baluchistan. It is the opinion of many scholars that further excavation at Zhob might extend the geographical limits of Zhob culture, and they are certain of its southern extension through the Nal valley, and to south of Bolan pass.

The Red-ware culture has been confirmed by modern observers at Rana Ghundai, a "tell" 40 feet high. The mound has been dismantled by the present dwellers of the village, and a clear stratification of the human occupation was thus exposed. Available evidence shows,a long history of settlements and their destruction.

The Rana Ghundai Sequence. (from earliest to latest strata; the letters in brackets are the groups of the original report).

The sequence was originally observed and propounded, by the late Brigadier Ross, but this stratigraphy is the modified form introduced by Piggot. The relics at the earliest layer (Rana Ghundai I) were blades and bones and it may be linked with the stone age culture of Lower Indus. No sign of buildings could be identified. There were numerous hearths consisting of ash, which suggested the site was temporarily and recurrently lodged by nomadic tribes, who domesticated cattle, sheep, asses and horses. No article of matel was found. As large scale pastoralists, they were more advanced than the Soan and Lower Indus stone cultures. Nomadism is dominant even at present in this area.

The next inhabitants at Rana Ghundai II, built houses of "boulder-footings" over the remains of the former village. It was clear from the finds, that they were excellent craftsmen producing beautiful painted pottery. In the pottery making technique, they employed wheels and decorated with designs of animal figures. This culture did not survive for a long space of time, and we know nothing about the type, size and the constructional material of the houses, or the size of the occupation.

The foregoing culture was followed, by a more sustained culture the Rana Ghundai III. Many traditions of the Rana Rhundai II were practiced by these people, especially the methods of ware-making, and brush work. The linear designs on the pots resemble those of the Amri culture; which infers the contacts and contemporanity of the Zhob and Amri cultures. (Plate 25) The striking feature was the occurrence of three storied structures, but no information exists about the plan of the settlements. The excavations at Nal show the houses with rooms or courtyards; varying in size from 11 by 13 feet; and a tiny thick walled chamber, covering a space of 5 feetsquare. The traces of defensive wall was noted at Moghul Ghundai. The buildings were normally constructed by boulder foundations with superstructures of mud bricks. The considerable thickness of the bricks suggests,that they had strong and well built houses, while the house residues also show,that they used timber beams freely, which suggests local forest cover.

The common trait between the cultures of Rana Ghundai III and Kulli was occurrence of both animal and female clay figurines. In addition to these, various articles of copper, gold, pieces of sheet metal, flint blades and points and leaf shaped arrow heads were also found. The continuous use of flint is an evidence of the local evolution of Rana Ghundai settlements from Rana Ghundai I-Rana Ghundai III. The copper objects show contacts with the Indus cities of Harappa. The Rana Ghundai III seemed to have ended in flames.

Rana Ghundai was succeeded by Rana Ghundai IV and Gana Ghundai V with its many ramifications. An entirely different cultural trait dominated the last two phases of the Zhob culture, particularly in the pottery works. There is a break in the continuity of traditional art of pot making. In opinion of the experts,the continuous and flourishing occupation of Zhob cultures was violently disturbed by the end of Rana Ghundai IIIc, about 2,000 B.C., when the settlement was destroyed with fire. The following occupation of Rana Ghundai III was a fresh culture. The pottery they made was inferior, coarse and tawdry in style. This humble settlement was again ruined with fire and another break occurred in the pottery works. The ruins of Rana Ghundai V shows the arrival of new people on this wreckage, who produced the unpainted pottery.

The later phases of the Zhob cultures show,evidence of disruption and destruction, which lead to a rapid and forced change of population. The sites exposed thick layers of ash of the repeated burning of the settlements.

The Zhob culture is comparatively a widely excavated zone, and gives a fair picture of one type of early settlement development. The earliest phases of the culture show,that the inhabitants were leading a nomadic life. They were succeeded by sedentary agricultralists who made advances in the art of pot making. They also introduced the use of metals, and pottery was shaped with the help of a wheel. Their relics indicate,that they had contacts with Harappa, South Baluchistan and Persia. The objects of gold show their contacts of exchange with South India. By the later years of Rana Ghundai IIIc,this flourishing culture was succeeded suddenly by the disaster of fire. The final phases furnish an evidence of insecure life with a poor type of art and culture. Rana Ghundai cultures are supposed to have continued to late pre-historic period.

The noticeable point in their building material was the general use of mud, and bricks, which will be discussed at the end of the pre-history account. (Plate 25 shows the different cultures).

The early pre-historic cultures may be regarded,as tentatively,having one main local site after which the whole culture has been named, situated in a natural valley zone made by the valley around which lay other settlements. For instance, Kulli is a site in itself but all those sites included in this culture had their "headquarters" or "capital" at Kulli,possibly for the purpose of administration of the satellites or neighbouring villages. Most probably, small villages were set up here and there, for the care of agricultural lands belonging to the whole domain. This idea is strengthened if we study the map. Fig.64A. Except, at Quetta no other culture is concentrated at a small space. Nal culture is the most scattered occupation. It suggests, that the people who adopted the Nal culture were relatively advanced and homogeneous,controlling agricultural lands over a wide area, from the central Brahui Range south, adjacent to the Kulli occupations, to the south east near the Indus delta. The same may be concluded for the distribution of the Zhob, Nal, Amri, which had definite contacts with foreign countries.

Another striking feature is that,both the northern and southern cultures spread only in their own northern and southern spheres. The sites are generally located on the hill tops in the upper reaches of the streams, except the Amri, which was centrally developed on the bank of the river at the foot of Kirthar. The reason for the location, is the constant supply of water in the upper reaches of the Baluchi rivers, small seasonal torrents. Both the size of settlements and tells suggest, that the population was small, the chief concentration of population probably supported by the central sites of Kulli, Nal, and Amri etc.

To sum up, the pre-historic villages of Baluchistan are field museums which display a very interesting amalgamation of various cultures, having traits of similarities and contrasts. Direct evidences of agricultural commodities has not survived, owing to their perishable nature, but conclusions can be reached from the architectural monuments and seals. Engravings of cattle and other domestic animals were common and the people's way of life was certainly agriculture plus subordinate stock keeping, localised and traditional. These ancient village tribes had definite trading relations with other countries and certainly, with the plain cities as the latter developed relation with the former.

Middle Pre-historic Period:- The Indus Civilization.

Turning to the plains from the often barren and forbidding mountainous domain of harsh climatic conditions, one enters, a great plain of alluvial flood deposits of the Indus system borne down from the Himalayas. As one goes away from the mountains, vegetation deteriorates from the piedmont forests to steppelike parks and scrubland, and then to the desert acacia and cactus, which is analogous to present Mesopotamia.

This vast level expanse of land is of the greatest economic significance as well as of historical importance. It contains few mineral resources, but its agricultural wealth, which is the result of deep alluvial soils and perennial surface water, makes it the highest economic asset of West Pakistan. This most fertile area supports the most thickly populated quarters of West Pakistan. The Indus River system also has formed a natural highway for communications since earliest days.

Climatically, the Indus plain is fundamentally akin to Baluchistan. Moreover, the pre-historic cities bear similarities to pre-historic Baluchistan village communities, in the art of agriculture and to some extent in pottery industry. The chief differences between the plateau villages and the Indus cities, is their geographical location which created contrasts in their functions and development. There was a great diversity among the cultures of the hill villages of Baluchistan, but the Indus cities showed, great similarities in their cultures ..... " over an area incomparably vaster than anything ..... a complete agreement" in all cultural aspects.(3)

The pre-historic Indus civilization we know, is confined to two highly composite cities together with their satellite towns, villages and outposts (Fig. 64B) showing, a strong nucleation in the settlements. One city, lies on the left of the river Ravi, near its former course in the district of Montgomery. The second, is located at a distance of 400 miles to the south on the right bank of the river Indus. The former is called "Harappa" - that which has been swallowed; and the latter is known as Mohenjo-Daro - the Hill of the dead.(2)(3)(6)

The first general impression made by the distribution of settlements, is of the concentration in two main clusters. Harappa and its associates, lie on the east of within a short distance of the Ravi, while to the south the settlements of the Mohenjo-Daro group, lie to the west but very close to the lower Indus, in Larkana district. Thus, the population centres of grouping tend to the west in the south, and to the east in the north, aligned with the chief cities of Harappa and Mohenjo-Daro.

Extent of Indus Civilisation:-

The extent compassed by the Indus civilisation, surpasses all the "known pre-classical civilisation". "From Rupar, to Sutkagen-dor is 1,000 miles".(6) The extent of the two Egypts was some 600 miles, the same as that of the Mesopotamian cultures. It means, the Indus civilisation extended from the Siwalik hills down to the Makran and Kathiawar; "forming a hugh irregular triangle with the sides measuring 950 by 700 by 550 miles".(3) The limits of the Indus civilisation were further extended to the Peshawar division, on the evidence of terra-cotta finds in the vicinity of Charsadda, but the final conclusion awaits more research and excavations.(7) The Indus culture was a "highly evolved urban discipline and economy, in other words a "civilisation"(6) (Fig. 64B) Throughout the length and breadth of this vast land more than 60 sites have been discovered. These sites are towns or villages in the riverain tracts, strung out along the ancient or present water courses. The ancient courses of the rivers are associated with the Saraswati or Hakra (Chapter 4 Hydrography). The size of the cities of Harappa and Mohenjo-Daro was estimated, at least a square mile each, and they are regarded as "twin capitals of an empire".(3) Mohenjo-Daro considered the Federal capital of the Indus empire because of its vastness and elaborated structures.

As a very large portion of the cities of Harappa and Mohenjo-Daro has been extensively excavated, and data interpreted by many authorities, the two cities are considered here from the point of view of our study.

Harappa:-

The existing Harappa is a large village adjoining the ancient city mound. The mound containing the ancient fabric of a city with a circuit of about 3 miles, is situated at a distance of 6 miles from the main stem of the river Ravi, with a north to south orientation.(6)(8)

The salient features of the plan shows,that it had two parts, the western and the eastern. The western part was higher and contained the citadel. The eastern or lower part was occupied by the city proper. The citadel was formed in the shape of a parallelogram, 40 feet high, and from north to south 400-500 yards and from east to west 200-300 yards.

The material employed for the construction of citadel at Harappa was of both fired and mud bricks, the interior structure placed on the platform,built by mud and mud bricks 20-25 feet above the level of the ground. It is surrounded by a massive defensive wall, which was built mostly by mud bricks but with an external facing of fire bricks, 4 feet wide. The base of the wall was 6-7 feet wide, narrowing as it rose. The defence wall has remained undamaged except by "external processes" which exposed its stratification of baked bricks.

To the north of the capital there was an impressive structure, thought to be the granaries. Their proximity to the river and the entrance towards the river indicates, that the grain was collected and distributed by river. The granary buildings, of fired brick and erected on a raised ground 4 feet high, were equipped with air passages to keep the grain in perfect condition, as in the granaries of the Roman forts. Their big size suggests they were state granaries.(6)

In the southern part of the site, at higher levels, 16 pear-shaped furnaces were explored, with a length of 3 feet 4 inches to 6 feet 2 inches each. Both cow-dung and charcoal were used for the function of these furnaces, thought to be the melting of bronze. The heat was induced by bellows of a type which is still usedin the village at present.

At Harappa seven layers have been observed and it passed through several cycles of destruction.

Mohenjo-Daro:-

The Mohenjo-Daro mound occupies,a land which is called The Island,in the plains of Larkana, in a narrow strip of land between the main bed of the Indus and the western Nara canal. Its exact situation demarcated is 27°19'N by 68°8'E. The surrounding country is green and fertile, hence, it is called the Garden of Sind.(8) The mound consists of series of nine successive cities. The chief and apparent agent of the destructions were river floods; and this is reflected by the presence of extensive bunds and defensive walls at Mohenjo-Daro. The flood phenomena is very important even at present, and life in modern cities, towns and villages is still regulated by the river regime. Both at Harappa and Mohenjo-Daro the raised level of the courtyards is a strong evidence of the protection from the destructive floods. Therefore it has been emphasised by Marshall that "Our picture ..... would be wrongly drawn if we imagined Mohenjo-Daro as free from the havoc of floods, for if there is one fact that stands out unmistakably amid these ruins, it is that the people must have lived in ever-present dread of the river." (See Plate 26).

Like Harappa, the city of Mohenjo-Daro was also placed upon an artificial hill 20 feet high, in the south, and 40 feet in the north, with the north south axis of direction. Plate 26. This artificial hillock was constructed with mud and mud bricks. The city platform

Plate 26

1

Excavations to the South-West of the Stupa mound. In the sides of the trench two bands of water-laid clay corroborated the evidence found elsewhere of the occurrence of two destructive floods in the history of the city.

was protected by a mud brick embankment 43 feet wide, provided with a baked brick drain running along the foot of the platform.(6)

The most impressive structure discovered at Mohenjo-Daro was that of the Great Bath or Tank. From north to south its length was 39 feet; and breadth was 23 feet, and 8 feet deep furnished with steps. Plate 27.

The granary belonging to the citadel, was massive, and fully ventilated.

At both sites (Harappa and Mohenjo-Daro) each successive reconstruction seems to have commenced after a little pause, not following immediately after devastation, but rather following a short state of desertion. These cities seemed to have existed and been destroyed almost as a matter of routine and finally, they were left in ruins upon raised ground, with a height of 70 feet covering an area of 240 acres at Mohenjo-Daro.(6)

The ruins disclosed by excavation allow tentative reconstruction of their cultures, the geographical conditions, and the mode of life of the people. The archaeologists have been struck by wonder by the remarkable skill in systematic and co-ordination of the planning of the two cities and the designs of buildings. The engineering feats are exhibited in streets which were amply wide for

Plate 27

(*a*) MOHENJO-DARO: THE GREAT BATH ON THE CITADEL. *See p. 26*

both wheeled and pedestrian traffics, and in the drainage system, the most striking feature of the city planning. These cities on the whole were the outcome of progressive engineering brains, as displayed by the strikingly regular sections of the city, which were served by laid streets, these streets serving the main private and public buildings. See Plate 28. These square and rectangular components were again divided with narrow streets, which were also furnished with drainage systems fitted with soak-pits for sediments. Plate 29. The type of architecture implies that those people possessed a considerable knowledge of land survey and mathematics.

The cities were full of dwelling houses of varied type and size, from humble servant-like quarters to medium size and to palatial buildings. The common building material was good quality burnt-bricks. It was especially noteworthy,that,every house was equipped with wells, drains and bathroom. Plate 30. The small towns and villages were generally built of mud bricks.

In addition, there were spacious buildings of huge structures, which seem to have been public places, temples, halls or schools etc. The most imposing of these was the Great Bath. Plate 27.

Though these relics present a picture of full fledged

a) Panoramic view of north-west part of VS. Area, from west.

Plate 29

(*a*) MOHENJO-DARO: LANE WITH DRAINS, DK AREA.

No. [illegible] 27.

Plate 30

Mohenjo-daro : excavated well left standing to show successive levels at which floors and walls had been raised.

cities yet no accurate estimate of their population can be made. The urban landscape shows only, that, population must have flourished under the sanitary conveniences, luxuries and comforts of a civic life.

By the scientific study of the ruins, a comprehensive view of the way of life of the people has been constructed by the modern archaeologists. Its most essential features are dealt with here.

Agriculture:- (3)(6)(8)

It was conjectured, that this primary industry was the chief mainstay of the people of both Harappa and Mohenjo-Daro. There is an evidence of a considerable variety of agricultural produce, but there is no evidence of their field arrangement and irrigation practices unlikely to survive frequent floods for 5,000 years. The information pertaining the agriculture is derived mainly from the remains of grains, and fruits. The knowledge of animals has been derived from the seals, drawings, and remains of bones. It has been conjectured, that mixed agriculture was the common practice. Plate 31.

The unearthed samples of wheat and barley have been identified. Triticum compactum and T. Sphaeroccum varieties of wheat were grown, which are still grown in the doabs of the upper Indus plain. Six-rowed varieties of barley were grow

grown,

Plate XVII


1


2


4


5


6


7


8


9
Pasupati, 'Lord of Beasts'


10
Cylinder seal.


11


12
Impression of cylinder seal.


14
Boat engraved upon a seal-amulet.


15

Mohenjo-daro : seal-amulets and cylinder similar to those discovered in pre-Dynastic graves in Egypt.(6) Wheat formed the main staple. Charred peas, melon seeds and sesamum are recorded from Harappa, and date stones have been discovered. The paintings of trees suggest the presence of coconut, pomegranate and banana. The other evidence to support the agriculture character of the people were the presence of cotton and wool fabrics. Cotton weaving is evidenced by the findings of spindle wheels.

The other items in the diet were poultry, beef, mutton, pork and fish. The remains of skeletons of humped bull, buffalo, sheep, and dog suggest that they were domesticated. (Plate 31.) Horse, camel and ass were used, and with less certainty the elephant was also used at Harappa. The study of seals further suggest that there existed rhinoceros, bison and lion which do not exist at present. See Plate 31. Contacts:- (3)(6)(8)(9)

Numerous seals have been discovered which were used for documents and messages, and for trade transactions. There is adequate proof, that people of the Indus cities maintained commercial relations not only with the cities of the Indus zone, but also with India, Messopotamia, Greece and Baluchistan.

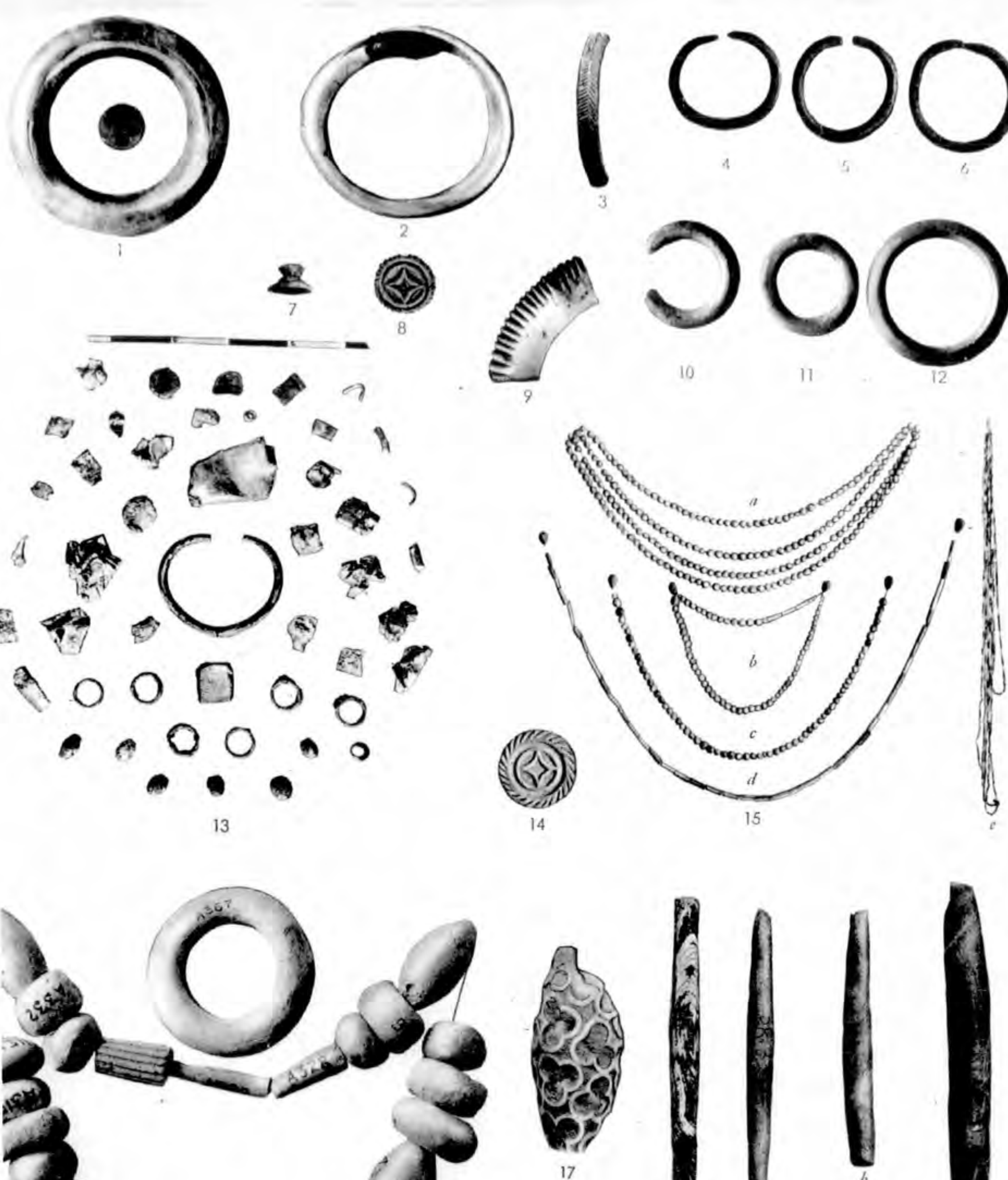
The Indus people exchanged agricultural products for copper and precious stones. It is significant in this context that the Indus valley has had an export of agricultural produce since pre-historic times. In Babylonia cotton was known as "sindhu" and in Greece "Sindon".(8) Moreover, the distinctive exported products as detected at Ur in Mesopotamia consisted of seals, inlays and pottery, these objects dated to 2,300 B.C.(2)

The copper for vessels and implements, probably was obtained from Baluchistan, Rajputana, or Afghanistan. Tin was also foreign to the Indus people. Gold for jewellery was either obtained from the river sands or imported from Mysore, since the finds bear resemblance to the Kolar gold. Silver was imported for the manufacturing of ornaments and utensils from Persia or Afghanistan.

The precious stones for ornaments were used prolifically by the Mesopotamian settlers and were less used by the Indus people, therefore it was suggested that the later people imported precious stones like turquoise, lapis lazuli, jade and amazonite from Badakshan province of Afghanistan and from Mesopotamia. The use of turquoise was rare, imported probably from the Khorassan province of Persia. Jade was derived from Turkestan. Plate 32 shows their ornaments in fashion. The commercial commodities indicate the links of the Indus valley from Greece to central Asia.

The question remains, how were these commercial and

Plate 32



trading contacts maintained? What were the means of transportation? The archaeologists interpretations of slender evidence lead to a conclusion, that the people knew the art of boat making and there existed a coastal traffic, via the Persian gulf. The link between the Persian gulf and Harappa has been considered the town of Sutkagen-dor on the bank of the river Dasht. The use of boats and small ships was probable.

Terra-cotta models of wheeled carts attest the use of a revolutionary device which would have facilitated transport and distribution of agricultral commodities, and endowed the people with enhanced mobility. Plate 33.

The stone sculpture of the Indus people has been considered the most monumental product. These products consist of human and animal figures. Most of the pottery is wheel-turned, with numerous designs and various shapes. Plate 34.

To sum up, it may be assumed that agriculture must have played an important role in the daily life of the commoners. Among other things wheat, barley and cotton were grown largely. Though agriculture was their main pursuit they were urban dwellers with modern amenities. It was a period of agricultural intensity, and probably little pressure on resources. The secondary industries included flour mills,

Plate 33

Miscellaneous objects.

1

2

3

4

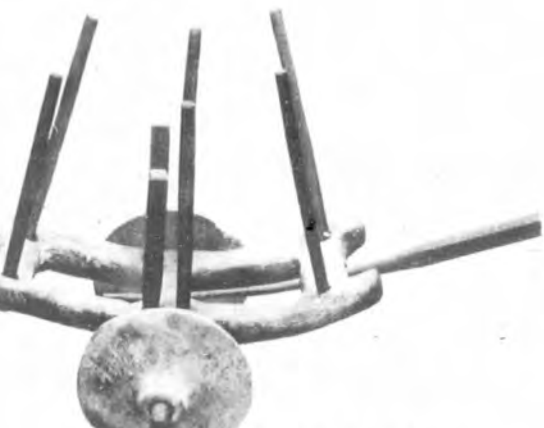
5

6

7

8

9



Pre-historic cart.

10

present cart.

11

Plate 34

PLATE 6. Harappā 1946: Painted Pots (black on red)

PLATE 7. Harappā 1946: Painted Pots (black on red)

pottery works, weaving work and employed masons. There were metal workers, jewellers and ivory makers. It is clear, that development in metallurgy and pottery and the invention of oven, made it possible to manufacture much finer pottery than could be hardened in an open fire.

The whole assembly of the remains belonging to the pre-historic cities, demonstrates a homogenity in an advanced technology and handicrafts, as exemplified by the boring of hard precious stones like lapis lazuli and the casting of alloy of metals. In addition, a very high asthetic sense is reflected by the delicate patterns of ornaments, the superb relief figures on seals, and the execution of beautiful stone statues. This city civilization stands parallel to the Mesopotamian civilization in technical accomplishment, art and craft, and social standards, but it was independent in origin and native, with strong contacts with the east and west.

As a conclusion, the above phases of the pre-historic humanity in West Pakistan show, that the archaeologist's spade has unveiled a concrete record of man's progress from savagery to hunter, to herder, to small purely agricultural communities and lastly to agriculturalists and industralists. Finally, the above account brings to light, that these cultures have always been sprung up near the water, settlement patterns being features of hills and streams. Water is the most crying need of West Pakistan today also. The Indus has been the life blood of the people since the antiquity which gave birth to an urban life. It was owing,to the attraction of the Indus,water that this flourishing civilization was plundered and set on fire by the Aryan invaders in 1,500 B.C. With the invasion of Aryans the epoch of Indus civilization closed.

We are now,in a position to assess the arguments,on the climatic conditions,during the occupation of the fore-mentioned pre-historic cultures.

It was first thought by Stein,and later supported by Marshall, and Mackay that West Pakistan had more rainfall than it receives today, and that the country is now under the sway of progressing dessication. Later, Wheeler and Piggott,have not been hesitant in their opinions on past climate.(4)(8)(9)(6)(3)

In case of pre-historic Baluchistan, the wet climate and more population have been interpreted on the existence of dams or "Gabar bands". Such dams are located near many settlements. Marshall was of the opinion,that the construction of dams was needed only to hold rainwater, which was of periodical nature. Marshall estimated the rainfall at about 15"-20" a year, four times more than the present rainfall. He regarded the facts about Baluchistan as indisputable. More lately Raikes,has rejected all the versions of the previous experts,who held the idea of dessication.(5) Raikes,in the first place,does not accept the "gabar bands" as storage devices. In the second place, he considers if they were reservoir dams,they indicate,that the people wanted to conserve the rainfall,which was inadequate. Thirdly,he does not believe in their remote antiquity,as he is of the opinion,that they are the constructions of more recent times. His idea is that,they were check dams,mostly built on porous gravel to trap silt and form fields. As far as their height is concerned they are too low to have a high storage capacity, with a size 8 feet wide and 300 yards long. Raikes believes,that the population was also not larger than at present. He believes that, climatic changes have occurred, but not to the extent his predecessors opined. It may be deduced from these and others, that rainfall was probably neither abundant nor scarce, but certainly regularly seasonal in its incidence. The inhabitants accumulated water in dams for the dry season for agricultural uses, otherwise a need would not have arisen for innovations in water collecting devices. The universal use of mud as opposed to fired brick also suggests that the rainfall was not copious.

Historical documents prove,that the dessication process was well advanced at the time of Alexander's retreating forces, and the whole Makran was then a hot dry waste.(10)

The aridity of Baluchistan may be attributed to natural as well as to the human action. Stein came across these two phenomena in Kalat and Makran. He observed,that the cause of aridity "distinctly pointed to the local climate having undergone a great change since chalcolithic times in its effect upon cultivation".(11) At another point, he observed,the decadence state of agriculture near the water even, "illustrating once more how in an arid land human factors can within certain limits produce results which centuries hence might easily be mistaken for those of true 'dessication'".(11) Thus there are manifold causes to bring the present arid state of affairs. To solve the mystery finally, more and more research work is awaited both of the present conditions as well as the past.

In the support of the dessication theory in the Indus valley, many arguments have been adduced by examining the remains and the building materials. The universal use of the burnt bricks by the city dwellers,demonstrates and suggests,not only the predominance of wood fuel at hand,but probably,also a need felt,to protect building from rain which would have washed away sun-dried bricks. Elaborate drainage system and protective dams imply not infrequent rain and floods, as both at Moheno-Daro and Harappa. Animals, such as elephants, tigers, rhinoceros on the seals also relate to moister conditions.

The arguments advanced by Raikes in this reference are, that the bricks are still baked by burning the tamarisk wood which grows in the areas of three inches of rainfall with a high water table along the rivers. Based on modern fuel requirements, Raikes calculated, the amount of fuel used by the ancient Indus people for brick baking; "as little as 400 acres of tamarisk gallery forest would have sufficed for each of the seven re-buildings of Mohenjo-Daro. As these rebuildings were spread out over about 800 years, normal regeneration of the forest would have enabled the same 400 acres to be used throughout."(5)

He considers the drainage system as a necessity under the torrential and seasonal rainfall conditions.

About the great variety of crops and advanced agriculture, Raikes considers the annual floods spread the layer after layer of fertile silt and retentive soil, which retained the water for great depths according to the duration of flooding, certainly adequate to grow shallow rooted crops. The flood gave opportunities to grow enough food in the proximity of cities, on the fertile soil left by receding water. In addition to this, it is surmised from the seals, that they used the "shadouf" for lifting water, which is still prevalent in Egypt and Iraq. This method might have been used during the drought period.

Finally, concerning the existence of varied fauna shown on the seals, Raikes believes, that the Indus civilization included within its boundaries, vast lands of varied type and climate from the Himalayan foot hills to Arabian Sea, from the border of Persia to Rajasthan. Even today this includes forests, deserts, with varied fauna. All the animals on the seal could have still existed in some of these areas, and the Indus people had been familiar with them.

In general, Raikes believes, that West Pakistan is going through very much the same climatic conditions as she had during the pre-history.

It is accepted here, that, West Pakistan may have in this period had more attractive ecological conditions, without necessarily invoking great climatic difference from the present. As we have seen, the delicacy of the ecological balance is considerable. The human element may be considered, to be the strongest factor responsible for tipping the balance towards aridity without changing the climate. This commenced possibly during the Harappa period, certainly with the Aryan invasions, which brought destructive ferment to the most advanced and sedentary peaceful people of the Indus valley.

The Post-Indus Cultures:-

Our main concern here is, to point out the significance of the geopolitical location held by West Pakistan from the Aryan invasions to the Mughal incursions. Throughout this long period from 1,500 B.C. to 1,526 A.D., West Pakistan remained a perennial attraction to the aliens. In this category our first invaders were the Aryan linguistic group.

The Aryans descended into the Indus plain and vanquished the cities of Harappa and Mohenjo-Daro, moving on to the Gangetic plain gradually. These people compared with the Harappa group were barbarians and wanderers. It is believed, by most climatologists, historians and archaeologists, that processes of dessication in Central Asia, compelled these people to go far and wide in search of water and fertile land. Various waves of Aryans turned towards the Indus valley, to Egypt, and Mesopotamia. (12)

The earliest Indus civilizations made their own evaluation of the Indus Basin. In light of modern knowledge we can see only a lack of continuity, in the Vedic period of Indo-Aryan invasion between the earliest cultures and its successors. Following the ethnic and racial invasions and changes we have a picture of non-urban agricultural village life.(13)

As the city life was unknown to them, they plundered the cities and made villages and nomad huts. The building material was perishable straw and thatch, their villages scattered here and there along the river valleys. The village folk were predominantly land tillers. The homestead with cultivable land was owned, in some cases by individuals and in some cases by families. The pastures were common. They manured their land and irrigated their fields. Their main crops were rice and barley, and they domesticated cattle, sheep, goats, horses and dogs. Their principal means of transport was chariots.(12)

There is some evidence, that the Aryans also used irrigation devices, which suggests the inadequacy and periodicity of rainfall, This was the heroic age of the great epics of Ramayana and Mahabharata, the Vedic age, when poetry and literature developed.

Pre-Muslim Cultures:-

In west Pakistan, these cultures sprung up in the mountainous and sub-mountainous regions; with two big nucleations of Peshawar and Taxila. First during Persian rule and then with the penetration of Alexander the Great and his armies in 326 B.C. the historical period opens.

By the 4th century B.C. the former provinces of North West Frontier and Punjab were distributed into water tight compartments, under various tribal princes.(2) Such an internal situation favoured foreign invasions.

The immediate affect of the Alexander's invasion, was negligible but it contributed an enormous amount of geographical knowledge of many countries. Some new cities were founded but Hellenistic influence remained cultural rather than economic. Some trade routes were opened.(12)

After a span of 12 years, Alexander's Taxila was conquered by Chandragupta from the Ganges plain.(2) Taxila became a viceroyal seat of a very big empire, stretching from Hindukush to Bihar. Under the new regime Taxila started its second cultural phase, during much of it was reconstructed, but in the same unsystematic and poor fashion, as it appears in Alexandrine descriptions.

With the accession of Asoka to the throne in 272 B.C., he converted Taxila into a famous Buddhist University. The old derelict city of Taxila on the Bhir Mound was deserted, and the new Taxila was erected, on the plain crossing the Tamra Nala. During that time the Bactrians infiltered, through the mountain passes and they also chose a new site for the construction of Taxila, and the Indo-Greek cultures thus mixed.(Fig. 65A)

After a century, the Indo-Greek kingdom in West Pakistan was overwhelmed by Sakas from Turkistan. Fig. 65 B. They were probably driven away by Chinese influence by Han dynasty. Their capital was Peshawar. Taxila started its 3rd phase under these fresh invaders. They built Taxila with a splendid architecture, and named it Sirkap. Its remains are supposed to be one of the most spectacular in Asia. The Sirkap city is enclosed by a strong defensive wall of stone 21 feet wide with several bastions. The streets were 25-30 feet wide, angular and systematic. The new buildings were also well planned and neat. Their constructional material was blocks of limestone, obtained from the local mountain ranges. The ruins disclose huge buildings like palaces and temples. (2)

In the late second century B.C. the fourth city of Taxila was raised by Kushans, at a distance of a mile, from the previous site in the plain of river Haro, it was named as Sirsukh. This city was also furnished by a defensive wall in the plain of a river. The rampart was constructed by unsquared limestone blocks and was 18½ feet thick at its base. Such precautions were taken for the monsoon rains, and the foundations were protected with "a heavy roll-plinth". The size of the settlement was not given. The personal opinion of the present writer is, that, the area covered by the four phases of Taxila is not less than 2-3 square miles.

The excavation of Sirkap has unveiled a mine of knowledge about the contemporary Buddhists. They were very advanced in sculpture and art, the well known Gandhara school belonged to that age, but they were not good architects.

In addition to the above, allied settlements of Taxila, again Buddhist, were discovered at Shah-Ji-Ki-Dheri, on the outskirts of Peshawar and elsewhere. It is believed that Taxila was finally destroyed by the White Huns during the fifth century A.D., but Buddhism survived until the coming of Islam.

A small town of the Kushana period was found 3 miles south west of Takht-i-Bahi in the plain. At Charsada, assembly of imposing mounds have been located; in the vale of Peshawar 18 miles to its north-east. It has been identified, as the Pre-Kushan capital of Gandhara and it had been a great trading city, situated on the ancient route from Balkh to West Pakistan and to China, known as the "silk-route". Again this site was on the Indus river which made it accessible to the Arabian sea.

In this early historic period, the majority of the population was agricultural. Village craftsmen in the large number of villages included carpenters, smiths and potters. The cultivation of lands in the Indus region was by a whole kinship; and every individual satisfied his need from the product, and the remaining was destroyed to discourage sloth. The range of total interest was wide, the social group including merchants and sailors, and the Indus was the chief commercial artery. Important articles for the trade were silk, muslin, embroidery, ivory, jewellery and gold. Coins were in general use but the barter system was also practised. The religion was Hinduism till the birth of Buddha, and the caste system was already developed.(12)

The villages were always in danger of flood, fire and locust, and Government especially under the Maurya Dynasty took precautionary measures. They had systems of fore-warning both for flood and drought, and special attention was directed towards pest and diseases of plants. Floods have appeared in the picture since civilisation dawned, and the early historic people were familiar with drought also,from which they were warned and protected. Roads were furnished with milestones, wells and shade trees. The latter two/also indicating,that the climate was periodic and not free of aridity.(12)

A mixed agricultural tradition appeared. Punjab cattle were already noted in the time of Alexander, and rice and wheat were the staple crops irrigated by animal powered lift wells. The pear and the peach had also been introduced, and a developed form of the "ard" had entered from the West.(14

Early Commerce:-

There had been no commercial relations among the villages, they were all self-sufficient in respect of necessities. The cultivators grew their grain and cotton and the surplus was given to the land lord, and to the King, There were some weavers,who as mentioned by Nearchus,prepared "a shirt which reached to the middle of the leg, a sheet folded about the shoulders and a turban rolled round the head".(14) Means of communications were inadequate as well as inefficient, and with small surpluses and poor stores; did not prove beneficial at the time of crop failure, hence famine was frequent. General internal commerce was more than merely domestic. Certain areas specialised in certain goods. The first form of exchange being the gifts to foreign rulers,which lat er developed into the commercial relations. This was a time of individual craftmanship and cottage industry.(14)(12)

The rivers of the Indus valley had always, been the cheapest routes for both inland and abroad contacts. The Indus river connected West Pakistan,with the great commercial high ways,both to the Arabian sea and towards Afghanistan, Persia and Greece. Fig.65A.This shipping was helped by the monsoon winds up the rivers,when snow melted. The major trade artery from Central Asia penetrated the Punjab,via the Kabul river.

The roads were maintained,where ever the Royal power was efficient. The Grand Trunk road is a legacy of that age. The roads were unmetalled and rivers were crossed by boat bridges. Wheeled traffic of ekka drawn by one pony,was mainly used.

The cities were established,where ever the trade routes and roads crossed and intersected the rivers. For instance Jhelum was founded by Alexander the Great on the Jhelum river. Lahore on the Ravi, Multan, Shorkot and Sialkot on the Chenab. Dera Ismail Khan and Dera Ghazi Khan on the Indus. Sangla was a military station between Chiniot and Lahore.(12)(14) The population was thus, centred in these towns,which depended on the surrounding country for their food; but owing to the primitive means of transport supply was difficult. Under such conditions, the land near the population agglomerations,was cultivated intensively and land rentals in kind were raised. The land fell into the hands of those cultivators who could produce sufficiently to pay those high rents. These practices could not survive crop failures, famine and epidemics or political upheaval, often towns were abandoned when local supplies failed. The Chinese traveller in the Punjab witnessed such ruined villages and cities.(14)

In the face of successive incursions, nucleated settlement for defensive purposes-predominated. Only, during periods of stability was dispersed settlement possible. The agglomerations were of course extremely vulnerable to large scale disruption of agriculture and food supplies.

The close study of Gupta and post Gupta period, discloses that West Pakistan was generally neglected under that regime also. There were eminent universities and big prosperous cities in the empire but none existed in the area which is now West Pakistan. The main reason is obviously location, all rulers being under a constant apprehension of a new invader from this side. It is also clear, that the Gangetic plain was more ecologically attractive.

From the brief survey of the early historic cultures, we may say, that these civilizations did not extend towards Quetta and Kalat. The most striking thing about the settlements is that they selected hilly terrain near the small river valleys, as did the hill village communities of pre-historic Baluchistan. Though West Pakistan had been a battle field and a corridor for the seekers of new land, yet it did possess, the advantages of maintaining part of the trading intercourses between Greece in the west to China in the east, and some key centres flourished. Peshawar, remained the capital city under the huge empire of Kushana, and occupied a key position in the world trade.

Besides, the land arteries, there was a transit trade by the Arabian sea with Persia. Fig. 65A.

Islamic culture:-

About 712 A.D. the Arabs entered West Pakistan through a new opening by sea, in the south near Karachi. (see Fig. 65B). They reached Multan, but their occupation was not of a long stay, hence no impression was left. West Pakistan remained under the annual incursions of Mahamud Ghazni from 1,000-1,030 through the Kyber pass. The area remained under a great political turmoil, hence there was no development. (2)(12)

Recent historical researches, throw light upon the economical and social conditions of the Pak-Hind Sub-Continent under Turko-Aghan rule. Agriculture was the main occupation of the majority but there were some textile industry of cotton, woollen and silk. All these industries were established, out of the realm of the present Pakistan. Famines seem to have been of frequent occurrence during which the prices of grain rose, as a result of rain failure. The differences in the standard of living of the opulent classes and the land tillers was "almost antipodal". Still, the villages were economically self-sufficient and their requirements were simple, which were supplied locally. The village life was never distrubed in spite of political instability of the Federal city.(12)

No estimate of the people was intimated by any scholar. No size of the villages and the type of houses are mentioned.

Under the Turko-Afghan regime the Muslim and Hindu cultures comingled. Hindus, learnt the science of horoscopy from the Muslims and Muslims acquired knowledge about the Hindu philosophy. The most important addition in the literary world was the growth of the Urdu language.

In West Pakistan, the number of the cities, more or less remained the same, but there are many Mughal monuments, which testify, that West Pakistan was not entirely neglected by the Moghals, though, the centre of gravity of their activities laid towards the metropolitan city of Delhi, Agra and Fatehpore, away from the arid Indus lands.

Terry, referred to the Mughal Punjab as "a large province and most fruitful. Lahore is the chief city thereof, built very large and abounds both in people and riches, one of the principal cities for trade in all India". According to Monserrat's assertions in 1581, Lahore was, "not second to any city in Europe or Asia". Lahore city, was walled with a fort on its northern skirts.(12)

There were adequate arrangements too for merchantile traffic. The highways were metalled and "main routes of land travel were clearly defined, in some cases by avenues of trees and more generally, by wall enclosures known as sarais, in which travellers and merchants could pass the night in comparative security."(12) Rivers were also used for traffic.

Agricultural crops, systems, methods of cultivation and implements, were much the same as existing today. The Ravi canal was built in 1639 by Ali Mardankhan, and people of Lahore were benefited very much. Lahore seems to have been thickly populated.

Otherwise, village type settled agriculture was the rule which still exists in most areas of Pakistan. The chief crops were millets, rice, cotton, barley, wheat and pulses. The general form of agriculture was subsistence, and the production of food for the peasant's family was the main concern. There was an absence of the cotton and wheat belts, which now characterise the irrigational colonies of West Pakistan. The agricultural practices and tools were primitive. The use of the Persian wheel for drawing the water from the wells became more general. The cultivators were generally small holders and substantially rich farmers were practically absent. The agricultural labour was poor and immobile. (12)(14)

The population and settlement pattern remained basically the same as already reviewed. The Grand Trunk Road was studded with cities, towns and villages for the obvious reasons. The sub-montane and riverine areas were secondary centres of population, the rest of the country was sparsely inhabited. Groups of small agricultural villages occurred, where ever the Imperial authority was strong. Where ever, the governing conditions were appalling, the people settled in contiguous villages for protection.(12)(14)

The most important feature of the later Mughal Empire, was the extension and diversity of the industrial pursuits of the country. In West Pakistan woollen textiles were manufactured at Lahore and Sind was famous for "ornamental disks, draughts boards, writing cases, and similar goods are manufactured locally in large quantities, they are pretty, inlaid with ivory and ebony and used to be exported in large quantities from Goa and the coast towns" as described by Pelsart.(12) The prices of the eatables were very low and it was observed by Terry, that "the plenty of provisions was very great throughout the whole country; ..... and everyone there may eat bread without scarceness."

West Pakistan had a very active foreign land trade during the Mughal period. The chief routes for export were from Lahore to Kabul, through Kyber pass and from Multan to

Qandahar through Gomal pass. River and sea traffics were equally busy. The chief port was Lahori Bandar in Sind.(12)

The Mughals were great patrons of art, literature and architecture. Lahore is overwhelming with the richness of their architectural legacy. The buildings are built of fine stone, black and white marble, gold, silver and precious stones, and consist of huge forts, villas, towers , mosques, serais, tanks, schools, wells, palaces, gardens and mausoleums.

Some centres in West Pakistan received attention during the Mughal reign, because political conditions were stabilised to a large extent, throughout the Pak-Hind subcontinent. There was in particular less danger of fresh invasions from the north west.

From the Aryan incursion to the Mughal intrusions,West Pakistan remained a corridor where the influence of the foreigners radiated. The result was that,the Indus valley had been always opened to a fresh cultural political and social influences. West Pakistan became a recipient of cultures of the Macedonians, Persians, Parthians, and Sakas, Sassanians, and Mughals. Moreover, West Pakistan presents still a very great comingling of numerous great nations, noble races, and rich cultures of the west and the east, this great variety still particularly persisting in the isolated hilly and mountain villages. The origin of the present hilly tribes which are still at variance, keeping their own individual culture, goes back to these varied invaders. The chief attraction for aliens, had been the agricultural fertility of the Indus alluvium, the fertility that is of the better favoured river served lands. As long as populations were small and cities lived on trade, this relative and localised attractiveness persisted.

The Early Routes:-

The Hindu Kush and its branch extensions though very lofty, imposing and encircling the Indus lowlands, nevertheless, they do not form a continuous rampart. The mountain ramparts are breached at several points and provide passable openings. These high elevations never acted as an effective barrier for invaders. "These are the outlets through Afghanistan, by which Alexandar the Great and all subsequent invaders have descended upon the low country of the Punjab and any one who, after traversing the interminable hills and stony valleys of Afghanistan, has seen on surmounting the last ridge, the vast plain spreading out before him in dusky haze like a sea, many imagine the feelings with which such a prospect was surveyed by those adventurous leaders, when they first looked down upon it from the Asiatic highlands."(14)

The most important routes, which had been in operation for both military and commercial purposes in the past are illustrated in Figs. 65 A-B.

1. From the Oxus plain over the Hindukush to Kabul and through the Kabul river valley on to the Indus plain.

2. Radiating from the Caspian sea to Herat through the mountains to Kabul, and branching through the Afghan highlands to Kandahar through Gazni to Kabul and then to the Indus valley. The route through the city of Kabul and the Khyber Pass has been the most celebrated throughout the cultural history of West Pakistan. In addition to these, alternative routes were also in operation:-

1. Leading from Kabul through the Kurram valley to Bannu, then to the Indus plain. It is joined with another route, leading from Ghazni through the Tochi valley.

2. The route which radiated from Ghazni through the Gomal pass on to Dera Ismail Khan and Dera Ghazi Khan was second, to Khyber in its importance.

Further south-west another classical route is from Kandahar to Quetta, through the Bolan pass, terminating on Sukkur, where the foreigners faced a formidable barrier of the Thar Desert and they had to follow the Indus river towards the Punjab.

The area occupied by post-Indus civilizations lies in the North Western Frontier provinces and the upper Indus plain (which was also occupied by the stone age cultures), to a very limited extent in the lower Indus plain, coincident with Indus traffic and the sea trade. The neglect of south west Pakistan is in a complete agreement with the present geographical pattern of aridity. As noted in Chapter 3 the average rainfall decreases from north east to south and south west. This sporadic rainfall condition is a continuation of at least some 1,500 years. All the towns, as indicated in the map were located along the rivers in the plains, because of soil fertility as well as for the river transport. No town is seen in the centre or top of the doabs, because these lay away from the river; only the riverine tracts were settled as they depended on the seasonal floods of the year for their agriculture, the doab tops left in the natural conditions of steppe vegetation.

Another point may be marked, that almost all the cities during the Afghan-Turk period, as well as during the Mughals, were situated on the left banks of the rivers. It has been explained in chapter 4, that rivers flowing north to south are still laterally shifting so that their right banks are corroded more heavily than the left.

Besides this direct geographical reason, the left bank situation of the settlements is part of the historical geography of West Pakistan. They were built entirely from the strategic point of view; as West Pakistan has always been attacked from the west and rivers were considerable barriers in those days,therefore,for safety sake,settlements were established on the eastern banks of the rivers.

Advent of the European:-

West Pakistan was not affected by the early European invaders,who entered the sub-continent by sea. West Pakistan,fell out of the reach of influences of the Portuguese, the Dutch and the French. British influence, was first exerted over the sub-continent during the Anglo-French wars in 1740 in the Madras presidency, but West Pakistan, the Punjab portion of which was under the sway of the Sikh raj, was annexed by the British in 1853. Before this British attempted the occupation of Afghanistan, an attempt which resulted in failure in 1844. This defeat was compensated for,by the conquest of Sind and the North West Frontier Province which offered a longer resistance.(12)(14) Fig.658.

West Pakistan was not strategically neglected by the British rule,as they had to defend this part of the sub-continent against Afghan encroachment. Thus they,established military posts at many strategic points namely Peshawar at the Kyber, Bannu on the Tochi and Quetta on the Bolan openings. Throughout their rule on the sub-continent, they had to be vigilant for the safe-guarding of the border.

There are incalculable reforms and innovations, which not only, West Pakistan, but the whole sub-continent owes to the British rule. The presidency of Madras, Bombay and Bengal are more developed because they came first under the British rule. West Pakistan was the last annexation, hence, modern developments of railways, and roads were introduced later.

With the opening of Suez Canal in 1869, the distance between Britain and the sub-continent was shortened considerably and the trade was much extended on a large scale.

Government directed her activities towards the progress of the material and resources of the sub-continent. The first was, the construction of railways which produced a greater internal mobility of the agricultural products. Railways proved a blessing in the times of famines and with an active provision of the food, the intensity and gravity of the famines were reduced considerably. A famine relief system was created.(12) The Government directed special attention towards the maintenance of forests in the Indian Empire as a whole, but no attention was paid to West Pakistan forest conditions.

West Pakistan was affected especially by the reconstruction of the Ravi canal and the establishment of the canal colonies in the Upper Indus plain. This area was a waste desert before the introduction of the canals between 1890 and 1899, and already by 1901 this area supported a population of 800,000 people.(15) Agriculture was given great importance and agricultural departments were opened in many provinces; in West Pakistan at Lyallpur, for agricultural research and advancement.

West Pakistan remained an agricultural country, especially with the introduction of canal irrigation, it produced so much grain that it supplied the sub-continent. The reason of being its agricultural county in the first place, was the lack of industrial fuel and other minerals. Industries were established in Bengal, Bihar, Orissa and Bombay became of the availability of the industrial fuel and raw material. The major resources of West Pakistan, being surface water and the soil, water was tapped and applied to the soil to produce food, according to the best contemporary practices, which proved an effective instrument in the rapid increase of population.

Moreover, under British rule modern schools and colleges, and better universities were begun. Efficient methods of postal services were started. The use of electricity became known. All these amenities and comforts were confined mainly to Lahore city, as it has been the provincial capital under the British rule as well as a military post. The second city, which was affected by these modern phases was Rawalpindi, as the General Headquarters of the Military. For the same reasons Peshawar, and Quetta were modernised to some extent. After the catastrophic earthquake of Quetta in 1935 less attention was directed to this city.

With the exception of three or four cities, West Pakistan, remained entirely devoid of industries and modern life, and most members of the growing population earned their living from the soil, with. age-old primitive techniques and implements.

In 1947, British rule was ended and rulers left the sub-continent in the form of Pakistan and Bharat according to the wishes of its people. The remaining story, since 1947 will be resumed in the succeeding chapters, and the main conclusions which can be drawn from our knowledge of historical conditions also postponed to chapter 8. We can however now make these points.

First, the very early development of an urban civilization shows, how effective were early adaptations to relative aridity and also, how much more ecologically attractive than at present were the Indus plains. Secondly, even though, climate has probably changed little, the succession of incursions, by invading peoples inhibited, any later large scale control of environment, in a region, in which control of water is essential to high civilization. On the credit side must be put new plants, tillage, techniques etc.

Lastly, during the periods of general political stability, the degree of local stability operating in critical relationship between man and the land become pre-eminently important. All the evidence points to permanently precarious equilibrium in the arid zone.

Chapter 8

Recent and Contemporary Settlements

In the preceding chapter the existence of pre-historic and historic settlement has been traced and, in so far as is possible, considered in relation to the environment. Water has been the foremost factor in influencing the growth and pattern of human settlement since the man first emerged in the Potwar Region on the banks of the river Soan. As human evolution proceded, population increased and eventually more and more land was acquired for new settlements along the river banks.

This chapter is the logical culmination of a study of arid and semi arid West Pakistan. For earlier periods, we have had to use meagre evidence restricted to the distribution and type of settlements and for the sake of continuity, the examination of recent periods is similarly restricted. As noted in the conclusion to Chapter 6, we cannot here study all the human implications of aridity. The enquiry here is directed, therefore, to study the relationship between the present settlement patterns and the water resources. Besides, this, existing patterns of settlement will be related to topographic, climatic, soil and ecological conditions for cultivated plants.

The aim is, to study the settlements as geographical entities in terms already considered in earlier chapters. Therefore, the co-ordination of the existing arrangements, the tracing of the origin of the settlements, in the classical human geography approach is not here specifically considered.

The preceding chapters, present a threefold aspect of West Pakistan, as composed of, first, the natural environmental elements, such as morphology, climate, and to some extent hydrography and soil; secondly, hydrography, soils, ecology and the cultivated plants as man influenced elements, and thirdly, the results of the human efforts to adjust environment, ecology and society. A relationship between the highly complex natural habitat and human activity is, thus blended throughout the work. The account which follows, is based as far as possible on personal observations.

Mountain Settlements:-

The mountainous areas considered, are the highland section forming Regions I-IV. The terrain of the highland region as explained already in the first chapter, is extremely precipitous, broken by gorges and narrow defiles. Too steep slopes and great altitudes are prohibitive to cultivation and the soil on the whole is thin, except in the river valleys. Throughout the highland of West Pakistan climate is rigorous. The altitudes above 12,000 feet are the abode of a perpetual snow. The wet and sunny slopes with favourable habitats of growth are generally covered with thick vegetation as illustrated in (Plate 2b Chapter 1). The extreme high slopes are covered with groves of coniferous trees, (Plate 35a-b) and crumbling slopes which do not support man, plant or beast. These Plates, show, typical landscapes in Region I 2b, c and III-IV. Morphological circumstances render transportation difficult. The chief means of communication is rivers and tracks which crossed and recrossed the gorges at several places by primitive bridges. Plate 36. These natural environments have enforced a hamleted type of dispersed settlements. The dispersion pattern is essentially different from the normal dispersed settlements in Britain, Austria, Germany, France, Australia, United States of America and Canada. Dispersed settlement units in North Western Europe, in particular, consist of, a main building owned by the family of a farmer, a few detached or semi-detached, and sometimes attached cottages of the farm workers, and separate structures for barns, byer and sheds etc. for animals, storage of fodder adjoining pens, machinery, yards, house gardens and orchards, depending on the economic conditions of an individual. This single isolated farmstead is the smallest unit of population.

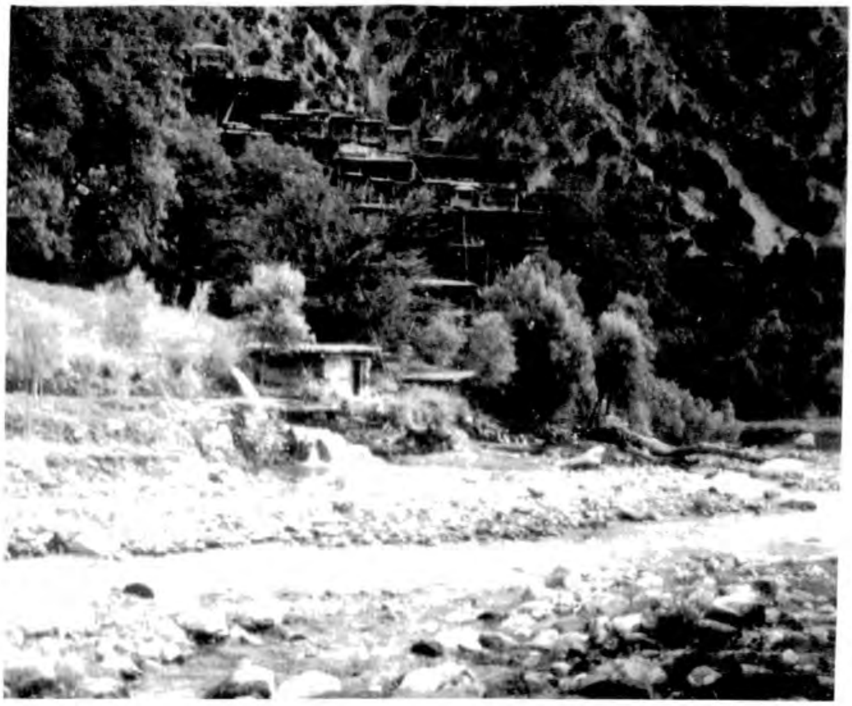
Plate 35

a

b

Plate 36

On the other hand, in the highlands of West Pakistan, the structure of isolated hamlet type of dwellings, is dictated by the climate and local geographical conditions. The dwelling huts are confined to the sunny slopes and the small river fans below. Plate 37a, shows a typical example of this type. The whole settlement of c.20 huts is built of stones and wood, easily obtainable from local mountains and forests. This group of hamlets appears like a set of pigeon holes, buildings attached and placed in tiers one on the other and surrounded by orchards, containing a variety of trees such as mulberry, plum and apricot. Every village has, a village green as a communal grazing grounds, the cultivated fields lying nearby. The field boundaries are of stones and mud. The main source of water is the river flowing at the foot of these hamlets. These clusters of hamlets are situated in scattered localities, privileged fan areas of fertile soil, forest and water. These settlements of the handsome, ancestor-worshipping 'Kafirs' are permanent. Plate 37b, is an illustration of a Kafir woman in her usual costumes. This hamlet type is the prevalent system in the Hindukush Mountains, known as the Kafir territories in Chitral state. In Region I 2b, C the increase in dispersion is in direct proportion to the ruggedness of the land surface, and lack of water. For



a

B

B

miles no sign of man or beast is visible.

The settlements in the wide fan plains at lower elevations in the States of Swat, Dir and Chitral are different from the above in design. They are grouped on the scattered terraces of arable land. As limestone is ubiquitous throughout the highland zone and because of the deficiency of surface water supplies (especially in Regions II-IV), the distribution of the human settlements is sharply determined by the occurrence of springs. This has given rise to small closely grouped habitations rather less dispersed.

The salient features, of the majority of villages, throughout the highland region is the defensive wall round every village. This feature may be related first, to their location in a zone lying now near international boundaries. It has been emphasised in Chapter 7, how the whole of West Pakistan in general, and the highland region in particular, from Malakand to Bolan and Zahidan, on the fringe of Pak-Iranian border and the Makran coastal region, had remained invasion routeway offered easy access to foreign invaders. Therefore, these settlements are fortified and built up at naturally elevated and sheltered spots. The defensive walls have a history, dating back to the early village cultures of prehistoric Baluchistan as noted already. The second, reason for the survival of these defensive traits, is the enmity among the different tribes who occupy the separate territories. The highland zone abounds in forts and watch towers. Plate 38a. The settlement groups grew round these forts again for defence. These frontal territories have had always a restless life, where life is so insecure that not only the villages are walled but every field is defended by a watch tower.(1)

The houses are built with stone obtained locally. The natural factors of their location are the same as mentioned above, the presence of water, arable land and grazing grounds. The river valleys are sprinkled with villages at favourable sites. The general appearance of the area is varied, containing smiling valleys of rivers Swat, Punjkora and Chitral, replaced by dreary landscapes at high elevations and in the areas which lack perennial surface flow. Among them, river fans are like oases, where natre has bestowed both water and arable land. The settlements are confined to the fans whether they are small or wide open. Plate 4a, Chapter 1 shows a typical example of a small fan settlement. Plate 38b. is an instance of a big fan, where 6 groups of villages are located at a short distance c. ½ furlong. The right bank of the river is a zone of deposition hence it offers more space and the number of

Plate 38

a

b

settlement is higher. The settlements are not widely scattered, but they are established in separate groups in one fan on the both banks of the river. The houses in these agglomerations are well-built, by both stone and bricks with slanting roofs to drift the snow. Each cluster of settlement is planted with a grove of fruit trees, and surrounded by terraced fields. The whole valley is clothed with trees because of relatively high and regular rainfall. These settlements have more land, bigger houses, and bigger crops, because of better physical and socio-economic conditions. The wider river courses put more water at their disposal. The valley is wider also hence, there is wider scope for cultivation, on the alluvium rather than the coarse grit and pebbles of the more remote highlands Plate 39 a-b. These fan settlements are served by good metalled roads also. These settlements bear some little resemblance, to the scattered farmstead hamlets in north western Europe.

In these mountainous river valleys, villages proper are predominantly sited in small low fans, with extensive terraced cultivation of rice fields. A village developed on a low fan may sometimes contain 500 houses, for instance Patrack village. (2) A small village has usually about 120 houses e.g. Biar. Rice is carefully planted and tended, but the leading crop is maize because it does not need such

Plate 39

a

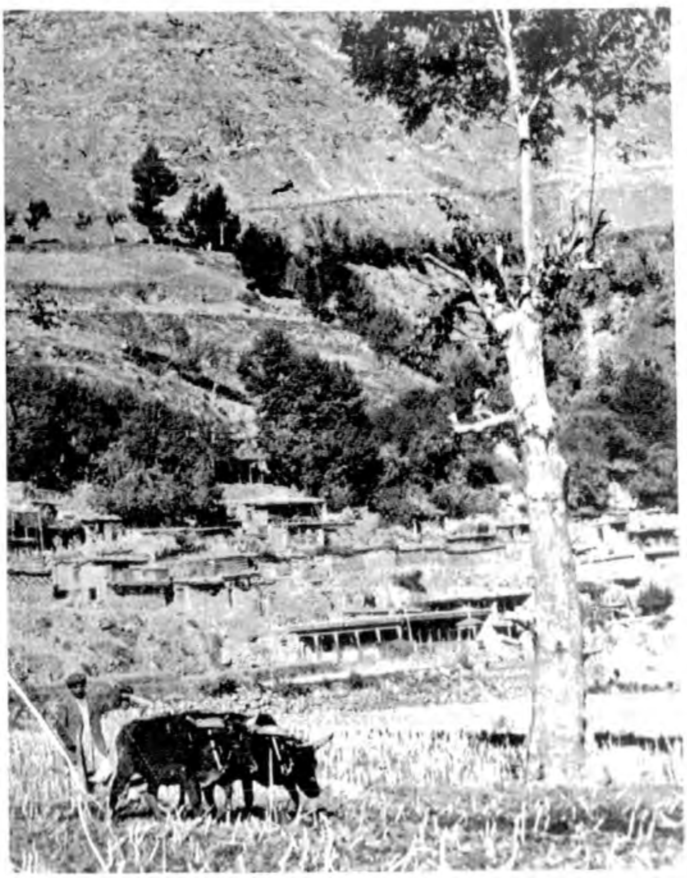
b

careful husbandry. The second crop is wheat because of its lesser demand for water, followed by rice and barley. A great variety of other crops like sugarcane, tobacco, pulses, mustard and potatoes are also cultivated. The choice of rice and maize annuals as the staple crops is undoubtedly influenced by climatic factors. The crops are grown on the fertile land in the valley and higher grounds are given to the grazing. The farming methods are primitive and on a subsistence basis, as there is no system of trade with the rest of the country. The whole population subsists on what ever is produced locally. Here the fields are stone walled to prevent grazing encroachment. Plate 40b. is a sight of primitive farming.

The large villages grow up on the river banks. The tiers of houses are constructed in east to west direction, so as to avoid the north western cold winds and to get the sun. The houses are more or less designed in the same fashion as the Kafirs huts, constructed in a long line of terraces one above the other, the roof of the lower houses in the first row, forming the verandah and open space of the row above. These roofs serve as a recreation space for men, women and their livestock as well. The general outlook of all these villages is pastoral, Plate 40 b, but cultivation is an essential even if slightly "degrading" element.

Plate 40

a



b

Besides these, well-defined villages the human landscape includes lowly isolated mud hamlets owned by the flour millers on the edges of river banks. These mills are run by water. There is marked heterogeneity in distribution pattern and in plan of settlements but everywhere the pull of water appears.

The Kurram valley an inviting smiling spot, rich in cultivation and orchard groves, bears a close resemblance in landscape to plates 39a-b, 38b. The inhabitants belong to various tribes of Mangala and Jajis. (1) Their houses are of dual purposes, built very strongly owing to their hostility as they are often blockaded by enemies, as well as by snow. Arable agriculture is the main activity in the valley and along the small streams. The rough ground is left for a wild grazing. In the Waziristan territory, a typical site chosen for a settlement in the mountainous terrain is a narrow ridge as occupied by the town of Kaniguran. The obvious reasons being the shelter from cold winds, frost, and also from enemies. This town consists of 1,200 houses. The construction of the houses is distinctly different from those considered earlier. The outer walls of the houses rest on the poles of fir trees; vertically planted in the hill slope; and horizontal timber is thrown across. The generous use of timber indicates the thick local fir forest, but consequent deforestation leads to severe soil erosion. Here it is clearly shown, that man has been and is really a very effective power, in creating the present ravined land, both directly and through his grazing herds. The medium of domestic heating is wood and dungs. The main pursuit of the settled communities is agriculture. Grazing by the nomads is also of importance.

The general appearance of Waziristan is, that of a scattered collection of towns, villages and houses, encircled by terraced maize fields. It has verdure here and there with attractive patches of wild sage.(3) Every settlement has a summer grazing ground, and patches of well-wooded area. All the villages are located on the bank of small streams, for instance Razin situated on the bank of Alora Toi (stream). This village, the home of 30 families, is built up of mud houses with one or two towers. On the other bank of the stream they have erected a number of sheds where the villagers take a refuge during summer from the flies. Algad is also often a settlement site (local word for the dry course of a mountain torrent). Besides agriculture and stock farming the people in the highland are engaged in various cottage industries, the most famous being the gun factories particularly in the territories of

Waziristan; mat, rug and carpet cottage industry is common in the states of Chitral-Swat and Dir. The Swat cotton woven mats are very famous, as are the beautiful caps of gold, silver and silk embroidery, fancy shoes and chapals. Every town has workers in these crafts together with gold and iron smiths and the large villages also; but the small villages depend for these equipment on the nearby towns.

In regions III-IV the villages lie close together and strongly built for safety. The settlement sites are predominantly controlled by the presence of underground water, which is obtained by Karez. The shafts are sunk in the river fans running along the hills, and the spring or sub-soil water is tapped for irrigation. Figure 66a, shows the location of Bostan, 15 miles north of Quetta.(5) Bostan, proper is a compact settlement located between two Karezes. It has fully cultivated land along with wooded areas. Bostan is surrounded by closely situated villages on its north west. To the south east of Bostan lies another neucleated settlement. This small example shows,how direct is the relationship between water availability, soil fertility and settlement sites. The settlements are on the periphery of the cultivated land, and the settlement type is an agricultural agglomeration of villages. In the north settlements tend to concentrate. The residents of these villages are the tillers of the soil and are concerned with the production of primary produce as wheat, barley, millet, potatoes, and fruits like apricots, peaches, apples and grapes.

In Makran territory again the size of the villages(6) varies with the amount and quantity of the available water, and the presence of cultivable land. The general pattern of the settlement is of medium sized rural villages with forts on the hills. Fort Dardau commands a village in a dry river valley of Dasht of 70 houses with 300 inhabitants; the residents own a number of livestock as buffaloes, cattle, sheep, and goats, their source of water is pools. On the other hand, a locality with 20 wells of good water carries a large village at Bul with 400 houses. (Bul is also a term applied to any grove or top of trees especially date palms). The village is surrounded by irrigated fields, and big date groves. Where ever a few springs of excellent water emerge a small village of 50 huts like Chelunki in the Nigore plain may be established. Besides these small villages, which are merely a congregation of small huts, there are clusters of villages known as the abadu or Toomp. (abadu-cluster). Each village has its distinctive application, but a general name of Toomp is applied to the whole cluster. These clusters are entirely associated with the course of the river Nihing, with their population of 8,000 persons. This group of the villages is very varied, and there are a great variety of occupations. Among the members there are 30 weavers, who make coarse silk and cotton cloth, also a few carpenters and smiths who prepare the simple crude type of agricultural implements for local demand.

The most populous settlement in the Makran is the town of Punggoor.(6) It comprises 13 abadus, five large and eight small. Each of these villages, is a "medley" of forts, orchards, date-palm, fields, houses and water courses. The areas which are not served by water are arid and unproductive. Rabi and Kharif crops are grown. This settlement unit is a trading centre especially for wool. The cottage industries make cotton and silk cloths, wool, caps, drum, flutes, and include carpenters and coblers.

On the sea coast the main settlements are of fishers, as Ormara. A trading centre also, this has about 500 mud-hovel houses.

The salient feature of big or small collective communities in Regions III-IV are plantations of date groves, cultivation of both rice and wheat, the use of Karez, the presence of a fort and of local handicrafts. Finally, the size of both collective and single settlements is entirely controlled by the presence of either underground or surface water. On the whole the economy is of subsistence type and the people are primitive in their methods of cultivation. The towns are served by secondary roads and the villages by pack tracks or lanes.

Another common element in Regions II-IV, is, the non-sedentary type. Occupation is mainly pastoral, based on the raising of goats, sheep and camels. These are regular as well as enforced nomads. The amount of cultivable land is often either too small or it is not feasible to cultivate it for want of water, hence the nomadism is enforced by the scarcity of water, and restricted amount of contiguous cultivable area. There are the areas, where population per cultivated square mile is high although general densities are very low. Fig. 67. In addition to livestock farming, these shifting human communities pursue occupations like petty trading, and handicrafts like caps, shoes and silk woven cloth making. Besides this, there is always an encroachment by the Afghan Powindhas, in a form of transhumance. They enter West Pakistan during winter and graze their livestock, reaching even to the Thal area. The majority of them come to the market towns of Chaman and Peshawar, leaving for their own country at the turn of hot season in March. They encamp in tents wherever they find a pastoral ground or a fertile piece of land. The Powindahs bring dried fruits, and cloth to trade, or they seek casual labour in canal, dams, or road construction.(1) The main points of these influx are the passes, Kyber, Gomal, Tochi, and Bolan. Plate 41A-B The sedentary and nomadic life in the highland is a direct consequence of the aridity. The supply and amount of water limits the size of settlement.

In the highland region the settlements are predominantly agricultural, and their layout is both compact and dispersed, sedentary, and mobile hamleted villages. The other incidental activities of the villagers is cottage handicrafts. There are other settlements which have sprung up in recent times with the opening of woollen mills as at Harnai, in the Quetta Division. The construction of Dargai and Malakand Power and irrigation plants have attracted settled non-agricultural communities in the Peshawar Division. The compact rural settlement at Warsak is now growing, as a response to the effects of the building of the Warsak Dam, with well built brick houses with modern facilities. The Kurram Garhi project has also resulted in the establishment of new housing schemes. The township has sprung up in the very inhospital region of dry Bugti hills in the foot of the Sulaiman range

Plate 41

A

B

owing to the incidence of gas reserves. The local wandering tribes have been housed in houses supplied with gas, and have adopted mechanisation. Water is provided to this settlement from the Indus 40 miles away.(7) These settlements which are accounted for directly by the presence of Headworks, Power Houses, and Dams will not expand, as each project only requires a limited number of workers. The settlements which are affected by the opening of manufacturers such as textile mills, stand better chances of expansion.

In the Quetta Division there are mining villages, settlements which grew for the exploitation of coal. The pure rural landscape is thus being blended with other pursuits, hence the slight heterogenity of the settlements not only in their form but also in their function.

Sub-montane Settlements

The sub-montane region is divided by the Indus river into two parts, the trans-Indus and the Cis-Indus. (see Fig. 3 1st Chapter). The whole area is hill-girt on its north and north west. The general appearance of the area is of barren scrubland with Babul and Jand trees. The river valleys are covered with alluvial detritus, gravels, and boulder clay. The dry parts are predominantly broken and present a badland topography. The areas which are privileged with surface or spring water offer opportunities for cultivation and carry groves of mulberry and willow tamarisk. The main occupation is tilling the soil and livestock farming. The settlement pattern is here again controlled by water availability. The rural landscape consists of clusters of small villages grouping round the water points. Each village has parcels of both arable and waste land, lying scattered around it, and each village possesses a communal pasture, orchards and woodland are also found. The house type is of rectangular construction of stone, wood and daubed with clay. Brick built houses may also be found. The setting of the houses are generally close-packed.(8)

The cis-Indus region lacks topographic homogenity. The region consists of the Potwar plateau and the Salt Range. These hills composed of soft sedimentaries belonging to the Siwalik Age, are cut deeply to form a fretwork of gullies. There are fragmentary islands of cultivated soil wherever the water exists. The vegetation covering is thin and sparse.

The accompanying diagram of the districts of Mianwali and Attock, Diagram 66b, illustrates the mode of settlements on the Cis-Indus sub-montane region.(9) The chief geographical features are as follows. It is highly dissected country with a scanty vegetation. The area is traversed by a few wadis which are seasonal. The bluffs of Indus flood plain vary in height from 14 to 35 feet. The settlements tend to concentrate near watercourses. The villages on the bluff are larger and closer, where as the villages become smaller in size as the distance from the water points increases, and they are also situated farther apart. The bluff villages are endowed with two types of land, the upland and the silty lowland of the valley-bottom of an excellent fertility. The valley bottom is sprinkled with many islands, which submerge and emerge with the arrival and departure of the rains and floods. Cropping in these section is risky but profitable. These lands are given to cash crops or to vegetable farming, which is benefited by well irrigation made possible by the high water-table. The diagram also suggests, that the settlements have taken roots where steep slope ends in a fan and where soil is fertile and water-table is high. These settlements flank the Salt-Range on its west. The settlements in the Potwar region are built on the bluffs which offers elevated dry flood-protected sites. In this case, the striking alignment of the villages along the levees is dictated by the environmental factors of water and fertile zones of land. The settlements on the whole form irregular mosaics corresponding to the patchwork of fertile soil and water points.

In the Cis-Indus region old [illegible] settlements are located in Khewara because of the Salt mining activity, and at a modern Soda Ash Factory which is based on the salt. A few miles west of Khewara, lies the coal mining village of Dandot and a modern brick making factory based on the coal fuel. In the same way settlements have been attracted by the extraction of oil in the Districts of Attock and refinery at Rawalpindi; the important settlements are Khaur, Dhulian, Balkassar, Joyamair and Ikarsal at the oil fields. These mining and industrial villages are served with both rail and road.

The Potwar region is also well-served with the roads and since the declaration of the new national capital, vast schemes of new settlements are under execution with the experts guidance.

<u>The Upper Indus Plain</u>:-

The most striking feature of the plain is its imperceptible gradient, which renders movement easy in all direction. The landscape is of cultivated fields and pastoral grounds depending on the soil, water and the drainage efficiency. This level plain offers great facilities to movement, and the settlements are closely connected, the natural landscape being replaced by a cultural landscape, as compared to the highland region.

The second feature of importance of this plain is the alternation of doabs or interfluves with flood plains. The high edges of the flood plains have been traditionally the settlement zones. The lower terraces or embankments are given to cultivation.

Throughout this plain of West Pakistan rivers are the easiest line of movement, and since pre-history the whole of life has been focussed on these rivers. Throughout the lowland they maintain their flood plains, spread a series of tentacles into the contiguous dry sandy regions, which are thus injected with the opportunity of agricultural life. At the southern end of the lowland lies the old and large sea port of Karachi which is a world trading centre.

Because of subdued topography the plain is served with a sprawling net of both rail and road lines, and primary commodities are easily distributed over the plain. Villages tend to grow rapidly and new colonies have also been opened, together acting as the collecting and distributing centres. Exchange economics are here mainly traditional.

We have seen, that in the highland, where land is of the lowest carrying capacity nomadism is dominant and the few settlements are small in size and sparsely distributed in favourable districts. Contrary to this the now fertile upper Indus plain offers a scene of aggregation of populous villages, towns and cities. The majority of the people are engaged in tilling the land; and raise heavy crops of wheat, rice, cotton, sugarcane, fruits and millets, because of easily available irrigation water and rich alluvial soils. The lowland is a green rural area with groves of mango trees, and tamarisk, rice and wheat fields. The combination of rich soil and water has resulted in compact and prolific settlements. Before the opening of the present canal system in 1860 the whole upper Indus region was still, in a desertic state of the type shown in Plate 42a. The new village settlements in the canal colonies offer a complete contrast to the unsystematic and chaotic setting of the Sub-Montane region. The villages are built in a rectangular form resembling Roman Castra.(5) It has been said "these villages, which for cleanliness at least, might be the pride of any country in the world" and their peasantry is reckoned as "one of the finest in the world."(10) The village pattern together with its farms is geometrically rectilinear.

Fig. 68, shows,a typical settlement arrangement in the doabs of the Upper Indus plan.(5) The figure illustrates a section of a doab, in the Lyallpur district, from the river bank which is known as the bet land,through the higher scrub ground, to the crest of the doab. The figure shows how, the contrasting settlements, have been conditioned by the geographic characteristics of the bet and doab lands. The crest of the doab is irrigated with the canals and wells are non-existent. The villages are planned, and numerous scattered field huts, and for livestock on the banks of the water courses are the rule. The human landscape of the canal colonies id described thus "The canal colony with its rectangular fields, its straight roads, its interminable avenues of shisham trees, and its trim four-cornered villages speak of a new order of things".(11) On Fig.68, the blank space between the canals is cultivated land, while the stippled area is waste scrubland.

Contrary to this well planned settlement, are the amorphous villages between the River and Degh Nala and between the canal settlements and the Degh Nala. Here wells predominate because the high water table enabled fairly early unplanned use, and because of the low cost of wells every hut has a well construction. This suggests the fertility of the soil and intensity of cultivation. The braided banks of both Ravi and Degh Nala, and marshy area indicates the recurrence of flood. The villages are set in irregular manner and are ungeometrical in the shape and form. These village avoid the scrubland and are located on raised ground. These settlements are not agglomerated, they are smaller in size than the canal colonies and are located at short distances from one another. The houses are mud-walled with flat-roofs. The well-styled houses in the canal colonies are of burnt brick. The houses in the primitive villages are built of sun-dried bricks of flat roofs, grouped together on a high eminence near the river. The mud applied to their construction is obtained by digging the land nearby. These depressions are filled with rainwater and this water is used for both man and livestock.

Livstock farming also exists, goats, sheep, camels, draft bullocks, buffaloes, and cattle are carried on the steppe lands.

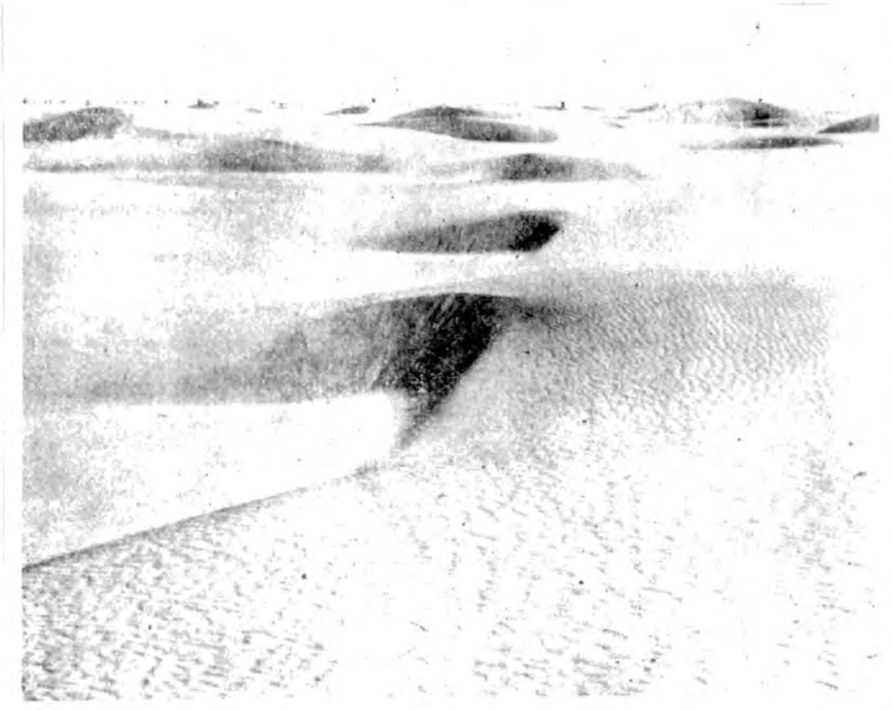
The canal colonies are well served by good roads and railways. These colonies are not only important for their agricultural produce, but they have become the hub of all activities. There are a number of factories run on local primary products such as cotton mill, flour mills, biscuit factories, and leather factories. Every colony has a college and a number of schools. These central doabs are now the most highly populated areas in West Pakistan, and the most important factor for the intensity of activity, is the provision of water by canals, the simplest control of aridity.

Recently, irrigation has been extended to reclaim the Thal desert in 1954, under the Thal Development Authority,(12) to rehabilitate about a quarter of a million refugees. The Thal project is similar to the Tennessee Valley authority plan, as it is also a multipurpose scheme for an overall development of a very big geographical region of hostile environmental conditions, as is illustrated in Plate 42a. The project envisages the afforestation of 10% of the total $1\frac{1}{2}$ million acres, in big plots or in the form of shelter belts, along the canal banks and roads, or in small woods belonging to the villages. The plan of such villages is illustrated in Fig. 69.

The Thal Development Authority has divided up the land into 900 chaks (villages) of 100 acres each. A holding of 15 acres is allotted to each settler, and each village consists of about 50 families. These chaks are provided with two types of houses, the first type contains one room, courtyard and a small verandah only, while the second type has two rooms, courtyard and a cattle shed near the house. The setting of the villages is regular and mathematically planned.

Each village has a grazing ground covering about 40-60 acres of land. In each chak an area of about 50 acres has been set aside for afforestation, in particular to serve

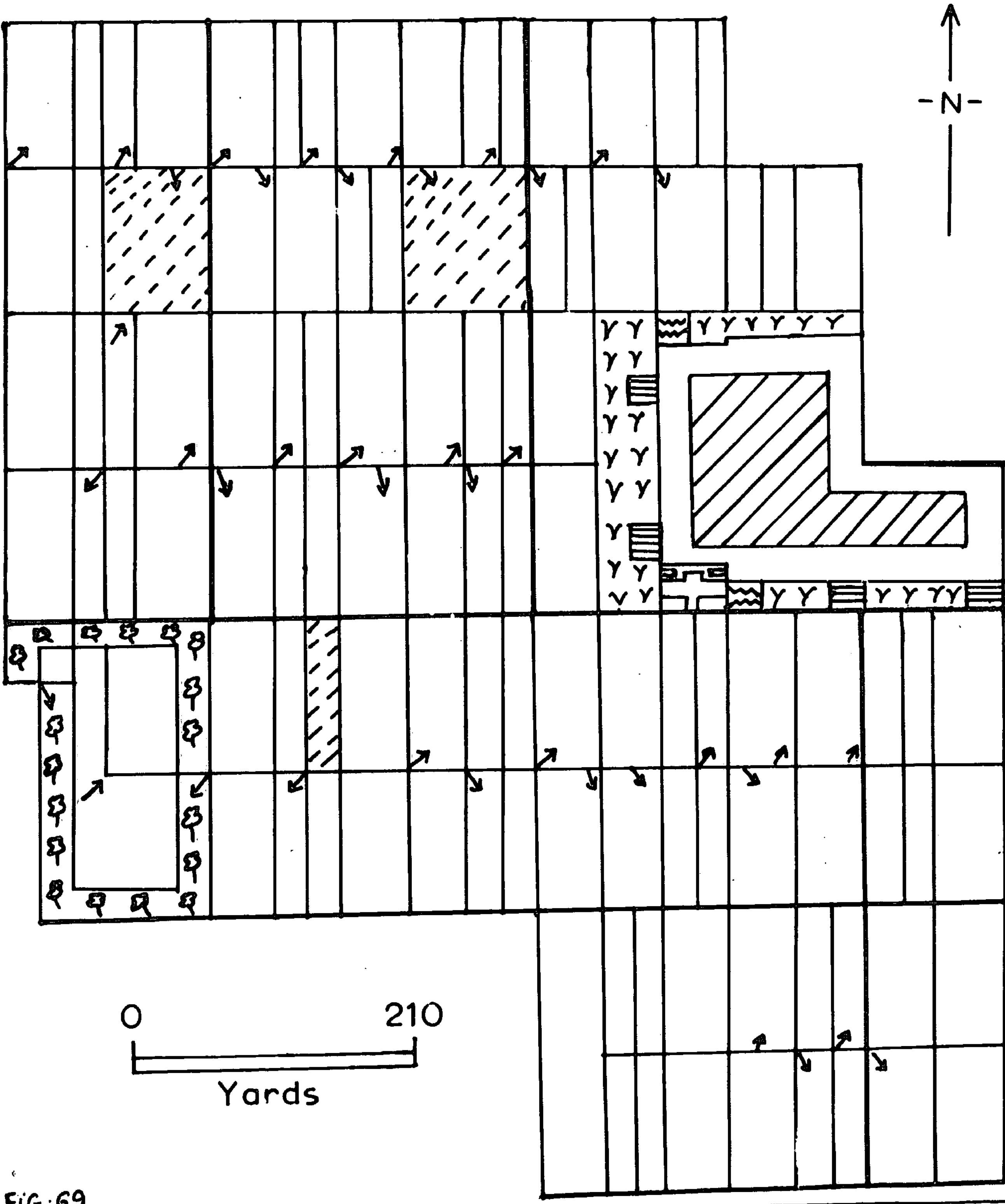
Plate 42



A

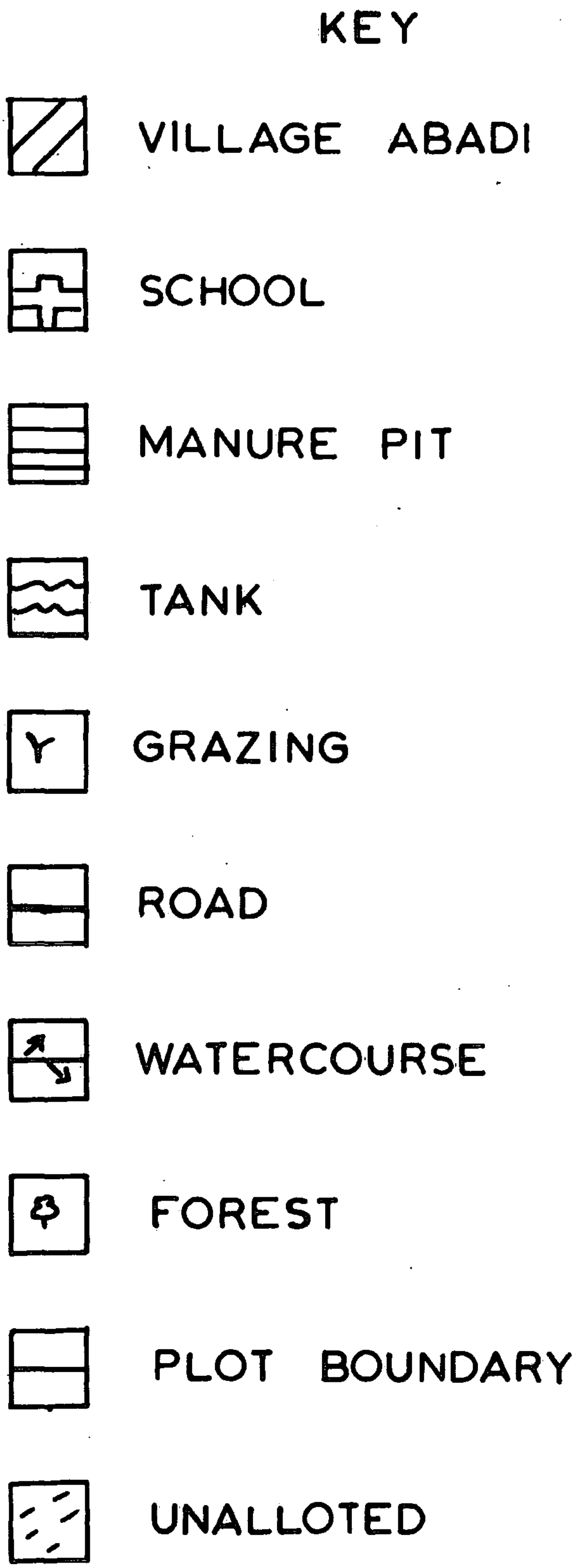
B

VILLAGE MAP OF CHAK 6/M L RAKH PIPLAN



FIG·69

Fig. 69


KEY
VILLAGE ABADI
SCHOOL
MANURE PIT
TANK
GRAZING
ROAD
WATERCOURSE
FOREST
PLOT BOUNDARY
UNALLOTED

as shelter belts against sandstorms. Each chak is also supplied with drinking water from hand pumps. The settlers are not charged for the cost of pump installation, but they are charged for the cost of repairs. Each holding is served with metalled roads which further connect the village with the main roads and the surrounding villages and market towns. A group of two to three villages is provided with a school, and one dispensary is put at the disposal of a group of 12 villages. Modern facilities of electricity-supply, water-supply, drainage, metalled roads and other amenities have been installed. The Thal development Authority intends to rehabilitate in this way, 44,000 families in the reclaimed desert area. More than $\frac{2}{3}$ of the plan has been achieved.

Chak 6/ML has been chosen here as a typical village in the reclaimed Thal area.(13) The village is situated in Rakh Nasirwala, police station Piplan Tehsil District Mianwali; near the railway line, and the metalled road runs from Piplan to this chak,via Liaquatabad. The whole area is 952 acres.

The soil of this village is sandy loam and clayey, and sandy and a great variety of crops are grown, according to the soil, for instant,cotton, sugarcane, rice and wheat, and fodder as Jantar, Gaura, Toria and grams. The farming methods are advanced and modern implements are in vogue and the use of fertiliser is encouraged.

Clayey Land -	Cotton, sugarcane, rice, wheat Janter, Jowar.
Loam and Sandy loam -	Sugarcane, cotton, bajra, Jowar, Gaura, wheat, Toria, Raya, Pulses.
Sandy -	Gram, berseem sugarcane in manured land and bajra.

Crop production depends on the canal irrigation. Fig. 69, shows, how every plot is served with a water course. The population of this village was 931 people in 1953. The settlers cultivate the land themselves.

The map of the village illustrates, that the village settlement or Abadi is established in the east of the village lands. This settlement is surrounded by the field plots, on its ~~east~~ west; and by grazing grounds on three sides. The continuity of the grazing land is interrupted by 3 water tanks, 3 manure pits and one school. The fields are crossed by 3 north to south roads and 2 east-west roads. The southern boundary of this chak is formed by a metalled road. The area allocated for the forest is in the south west of the village to check the fast south west winds. The details of the different uses of the land may be ascertained from the table below.

Given to settlers	660 Acres
Share of Lambardar (village head)	15

Reserved for sheep	15 Acres
Distributed to menials (Moecins)	25 Acre (a landless field labour)
Covered by abadi (houses)	64
Covered by school	3
Covered by grazing	27
Tanks	6
Forest	52
Not distributed	85
Total	952

The majority of these settlers are former military or naval persons. Besides.this,the village has its own iron smith, carpenter, cobler, potters, barber, watchman and the oil man.

The implementation of Thal project bears the witness, that with the provision of water even the most inhospitable deserts can be settled with modern technical and engineering skills. The rest of the arid areas in West Pakistan also await such treatment.

The Lower Indus Plain Settlements.(14)

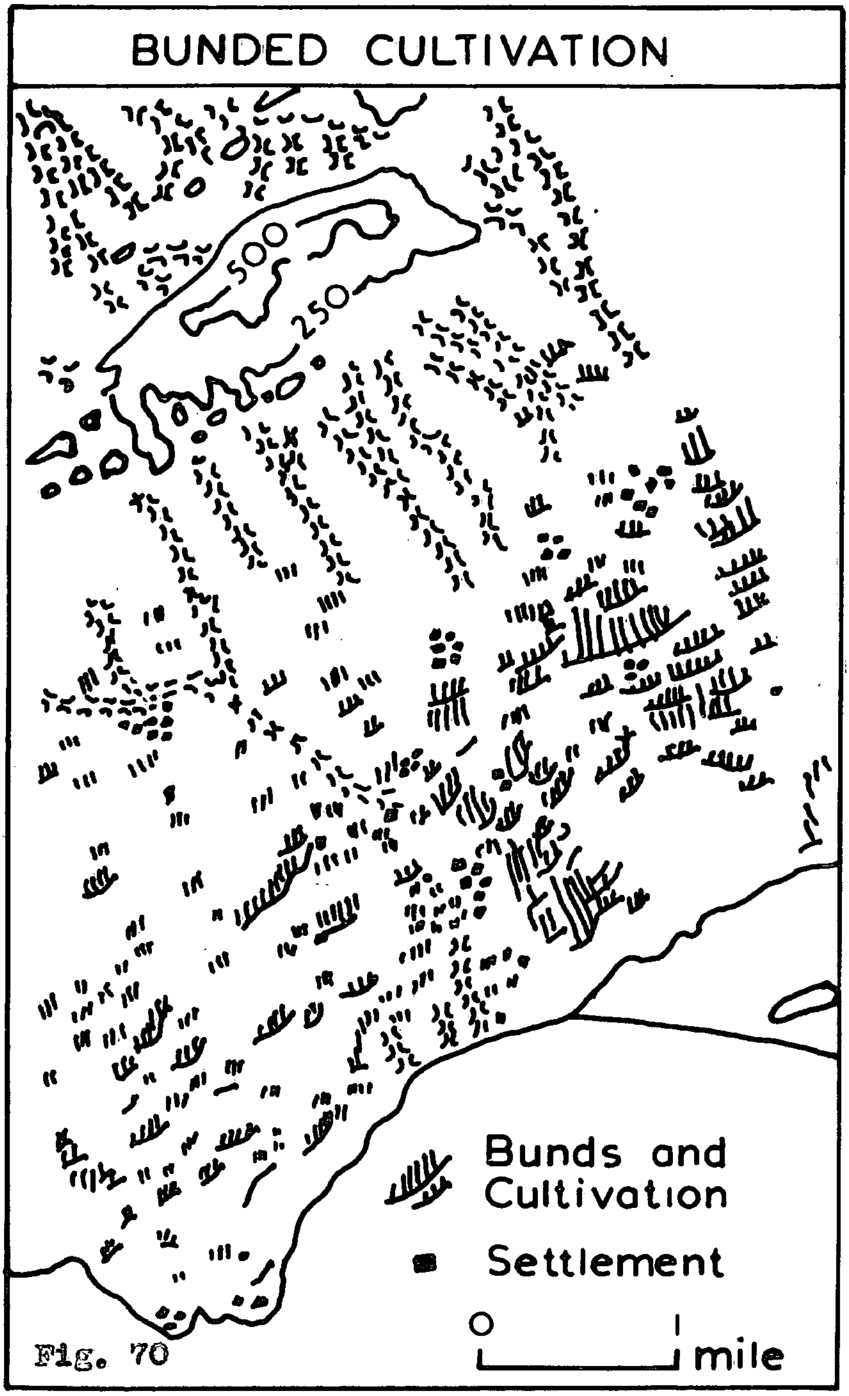
The settlement pattern in this region is again determined by water supply and the fertility of the soil. Like the Thal Doab and other eastern doabs of the Upper Indus Plain, the Lower Indus Plain was also for the most part a desert till the construction of the Sukkar Barrage in 1932. The rainfall in this area is between 5-10 inches.

In this region two categories of settlements may be taken (1) The settlements in the irrigated areas where the soil is new alluvium, and (2) the settlements in the non-irrigated areas of old alluvium. Life in these areas is sedentary and the nucleation is very striking. In the Kacchi plain villages tend to be isolated centres, lining the canals. The agricultural land is mostly laid out in large estates and cultivated by share-croppers (haris). The farming system is very peculiar, as reported by the United Kingdom Industrial Mission to Pakistan in1950. "All cotton land of an estate will be arranged in one compact block, all the wheatland in a second block, and all the fallow in a third. These blocks are then parcelled out among the haris for cultivation and cropping. They are rotated from year to year over the whole estate, so that the areas cropped by individual tenants is constantly varying".(15) Here given the basic control of irrigation water, the settlement pattern is derived from socio-economic response.

The unirrigated settlements:-

These villages depend on precarious rainfall, or on underground water. Both rainfall and the extent of arable land are precariously balanced, the occasional downpours rapidly removing the thin layer of the soils from the uplands and leaving the land stony and barren. Such physiographic conditions give rise to isolated settlements corresponding in distribution pattern mainly to topography and geology. Few villages appear in the valleys of the dry limestone in Kohistan and these, using wells subsist on small patches of arable land. Where the pasture is better milch cattle dominate the areas of poor pasture, which otherwise are used by sheep. Figure 70, shows the bunded cultivation on the damans or fans.(5) Small clay bunds have been built to collect the seasonal stream water. The settlements consist of small groups of hamlets. Plate 42b. The size and the number of hamlet decrease where the cultivation is patchy. Examples of true dispersed settlements are afforded here.

In the desert and Kohistan areas, which are still left destitute of irrigation water, settlements are not permanent, the villagers moving from place to place in search of pasture for their herds. These settlements draw water from deep sunk wells as the water table is very low. (See Chapter 4). The water table is 20-50 feet in the deserted river or canal beds, but fresh sweet water is not easy to obtain, as water is frequently brackish and wells dries up rapidly. Wells are frequently dug out one after the


BUNDED CULTIVATION
500
250
Bunds and Cultivation
Settlement
0
1
mile
Fig. 70

other, drying out equally rapidly because of the diminishing percolation from the river beds as well as the excessive evaporation.

Thus the settlements are sparse in the dry inhospitable deserts and valleys. Sedentary sown and nucleated settlements are possible wherever the permanent water supply supports pastoral grounds. Such settlements exist along the river and canal banks which afford the wide arable land and natural pastoral grounds. Agglomeration is only possible in irrigated areas where irrigation water is reliable and regular; soil is fertile and cash cropping is the rule. Superimposed on this rural pattern, settlement concentration is found near factories and railway junctions, etc.

Settlement distribution in general may well be explained with the help of Fig. 56A, illustrating the percentage of cultivated area to total geographical area in each Division for year 1959. The high percentage of cultivated area in the Divisions of Lahore, Multan is related to the high intensity of irrigation, concentration of communication lines and chances of more settled life. These are the areas where density of population is also high. Besides these, there are cultural reasons for the expansion of these areas such as Lahore, the ancient centre of culture, and rapid urbanization, the same also being true at Multan, Hyderabad, and Khairpur. The least percentages are shown by those regions where both irrigation and rainfall are deficient. The marked dependence on water, is clear.

Table below shows the progress in the area of cultivated land since 1931. Multan attains the highest expansion from 57% in 1931 to 68.8% 1959. In Bahawalpur arable land increased from only 13% to 21.4%. The factor accounting for this change, is the extension in irrigation schemes over the vast virgin lands which have thus been brought under the plough. The same factors are responsible for the progress in the cultivated area in the Divisions of Hyderabad and Khairpur Divisions. The increase in the arable land in the old settled areas of Lahore and Rawalpindi is not considerable. At Quetta, only 2% of the total area was cultivated in 1931, reaching 4.5% in 1959, owing to the small irrigational schemes launched since 1950 in the fertile valleys. There are still potential resources of cultivable land now classed as cultivable waste, amounting to 16% of the total area awaiting development by the provision of water and drainage.

Increase in cultivated Area since 1931

	Cultivated Area in 000 Acres		Percentage of the total Area	
	1931	1959	1931	1959
West Pakistan	32,611	38,131	15	19.2
Peshawar Division	2,296	2,710	13	15.4
D. Kher	2,656	2,795	19	20.5
Rawalpindi	3,861	4,191	50	55.1
Lahore	3,879	3,891	60	66.7
Multan	5,794	7,393	57	68.8
Bahawalpur	3,776	4,637	13	21.4
Khairpur	3,965	4,312	29	34.1
Hyderabad	5,784	6,968	25	28.8
Quetta	520	1,129	2	4.5
Kalat	80	105	1	.2

Table below shows,the density of population. The average density according to the 1951 census is 108 persons per square mile suggesting incorrectly a fairly low pressure on land resource. A truer picture of population pressure is conveyed when one considers the density for Lahore, 588, Multan 415 and Rawalpindi 327 persons per square mile. The greatest concentration of people per square mile, 1378, is at Karachi. The regions of lowest densities are Quetta and Kalat, 18 and 16 respectively.

Per Square Mile Density of Population		Density of Population per square mile cultivated		Variation
		1931	1951	
West Pakistan	108	480	566	86
Peshawar	185	1,129	1,262	133
Dera Ishmail Khan	98	392	451	59
Rawalpindi	327	482	605	123
Lahore	585	644	833	189
Multan	415	440	620	180
Bahawalpur	96	355	448	93
Khairpur	121	326	372	43
Hyderabad	69	192	217	25
Quetta	18	542	331	-211
Kalat	6	3,964	35,927	-372
Karachi	1378	NA	10,429	NA

The intensity and extent of aridity and settlement disposition are better illustrated in Fig.67, showing the density of population per cultivated square mile. On an average in the whole of West Pakistan, effective density is 566 persons per cultivated square mile. The true index of pressure of population on the cultivated area is thus established. The areas which are of scant population in respect of average density per square mile are thickly populated in regarding the cultivated area per square mile. These are the areas of moving and sparse settlements. In the Division of Kalat the percent of cultivated area is only 2 and pressure builds up to 3,592 persons per cultivated square mile. The causative factors here are, the paucity of both meteoric and surface water and inadequately developed underground resources, combined with the limited amount of continuous fertile land and apathy of the people.

In the Division of Peshawar one cultivated square mile supports 1,262 persons. Except for the Peshawar district, the rest of the Peshawar Division is densely populated by agriculturalists. In the states of Chitral, Dir, Swat and tribal areas the major occupation is agriculture, and the village craft like iron smiths are also dependent on agricultural population as they make the tilling implements. Hence again, the people are centred on a few restricted fertile areas, the low river fans, and valleys. The prevailing landscape is rural with small village. Peshawar is the chief city and the centre of urban, cultural and commercial life and an international gateway. Plate 43.

The map illustrates the relatively lower density of people per cultivated square mile in the Divisions of Rawalpindi and Multan the richest rural areas. The reason

Plate 43

being the availability of both fertile vast tracts of land and water, they show the densities of 605 and 620 respectively. Lahore shows the highest degree of population of per cultivated square mile with 833 persons, owing to high urbanization. The rural areas are also much developed and well connected with the urban centre.

The densities at Dera Ismail Khan and Bahawalpur are 451 and 448, owing to flood irrigation in the first instance and provision of canal irrigation in the second case. The low densities at Quetta and Khairpur are related to the Karez system of agriculture and canal irrigation respectively. The pressure over the land is relatively low.

The least pressure of population on the cultivated land is in the Division of Hyderabad, below 250 per cultivated square mile, because of available surface water and a large amount of arable land, as compared to the population it supports.

The highest density of Karachi is associated with the rapid increase in industrial, trading and commercial functions.

The high densities in Karachi and Lahore Regions are not of a very serious nature, because these areas in particular and the whole lowland in general are provided with adequate communications. Food can be supplied to these areas whenever there is a scarcity. In fact, Karachi and Lahore are the chief centres of consumption of the agricultural produce. The situation is grave in case of the whole highland region, where the transportation is poor and local isolation predominates. These completely subsistence regions are the areas of endemic famine.

During 1931 the area occupied now by West Pakistan, carried 480 persons for each cultivated square mile. In 1951 this reached 566 persons, which means the same cultivated square mile had to supply an additional 86 persons. The balance in the productivity of one square mile and its population has to be maintained. As the population increases both naturally and by the influx of refugees, in the same way productivity should be increased by using fertilizers, by sowing better seeds and by using efficient tillage and farming practices. Since, in Pakistan this balance is never thought of by the farmers themselves, the increase in population becomes appalling. In the same way, each Division shows an increase in population of cultivated per square mile. The largest additions of people occurred in the old centres of Lahore and Multan, but this increase is mainly due to rapid expansion of urban activities.(16)

The Divisions where cultivated area has recently been extended with the application of irrigation water, shows lesser variations such as Hyderabad, where the pre-Barrage conditions of flood irrigation have been replaced by a regular supply of water.

The land capability may further be weighed by examining ratio of land in terms of cultivated land per person 1931 and in 1951. All the divisions show a decrease by 1951, except Quetta and Kalat where aridity control measures were recently installed. See Fig. 60, and Table below:

Cultivated Area Per Capita
Acres

1931	1951
1.4	1.12
.56	.53
1.62	1.50
1.7	1.5
1.0	.7
1.4	1.16
1.8	1.12
2.15	2.00
3.20	2.99
1.1	1.9
.16	.18
NA	NA

The land per capita in 1931 was 1.1 and .16 for Quetta and Kalat increasing to 1.9 and .18 in 1951 respectively.

The marked decrease in the rest of the divisions, resulted from the sudden rise in population by refugees influx.

The two areas having the highest amount of cultivated land per person in 1951 were Hyderabad 2.99 acres and Khairpur 2 acres. The second highest availability of land per capita is found, in Dera Ismail Khan and Bahawalpur, where the increase in persons per cultivated square mile remained below 100 and per capita with 1.50 and 1.12 respectively. At Rawalpindi, the population per cultivated square mile has been increased and the land per capita fell from 1.7 acres in 1931 to 1.5 acres in 1951. This sub-mountainous region lacks large flat fertile expanses and because irrigation is not easily feasible agriculture is mainly rainfed. The statistics show, a growing adverse balance between the increase in the cultivated land per square mile and the increase in population per cultivated square mile, in spite of an increase in total cultivated area. The smallest per head availability of cultivated land is shown by Kalat, Lahore and Peshawar, less than an acre per capita.

The status of per capita land availability in some of the other countries may be noted. The density of per cultivated square mile is very high in China, Japan, Indonesia, Germany and U.K. as 1,416, 4,204, 1,750, 1,318, 1,807. The density of per cultivated square mile is low in Iran, Turkey, U.S.A, 112, and 3 acres of cultivated land per capita. Argentine and Canada have 4.2 and 6 acres of cultivated land per person with 150 and 100 persons for a square mile. India has 0.9 acres of cultivated land per head.

In the light of maps showing the grazing land, land use, the % of cultivated area, Irrigation, the forests, rainfall, and the cities and towns in West Pakistan, (Fig. 71) the following conclusions may be drawn. (Figs.56A+B,55,49,A+B, 28, and 21b). The grazing land increases with the decrease in the percentage of forested area to total geographical area; decrease in rainfall, and irrigation intensity and finally, the decrease in the concentration of cities and towns. The cities and towns traditionally and now tend to grow where ever the water is in plenty. Not only this, large cities, with populations of over 100,000 people, could only flourish on the banks of the Indus, Jhelum, Chenab and Ravi on the alluvial soil in the absence of other resource basis. Thus, the factor of over riding importance is the presence of water, with the use of which the wasted fertility of the land has been put into profitable uses. The population here is sedentary.

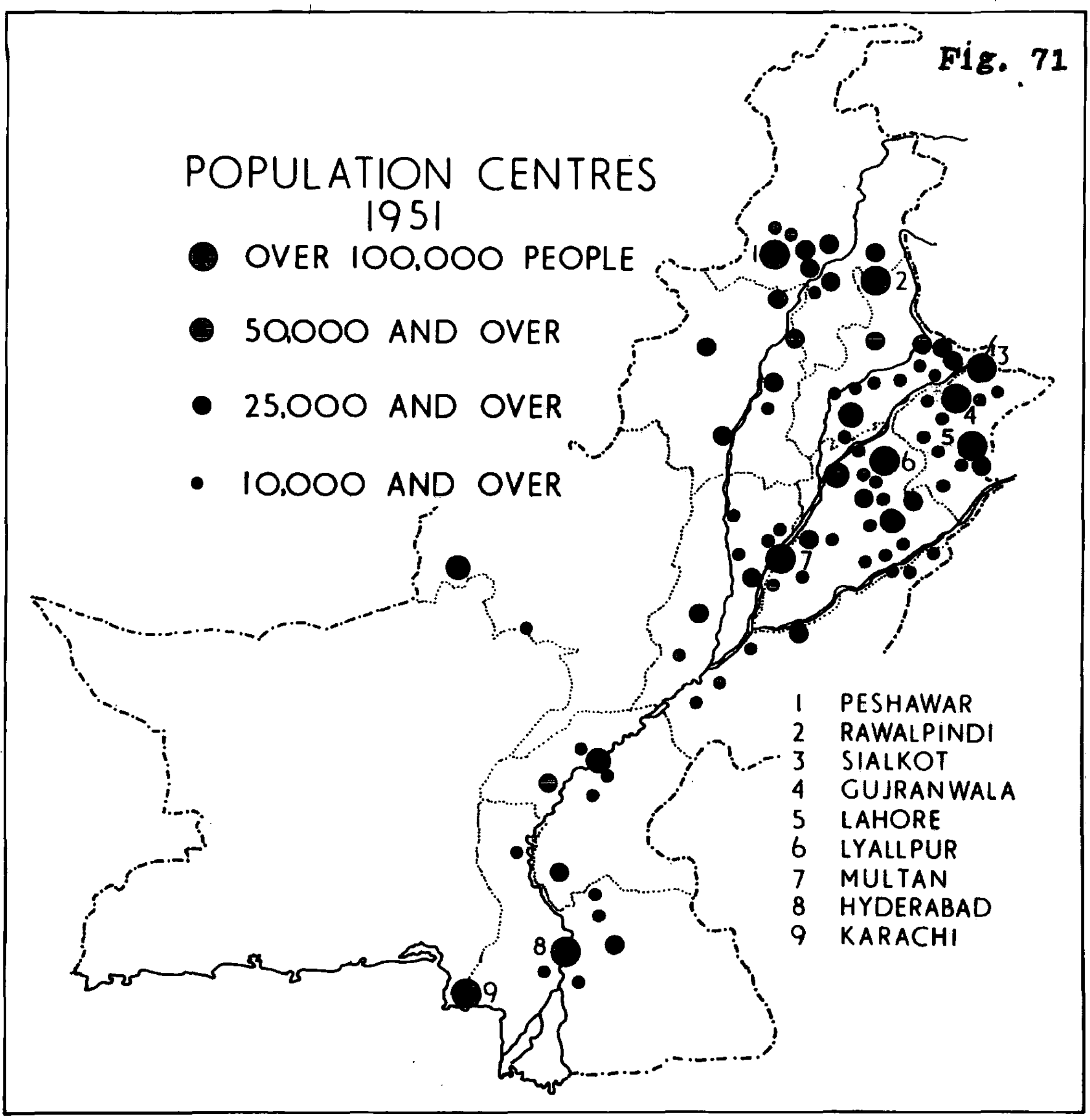


Fig. 71
POPULATION CENTRES
1951
OVER 100,000 PEOPLE
50,000 AND OVER
25,000 AND OVER
10,000 AND OVER
1 PESHAWAR
2 RAWALPINDI
3 SIALKOT
4 GUJRANWALA
5 LAHORE
6 LYALLPUR
7 MULTAN
8 HYDERABAD
9 KARACHI

As the distance from the rivers increases the cities are replaced by towns in the lowland. In the highland, Quetta is the only worth mentioning city which commands a nodal situation. The factors allowing for the development of Quetta as a route focus are the presence of underground water as well as the streams, the occurrence of fertile soil and protected position from the N. western cold winds. The map further reveals, how, the number of towns tend to grow around the major cities, which have good access to the rivers, as for instance Multan, which has developed many satellite towns on its periphery, and secondary towns on the fringe of the periphery. In case of Peshawar, towns have grown on its northern peripheral side because of an abundance of surface water.

In the Region of Kalat, there is not a single settlement with a population of over 10,000 people. The common unit of the settlement is both of scattered and clustered villages in the vicinity of water. The same may be applied to all the blank spaces in Fig. 17, as in the States of Chitral, Swat and Dir, the tribal areas, the Zhob Loxa basin, the Sibi territory, the parts of Cholistan, the Tharparkar. The causative factors for the clustered and the scattered pattern have been summed up thus: "The scattered manner of grouping suits localities where as a result of the dissection of relief, soil, and hydrography, the arable land is itself divided up. The clustered village is indigenous, on the other hand, in districts where the arable area is continuous admitting of uniform and extensive exploitation".(17)

Settlement in the pasture lands:-

The pastoral areas receive too meagre rainfall to carry on the cultivation of agronomic crops. Where ever irrigation facilities are extended cultivation takes a step forward, but otherwise arable farming is uneconomic. Such land can best be made forage producing ground for a substantial livestock farming. These range areas have been so much over-grazed that plant associations have been selectively ruined, the better forages dying out.

The carrying capacity of the land is reduced while grazing pressure increases. Consequently live-weight is very much reduced and inferior qualities of animals are produced, susceptible to disease and death.

Pasture lands are used by the local settled pastoral communities and the mobile communities as Powindhas (Afghan nomads) who move into Pakistan during winter with the livestock as goats, sheep and camel. It is estimated, that the transhumant Afghan nomads bring with them nearly 2.1 million animals each year, and they reach even to the Sindsagar Doab.(18) The pastoral grounds of the whole

Kalat, Quetta, Dera Ismail Khan have been primarily deteriorated by these Powindhas. Plate 41 a and b.

The other reason for the deterioration of ranges, is the absence of any programme to co-ordinating the ranges with other development programmes.

Fig. 56B, shows clearly the various zones of pasture land and the land carrying capacity increases with the march of annual rainfall, the grazing capacity can thus be measured approximately. The grazing capacity is zero in the regions of below 5" rainfall, except in crop stubble in irrigated tracts and natural vegetation in inundated areas.(19) The areas falling below this standard are Makran, Kharan, Chagai, Sibi, Khairpur, Sukkur, Daddu and Larkana. The zone with an annual rainfall of between 5" and 9" has a stock carrying capacity of some 120 acres per animal units per year. The intensity of present grazing is very high as compared to rainfall, which is very sporadic in its incidence and natural vegetation is non-continuous and impermanent. The belt of rainfall of 10-14", has a grazing capacity of 60 acres per animal unit in a year. The carrying capacity of the areas with an annual rainfall between 15"-19", is 40 acres for one animal unit for a year. 30 acres per animal unit is estimated for the region 20-24" rainfall.

This shows that the pressure of animals and grazing intensity increases with the amount of rainfall, the land animal ratio becoming as delicate as the man land ratio.

The Indus lowland is a region of sporadically high intensity of varied economic activities, like arable farming, livestock production and industries on which are finally based the population concentrations. In the whole of West Pakistan, population is centred in the 15 districts which are favoured with the supply of surface flow, easy terrain and river borne alluvium. These are the factors which ultimately affect the pattern of settlement types.

The paucity of water and the dearth of suitable land for cultivation, has given rise to the isolated hamleted type of settlements in the highland region, and also in the region which lies on the margin of rainfed and irrigated areas. The settlements are fully related to the type of economy and historical events, but natural environmental factors have proved effective determinants in the evolution of these. Under the most adverse natural conditions the economy is compelled to be pastoral involving transhumance. Some of the dwellings are only seasonal and they coexist with the isolated sedentary rural units. These settlements are generally hamleted types, and restricted to water points and rich soils, capable of growth only at focal points on the historic highways. In the Upper Indus Plain canal colonies settlements are nucleated and are of large size, causative factors being the availability of canal water, fertile soil and population concentration owing to general aridity. Such settlement pattern and types reflect regional variations in the man:land ratio, ability of the former and the potential of the latter being both variables. In this chapter the candidate has briefly sketched the main observable landscape characteristics of settlement form in the major regions. Other social and economic analysis are possible but from this basically simple descriptive differentiation,we can see most clearly the direct consequences of aridity in the cultural landscape.

With a knowledge of the climatic elements and the mountain-lowland relationships in West Pakistan,it is readily visible why the early cultures were established at specific points. The later cultures with houses, farms, and industries for the most part developed near the mouths of the valleys at the base of the highlands. These locations were preferred primarily,because of the availability of fertile soils.and favourable temperatures,and in part, because the adjacent mountains provided sources of plentiful timber for their dwellings, forage for their flocks and herds and above all the perennial water,that was necessary for sustaining life throughout dry summer months in the valleys below.

Later engineering developments were introduced in the form of river diversion barrages, and elaborated canal systems, and these alone made it possible to extend the settlement further out, into the major valley lowlands and plains away from the most easily used and least dangerous small stream basins.

The maps Figs. 23, 43, 71, strikingly illustrate how the available water in the first place, and secondly the soil determines the pattern of settlement. The population is most congested, where the mountain waters meet the soils of the valley. Again, water, soil capability and temperature restrict the number of people, that a given area can support, and the location of the rural settlements has rather rigidly been determined. The centralisation of cities, and towns plainly mark the course of Indus and the foothill zone. This effect of availability of water is most clearly illustrated in the Upper Indus Plain.

In the recent past, the limit between aridity and water-availability, was a line separating uninhabited waste and regions in which, apart from a few centres where historical momentum maintained a special life, primary settlement, had a relatively simple and direct relationship to the facts of physical environment. This division has not been eradicated but instead has been replaced by a new one, still geographically based and still ultimately an indicator of aridity.

Previously uninhabited areas are now populated, because of technical advance, social and political security and the availability of capital. These have not abolished the facts of aridity but made possible new human adjustments to it. The boundary line between the old settlements and new, an observable physical differentiation, is in fact virtually, the boundary between climatic-edaphic semi-aridity and aridity.

Conclusion

As noted in the Introduction, the purpose of this thesis has been not to pursue one detailed line of investigation, but rather to produce for the first time an integrated study of aridity, its climatic and non-climatic implications and consequences. The range of these is so great that considerable selection has had to be made. The whole of West Pakistan is strongly affected by the interaction of elements such as climate, soil and cultures. Over-riding all is aridity in its manifold aspects. The delicate nature of the balance now existing between man and the natural elements, which this thesis illustrates, is not yet completely appreciated in Pakistan.

Pakistan is one of the undeveloped countries of the world, with the majority of its population engaged in the primary industry of agriculture. Living standards are low and poor material resources not fully or properly used. This is a consequence of a combination of natural, economic, political and traditional forces. The strength of these various forces as we have seen varies from region to region and has changed with time. Therefore general formulas cannot be applied except only in the case of perpetual need to consider the direct and indirect consequences of aridity. Of greatest immediate importance is the balance between population and water and land resources. The present position is as follows:

West Pakistan

Total Area 1956/57	197,924,000 Acres(1)
Total Population provisional results of 1961 Census	42,968,000 persons(2)
Total Cultivated area 1956/57	38,940,000 Acres(1)
Total staple food production, (Rice, Wheat, Barley, Maize, Bajra, Jowar, Gram, 1958/59	5,993,982 tons
Total available water (1960 estimates)	195.5 m.acre feet(3)
Area per person	4.6 acres
Cultivated area per capita	0.9 acres
Staple food production per capita	c.0.1 tons
Water available per capita	4.55 Acre feet

In the course of the present work, it has been made clear, that man does not move out of climate but merely changes the points of contact with it. The climatic factors hold a key position in each region. Some general points can be made here. Extreme climates with high temperature, low and extremely capricious rainfall is far from being physiologically healthy. Under such extreme climatic conditions human efficiency is reduced, particularly the efficiency of the outdoor labour of the peasant population. These extreme climatic conditions are favourable to organisms producing many infectious diseases which are transmitted by epidemics in summer, particularly in the densely peopled Indus lowland.

Indus lowland:-

The cold season in this lowland is a short period when the epidemics are dormant but otherwise diseases are always active. Thus the climate affects directly individual physiology with a cumulative affect on the community - both micro and macrocosmic effect. The highland people are not directly adversely affected by the climate, but their work inefficiency is owing to isolation and poor subsistance living.

It was first established by Huntington(4) and followed by Taylor(5) that climate and civilization go with hand in hand. Taylor has shown that every organism flourishes under an optimum climate and excessiveness and deficit in any climatic factor can be injurious to that organism. He also proved that though human beings can live under extreme climatic conditions, but extreme conditions are disadvantageous as compared to optimum conditions.

There is no doubt that there are certain optimum conditions in climate and diet which produce the most vigorous societies. This has been shown by Huntington in his correlation of human energy and climate. He considered the ideal climate with the standard of c.64°F temperature both diurnal and nocturnal, with a relative humidity 80%. The mid day temperature as 70°F and relative humidity 60%. He stressed that an optimum climate should have minimum temperature always remaining above 38°F and maximum temperature around 65°F. Huntington recognised optimum climate as one where the range in temperature is insignificant. In West Pakistan diurnal and periodic ranges are very high, and it is far away from an ideal climate.

In the same context, Taylor introduced a theory of 'comfort' and 'discomfort' zones. He considered an ideal climate is one, in which the wet bulb temperature is 44°F to 55°F and humidity is between 70-80%. On the consideration of these experts' findings our climate is evidently far from their standard of uniformity and human comfort. These conditions may be related to Lahore by considering the mean wet bulb temperature, and Figs. 16 and 17 for Lahore:

		°F
January	M	41.8
	E	52.2
February	M	46.5
	E	56.5
March	M	54.4
	E	59.7
April	M	61.5
	E	65.7
May	M	68.1
	E	72.8
June	M	74.7
	E	77.7
July	M	78.6
	E	80.7
August	M	78.1
	E	80.1
September	M	73.5
	E	76.4
October	M	62.4
	E	69.4
November	M	50.6
	E	61.9
December	M	42.7
	E	55.4

According to the scale of climatic optimum suggested by Taylor, the optimum conditions of temperature are available only in January-February and November-December, and his condition of optimum humidity is available in December-

February and then in July-September, the later period is a term of excessive humidity and heat which leads to unbearable conditions. Huntington's climatic optimum is non-existent at Lahore, though the minimum temperature always remains above 38°F but maximum is never less than 68°F. No uniformity is seen throughout the year. In this context research is invited to find out how many hours of outdoor work is done efficiently in summer and winter in Pakistan. This problem of climatic optimum conditions is far from solved, but even remembering other factors such as diet etc. Pakistan's relative physiological unattractiveness is clear.

Aside from the subsistence level of the peasantry and low human efficiency several other factors impede the human progress. The low productivity of crops, low quantity of food, means under-nourishment. Poor transportation and lack of market facilities, non-existence of fixed prices and good commercial pattern, traditions coupled with illiteracy of the common people intensify this problem. Many conditions have created the present precarious and dismal situation in a vicious circle of shortage of water ⟶ soil deterioration ⟶ low yields ⟶ poor diet ⟶ poor farming. The task before Pakistan is to eliminate and break this vicious circle. To achieve this purpose multi-frontal action should be embarked upon. It becomes imperative in this unevenly advancing world to find out solutions for the problems of the underdeveloped areas, as total information is still inadequate.

We now see how the environments have affected the whole human and agricultural complex. In our study it is shown how the land of young mountains, steep, barren slopes, almost devoid of plant cover; gets downpours of many inches in a day, erosion and floods sweep the fields. There is only slow natural supply of humus to the soil. The soil is chiefly composed of mineral matter and is readily eroded. This erosion process is a macrocosmic phenomena in the sub montane region where soil cover has not been permitted to form. In the low lying areas fertility of soil of deposited material, is lowered by salinity and waterlogging, with such a speed that reclamation is not keeping pace with the deterioration. The chemical changes making the soil utterly sterile, occur under low rainfall conditions with little leaching. The solution is to leach the salts artificially with the application of non-meteoric water, but there is no really adequate water supply. Soils lacking humus are mostly sandy, and offer problems for irrigation. The sandy soils require much water in the beginning of reclamation, but in spite of absorption, because of the large size of particles and high temperatures, much water is lost to evaporation. This pressure on water results in low yield and low irrigated acreage. The limiting factor is severely water, not the soil, and yield of crops might well be measured in terms of units of water.

The primary source of water in Pakistan is the surface flow of her rivers. The rivers as they leave their feeding grounds embouch on to a low dry land where much of their volume is currently lost by evaporation, seepage and irrigation diversion. The Himalayas supply both water and the deep accumulation of silt and alluvium. The south west highland is a source region of several drainage systems but the drainage is ill-defined owing to the general desiccation of the region.

Though water is a renewed resource but its volume distribution is very precarious and poor as noted in the account of hydrography. The river regimes are stamped by dry and wet climatic phases. Early spring snow melt and summer rains bring floods. Volume sinks in the dry phases, the fluctuations being marked. The highest discharges accompany monsoon rainfall while moderate discharges are associated with snow melt, winter rains giving regional minor increases, there is always a plenty of river water between July-September. The difficult periods are pre-spring snow melt and October to November. River regime in the west and south west highlands is affected solely by seasonal rainfall, and the fact, that the geological constitution of this part is predominantly of limestone, where water accumulates in fissures and caves and often appears in perennial as well as seasonal springs.

The perennial supply of water in the big rivers in spite of varying volume led to the opening of virgin waste-lands. In the late nineteenth century an obscure region became a leading grain and commercial crop producing area, with the application of irrigation water. Socially, it resulted in the increase of population and expansion of settlements. A new society was planted which depended on the new irrigation supplies.

The pattern of production in general, and more particularly, in the highland is basically self-sufficiency not commercial. The intensification of resource use implied by the development of the largest single irrigated expanse in the world, was the result of technical work by a non-indigenous group, ultimately for the benefit of a numerically increasing but technically slowly developing peasantry. Advanced ideas made more land available for traditional husbandry.

Pakistan relies on the primary agricultural produce both for cash and subsistence, the part played by industries remaining small. In view of the present low returns from the land, the inadequacy of the financial means of the cultivators and of the resources of the nation, the high cost of developing land and farming, economic "take off" is difficult. The intensification of yields of existing crops by use of better seeds, transport, marketing and improved social conditions are highly desired. This must be done in the light of increasing but inadequate knowledge of the manifold consequences of aridity.

In her second 5 year Plan Pakistan aims to attain self-sufficiency in the production of food and improve the dietary standard of her people, and chief priority is given to agriculture.(6) The measures to be taken will be bringing 1½ million acres of virgin land under cultivation with a supply of irrigation water and drainage. The provisions for increasing the use of organic manure and synthetic fertilisers are also made, along with measures for plant protection. It is anticipated, with such measures an increase of 21% in food grain could be achieved. Such schemes will implement to food situation and to elevate the standard of subsistence. Along with these steps, it will be necessary to link up the backward areas, with the relatively developed lowland, in order to utilise all those resources which are unevenly distributed and unevenly exploited.

The cultural landscape of the highlands excluding the extreme North East reflects, still a simple adaptation of society to arid and semi-arid mountain conditions. Here hamlet dwelling, subsistence cultivators and nomadic pastoralists have limited their own lives so as to survive. Still also in the unirrigated lowlands although to a smaller extent than even eighty years ago, subsistence village life shows direct control by the simplest environmental elements. Where water and soil are present there is life; otherwise not. Sedentary irrigation settlement, even if predominantly of peasant character produces a third different cultural landscape. The carrying capacity of the land is now increased by the human ability to use more intensively than in the other cases the same physical resources. In time and in space these differences appear and have been noted in this thesis. The present emphasis on development results from the need to extend the last stage in order to support a population growing by natural increase and refugee influx.

All this must be referred to in terms of the problem of aridity, and it is in this whole context, both the physical and cultural aspects of West Pakistan have been treated. It is seen that the cultural interlude has been rooted in a physical frame work, which has not been much changed materially since pre-history. Rivers have shift[ed] their courses but the basic pattern is the same. The snows have retreated and flow has probably diminished, thus leading to the decrease in the natural moisture lev[el] of the soil, in addition to this, floods have renewed and destroyed the soil cover. These are the apparent changes which have taken place since 5,000 B.C. There [is] little evidence for climatic desiccation on a large scale during this period. A diminished water supply does not necessarily imply the decrease in rainfall. Early cultu[res] show that even then the torrential rains did not supply enough water without the construction of dams and reserv[oirs]. All the devices of water conservation such as gabarbands aqueducts are evident in the remains of early cultures.

The complexity of present aridity received much varied attention but this has produced few conclusive results. What is clear is that at all levels of action, primitive and advanced, man's appraisal of the land has resulted in disturbances of equilibria. The force of climatic aridity in this region is so strong, any attempt to escape the consequences of aridity in one direction leads to collision with other factors, equally influenced by dominant climate. Irrigation, for example, may star[t] by meaning a simple artificial application of water to d[ry] land but ends in the complexities of watershed managemen[t] flood control, the avoidance of waterlogging and salinity and many others. As implied in the title of the thesis, aridity is finally a subject for geographical not only climatic study.

References

Chapter 1

1. Ahmad, K.S. "A Political-Regional Plan". Pak. Geogr. Rev. Vol. IV No. 2. pp. 18-25. 1949.
He proposed for the amalgamation of provinces into "one unit", which attained recognition and the present west and East units of Pakistan are an outcome of his scheme.

2. Baker, J.N.L. "Notes on the Natural Regions of India". Geography Vol xiv, pp. 447-55, 1928.

Stamp, L.D. Ibid. pp. 502-6.

Ahmad, K.S. "Physiographic Divisions of India". Ind. Geogr. Journ. Vol. VI 1941. pp. 257-67.

Pithawalla, M.B. "The need of Uniformity in the Physiographic Divisions of India". Journ. of Madras Geogr. Asso. vol. xiv pp. 213-28, 1939.

Spate, O.H.K. India and Pakistan, pp. 351-60, 1957.

3. Thornbury, D.M. Principles of Geomorphology pp. 34-35, 1958.

4. Wadia, D.N. Geology of India, p. 417, 1957.

5. Davis, W.M. Geographical Essays, p. 249 Dover Ed. 1954.

6. Pascoe, H.E. Manual of the Geology of India and Burma, Vol. 1, 3rd Ed. p. 7, 1950.

7. Wadia, D.N. Op. cit. p. 430.

8. Pascoe, H.E Op. cit. p. 7.

9. Krishnan, M.S. Geology of India and Burma. p. 170, 1949.

10. Oldham, R.D. Manual of geology of India. pp. 4 2 7-48, 1893.

Geogr. Journ. Vol. 51 pp. 176-182, 1918.

Mem. Geol. Sur. Vol. XLII, pp. 1-153, 1917.

11. Wadia, D.N. Op. cit. p. 389.

12. Thornbury Op. cit. p. 25.

13. Rec. Geol. Sur. India, Vol. 43, Pt. 3. pp. 229-36, 1913.

14. The Times, London, p. 5, 11th July 1959.

15. Imperial Gaz. Ind. Vol. XIX, p. 140, 1908.

and Wadia Op. Cit. p. 10.

and Pascoe Op. cit. pp. 17-18.

16. Imp. GAZ. Ind. Vol. XII, p. 75, 1908.

17. Geogr. Journ. Vol. V, p. 411, 1895.

18. Geogr. Journ. Vol. 40, p. 46-1912.

19. Imp. GAZ, Ind. Vol. XIX , p. 140, 1908.

Imp. GAZ, Ind. Vol. XXI, p. 349, 1908.

Geographical Journ. Vol. XVII, p. 464, 1901.

20. Proc. Geogr. Soc. Vol. I, pp. 38, 41-42, 1879.

21. Proc. Geogr. Soc. Vol. IV, p. 539, 1882.

22. Imp. GAZ. Ind. Vol. XXIV, pp. 379-81, 1908.

23. Wadia, D.N., Op. Cit. p. 430.

24. Imp. GAZ. Ind. Vol. VI, p. 266, 1908.

25. Mem. Geol. Sur. Ind. Vol. XXXI, Pt. 2, pp. 185-188.

Mem. Geol. Sur. Ind. Vol. XVII, Pt. 1, pp. 20-135, 1879.

26. Census of Ind. Vol. IV, Pt. 1, pp. 9-10, 1911.

27. Geogr. Journ. Vol. VII, p. 394, 1896.

28. Imp. GAZ. Ind. Vol. VIV, p. 299, 1908.

29. Imp. GAZ. Ind. Vol. VI, p. 268.

30. Geogr. Journ. Vol. IX, p. 405, 1897.

31. Mem. Geol. Sur. Ind. Vol. XVII, Pt. 1, pp. 274-76, 1881.

32. Geography, Vol. XIV, p. 502.

33. Imp. GAZ. Ind. Vol. XX, p. 112, 1908.

34. Imp. GAZ. Ind. Vol. XIX, p. 139.

For Potwar

35. Rec. Geol. Sur. Ind. Vol. XLIX, p. 140, 1918.

Mem. Geol. Sur. Ind. Vol. 55, pp. 63-100, 1930-33.

Mem. Geol. Sur. Ind. Vol. LI, Pt. 2, pp. 209-10, 334-65.

36. Wadia, D.N. Op. cit. p. 438.

37. De Terra, H. and Paterson, T.T. Studies on the Ice Age in India, p. 256, 1939.

38. Pakistan News, London, p. 2, 15th November, 1959.

39. Mem. Geol. Sur. Ind. Vol. LI, Pt. 21, Op. cit. pp. 209, 345.

40. See Chapter 4 Hydrography, and 7 The Early Cultures.

For Salt Range

41. Wadia, D.N. Op. cit p.431, 1957.

Pascoe, H.E. Op. cit. p. 17, 1950.

Imperial GAZetteer India, Vol. XXI, pp. 412-13, 1908.

Punjab Geogr. Rev. Vol. II, pp. 27-28, 1947.

Imp. GAZ. Ind. Vol. XIV, p. 150.

<u>Salt Range Lakes</u>

42. Journ. Asiat. Soc. Beg. Vol. <u>XXII</u>, pp. 239-452, 1853.

Ibid. Vol. <u>XXIII</u>, pp.651-677, 1854.

Mem. Geol. Sur. Ind. Vol. <u>XIV</u>, pp. 46-62, 1874.

Rec. Geol. Sur. Ind. Vol. <u>XL</u>, Pt. 1, pp. 36-51, 1910.

Wadia, D.N. Ibid. p. 439.

43. Spate, O.H.K. Op. cit. p. 464.

44. Rec. Geol. Sur. Ind. Vol. 72, p. 443-1937.

Journ. Roy. Geogr. Soc. Vol. <u>XLII</u>, p. 394, 1872.

Oldham, R.D. Manual of Geolog. of India, pp. 436-42.

<u>For Thal</u>

45. Rec. Geol. Sur. Ind. Vol. 72, p. 443, 1937

Imp. GAZ, Ind. Vol. <u>XXVII</u>, pp. 285-86.

Handbook of the Thal Development Authority, pp. 1-10, 1954.

Murphy, P. and Henry, N.O.H. <u>The Agricultural Geography of the Thal Desert</u>. pp. 1-4, 1957.

46. Imp. GAZ. Ind. Vol. <u>XI</u>, pp. 248-259,

Punj. Geogr. Rev. Vol. <u>II</u>, pp. 38-40, 1947.

Mem. Geol. Sur. Ind. Vol. XVII, Pt. 2, p. 13, 1880.

Oldham, R.D. Manual of Geology of India, pp. 447-60.

47. Stamp, L.D. Asia. p. 286, 1957.

Pithawala, M.B. Geogr. Analysis of Lower Indus Basin Sind. Pt. II, pp. 283-316, 1936.

Proc. Geogr. Soc. Vol. II, p. 530, 1880.

48. Mem. Geol. Sur. India, Vol. 47, Pt. 2, pp. 1-9, 1923.

Imp. GAZ. Ind. Vol. XXII, pp. 389-94.

Rec. Geol. Sur. Ind. Pt. 2, Vol. XXXVIII, pp. 154-68, 1902.

Bull. Nat. Inst. Sci. India, p. 6, September, 1952.

49. Imp. GAZ. India, Vol. VI, p. 195.

Geogr. Journ. Vol. XLII, p. 393, 1872.

50. Oldham, R.D. Manual of Geology of India, p. 455, 1893.

Geographical Journal, Vol. IX, pp. 305-8, 1897.

Mem. Geol. Sur. Ind. Vol. XXXIV, Pt. 3, pp. 1-133, 1903.

51. Imp. GAZ. Ind. Vol. XXII, p. 390.

52. Imp. GAZ. Ind. Vol. XXII, pp. 389-92.

53. Pithawalla, M.B. Op. cit. 1936, pp. 305-6.

54. Wadia, D.N. Op. cit. pp. 36-40.

Geographical Journal, Vol. 103, p. 180, 1944.

Chapter 2

1. Mem. Geol. Sur. Ind. Vol. XIV, 1874

Bull. Nat. Inst. Sci. Ind. Sept. pp. 3-7, 1952.

Mem. Geog. Sur. Ind. Vol. XVII, Pt. 2, pp. 11-15, 1880.

2. Krishnan, M.S. Geology of India, p. 68.

3. Wadia, D.N. Geology of India, p. 64.

4. Ibid., p. 153.

5. Thornbury, D.M. Principles of Geomorphology, p. 25, 1958.

6. Wadia. Op. cit. pp. 204-10.

Mem. Geol. Sur. Ind. Vol. XVII, Pt. 1, pp. 22-131, 1879.

7. Rec. Geol. Sur. India, Vol. XXXVIII, Pt. 3, 1910.

8. Wadia. Op. cit. pp. 260-61.

9. Proc. 6th pacific, Sci, Cong. pp. 483-500, 1939.

10. Thornbury, D.M. Op. cit.

11. Rec. Geol. Sur. India, Vol. LXI, pp. 327-34, 1928-29.

12. Oldham, R.D. Manual of Geology, pp. 436-50.

Wadia, D.N. p. 396.

13. Thornbury, D.M. Op. cit. p. 283.

Cotton, C.A. Geomorphology, p. 260, 1945.

Cotton, C.A. Climatic accidents in landscape ~~x~~ Making, pp. 3-10, 1942.

Desert Evolution

14. Wadia, D.N. Op. cit. pp. 4-5, 52-53.

15. Mem. Geol. Sur. Ind. Vol. 35, Pt. 1, pp. 9, 13-14, 37, 115, 1902.

16. Imp. GAZ. Vol. I, p. 30.

Journ. Roy. Geogr. Soc. Vol. 47, p. 391-92, 1872.

17. Institute of Biology, London, p. 7, 1954. Biology of Deserts.

18. Mem. Geol. Sur. India, Vol. 51, p. 289, 1926-28.

Reviews of Research on Arid Zone Hydrology, pp. 230-51, 1953.

19. Tolman, C.F. Ground Water. pp. 13,23,36-38,61-65, 1937.

20. Dixey, F. "Some Recent Studies in Ground Water Problems ". Colonial Geological and Mineral Resources. Vol. 4, No. 2, pp. 121-48, 1953-54.

Ibid, A Practical Handbook of Water Supply, pp. 143-50, 1931.

Auden, J.B. Suggestions for Future Studies on Ground Water in India, Microfilm obtained from National Physical Laboratory, New Delhi.

Chapter 3

Climate

1. Kendrew, W.G. Climates of the Continents, pp. 112-114 1937.

2. Imp. GAZ. Ind. Vol. VI, p. 273.

3. Strategic Aerologic Surveys, No. 222. "Coasts of the Persian Gulf and the Gulf of Aman". Climate No. 25.

For Western Depressions

4. Blanford, H.F. Mem. Ind. Met. Dept. Vol. 3, pp.83-93.

Ibid. A practical guide to the climate and weather of India, 1889.

Eliot Sir John Mem. Ind. Met. Dept. Vol. 4, Pts. 8 and 12, pp. 529-973, 1886-93.

Imp. GAZ. Ind. Vol. I, p. 109.

Walker Sir G. T. Mem. Ind. Met. Dept. Vol. 21, pp. 1-3, 1910-16.

Ind. Met. Dept. Technical Note No. 25, 1947.

Mem. Ind. Met. Dept. 1931.

Mem. Ind. Met. Dept. Vol. 21, Pt. 7, pp. 4-12, 1910.

Ind. Journ. Met and Geophysics, Vol. 7, No. 1, pp. 333-34, 1956.

Imp. GAZ. Ind. Vol. XIX, p. 147.

Imp. GAZ. Ind. Vol. VI, p. 273.

Imp. GAZ. Ind. XIX, p. 257.

5. Miller, A.A. Climatology, p. 142, 1957.

Imp. Journ. Experi. Agri. Vol. XIV, No. 54, p. 87, 1946.

For Monsoons

6. Quart. Journ. Roy. Met. Soc. Vol. 47, p. 152,

Ibid, Vol. 73, Nos. 317, 318, pp. 101-104, 1947.

Ibid, Vol. 79, No. 342, pp. 464-73, 1953.

Mem. Ind. Met. Dept. Vol. 24, Pt. 8, pp. 249-73, 1922-25.

Ibid. Vol. 26, Pt. 2, pp. 1-36, 1933.

Ind. Met. Dept. Scientific Notes, Vol. 3, No. 21, pp. 21-27, 1930.

7. Naqvi, S.N. "The pulsating Monsoon in South East Asia". Pakistan, Sci. Conf. 1959.

8. Kendrew, W.G. Op. cit. pp. 132-33.

9. Quart. Journ. Roy. Met. Soc. Vol. 77, pp. 589-90, 1951.

10. Ibid.

11. Auden, J.B. Report on the Ground Water Conditions in the Quetta Basin. June 1946, Microfilm obtained from National Physical Laboratory, New Delhi.

12. Blanford, H.F. The Climates and Weather of India, Ceylon and Burmah, 1889.

13. Pithawalla, M.B. and Shamshad, M.K. "The Climate of Karachi and how to live in it". 1953.

14. Miller, A.A. Op. cit. p. 17.

15. Ibid. p. 153.

16. Quart. Journ. Roy. Met. Soc. Vol. 57, p. 43, 1931.

17. Ind. Journ. Met. and Geophy. Vol. 14, No. 4, p. 91, 1953.

18.-19. Imp. GAZ. Ind. Vol. I, pp. 146, 149.

20. Miller, A.A. Op. cit.

21. Geography, Vol. 28, pp. 114-15, 1943.

22. Amr. Geogr. Rev. Vol. 35, pp. 599-600, 1945.

23. Pollak, L.W. Methods of Climatology, p. 272, 1950.

24. Mem. Ind. Met. Dept. Vol. III, pp. 17, 70, 71, 192, 240, 1880.

25. Imp. GAZ. Ind. Vol. I, pp. 126-46.

26. Quart. Journ. Roy. Met. Soc. Vol. 57, pp. 43-58, 1931.

27. Geography, Vol. 16, pp.98-108, 1931.

28. Ibid. Vol. 17, pp. 286-92, 1932.

29. Ibid. Vol. 18, pp. 132-34, 1933.

Ind. Met. Dept. Scientific Notes, Vol. VII, Nos. 76-77, 1938.

30. Ibid. Vol. V, No. 15, pp. 49-52, 1932.

31. Mem. Ind. Met. Dept. Vol. XXVII, Pt. III, pp. 121-22.

32. Naqvi, S.N., "Periodic Variations in Water Balance in an Arid Region". Unesco Paper, pp. 2-9, Canberra, 1956.

33. Ind. Journ. Met. and Geophysic, Vol. 3, pp. 1-9, 1952.

Ibid. Vol. 10, No. 1, pp. 47-56, 1959.

34. Geography, Vol. 18, p. 136, 1933.

35. White, F.G. Editor Future of Arid Lands, p. 88, 1956.

36. Unesco News letter on Major Projects on Scientific Research No. 4, p. 8, June 1959.

37. White, F.G. Op. cit. p. 3, 1956.

38. Quart. Journ. Roy. Met. Soc. Vol. 57, p. 53, 1931.

39. Auden, J.B. Op. cit. p. 12.

40. Naqvi, S.N. Op. cit, 1956.

41. Amr. Geogr. Rev., Vol. 17, pp. 405-9, 1927.

42. Ibid., Vol. 38, pp. 55-94, 1948.

43. Studia Societatis Scientiarum Torunensis, Torun-Polonia, Sectio A. Vol. 1, NR. 7, pp. 44-45, 66-67, 1949.

44. Proc. Nat. Inst. Sci. India, Pt. B, No. 3, Vol. 24, pp. 150-56, 1958.

45. Geogr. Journ. Vol. XLIV, p. 172, 1874.

46. The Observer, June 7th, 1959, p. 10 Col. 5.

47. Reviews of Research on Arid Zone Hydrology, p. 204, 1953.

48. White, F.G. Op. cit., p. 5, 1956.

49. Brooks, C.E.P. Climate through the Ages, pp. 24, 235-39, 1949.

Quart. Journ. Roy. Met. Soc. Vol. 57, pp. 13-26, 43, 1931.

50. Flint, R.F. Glacial and Pleistocene Geology, p. 224, 1957.

51. Quoted by Brooks, Op. Cit. p. 276.

52. Wheeler, R.E.M. Five thousand years of Pakistan, p. 12, 1950.

53. Mem. Ind. Met. Dept. Vol. III, pp. 70-72.

Miller, A.A. Op. cit. p. 151.

54. Mem. Geol. Sur. Ind. Vol. XXXI, Pt. 11, pp. 189, 212, 1901.

55. Census of India, Vol. I, p. 454, 1931.

56. "Desiccation in Asia, A Geographical Problem in the light of human history". Hungarian Quart. November, 1939.

57. Geographical Magazine, August, 1935.

58. Geogr. Journ. Vol. 99, No. 4, p. 173, 1942.

59. Journ. Asiatic, Soc. Bombay, Broach. p. 53, 1933.
and pp. 10-38, 1934.

60. Brooks, C.E.P. Op. cit. p. 360, 1949.

61. Trevaskis, H.K. The Land of Five Rivers, pp.10-11, 1928.

62. Biology of Deserts, Op. cit. p. 22.

63. Spate, O.H.K. India and Pakistan, p. 466, 1957.

64. Biology of Deserts, Op. cit. p. 123.

65. Amr. Geogr. Rev. Vol. 38, p. 30, 1948.

66. White, G.F. Op. cit. p. 204.

Clark, A.H. The invasion of New Zealand by people, plants and animals: the South Island, 1949.

67.-68. Biology of Deserts, Op. cit. pp. 125, 156.

69. Survey of Indian Geodetic Report, Vol. VII, 1932.

70. Geographical Journ. November, 1919, pp. 272-73.

71. Quoted by Pithawalla, M.B. "The Great Indian Desert". A Geographical Study, pp. 139-40, 1952.

Antiquity, 1928.

Ibid., 1931.

72. Mem. Ind. Met. Dept. Vol. XXI, Pt. 1, 1910.

73. Brooks, C.E.P. Op. cit. p. 360.

74. Ind. Jour. Met. and Geoph. Poona, 1953, 1954, 1955.

75.- White, F.G. Op. cit. pp. 51, 209-302.
76. Ibid pp. 291-99

77. Johnson, J.C. Physical Meteorology, pp.268-70,1954.

78. Naqvi, S.N. Arid Zone Research Report, pp. 4-7, March 1960.

Chapter 4

1. First 5 Year Plan, Government of Pakistan, p. 355, 56, 1957.

372,700 square miles as in the Imp. GAZ. India, Vol. XIII, p. 357.

373,000 square miles by Pascoe, H.E. Manual of Geology of India and Burma, Vol. I, p. 24, 1950.

2. Pakistan News, London, p. 2, October 1st, 1960.

3. Graaff de Van M.R.H. Unpublished Report, "Salinity Problem in West Pakistan, pp. 11, 31-32, 34, 36-37, 40, 70-74-80, 1959.

4. Gorrie, R.M. Soil and Water Conservation in the Punjab, pp. 190, 210, 184, 1946.

5. Burrard, S.G. and Hayden, H.H. A sketch of the Geography and Geology of the Himalayan Mountains and Tibet. Pt. III, pp. 131-32, 173, 192-194, 1908.

6. Imp. GAZ. Ind. Vol. I, pp. 23-29.

7. Chambers' World Gazetteer and Geographical Dictionary, p. 481, 1954.

8. Daily Pakistan Times, Lahore, p. 7, March 3rd, 1959.

9. Topographic Sheets, 1:1,000,000.

10. Pakistan Journal of Science, Vol. 9, No. 6, pp. 254-55, 57, 1957.

11. Imp. GAZ. Ind. Vol. XIII, pp. 364, 360, 362, 361.

12. Trevaskis, H.K. The Land of Five Rivers, pp. 9,

13. Pithawalla, M.B. The Lower Indus Basin, Pt. 1, p. 325, 1936.

14. Imp. GAZ. Ind. VIV, pp. 160-61.

15. Daily Pakistan Times, Lahore, p. 1, 6th July, 1959.

Ibid., P. 6, 8th July, 1959.

16. Oldham, R.D. Manual of Geology of India, pp. 444, 1893.

17. Quart. Journ. Geol. Soc. London, Vol. 75, pp. 138, 149

18. Journ. Asiatic Soc. Bengal, New Series, Vol. XV, pp.81-99, 1919.

19. Proc. 6th Pacific Sci. Cong. Vol. 2, p. 495, 1940.

20. Wadia, D.N. Geology of India, pp. 56-57, 446.

Mem. Geol. Sur. Ind. Vol. XL, Pt. 3, p. 464.

21. Geographical Journal Vol. 99, p. 182, 1942.

22. Spate, O.H.K. India and Pakistan, p. 30- 1957.

23. Trans and papers Inst. British Geograph. pp. 257-59, 1960.

24. Rec. Geol. Sur. Ind. Vol. LXXIV, Part 4, 1939-40.

25. Sain Kanwar "The Role of Glaciers and Snow on Hydrology of the Punjab rivers", Central Board of Irrigation, Publ. No. 36, p. 14, 1946.

Pak. Geogr. Rev. Vol. XIII, No. 1, p. 14, 1958.

26. The Daily Pakistan Times, Lahore, 7th June, 1959.

West Pakistan Year Book, p. 38, 1959.

27. Pakistan Geogr. Rev. Vol. IV, No. 2, pp. 8-10, 1949 for Figs droughts and floods.

Tannehill, I.R. Drought its causes and effects, O.U.P. Lond. 1947.

28. Jacks, C.V. and Whyte, R.O. The rape of the earth, p. 31. Pakistan Journ. of Forestry, January, 1951.

29. Asian Rev. January 1960, pp. 17-18.

30. Pak. Geogr. Rev. XIII, No. 2, pp. 750-88, 1958.

31. Smith, G.H. Conservation of Natural Resources, pp. 269-77, 119, 1958.

32. Khushalani, K.B. Irrigation (Practice and Design), Vol. I-II, pp. 273-77, 1950.

33. Bennett, H.H. Soil Conservation, pp. 313, 335, 378-450, 544-48, 1939.

Rev. Geogr. Inst. Uni. Istanbul, pp. 36-42, Nov. 1954.

Haw, R.C. The conservation of Natural Resource, 1959.

34. Al-Barazi, N.K. "The Geography of Agriculture in irrigated areas of the Middle Euphrates Valley". Vol. I, p. 175, Ph.D. Thesis, 1960, Durham University.

35. Central Board of Irrigation Popular Series Leaflet, No. 7, p. 2, 1951, "Irrigation in India through Ages".

36. The Daily Dawn Karachi Editorial, 15th November, 1958.

37. Ferozsons,Karachi "The Indus Basin Dispute, pp. 8, 1-4, 1959.

Arnold, F.B. Overseas Economic Surveys, May, 1954, pp. 146-49.

38. The Daily Pakistan Times, Lahore, 12th-20th May, 1959.

39. The Hyderabad, Govt. Bull. Econ. Affairs, Vol. VI, p. 101, March-April, 1953.

40. Uni. London, Inst. Common wealth. Studies, Post-Graduates Seminar Com.wealth Relation. "Indo-Pakistan Water dispute". Nov. 1958,

41. The Daily Pakistan Times, September 19th, 1960.

Canal Dispute Supplement, The Daily Times Supplement on Pakistan, February 1961.

42. Pakistan Publications - Irrigation Projects, January 1956, pp.6-10.

ibid., Hydro Electric Projects, January 1956, pp. 1-17.

West Pakistan Water and Power Development Authority 1959.

Irrigation Projects unpublished Report 1960.

Thal Project

43. Daily Pakistan Times Supplement, 14th August 1959.

Lectures on Formulation and Economic Appraisal of Development Projects, Vols. I and II 1951.

White, F.G. The Future of Arid Lands, p. 54-56, 1956.

Handbook of Thal Development Authority, 1954, pp.7-20.

44. Mahbub, S.I. Welcome Address to General Mohammad Ayub Khan. President of Pakistan. On the Opening of the Taunsa Barrage. p. 1. 3rd March, 1959.

45. White F.G. Op.cit. pp. 100, 131, 253.

46. Zuur, A.J. Unpublished Report, pp. 33, 35, 1958, pp. 39, 36-50.

47. Asghar, A.G. "Use of Brackish Water for Irrigation with Special Reference to Saline Soils". The Unesco-Iran Symposium on Salinity Problem. pp. 12-20, 11-15 Oct. 1958.

48. Agricultural Statistics of the Punjab and Sind, 1901-1947.

Board of Economic Engineering Punjab, Lahore, 1950.

Census of Pakistan, Vols, 1,2, 4-6, 1951.

49. Naqvi, S.N. Arid Zone Research Report, p. 3, March 1960.

Waterlogging

50. Asghar, A.G. "Waterlogging and Soils of the Water-logged Area". pp. 2-12, 1949.

51. Ahmad, N, Ali D. and Ahmad A. "A new concept on the waterlogging and Salinity Problems of Rechna Doab". (Symp; Waterlogging and Salinity in West Pakistan, Lahore) pp. 1-22, February 1959.

52. Williams, M.B. FAO, Publ. 52/11/7679, pp. 3-9, 1950.

53. Asghar, A.G. and Ahmad, N. "Drainage of Irrigated Soils in Arid Regions". Proc. Pun. Eng. Lahore Paper, No. 312, Vol. XXXIX, pp. 62-121, 1955.

54. Ahmad, M.M. "A study of Waterlogging and Thur Problems of West Pakistan". pp. 6, 14, 9, 18-25, 7-9, 14, 12, 1958.

55. McLeod, W.N. "A Review of Waterlogging and Salinity in the Punjab". FAO/53/1/122, p. 21. 31st December, 1952.

56. The Bull. Karachi, Geogr. Soc. p. 32, 1949.

57. Asghar, A.G. and Majid, A. "Some Aspects of Irrigation Practices in the Punjab". Research Pub. Vol. II, No. 3, 1955.

58. Proc. Punjab, Eng. Lahore, Pakistan., Vol. XXXIX, No. 311, pp. 1, 9-12, 1955.

59. International Commission on Irrigation and Drainage, R.2, Question 7, pp. 7-25, 1959.

60. FAO, Report to the Government of Pakistan, No. 167, Rome pp. 5-23, September, 1953.

61. Asghar, A.G. Experiments at Moharanwala Experimental Reclamation Farm, Research Pub. Vol. II, No. 2, pp. 1-6.

62. Institute of Biology, London, "Biology of Deserts, p. 14, 148-50, 1954.

63. Young, F.O. FAO Report, No. 158, to the Government of Pakistan, Rome, p. 18, September, 1953.

64. Pithawala, B.M. The Problem of Baluchistan, pp. 63, 65-70, 1952.

65. Rec. Geol. Sur. Pakistan, Vol. III, Pt. 1, pp. 1-41, 60, 65.

66. Unesco News Letter, No. 4, pp. 4-11, June 1959.

First 5 Year Plan, p. 374, 1957.

67. Rec. Geol. Sur. Ind. Vol. XXXVIII, Pt. 3, 1909.

Mem. Geol. Sur. Ind. Vol. XXXI, pp. 187-214, 1901.

68. Hakim, S.A. "Extension of Irrigation Facilities in Quetta". Radio talk, 26th Nov. 1959.

69. FAO/52/5/2992, Report, p. 6, January 1951.

70. Holdich, H.T. India, p. 40, 1904.

Ibid, Indian Borderland, p. 15, 1909.

Rec. Geol. Sur. Pak. Vol. III, Pt. 1, p. 41.

71. Dixey, F. A Practical Handbook of Water Supply, pp. 19-30, 143, 1931.

72. Proc. Punjab Eng. Cong. Vol. 10, pp. 109-25, 1922.

73. Survey of India, Geodetic Report, Bull. Ser. B, No. 1, Pl. 6 1938.

74. Rec. Geol. Sur. Ind. Vol. 72, pp. 440-66, and pp. 232-60, 1939.

75. Mem. Geol. Ind. Vol. 51, pp. 213-20.

Rec. Geol. Sur. Pakistan Vol. V Pt 1, pp. 20-30.

Ibid, Vol. VI, Pt. 1, pp. 20-30.

Ibid, Vol. VII, Pt. pp. 10-15.

76. Auden, J.B. Report on the Ground Water Conditions in the Quetta Basin, June 1946.

Ibid, "Suggestions for Future Studies on Ground Water in India."

77. Tollman, C.F. Ground Water, p. 380, 499-556, 1939.

78. Bowen-Jones, H. and Dewdney, J.C. Agriculture in Malta, 1959.

79. Rec. Geo. Sur. Ind. Vol. 25, Pt. 1, pp. 36-53, 1892.

80. Finch, V.C. and Trewartha, G.M. Elements of Geography, 4th Ed. p. 401, 1957.

81. Rec. Geol. Sur. Ind. Vol. 14, Pt. 3, pp. 205-38, 1881.

82. Rec. Geol. Sur. Ind. Vol. 32, Pt. 1, pp. 1-88, 1904.

83, Geogr. Journ. December 1950.

84. "Report of the Director of Irrigation" Union of South Africa, Pretoria, p. 42, 1947.

85. Clark, J.I. Ed. Modern Aman, Research Series No. 3, 1960, Dept. Geog. Durham.

Geogr. Journ. December, 1950.

86. National Resources Planning Board, "Regional Plains". Parts I-X, 1940.

Chapter 5

1. White, F.G. — The Future of Arid Lands, p. 34, 1956.

2. The Journ. Soil Sci. Vol. 10, No. 1, pp. 15-17, 1959.

3. Rec. Geol. Sur. Ind. Vol. LXVIII, Pt. 4, pp. 365-76, 1935,

   Oldham, R.D. — Manual of Geology of India, pp. 427-58.

4. See Chapter 1, Fig. 3.

5. Lyon, T.L. and Buckman, H.O. — The Nature and Properties of Soils.

   Robinson, G.B. — Soils Their Origin, Constitution, and Classification, pp. 329, 45-48, 52, 62-65, 72-79, 13, 410-18, 347, 102-108, 63, 257-60, 347, 1949.

6. Sigmond, A.L.J. — The Principles of Soil Science, pp. 64, 63, 35, 50, 80-81, 43-46, 335-36, 255,80, 264, 1939.

7. The Journ. Tropical,Geography, Vol. 12, March 1959, p. 82.

8. Data obtained from Ind. Journ. Agri. Sci. Vol. XIV, pp. 336-40.

9. Proc. Roy. Soc. Lond. Series B, Vol.17, pp. 27-28, 1930-31.

10. Journ. Amer. Soc. Agron. Vol. XX, No. 9, pp. 900-12, 1928.

    Soil Sci. Vol. XXVII, No. 3, pp. 170-86, 1929.

11. Robinson, G.B. — Soils, pp. 102-8, 235, 1949.

12. Agro. Journ. Vol. 44, p. 227, 1952.

13. Soil Sci. Vol. 18, p. 234, 1954.

14. Texas Agri. Experi. Station. Mimeographed, 1954.

15. Central Board of Irrigation and Power. Publ. No. 43, Vol. 1, pp. 29, 33-35, 219-77, 10-11, May, 1951.

16. Journ. Agri. Research, Vol. 78, pp. 347-352, 1949.

17. Trans, 4th, International, Cong. Soil Sci. Vol. II, pp. 139, 136-40.

18. Bull. National Inst. Sci. Ind. p. 256-76, September, 1952.

19. Russell, E.J. The World of the Soil. pp. 29, 33, 25, 22-23, 1957.

Shaw, B.T. Ed. Soil, Physical Conditions and Plant Growth, pp. 17-19, 1952.

20. Baver, L.D. Soil Physics, pp. 123-24, 184-88, 164-66, 1956.

2 1. Shaw, B.T. Op. cit. pp. 21-23.

Advances in Agron. Vol. III, pp. 31-45, 1951.

22. Unesco, Arid Zone Research Guide Book, p. 117, 1957.

23. Proc. Punjab Eng. Lahore Paper No. 311, Vol. XXXIX, pp. 1-16, 1955.

24. Marshall, J.T. Relations Between Water and Soil. Comm.wealth Agr. Bur. pp. 1-3, 7-17, 51-58, 1959.

Ibid, p. 58 Quoted by Marshall.

Power, W.L. and Teeter, B.S. Land Drainage, p. 261, 1932.

25. Journ. Agri. Sci. Vol. 31, pp. 455-60, 1941.

26. Soil Sci. Vol. 85, pp. 229-30, 1958.

27. Proc. Soil, Sci. Soc. Amr. Vol. 20, pp. 120-25, 1956.

28. South Dakota Agri. Exper. Sta. Bull. No. 314, p. 21, 1937.

29. Browning, G.H. Proc. Soil Sci. Soc. Amr. Vol. 2, pp. 85-96, 1939.

Myers, H.E. Soil Sci. Vol. 44, pp. 331-59, 1937.

Hide, J.C. and Metzger Proc. Soil, Sci. Soc. Amr. Vol. 4, pp. 19-22, 1939.

Nijhawan, S.D. and Dhingra, L.R. Proc. Soil Sci. Soc. Amr. Vol. 12, pp. 39-43, 1947,

30. Eden, T. Elements of Tropical Soil, pp. 32-33, 44-45, 1956.

31. Jackson, M.L. Soil Chemical Analysis, p. 38, 1959.

32. Obtained through private communication.

33. Hall, A.D. The Soil.

F.A.O. Agricultural Studies No. 20, "Soil Surveys for Land Development". pp. 1-20, 1953.

34. Spate, O.H.K. India and Pakistan, pp. 81-92.

35. F.A.O. Report No. 417, "The Chuharkana Tubewell Reclamation Scheme", November, 1955.

F.A.O. Report No. 158. "The Soils and Agriculture". pp. 1-15, September 1953.

36. Hodges, R.C. Canadian Geographer, 1956.

37. Unesco, Symposium on "Soil Erosion and its control in the Arid and Semi-Arid Zones". Karachi, November 1957.

38. Wadia, D.N. Geology of India, pp. 294-95, 1949.

39. Asghar, A.G. "Waterlogging and the Soils of Waterlogged Area". pp. 13, 1949.

40. Ibid. "The Problem of Salinity and Alkalinity of Soils and its Solution". pp. 1-6, 13, 1952.

41. Proc. Nat. Acad. Sci. Ind. Vol. VI, Pts. I-II, pp. 5, 141, 138-38 and 297, 1936.

42. Proc. Punj. Eng. Cong. Paper No. 235, 1940.

43. Asghar, A.G. "Causes and Remedies for excess Salinity and Alkalinity in Irrigated Lands". pp. 5-20, 1958.

44. Quoted by Graaff de Van R.H., Unpublished Report, "Salinity Problem in West Pakistan", 1959.

45. F.A.O. Report No. 3, February 1948.

Ibid, No. 158, September, 1953.

Ibid. No. 167, September 1953.

Agricultural Information, Bull. No. 195, U.S. Dept. Agr. January, 1959.

Bower, C.A. and Milton Fireman. "Saline and Alkaline Soils". Yearbook of Agriculture, pp. 282-90. 1957.

46. FAO Report No. 158, p. 11, September, 1953.

Ibid, No. 52/5/2992, January 1951.

47. Khushalani, K.B. Irrigation Practice and Design Vols. I-II, pp. 35-36, 1950.

FAO Report 52/11/7679, p. 10, 1950.

Ahmad, N. "Soil Salinity in West Pakistan" ([illegible]. Tehran Symposium, Paper No. 27, October, 1958.

48. World Crops, Vol. 11, pp. 163-64, 1959.

49. Pakistan, Journ. Sci. Vol. 5, No. 2, pp. 2-8, 1953.

Proc. Punj, Eng. Lahore Paper No. 311, Vol. XXXIX, pp. 5, 2-16, 1955.

Graaff de Van R.H. Op. cit. 1959.

Problem of Salinity and Alkalinity of Soils and its Solution, Op. cit. 1952, pp. 4-6.

50. Zuur, A.J. Unpublished Report 1958.

51. Asghar, A.G. and Dhawan "Percolation of Water through Soils". Research Publ. No. 13, Vol. IV, 1945.

52. Asghar, A.G. "Experiments at Moharanwala Experimental Reclamation Farm". Res. Pub. Vol. II, No. 2, pp. 1-8, 1954.

53. Gorrie, R.M. Soil and Water Conservation in the Punjab, pp. 1-10, 1946.

Haw, R.C. The Conservation of Natural Resources. 1959.

54. Jacks, G.V. and Whyte, R.O. — The Rape of the Earth, 1939.

55. The Daily Dawn Karachi, Editorial 26th October, 1958.

Jacks, G.V. and Whyte, R.O. — The Rape of the Earth, pp. 17-22, 1939.

56. The Daily Pakistan Times Lahore, 1st August, 1959.

57. Geogr. Rev. Vol. XV, No. 3, 1925, pp. 459-64.

58. Stephen, H.G., Wright, J.K., and Teelaff, E.M. Eds. — A World Geography of Forest Resources. pp. 2-14, 1956.

59. Proc. Geogr. Soc. Vol. III, 1881, p. 282.

60. Raymond, F.D. — Environmental Conservation, pp. 104-110, 1959.

Bennett, H.H. — Soil Conservation, pp. 16-20, 60-90, 179-85, 226-50, 1939.

61. Agriculture of Pakistan, 1959.

61a. Comptes Rendus du Congres International di Geographie Tom II, Sec IIIc, p. 127, 1938.

62. Census of India, Vol. IV, Pt. 1, pp. 9-10, 1911.

63. Brandt Karl — The Reconstruction of World Agriculture, p. 24, 1945.

64. Quoted from Agriculture of Pakistan. 1959.

65. West Pakistan Village Aid Year Book, pp. 1-8, and 237, 1959.

Chapter - 6

1. Journ. Bom. Nat. His. Soc. Vol.12, No. 1, pp. 124-149,

   Ibid. Vol. 42, No. 2, pp.342-379,

   Ibid. No. 3, pp. 533-86.

2. Ibid. Vol. 36, No. 3, pp. 667-87.

   Ibid. No. 4, pp. 950-77.

   Ibid. Vol. 37, No. 1, pp. 150-70, 1934-35.

x xx 3. Selec. Rec. Bom. Govt. Vol. 17, No. 2, 1855.

   Murray, G.A. Plants and drugs of Sind, p. 291, 1881.

4. Journ. Ind. Bot. Soc. Vol. 3, No. 5, pp. 151-53.

   Ibid. No. 6, pp. 178-80.

   Ibid. No. 7, pp. 204-6.

   Ibid. No. 8, pp. 227-32.

   Ibid. Nos. 9-10, pp. 277-84.

5. Ibid. Vol. 8, No. 4, pp. 263-86.

6. Proc. 26th Ind. Sci. Congr. 1939.

7. Sci. Monogr., No. 2; Bom. Ind. Central Committee, 1944.

8. Lace, J.H. and Hemsley, W.B. Sketch of the Vegetation of British Baluchistan.

9. Bot. Sur. Ind. Vol. 1, No. 8.

10. Journ. Ind. Bot. Soc. Madras, Vol. 1, Nos. 2-7, 1919.

    Ibid., Vol. 1, Nos, 8-10, 1920.

11. Journ. Bom. Nat. Hist. Soc. Vol. 24, No. 4.

11a Stebbings E.P Forest Types in India.

12. Champion, H.G. Indian Forest Records. Silviculture, Vol. I, 1938.

13. Pakistan First 5 Year Plan, pp. 255-85, 1957.

x 2a Gorrie, R.M. Soil and water conservation in the Punjab. 1946.

xx 2b Glover. H. Erosion in the Punjab. 1946.

14. Stephen, H.G., Wright, J.K. and Teclaff, E.M. A World Geography of Forest Resources, pp. 441-54.

15. Bull. Karachi Geogr. Soc. Vol. 2, pp. 22-24, 1950.

16. Unesco Symp. on Soil Erosion and its Control in the Arid and Semi-arid Zones, Karachi, November, 1957.

17. Naqvi, S.N. Report on Arid Zone Research, pp. 8-12, March 1960.

18. Unesco News Letter, No. 6, p. 18, December, 1959.

19. Raunkiacar, C. The life forms of plants and plant geography, p. 8, 1934.

20. United States Department of Agriculture, Year Book of Agriculture "Soil and Man". pp. 835-60, 1938.

21. Schimper, A.F.W. Plant Geography, pp. 130-40, 1903.

22. Quoted by Tansley, A.G. Foundations of Plant Geography, p. 11, 1944.

23. Unesco Symposium on Plant Ecology, Montpellier p. 17, pp. 30-41, 1955.

24. Quoted by Klages, K.H.W. Ecological Crop Geography, pp. 76-77, pp. 346-50, 191-92, 5th printing, 1954.

25. Central News Agency South Africa. "Moisture and Farming in South Africa". 1936.

26. Ecology, Vol. 6, pp. 325-32, 1925.

27. Ibid., Vol. 8, No. 2, pp. 145-57, 1927.

28. White F.G. "The Future of Arid Lands". pp. 7-9, 1956.

29. Land and Crop Statistics of Pakistan, Fact Series III, pp. 27-45, 66, 79-95, March, 1959.

30. Imp. GAZ. Ind. Vol. III, p. 6, 1907.

31. Journ. Roy. Geogr. Soc. Vol. XLII, p. 403, 1872.

32. Russel, J.A. and Mohammed, A.F. The economy of Pakistan, pp. 20-30, -50, 118, 1958.

Economic Survey of Asia and Far East, pp. 9-30, 1957.

33. Daily Pakistan Times, July 10th 1959.

34. Darling, M.L. The Punjab Peasant in prosperity and debt. p. 63, 1932.

35. Ministry of Agriculture, Crops,Vegetables and fruits in Pakistan. Fact Series, No. 2, p. 5, May, 1955.

36. Miller, A.A. Climatology.

37. Agriculture of Pakistan, pp. 2-5, 60-66, 31, 46-58, 20-30, 1959.

38. Quoted by Graaff De Van R.H. Unpublished Report. Salinity Problem in West Pakistan, p. 79, 1959.

39. Nelson, W.P., Mohammed, U. and Rucker, G.W. Basic Data of the Economy of Pakistan, pp. 48, 61, 1959.

40. The Daily Pakistan Times, 12th September, 1959.

41. Land and Crop Statistics of Pakistan, Fact Series III, pp. 1-2, March, 1959.

42. The New India Reprinted from the Time. p. 150, 1937.

43. Murphy, P. and Nott, H. The Agricultural Development of the Thal Desert, Pakistan. p. 17, 1957.

44. Pakistan Agricultural Enquiry Committee Report, pp. 10-22, 1951-52.

45. F.A.O. Agricultural Studies, No. 20, "Soil Surveys for Land Development". pp. 49-145, 1953.

46. Woytinsky, W.S. and Woytinsky, E.S. World Population and Production Trends and Outlook, 1953.

47. Pakistan News London, p. 2 1st October, 1960.

48. Ibid London, p. 1, 11th April, 1959.

49. Moreland, W.H. The Agrarian System of Muslim India. 1930.

50. Lord Hairley. Agricultural Journal of India, 1914.

51. UNO, 1950, II, 8, I Agricultural Requisitu in Latin, America.

Chapter 7

1. De Terra H. and Patterson, T.T. Studies on the Ice Age in India, pp. 302-10, 331-36, 1939.

2. Wheeler, R.E.M. Five Thousand Years of Pakistan, pp. 15-16, -18, -20, 30-37, 1950.

3. Piggott, S. Prehistoric India, pp. 30, 72,119-135, 77-80 -242, 1950.

Ibid. Some Ancient Cities of India, pp. 9-12, 1945.

4. Stein, A. Mem. Arc. Sur. Ind. No. 43, pp. 7-24.

5. The Daily Pakistan Times, p. 5, September, 19th, 1960.

6. Wheeler, R.E.M. The Cambridge History of India, Sup. Vol. "The Indus Civilization", p. 2, 21-22, 1953.

7. Corbian, S. "New finds in the Indus Valley". Iraq, Vol. IV, Pt. 1, Spring 1937.

8. Marshall, J. Mohenjo-Daro and the Indus Civilization, pp. 1-70, Vol. II, 1931.

9. MacKay, E. Early Indus Civilization, p. 103-38, 1948.

10. The Geographical Journ. Vol. CXVII, Pt. 4, pp. 422-24, 1951.

11. Journ. Roy. Asiat. Soc. 1917.

Mem. Arch. Sur. Ind. No. 42,

12. Majumdar, R.C. Raychaudhuri, H.C. and Dattta, K. An Advanced History of India. pp. 31-34, 41-47, 75-81, 131-38, 153, 181, 195-198, 275-80, 374-76, 395-400, 410-22, 425, 566-570, 571-76, 578-600, 735-61, 805-26, 829-37, 870-73, 928-1012, 1958.

13. Mukerjee, R. The Culture and Art of India, pp. 1-60, 1959.

14. Trevaskis, H.K. The Land of the Five Rivers. pp. 11-15, 18-24, 29-36, 40-45, 73-75, 79-84, 91-104, 110, 240-250, 315, 1928.

Cressey. G.B. "Cross Road, Land and Life in South West Asia". pp. 63, 1960.

15. Venka tachar, C.S. Eastern Economist Pamphlets, No. 34, "Geographical Realities of India". pp. 20-65, 1955.

<u>Chapter 8</u>

1. Proc. Geogr. Soc. Vol. I, pp. 39, 49, 52-53, 1879.

2. Geogr. Journ. Vol. 40, pp. 48,53, 1912.

3. Geogr. Journ. Vol. 72, pp. 309, 313, 1928.

4. Proc. Geogr. Soc. Vol. II, pp. 237-40, 1880.

5. Spate, O.H.K. India and Pakistan, pp. 428-30, 97-105, 274-77, 459-60, 1957.

6. Jour. Roy. Geogr. Soc. Vol. XLIV, pp. 164-80, 1874.

7. The Daily Times Supplement on Pakistan, February 1st,1961.

8. Geography, Vol. 37, pp. 142-45, 1952.

9. Ibid

Census of Pakistan Vols. 1-2, 4-6, 1951.

10. The New India, Reprinted from the Times "Irrigation and Agriculture", p. 170, 1937.

11. Darling, M.L. Wisdom and Waste in the Punjab Village, p. 55- 1934.

12. Pak. Geogr. Rev. Vol. XIII, No. 2, pp. 59-60, 1958.

Handbook of Thal Development Authority, pp. 87-98, 1954.

13. Board of Economic Inquiry Punjab Pakistan Publ. No. 110, "Economic Survey of Eight Typical Villages in the Thal". pp. XI, 25-27.

14. Pithawala, M.B. Settlements in the Lower Indus Basin. pp. 4-10, 1939.

15. Report of the United Kingdom Industrial Mission to Pakistan, p. 29, 1950.

16. Census of Pakistan, Vol. 1, pp. 23-40, 1951.

" " " Vols,2, 4-6, 1951.

17. Black, V.d. Principles of Human Geography, p. 316, 1926.

18. First 5 Year Plan of Pakistan, p. 253, 1957.

19. Unesco Symposium on "Soil Erosion and its Control in the Arid and Semi-Arid Zones". Karachi, November, 1957.

Conclusion

1. Land and Crop Statistics of Pakistan, Fact Series III, pp. 4 and 79-94, March, 1959.

2. Daily Times, p. 5, 4th March, 1961.

Pakistan News, London, p. 1, 15th March, 1961.

3. The Daily Pakistan Times, 19th September, 1960, p. 6.

4. Huntington E. Civilization and Climate, pp. 136-40, 194-227, 295, 1924, (New Haven).

Ibid. World Power and Evolution, pp. 60-80, 1919.

Markham, S.F. Climate and Energy of Nations, pp. 34-36, 134-40, 1942.

5. Commonwealth of Australia, Bur. Met. Bull. No. 14, pp. 16-20, 1916.

Winslow, C.E.A. and Herrington, L.P. Temperature and Human Life, pp. 186-90, 1949.

6. Outline of 2nd 5 Year Plan, 1960-65, pp. 30-38.

Geochronologi

Era	Period or System	Series	Stage	Areas affected
5 Quaternary	Recent (Holocene)			Hyderabad, Khairp Bahawalpur Divisi Thal, Makran Coas Salt Range, Quett Kalat Divisions Salt Range Quetta valley pla Indus Basin Hazara
	Upper Pleistocene			Salt Range Indus Basin
	Middle Pleistocene			Potwar Salt Range, Quett Kalat Divisions, Daman slopes of C and Waziristan. Area between Atto Campbellpur
	Lower Pleistocene			Boulder Conglomer
4 Tertiary or Cenozoic	Pliocene or Upper Siwalik	Manchar		Hyderabad Divisio
		Pinjor		Salt Range
		Tatrot		Salt Range

Appendix – 2

Mean monthly minimum and maximum temperature and normal monthly rainfall

Province		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	annual
Pasni	M	74·5	76 9	84·6	90·7	94·3	93·8	91·2	88·2	89·2	90·5	85·4	77·9	86·4
	N	54·7	56 6	61·9	67·8	74·2	78 5	78·9	76·3	72·5	67·3	60·5	56·6	67·1
	R	1·95	1·41	0·51	0·40	0·01	0·26	0·47	0·17	0·00	0·00	0·14	0·84	6·16
Las Bela	M	78·1	82·4	88·9	97·7	106·0	105·6	100·8	99·2	99·4	99·7	92·9	83·3	94·5
	N	46·0	51·3	57·0	64·8	73·6	80 4	80·7	77·7	73·6	63·3	53·5	49·0	64·2
	R	0·26	0 88	1·03	0·54	0·42	0·42	2·63	[illegible]	0·58	0·01	0.00	0·56	8·39
Karachi Manora	M	75·5	76·9	81·8	85·4	88 6	90·4	88·5	85·8	85·6	87·3	85·2	78·7	84·1
	N	57·4	61·0	68 1	74·2	79·0	82·3	81·1	78·5	76·7	73·7	66·9	60 1	71·6
	R	0·46	0·44	0·29	0 15	0·06	0·72	3·20	1·56	0·52	0·02	0·08	0·20	7·70
Hyderabad	M	75·8	81·2	92·5	101·8	107 0	104·5	99·3	95·8	97·3	97·8	88·8	78·6	93·4
	N	50·6	54·5	63·8	71·9	78·2	82·0	81·4	79.2	76·4	70·2	58 8	52·6	68·3
	R	0·17	0·21	0·20	0·07	0·19	0·39	2·98	2·03	0·63	0·03	0·06	0·10	7·09
Badin	M	76·3	82·4	91·7	100·4	103·9	[illegible]	94·9	92·2	94·1	96 0	90·2	80·5	[illegible]
	N	47·2	54·5	[illegible]	70·1	78·3	82 0	81·2	79·3	77·2	69·9	59·9	51·8	67·7
	R	0·15	0 38	0·15	0 0	0·22	0·65	3·97	2·32	0·89	0·03	0·18	0·15	9·7
Sukkur	M	72·3	78·7	87·9	98·2	107·4	100·1	104·2	101 2	100·4	96·0	86·2	76.2	93·2
	N	45·0	[illegible]	59·6	68 4	78 6	83·4	83 0	89·8	78·7	68·9	58·1	48·7	67·2
	R	[illegible]	[illegible]	0 24	0·10	0 14	0·14	1·44	1·12	[illegible]	0·01	0·0	0·03	[illegible]
Jacobadad	M	72·7	78 5	89·5	100 4	111·6	113·9	108·0	104·3	103·2	99·0	87·6	76·1	95·5
	N	43·8	[illegible]	59·9	70·2	79·0	84·9	85·0	82·2	77·0	64·4	52·8	44·9	66·1
	R	0·23	0 33	0·22	0 17	0·14	0·26	0.95	0·88	0·17	0·03	0·05	0·17	3·60

APPENDIX *Continued*

Province		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	annual
Fort Sandeman	M	59·7	59·3	69·9	80·3	90·5	99·2	99·3	96·9	92·7	82·6	71·4	59·9	79·7
	N	30·6	35·4	44·8	54·5	63·9	72·9	75·1	73·3	66·2	52·8	41·1	33·4	53·7
	R	0·72	1·06	1·38	0·94	0·91	0·64	2·14	1·90	0·32	0·10	0·13	0·57	10·83
Leh	M	29·4	33·0	44·2	55·4	63·7	71·3	76·4	75·9	69·7	58·3	46·8	35·3	54·9
	N	8·0	10·3	12·0	30·3	37·1	44·3	50·3	49·7	41·8	30·6	20·4	12·7	29·7
	R	0·38	0·31	0·28	0·23	0·22	0·18	0·47	0·59	0·27	0·10	0·04	0·19	3·26
Skardu	M	33·5	38·2	50·3	62·8	72·6	81·3	87·6	87·3	78·5	66·3	53·5	40·6	62·7
	N	16·4	19·2	32·4	42·4	49·4	56·1	61·8	61·5	53·3	40·7	28·5	21·8	40·3
	R	0·88	0·69	1·02	0·97	0·79	0·24	0·39	0·34	0·40	0·14	0·06	0·38	6·30
Gilgit	M	46·3	52·5	62·4	72·2	82·3	91·3	95·6	93·5	85·2	73·7	62·2	49·9	72·2
	N	32·0	36·9	45·1	52·7	59·4	66·3	71·7	71·0	63·0	52·2	41·3	33·8	52·1
	R	0·25	0·26	0·80	0·96	0·80	0·37	0·39	0·55	0·40	0·24	0·05	0·11	5·18
Quetta	M	50·2	53·6	63·6	74·0	83·8	91·6	94·0	92·2	86·2	75·7	65·4	55·5	73·8
	N	27·6	30·8	38·3	45·8	51·9	58·7	65·0	61·6	49·7	38·9	32·1	28·5	44·1
	R	1·94	1·98	1·74	0·98	0·39	0·17	0·46	0·33	0·04	0·12	0·28	1.01	9·44
Kalat	M	49·7	52·8	61·8	71·7	81·8	89·9	92·1	90·0	83·0	73·4	64·1	54·4	72·1
	N	...	...	...	...	...	...	...	...	...	...	...	...	...
	R	1·31	1·39	1·05	0·56	0·20	0·19	0·60	0·33	0·09	0·09	0·23	0·94	6·93
Panjgur	M	62·9	68·0	78·1	88·5	97·9	103·2	103·3	100·9	95·7	87·2	75·9	66·5	85·7
	N	38·6	42·5	50·2	59·2	68·2	74·6	76·3	73·2	65·0	55·4	45·6	39·8	57·4
	R	0·88	0·96	0·80	0·39	0·11	0·12	0·79	0·34	0·04	0·01	0·05	0·57	4·81

Multan	M	68·0	72·8	83·9	95·3	104·8	106.6	102·4	98·9	98·7	94·4	82·9	71·7	90·1
	N	42·0	46·8	57·2	67·5	77 4	84 8	85·5	82·9	77 7	63·7	50·9	43·4	65 0
	R	0 37	0·38	0·40	0·27	0 33	0·55	2·01	1·82	0·54	0·08	0·06	0·24	7·05
Montgomery	M	68·1	72·5	83·8	95·7	105·4	107 8	102·9	100·1	99·3	95·0	83·4	72 0	90·5
	N	41 7	46·4	56·0	66·6	76·9	83·5	83·7	81·7	75·9	63·5	51·6	43·1	64·2
	R	0·46	0·50	0·42	0·34	0·36	0 98	2·42	2·90	1·27	0·08	0.05	0·26	10·04
Lyallpur	M	67·1	71·3	81·6	92·9	102·4	106·0	101·5	98·0	98·1	93·2	82·2	70·7	88·7
	N	39·9	45·1	53·6	63·9	73·9	81·7	82·7	80 5	75·2	62·4	49·1	42·2	62·5
	R	0·40	0·57	0 56	0·47	0 43	1·22	2·86	3·58	1·49	0·12	0·11	0·25	12 06
Lahore	M	68 0	72·1	82·6	94·5	103·7	105 9	99·6	97·0	97·3	94·0	82·9	72·3	89 2
	N	40·1	44 5	53·2	63·2	72·2	79·0	80·1	78·7	73·1	59·8	47·3	40 6	61·0
	R	1·04	0·97	0·79	0·57	0·59	1·64	5·45	5·15	2·20	0·24	0·10	0·37	19·21
Sialkot	M	65·6	69·4	80·1	92·4	102 2	105 0	97·4	94·2	94·6	91·4	80·6	69·4	86·9
	N	42·2	45·5	54·2	64·7	74·3	80·3	79·6	78·2	73·8	62·1	49·1	42 2	62·2
	R	1·96	1·67	1·51	1·00	0.99	2·39	8·35	9 30	3·43	0·34	0·17	0·72	31·83
Khushab	M	67·7	71·3	81·3	92 9	103·7	106·6	102·2	99·8	98·6	93·6	82·8	71·7	89 5
	N	40·7	46·0	55·8	66·7	76·3	82·3	82·4	81·1	76·1	63·4	49 8	41·5	63·5
	R	0·69	0·92	1 04	0 91	0·76	1·41	3·90	3·51	1·38	0·15	0·08	0·43	15·18
Srinagar	M	41·0	44 1	56 9	66·8	77 0	85·4	87·8	86·6	83 5	73·8	62·5	48·2	67·8
	N	27 3	29 5	37 0	44·6	50·9	57·3	64·3	63·4	53·5	40·6	30·9	27·6	43·9
	R	2 80	2·84	3·61	3·65	2·38	1·40	2·33	2·42	1·53	1·17	0·14	1·32	25 99
Drosh	M	45·7	49 0	58·1	68·9	81 5	91·9	96·7	95·2	88 0	76·7	64·1	50·5	72·2
	N	31·4	33·6	40·4	48 4	59 0	68·5	73·5	72 6	64·4	53 2	43·6	35·6	52·0
	R	1 37	1 55	3·73	4·08	1·91	0·65	0 60	0·65	0,69	1 27	0·34	1·20	18·04
Parachinar	M	49 8	51·8	59 8	68·7	79·5	87·7	87·1	84·7	81·2	74·2	64·7	54·8	79·3
	N	28 6	31·3	38·6	46·9	55·6	63·7	66·4	64·8	51·6	48·7	39·3	32·5	47·9
	R	2·03	2·63	4·34	4 03	2·31	2·00	3·52	3·70	2·11	1·95	0 40	1·23	29.25

Read M for Maximum. N for Minimum. R for Rainfall.

Nokhandi	M	65·4	71·8	77·1	90·7	103·9	110·1	109·4	108·2	101·5	93·3	79·8	70·2	89·9
	N	38·3	47·0	51·8	63·1	74·5	81·8	83·6	81·1	70·9	60·1	49·7	43·4	62·1
	R	0·89	0·40	0·12	0·35	0·02	0·0	0·0	0·0	0·0	0·0	0·03	0·14	1·95
Sibi	M	70·1	75·7	86·0	97·7	109·2	112·7	107·8	104·9	104·0	97·6	86·4	74·9	93·9
	N	42·0	49·7	59·4	70·1	81·3	87·5	87·2	85·3	78·9	65·5	53·1	45·5	67·1
	R	0·44	0·87	0·32	0·11	0·14	0·30	1·40	0·58	0·13	0·0	0·02	0·30	4·61
D. I. Khan	M	68·0	71·6	81·8	92·6	103·5	107·8	103·3	100·5	99·4	93·3	81·9	71·5	89·6
	N	40·3	44·9	55·0	65·2	74·7	81·5	82·7	81·2	75·6	61·7	48·7	41·2	62·7
	R	0·45	0·67	0·96	0·69	0·39	0·61	2·29	1·90	0·63	0·11	0·15	0·24	9·09
Bannu	M	65·5	68·6	78·0	88·4	99·8	106·1	103·1	100·0	97·9	90·6	80·2	70·1	87·3
	N	39·9	45·2	52·9	62·1	71·5	79·7	82·5	80·3	73·7	61·9	49·9	42·0	61·8
	R	0·52	1·18	1·58	0·98	0·61	0·91	2·21	1·89	0·63	0·04	0·16	0·40	11·11
Peshawar	M	63·0	66·2	74·8	85·2	97·0	105·0	102·5	98·2	95·0	87·8	76·8	68·7	85·0
	N	40·4	44·0	52·4	60·5	70·4	77·2	80·2	78·9	71·8	60·5	48·9	40·9	60·5
	R	1·44	1·53	2·44	1·76	0·77	0·31	1·26	2·03	0·81	0·23	0·31	0·67	13·56
Rawalpindi	M	62·3	65·2	75·1	86·2	97·7	103·5	97·8	93·7	93·4	88·6	77·7	66·8	84·0
	N	37·9	41·7	50·4	59·3	68·7	75·9	77·1	75·5	69·3	57·0	44·4	37·8	57·9
	R	2·49	2·48	2·67	1·92	1·25	2·31	8·07	9·17	3·89	0·60	0·28	1·24	36·37
Jammu	M	65·1	68·6	78·9	90·0	99·9	102·5	95·4	91·8	91·9	88·1	78·0	68·0	84·9
	N	47·5	51·2	59·3	68·9	78·2	82·5	79·3	77·7	75·1	67·2	56·2	49·1	66·0
	R	2·29	2·43	2·03	1·29	0·93	2·80	12·79	11·75	3·51	0·76	0·28	1·21	42·1[illegible]
Murree	M	45·2	46·7	55·6	65·3	75·1	80·7	76·2	73·2	72·3	67·6	59·5	50·7	64·0
	N	20·7	31·1	37·8	46·9	55·6	60·5	58·9	57·4	54·8	49·3	41·0	34·9	46·6
	R	3·70	4·31	4·81	4·13	2·[illegible]	3·98	12·40	13·81	5·42	1·56	0·73	1·80	59·36

Read M for Maximum, N for Minimum R for Rainfall.

QUETTA

TEMPERATURES

		Mean /of/		Mean /of/		Extreme			
		Daily Max.	Daily Min.	Highest in the month	Lowest in the month	Highest recorded	Date and year	Lowest recorded	Date and year
		°F	°F	°F	°F	°F		°F	
January	I	50.2	27.6	65.6	16.7	78	30	3	17
	II	-	-	-	-	-	1898	-	1910
February	I	53.6	30.8	67.4	20.4	80	14	8	3
	II	-	-	-	-	-	1934	-	1918
March	I	63.6	38.3	75.9	26.8	84	24	15	1
	II	-	-	-	-	-	1892	-	1905
April	I	74.0	45.8	84.2	35.0	91	23	27	6
	II	-	-	-	-	-	1925	-	1918
May	I	83.8	51.9	92.4	42.7	98	31	34	3
	II	-	-	-	-	-	1936	-	1888
June	I	91.6	58.7	97.7	49.3	103	22	43	4
	II	-	-	-	-	-	1933	-	1893
July	I	94.0	65.0	96.0	56.0	103	8	47	1
	II	-	-	-	-	-	1933	-	1938
August	I	92.2	61.6	97.1	52.0	103	13	45	26
	II	-	-	-	-	-	1931	-	1899
September	I	86.2	49.7	92.3	39.6	97	19	33	30
	II	-	-	-	-	-	1936	-	1923
October	I	75.7	38.9	84.1	30.1	91	3	22	28
	II	-	-	-	-	-	1921	-	1937
November	I	65.4	32.1	72.1	23.4	81	5	12	25
	II	-	-	-	-	-	1923	-	1916
December	I	55.5	28.5	67.0	18.6	76	6	3	21
	II	-	-	-	-	-	1904	-	1929

PESHAWAR

TEMPERATURES

		Mean /of/		Mean /of/		Extreme			
		Daily Max.	Daily Min.	Highest in the month	Lowest in the month	Highest recorded	Date and year	Lowest recorded	Date and year
		°F	°F	°F	°F	°F		°F	
January	I	63.0	40.4	71.1	32.1	77	7	26	22
	II	-	-	-	-	-	1890	-	1934
February	I	66.2	44.0	76.0	34.7	86	25	28	3
	II	-	-	-	-	-	1921	-	1905
March	I	74.8	52.4	86.8	41.3	99	26	33	1
	II	-	-	-	-	-	1892	-	1905
April	I	85.2	60.5	97.3	50.8	108	23	41	8
	II	-	-	-	-	-	1925	-	1918
May	I	97.0	70.4	109.9	60.1	118	31	51	2
	II	-	-	-	-	-	1911	-	1881
June	I	105.0	77.2	115.3	69.1	120	17	63	2
	II	-	-	-	-	-	1914	-	1893
July	I	102.5	80.2	113.1	72.4	122	5	66	1
	II	-	-	-	-	-	1920	-	1881
August	I	98.2	78.9	107.0	71.5	118	9	66	13
	II	-	-	-	-	-	1915	-	1893
September	I	95.0	71.8	102.0	62.9	110	2	58	30
	II	-	-	-	-	-	1920	-	1940
October	I	87.8	60.5	95.9	50.4	101	2	43	30
	II	-	-	-	-	-	1932	-	1916
November	I	76.8	48.9	84.9	38.1	91	2	32	30
	II	-	-	-	-	-	1933	-	1912
December	I	66.7	40.9	75.1	32.5	83	4	28	22
	II	-	-	-	-	-	1932	-	1915

LAHORE

TEMPERATURES

		Mean /of/		Mean /of/		Extreme			
		Daily Max.	Daily Min.	Highest in the month	Lowest in the month	Highest recorded	Date and year	Lowest recorded	Date and year
		°F	°F	°F	°F	°F		°F	
January	I	68.0	40.1	74.2	34.7	82	29	28	19
	II	-	-	-	-	-	1902	-	1935
February	I	72.1	44.5	80.5	37.4	90	26	30	2
	II	-	-	-	-	-	1934	-	1905
March	I	82.6	53.2	94.0	45.6	106	25	39	5
	II	-	-	-	-	-	1892	-	1910
April	I	94.5	63.2	105.2	55.6	112	27	46	2
	II	-	-	-	-	-	1892	-	1903
May	I	103.7	72.2	113.5	64.5	118	21	59	12
	II	-	-	-	-	-	1892	-	1914
June	I	105.9	79.0	115.2	71.7	119	8	65	3
	II	-	-	-	-	-	1929	-	1886
July	I	99.6	80.1	110.3	73.2	118	6	69	9
	II	-	-	-	-	-	1901	-	1934
August	I	97.0	78.7	104.0	73.3	112	8	67	27
	II	-	-	-	-	-	1911	-	1932
September	I	97.3	73.1	102.8	67.1	110	4	63	30
	II	-	-	-	-	-	1905	-	1940
October	I	94.0	59.8	98.8	53.1	106	4	46	31
	II	-	-	-	-	-	1899	-	1890
November	I	82.9	47.3	89.0	41.7	94	1	36	30
	II	-	-	-	-	-	1909	-	1937
December	I	72.3	40.6	78.3	35.6	87	1	29	23
	II	-	-	-	-	-	1899	-	1910

KARACHI

TEMPERATURES

		Mean /of/		Mean /of/		Extreme			
		Daily Max.	Daily Min.	Highest in the month	Lowest in the month	Highest recorded	Date and year	Lowest recorded	Date and year
		°F	°F	°F	°F	°F		°F	
January	I	75.5	57.4	81.7	50.9	86	3	43	17
	II	-	-	-	-	-	1937	-	1935
February	I	76.9	61.0	84.0	52.5	90	17	43	6
	II	-	-	-	-	-	1930	-	1920
March	I	81.8	68.1	90.8	60.1	99	31	54	2
	II	-	-	-	-	-	1928	-	1936
April	I	85.4	74.2	93.5	67.9	104	13	63	3
	II	-	-	-	-	-	1932	-	1940
May	I	88.6	79.0	96.3	75.1	109	9	71	2
	II	-	-	-	-	-	1938	-	1917
June	I	90.4	82.3	94.8	78.9	105	8	73	3
	II	-	-	-	-	-	1916	-	1940
July	I	88.5	81.1	92.5	76.8	98	12	71	13
	II	-	-	-	-	-	1932	-	1924
August	I	85.8	78.5	89.2	74.9	95	5	70	20
	II	-	-	-	-	-	1916	-	1929
September	I	85.6	76.7	90.6	73.2	101	29	65	29
	II	-	-	-	-	-	1929	-	1923
October	I	87.3	73.7	96.3	68.1	104	7	63	22
	II	-	-	-	-	-	1925	-	1931
November	I	85.2	66.9	91.8	60.8	98	4	52	29
	II	-	-	-	-	-	1939	-	1938
December	I	78.7	60.1	84.5	53.6	87	6	47	30
	II	-	-	-	-	-	1930	-	1932

JACOBABAD

TEMPERATURES

		Mean /of/		Mean /of/		Extreme			
		Daily Max.	Daily Min.	Highest in the month	Lowest in the month	Highest recorded	Date and year	Lowest recorded	Date and year
		°F	°F	°F	°F	°F		°F	
January	I	72.7	43.8	81.7	34.6	89	21	25	23
	II	-	-	-	-	-	1902	-	1905
February	I	78.5	49.1	88.8	37.5	103	26	29	1
	II	-	-	-	-	-	1928	-	1905
March	I	90.5	59.9	101.5	47.3	112	26	37	2
	II	-	-	-	-	-	1892	-	1936
April	I	100.4	70.2	111.7	58.3	119	24	48	4
	II	-	-	-	-	-	1925	-	1903
May	I	111.6	79.0	120.0	68.7	126	27	61	7
	II	-	-	-	-	-	1914	-	1909
June	I	113.9	84.9	120.7	76.8	127	12	70	3
	II	-	-	-	-	-	1919	-	1899
July	I	108.0	85.0	115.7	78.0	126	6	71	8
	II	-	-	-	-	-	1901	-	1936
August	I	104.3	82.2	110.0	77.0	117	7	68	13
	II	-	-	-	-	-	1918	-	1923
September	I	103.2	77.0	108.5	69.1	113	16	60	30
	II	-	-	-	-	-	1938	-	1923
October	I	99.0	64.4	105.8	54.8	112	2	47	31
	II	-	-	-	-	-	1911	-	1890
November	I	87.6	52.8	96.1	44.3	103	1	36	30
	II	-	-	-	-	-	1909	-	1938
December	I	76.1	44.9	83.7	37.0	89	1	31	23
	II	-	-	-	-	-	1934	-	1910

RAWALPINDI

TEMPERATURES

		Mean /of/		Mean /of/		Extreme			
		Daily Max.	Daily Min.	Highest in the month	Lowest in the month	Highest recorded	Date and year	Lowest recorded	Date and year
		°F	°F	°F	°F	°F		°F	
January	I	62.3	37.9	70.6	30.8	80	22	25	14
	II	-	-	-	-	-	1902	-	1937
February	I	65.2	41.7	75.2	33.9	85	26	27	1
	II	-	-	-	-	-	1934	-	1929
March	I	75.1	50.4	86.5	40.7	96	15	34	1
	II	-	-	-	-	-	1900	-	1905
April	I	86.2	59.2	97.5	49.4	106	23	41	8
	II	-	-	-	-	-	1925	-	1918
May	I	97.7	68.7	108.3	58.5	114	27	43	13
	II	-	-	-	-	-	1940	-	1920
June	I	103.5	75.5	113.0	66.8	117	4	60	2
	II	-	-	-	-	-	1929	-	1885
July	I	97.8	77.1	109.3	68.7	117	1	64	30
	II	-	-	-	-	-	1912	-	1901
August	I	93.7	70.5	100.0	68.1	111	7	63	4
	II	-	-	-	-	-	1918	-	1914
September	I	93.4	69.3	99.1	61.2	107	5	53	30
	II	-	-	-	-	-	1905	-	1940
October	I	88.6	57.0	95.1	48.2	100	4	42	29
	II	-	-	-	-	-	1938	-	1890
November	I	77.7	44.4	85.0	36.1	93	14	31	30
	II	-	-	-	-	-	1921	-	1938
December	I	66.8	37.8	74.9	31.0	82	2	27	26
	II	-	-	-	-	-	1899	-	1937

QUETTA

No. of Days

		Precipitation .01" or more	Fog	Overcast	Relative Humidity %
January	I	9	1.0	10	79
	II	-	-	8	51
February	I	9	0	8	78
	II	-	-	10	54
March	I	8	0	5	69
	II	-	-	9	42
April	I	5	0	3	64
	II	-	-	5	36
May	I	1.7	0	1	55
	II	-	-	2	31
June	I	1.6	0	1	55
	II	-	-	2	29
July	I	2	0	0	61
	II	-	-	1	34
August	I	0.3	0	0	57
	II	-	-	0	28
September	I	0.1	0	0	53
	II	-	-	0	23
October	I	0.1	0	0	52
	II	-	-	0	24
November	I	0.3	0	0	58
	II	-	-	1	26
December	I	0.6	0	4	75
	II	-	-	4	43

PESHAWAR

No. of Days

		Precipitation .01" or more	Fog	Overcast	Relative Humidity %
January	I	6	0.4	7	72
	II	-	-	7	44
February	I	7	0.3	10	79
	II	-	-	9	51
March	I	8	0.1	7	72
	II	-	-	8	42
April	I	7	0.1	4	59
	II	-	-	5	34
May	I	4	0	1	39
	II	-	-	2	18
June	I	2	0	1	39
	II	-	-	1	25
July	I	4	0	1	60
	II	-	-	1	36
August	I	3	0	2	70
	II	-	-	1	40
September	I	2	0	0	64
	II	-	-	0	34
October	I	1.8	0	1	57
	II	-	-	0	31
November	I	1.2	0	1	58
	II	-	-	1	28
December	I	2	0.2	4	67
	II	-	-	5	44

LAHORE

No. of Days

		Precipitation .01" or more	Fog	Overcast	Relative Humidity %
January	I	4	3	6	85
	II	-	-	5	41
February	I	5	1.6	10	78
	II	-	-	7	46
March	I	4	0.1	5	62
	II	-	-	4	30
April	I	3	0	1	47
	II	-	-	2	20
May	I	3	0	2	39
	II	-	-	1	17
June	I	6	0	4	50
	II	-	-	2	35
July	I	9	0	5	71
	II	-	-	3	49
August	I	9	0	3	76
	II	-	-	2	48
September	I	3	0.1	1	70
	II	-	-	0	39
October	I	0.9	0	0	61
	II	-	-	0	32
November	I	0.4	0.7	2	68
	II	-	-	1	40
December	I	1.8	2	3	86
	II	-	-	4	45

KARACHI

		No. of Days			
		Precipitation .01" or more	Fog	Overcast	Relative Humidity %
January	I	2	0.1	4	63
	II	-	-	3	44
February	I	3	0.6	3	72
	II	-	-	3	55
March	I	0.7	0	3	79
	II	-	-	3	58
April	I	0.7	0.1	2	87
	II	-	-	1	70
May	I	0.1	0.3	4	88
	II	-	-	0	76
June	I	1.0	0	10	86
	II	-	-	4	74
July	I	6	0	19	88
	II	-	-	9	77
August	I	3	0	19	90
	II	-	-	10	76
September	I	0.7	0.2	10	89
	II	-	-	3	75
October	I	0.2	0.7	1	83
	II	-	-	0	72
November	I	0.4	1.8	1	68
	II	-	-	1	53
December	I	1.3	0.3	3	64
	II	-	-	1	48

JACOBABAD

No. of Days

		Precipitation .01" or more	Fog	Overcast	Relative Humidity %
January	I	1.8	0.1	5	65
	II	-	-	5	28
February	I	3	0.2	5	60
	II	-	-	4	32
March	I	2	0	4	52
	II	-	-	6	27
April	I	1.2	0	2	47
	II	-	-	3	23
May	I	0.2	0.2	0	49
	II	-	-	1	23
June	I	0.3	0	1	61
	II	-	-	0	27
July	I	2	0	2	69
	II	-	-	2	39
August	I	1.9	0	1	75
	II	-	-	1	41
September	I	0.1	0	1	75
	II	-	-	0	37
October	I	0	0	0	63
	II	-	-	0	28
November	I	0	0	1	63
	II	-	-	0	27
December	I	1.0	0	2	66
	II	-	-	2	32

RAWALPINDI

No. of Days

		Precipitation .01" or more	Fog	Overcast	Relative Humidity %
January	I	7	1.2	7	83
	II	-	-	7	46
February	I	6	0.6	7	81
	II	-	-	8	50
March	I	7	0	6	63
	II	-	-	5	39
April	I	6	0	4	51
	II	-	-	4	29
May	I	4	0	1	35
	II	-	-	1	17
June	I	7	0	6	38
	II	-	-	5	29
July	I	13	0	6	67
	II	-	-	1	48
August	I	10	0	5	75
	II	-	-	3	52
September	I	5	0	2	62
	II	-	-	1	37
October	I	2	0	1	58
	II	-	-	1	29
November	I	1.3	0	1	67
	II	-	-	0	29
December	I	3	0.3	5	77
	II	-	-	4	41

QUETTA

RAINFALL

		Mean monthly total	Mean No. of rainy days	Total in wettest month with year	Total in driest month with year	Heaviest fall in 24 hours	Date and year
		in.		in.	in.	in.	
January	I	1.94	4.9	6.37	0.02	2.20	25
	II	-	-	1885	1899	-	1888
February	I	1.98	4.6	7.77	0.03	1.63	5
	II	-	-	1893	1908	-	1924
March	I	1.74	4.7	5.30	0	1.82	18
	II	-	-	1903	-	-	1883
April	I	0.98	2.7	5.08	0	1.40	4
	II	-	-	1885	-	-	1930
May	I	0.39	1.1	1.96	0	0.98	7
	II	-	-	1885	-	-	1899
June	I	0.17	0.4	2.66	0	2.17	28
	II	-	-	1934	-	-	1934
July	I	0.46	1.1	2.68	0	1.48	14
	II	-	-	1882	-	-	1882
August	I	0.33	0.7	2.50	0	1.37	10
	II	-	-	1917	-	-	1889
September	I	0.04	0.1	0.68	0	0.53	8
	II	-	-	1884	-	-	1884
October	I	0.12	0.3	1.87	0	0.95	31
	II	-	-	1914	-	-	1914
November	I	0.28	0.8	3.76	0	1.03	18
	II	-	-	1890	-	-	1890
December	I	1.01	2.6	4.44	0	1.68	2
	II	-	-	1936	-	-	1892

PESHAWAR

RAINFALL

		Mean monthly total	Mean No. of rainy days	Total in wettest month with year	Total in driest month with year	Heaviest fall in 24 hours	Date and year
		in.		in.	in.	in.	
January	I	1.44	2.9	4.60	0	3.03	17
	II	-	-	1910	-	-	1891
February	I	1.53	3.3	5.11	0	2.17	8
	II	-	-	1936	-	-	1915
March	I	2.44	4.6	7.76	0	2.20	15
	II	-	-	1939	-	-	1926
April	I	1.76	3.8	7.35	0.03	2.42	1
	II	-	-	1885	1892	-	1885
May	I	0.77	2.0	5.16	0	3.85	5
	II	-	-	1901	-	-	1901
June	I	0.31	0.9	3.85	0	2.65	11
	II	-	-	1881	-	-	1881
July	I	1.26	2.0	6.87	0	2.75	29
	II	-	-	1929	-	-	1892
August	I	2.03	2.5	17.75	0	5.94	4
	II	-	-	1892	-	-	1892
September	I	0.81	1.5	4.73	0	2.02	2
	II	-	-	1908	-	-	1924
October	I	0.23	0.6	1.95	0	1.22	29
	II	-	-	1931	-	-	1914
November	I	0.31	0.6	4.28	0	1.99	1
	II	-	-	1890	-	-	1936
December	I	0.67	1.6	4.35	0	1.61	19
	II	-	-	1919	-	-	1905

KARACHI

RAINFALL

		Mean monthly total	Mean No. of rainy days	Total in wettest month with year	Total in driest month with year	Heaviest fall in 24 hours	Date and year
		in.		in.	in.	in.	
January	I	0.46	1.0	2.81	0	1.64	30
	II	-	-	1894	-	-	1888
February	I	0.44	1.0	2.03	0	1.15	6
	II	-	-	1907	-	-	1924
March	I	0.29	0.6	3.83	0	2.10	29
	II	-	-	1911	-	-	1939
April	I	0.15	0.2	4.67	0	4.11	12
	II	-	-	1881	-	-	1881
May	I	0.06	0.1	1.85	0	1.21	13
	II	-	-	1902	-	-	1902
June	I	0.72	0.6	10.59	0	7.17	17
	II	-	-	1902	-	-	1902
July	I	3.20	2.5	18.63	0	7.86	24
	II	-	-	1894	-	-	1930
August	I	1.56	1.6	14.15	0	5.41	1
	II	-	-	1916	-	-	1921
September	I	0.52	0.5	15.35	0	8.11	6
	II	-	-	1926	-	-	1926
October	I	0.02	0.1	0.52	0	0.52	26
	II	-	-	1928	-	-	1928
November	I	0.08	0.3	1.03	0	0.87	6
	II	-	-	1929	-	-	1890
December	I	0.20	0.5	2.58	0	1.83	30
	II	-	-	1937	-	-	1937

LAHORE

RAINFALL

		Mean monthly total	Mean No. of rainy days	Total in wettest month with year	Total in driest month with year	Heaviest fall 24 hours	Date and year
		in.		in.	in.	in.	
January	I	1.04	2.0	3.91	0	2.94	29
	II	-	-	1894	-	-	1935
February	I	0.97	2.1	4.37	0	2.43	24
	II	-	-	1937	-	-	1889
March	I	0.79	1.9	5.37	0	2.33	4
	II	-	-	1904	-	-	1904
April	I	0.57	1.6	2.99	0	1.64	8
	II	-	-	1935	-	-	1935
May	I	0.59	1.3	4.38	0	3.00	27
	II	-	-	1885	-	-	1883
June	I	1.64	2.8	7.54	0	4.94	19
	II	-	-	1894	-	-	1894
July	I	5.45	5.9	16.47	0.32	8.27	28
	II	-	-	1916	1918	-	1924
August	I	5.15	5.7	20.39	0	5.06	1
	II	-	-	1908	-	-	1882
September	I	2.20	2.5	10.72	0	6.61	12
	II	-	-	1883	-	-	1905
October	I	0.24	0.5	2.27	0	2.04	7
	II	-	-	1886	-	-	1886
November	I	0.10	0.3	1.52	0	0.66	30
	II	-	-	1928	-	-	1928
December	I	0.47	1.0	2.51	0	2.18	10
	II	-	-	1909	-	-	1924

JACOBABAD

RAINFALL

		Mean monthly total	Mean No. of rainy days	Total in wettest month with year	Total in driest month with year	Heaviest fall 24 hours	Date and year
		in.		in.	in.	in.	
January	I	0.23	0.7	1.20	0	1.09	10
	II	-	-	1894	-	-	1908
February	I	0.33	0.9	2.90	0	1.01	21
	II	-	-	1906	-	-	1906
March	I	0.22	0.7	1.57	0	1.27	3
	II	-	-	1904	-	-	1904
April	I	0.17	0.5	2.29	0	1.92	21
	II	-	-	1919	-	-	1919
May	I	0.14	0.4	1.60	0	1.60	5
	II	-	-	1899	-	-	1899
June	I	0.26	0.3	3.25	0	3.25	30
	II	-	-	1930	-	-	1930
July	I	0.95	1.5	4.35	0	3.34	16
	II	-	-	1883	-	-	1883
August	I	0.88	1.3	4.97	0	4.00	2
	II	-	-	1917	-	-	1884
September	I	0.17	0.3	4.79	0	1.25	5
	II	-	-	1917	-	-	1917
October	I	0.03	0.1	0.68	0	0.68	29
	II	-	-	1914	-	-	1914
November	I	0.05	0.1	2.50	0	1.82	28
	II	-	-	1890	-	-	1890
December	I	0.17	0.5	2.46	0	1.85	20
	II	-	-	1921	-	-	1921

RAWALPINDI

RAINFALL

		Mean monthly total	Mean No. of rainy days	Total in wettest month with year	Total in driest month with year	Heaviest fall 24 hours	Date and year
		in.		in.	in.	in.	
January	I	2.49	3.8	8.71	0	3.00	7
	II	-	-	1911	-	-	1885
February	I	2.48	4.4	7.84	0.01	3.78	28
	II	-	-	1939	1902	-	1939
March	I	2.67	4.7	11.35	0	4.0	14
	II	-	-	1911	-	-	1926
April	I	1.92	4.1	6.13	0	2.45	13
	II	-	-	1908	-	-	1908
May	I	1.25	2.5	8.24	0	3.69	21
	II	-	-	1885	-	-	1885
June	I	2.31	3.3	13.55	0	4.74	26
	II	-	-	1938	-	-	1895
July	I	8.07	8.8	21.06	0.58	9.80	20
	II	-	-	1890	1918	-	1893
August	I	9.17	9.1	23.58	1.92	7.45	28
	II	-	-	1916	1928	-	1929
September	I	3.89	4.6	11.34	0.01	5.82	1
	II	-	-	1922	1907	[illegible]	1928
October	I	0.60	1.4	5.35	0	1.70	16
	II	-	-	1914	-	-	1921
November	I	0.28	0.5	3.42	0	2.22	12
	II	-	-	1883	-	-	1883
December	I	1.24	2.3	4.47	0	2.35	15
	II	-	-	1890	-	-	1909

Appendix 6 Hydrological data of Catchment Area of the Indus Basin (Eastern tributaries)

Name of river	Catchment area at debouchment in plains sq. mls.	Area under Glacin sq. mls.	Maximum recorded flood (appr.) cusecs	Mean annual rain-fall in "	Run off in acre feet	Percentage run off of rainfall	Minimum recorded discharge curves	Min. monthly discharge curves	Total length of the rivers in miles
Indus	118,400	14,415	10,000,000	17.74	87,355,000	77.98	18,870	26584	1830
Jhelum	12,445	142	8,000,000	42.33	23,860,000	84.93	4,500	7246	430
Chenab	11,399	1,475	7,500,000	47.24	23,277,000	81.06	3,884	6830	640
Ravi	3,562	100	2,000,000	93.00	6,541,000	40.89	1,332	2086	420
Beas	5,384	277	500,000	56.50	12,546,000	77.34	2,600	4641	250
Sutlej	23,400	2,468	4,000,000	19.71	13,938,000	56.67	2,818	4325	900

APPENDIX 7

Existing Canal Systems

Semi-Aris Zone

Pre-1947 Canals	Area Commanded in (000,Acres)	Post-1947 Canals	Area Commanded in (000,Acres)	Estimated food in (000, tons)
1. Upper Bari Doab at Madhopur (India) on Ravi. 1859.	650	1. Bambanwala-Ravi-Bedian Dipalpur Link completed in 1956.		
2. Lower Chenab at Khanki on Chenab in 1890.	2,900	2. Balloki-Sulaimanki Link completed in 1957.		
3. Lower Jhelum at Rasul on Jhelum. 1891.	1,275	3. Pehur flow irrigation from right bank of the Indus completed in 1957.	60 in Mardan District	15
4. Triple Canal project. 1917.	Irrigate the area between Ravi and Sutlej by transferring water from Jhelum.	4. Marala-Ravi Link oompleted in 1958.	260	21
a. Upper Jhelum at Mangla on Jhelum.	500	5. Warsak high level Canals on Kabul, completed 1960.	93	28
b. Upper Chenab at Marala on Chenab.	1,450			
c. Lower Bari Doab at Balloki on Ravi (it serves arid territory of Multan also).	1,460	6. Gomal-Zam flood control irrigation completed 1960.	75	25
5. Upper Swat canal at Amandarra in 1885.	650	7. Bara Canals completed 1960.		
6. Lower Swat Canal.		8. Kurram Garhi Weir completed 1957.	270	50
7. Kabul River Canal.	Peshawar District.			
8. Paharpur Canal.	D.I. Khan District.			
9. Dipalpur at				
a. Ferozepur on Sutlej (India).	990. in Lahore and Montgomery Districts.			

APPENDIX 7 (cont'd)

Existing Canal Systems

Arid Zone

Pre-1947 Canals	Area Commanded in (000, Acres)	Post-1947 Canals	Area Commanded in (000, Acres)	Estimated Food in (000, Tons)
1. Lower Bari Doab	1,460	1. Thal Project	1,167	343
2. Sidhnai on Ravi in 1886.	Multan District	2. At Panjnad on Sutlej, Abbasia Canal completed in 1956.	73	
3. Sutlej Valley Canals 1932.		3. Taunsa Project completed 1957.	710 Districts of D.G. Khan and Muzaffargarh.	197
b. At Sulaimanki (i) West Bank Pakpattan Canal	1,395	4. Gudu Barrage completed 1959.	2,294	666
(ii) East Bank, Eastern Sadiqia Canal.	North East of Bahawalpur Division	5. Makhi Dhand Reclamation Project completed 1959.	150	
c. At Islam	928			
(i) West Bank, Mailsi canal.	756 Apex of Bari Doab triangle.	6. Nari-Bolan.	34	85
(ii) East Bank Bahawalpur Canal	645 in Bahawalpur District	7. Anamber Weir Project completed	9	
d. At Panjnad, Eastern Bank Panjnad Canals.	1,300	8. Ghulam Mohammed Barrage at Kotri completed 1960.	2,750	825
4. At Trimmubn Chenab. Haveli Canals 1938 (and Sidhnai)	1,005	9. Extension of Sailaba cultivation.	81	81
5. Rangpur on West Bank of Chenab.	340			
6. Sukkur Barrage Canals on the Indus in 1932.	6,000			
Innundation Canals of Shahpur on Jhelum,	1,300			
Musaffargarh on Chenab.	6,400			
on Indus.	7,250			

Sources

1. The First Five Year Pla pp.330-51. 1957.
2. Irrigation Projects Pak. Publ. Jan. 1956. Pages 5-6.
3. Arnold F.B. Overseas Econo ic Surveys. 'Pakistan' May 1954. p.148.
4. Unpublished Report of the Irrigation Department 1960.

Appendix 8.—Area irrigated by different sources, total cropped area and percentage of irrigated area to total cropped area in various divisions (as enunciated in the G.G's. proclamation) of West Pakistan.

Divisions	Year	Area irrigated by Sources: Government Canals	Private Canals	Tanks	Wells	Other sources	Total area irrigated	Total irrigated and un-irrigated area (b)	Percentage of irrigated area
		(In thousand acres)							
Peshawar … …	1952-53	479·3	217·4		137·9	12·8	847·4	2,362·3	35·9
D. I. Khan … …	1952-53	136·5	232·1	1·8	47·9	48·8	467·1	2,158·0	21·6
Rawalpindi … …	1952-53	1,320·6	3·5	0·2	223·1	6·3	1,553·7	3,659·6	42·5
Lahore … …	1952-53	1,645·8	2·2	13·0	1,082·5	19·3	2,762·8	3,664·7	75·4
Multan … …	1952-53	5,677·2	…	5·0	653·6	4·7	6,340·5	6,585·3	96·3
Bahawalpur … …	1952-53	2,657·6	…	11·1	397·7	16·2	3,082·6	3825·6	80·6
Khairpur (a) …	1945-46	2,317·2	..	…	10·1	201·1	2,528·4	2,528·4	100·0
Hyderabad … …	1945-46	2,443·8	1.0	..	13·2	974·7	3,432·7	3,432·7	100·0
Quetta … …	1951-52	307·2	103.0	…	..	161·8	572·0	572·0	100·0
Kalat … …	1951-52	…	4.7	..	…	15·9	20·6	20·6	100·0
Karachi … …	1953-54	…	…	…	27·3	24·4	51·7	51·7	100·0
Total West Pakistan		16,985·2	563·9	31·1	2,593·3	1,486·0	21,655·5	28,860·9	75·4

(a) Figures in respect of Khairpur State relate to the year 1952-53.

(b) Figures do not tally with those of Appendix iv because of difference in coverage.

Appendix – 9

DICHARGE DIVISION

Statement showing variation in areas of various depths upto sub soil water-table in Chej and Rechna Doabs worked out from the depth maps of June observations for the years 1892, 1930, 1935, 1940, 1945 and 1950.

Total area of Chej Doab = 3,229,000 acres and of Rechna = 6,1918,000 acres.

Year	Particulars	Areas in acres divided into zones of various depths upto spring levels.			
		0 – 5′	5′ – 10′	10′ – 15′	**Above 15 ft.**
1	2	3	4	5	6
			CHEJ DOAB.		
1892	Areas	...	15,600	281,800	2,931,600
	p.c.		1	9	90
1930	Areas	174,800	1,005,900	860,600	1,187,700
	p.c.	5	31	27	37
1935	Areas	115,300	1,192,700	1,206,300	604,709
	p.c.	7	37	37	19
1940	Areas	211,300	1,279,500	891,300	846,900
	p.c.	6	40	28	26
1945	Areas	310,000	1,490,500	768,800	659,700
	p.c.	10	45	24	20
1950	Areas	226,900	1,663,700	806,000	532,400
	p.c.	7	52	2[illegible]	16

Appendix 10 Rate of soil deterioration in Acres

		1952	1952	1953	1955	1957
1.	Punjab gross area	37,000,000	-	-	37,000,000	37,000,000
2.	Area under plough	12,000,000	-	-	20,000,000	20,000,000
3.	Area under canal irrigation	9,500,000	7,000,000	18,700,000	11,300,000	13,000,000
4.	Moderately salt affected area i	-	4,600,000	4,600,000	46,000,000	5,000,000 & 3,000,000
5.	Seriously salt affected area ii	-	2,300,000	2,300,000	2,300,000	-
6.	Area out of cultivation	-	680,000	200,000	800,000*	1,300,000
7.	Area going out of cultivation annually	-	34,000	-	40,000	70,000**

i contain by unit blocks 0-20% of land with salt on surface.

ii contain by unit blocks 20% of more land with salt on surface.

* Includes unsuitable previously virgin lands.

** Average of the last decade.

Appendix 11

Crops	% of Total Salts	% of ack Kalar	% of Common Salt	% of Glaube Salt
All crops	0.00 to 0.20	0.00 to 0.05	0.00 to 0.125	0.00 to 0.25
All but the most sensitive	0.20 to 0.40	0.05 to 0.10	0.125 - 0.25	0.25 to 0.50
Sugar beet and barley	0.40 to 0.60	0.10 to 0.20	0.25 to 0.50	0.50 to 1.00
Only the most resistant plants	0.60 to 1.00	0.20 to 0.30	0.50 to 0.75	1.00 to 1.50
No plants	1.00 to 3.00	0.30 + above	0.75 + above	1.50 + above

Appendix 12

Blocks	1941 - 45 Kh - Rabi	1945 - 46 Kh - Rabi	1946 - 47 Kh - Rabi	1947 - 48 Kh - Rabi	1948 - 49 Kh - Rabi	1949 - 50 Kh - Rabi
A	F - G/B	C - F	F - W	F - GB	C - F	G(gm) - W
B	F - W	F - G/B	C - F	G(gm) W	F - G/B	C - F
C	F - F	F - W	F - G/B	C - F	G(gm) W	F - GB

C = Cotton. G = Grain. B = Berseem. W = Wheat. F = Fallow.

G(gm) = Guara (green manured). Kh = Kharif.

PROGRESS IN RECLAMATION 1945 - 1956

S.No.	Name of Year	water supply sanctioned (Cs)	water supply utilized in (Cs)	Area put under Rice (Acres)	Area reclaimed during the year (Acres)	Area Reclaimed up-to-date (Acres)
1	2	3	4	5	6	7
1	1945-46	3011.00	2557.70	85421	23086	86007
2	1946-47	3009.65	2615.65	88644	28913	114920
3	1947-48	2683.23	2498.19	73310	29336	143266
4	1948-49	2626.68	2254.47	60520	24164	167430
5	1949-50	2614.85	2345.79	67839	17110	184540
6	1950-51	2387.06	2004.89	55537	22190	206730
7	1951-52	2571.25	2100.85	61644	17399	224139
8	1952-53	3005.80	2554.70	77419	12907	237036
9	1953-54	4159.85	3480.16	172623	26810	263846
10	1954-55	4277.18	3973.77	114687	26240	290086
11	1955-56	3870.08	3514.01	108408	36771	328769
12	1956-57	3492.96	3156.32	96272		
	Total:-	37709.59	33056.41	1062324	264926	328769

Note:- 1. Yearwise figures of the Reclamation operations from 1939 to 1944 are not available.
2. Figures of the area reclaimed transferred to India after partition have been excluded from col. 7 against the year 1947-48.

Appendix - 14

SOILNUTRIENTS REMOVED BY DIFFERENT CROPS.

Crops.	Yield per acre.	Nutrients removed per acre. N.	P.	K.	Ca.	Mg.
		Lbs.				
Maize	3,391	233.2	85.8	271.1	13.2	13.2
Oats	1,606	74.8	15.4	19.8	4.4	6.6
Wheat	1,785	123.2	48.4	74.8	22.0	8.8
Rice (Paddy)	1,963	68.2	22.0	123.2	48.4	..
Soyabean	1,428	308.0	99.0	147.4	11.0	11.0
Lucerne	5,988	345.4	85.8	332.2	299.2	37.4
Red Clover	4,015	198.0	48.4	271.2	149.6	37.4
Tomatoes	19,898	246.4	85.8	431.2	37.4	44.0
Cabbage	29,982	246.4	61.6	266.2	107.8	23.2
Onions	19,988	..	44.0	253.0	66.0	22.0
Potatoes	18,025	308.0	85.8	418.0	6.6	15.4
Apples	19,185	74.8	24.2	85.8	6.6	6.6
Grapes	8,031	61.1	24.2	85.8	4.4	4.4
Oranges	39,975	222.2	74.8	321.1	28.6	11.0
Tobacco	1,428	198.0	48.4	282.8	147.4	22.0
Cotton Seed and lint ..	535	160.6	61.6	123.2	17.6	13.2

Source: "*Efficient use of fertilizers*", *F.A.O.* 1949.

Appendix—15

AREA AND PRODUCTION OF IRRIGATED AND RAINFED WHEAT IN WEST PAKISTAN.

Year	Area Thousand acres			Production Thousand tons.		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
1947-48	6,809	2,962	9,771	2,628	673	3,301
1948-49	7,274	3,317	10,591	3,076	898	3,974
1949-50	7,092	3,244	10,336	2,980	882	3,862
1950-51 ..	7,163	3,636	10,799	3,059	878	3,930
1951-52 ..	6,711	3,433	10,144	2,312	637	2,949
1952-53	6,553	2,878	9,431	2,020	346	2,366
1953-54	6,911	3,515	10,426	2,795	780	3,575
1954-55	7,037	3,513	10,550	2,574	572	3,146
1955-56	7,098	4,094	11,192	2,566	721	3,287
Average ..	6,961	3,399	10,360	2,668	709	3,377

Source:—*Ministry of Agriculture.*

Note.—Separate figures of area for Baluchistan and Khairpur are not available. All the area in these regions has been assumed to be irrigated.

Appendix-16

LAND UTILIZATION.

	Area reported.						Area not reported.	Total Geographical Area.
	Forests.	Not available for cultivation.	Uncultivated land excluding Current fallow.	Current fallow.	Net area sown.	Total.		
	Thousand acres							
East Pakistan ..	5,472	[illegible]465	4,307	1,965	20,096	34,305	631	34,936
Divisions of West Pakistan.								
Peshawar ..	403	1,649	[illegible]	457	[illegible]	[illegible]	11,466	[illegible]
D. I. Khan ..	91	2,778	[illegible]	[illegible]	[illegible]	[illegible]	5,076	[illegible]
Rawalpindi ..	738	1,584	1,100	810	3,5[illegible]	[illegible]	..	7,619
Lahore ..	38	693	[illegible]	[illegible]	[illegible]	[illegible]	150	5,836
Multan ..	39	1,044	4,273	[illegible]	[illegible]	[illegible]		[illegible]749
Bahawalpur ..	300	2,310	4,496	[illegible]	[illegible]	[illegible]	9,890	21,03[illegible]
Khairpur ..	604	3,256	1,280	2,89[illegible]	3,447	9,452	3,202	12,654
Hyderabad ..	709	9,924	3,951	3,549	[illegible]	21,48[illegible]	[illegible]	23,702
Quetta ..	1,140	16,308	961	645	49[illegible]	21,547	3,412	24,959
Kalat ..	899	7,911	3,520	94	11	12,435	47,498	59,933
Karachi ..	..	161	101	17	52	331	166	497
Total West Pakistan.	4,975	49,620	22,992	10,625	27,50[illegible]	115,718	83,088	198,806
Total Pakistan ..	10,447	52,085	27,299	12,590	47,602	150,023	83,719	233,742

Source:—*Provincial Land Record Departments.*

APPENDIX 17

Climatic and Edaphic Control of Plants.

No.	Zone	Station	Rainfall in "			Temperature in °F.		Other sources of Water	Soil	Vegetation	Trees	Cereals	Fruits
			Total Annual	Total-A M.No. R.days.	Heaviest fall in 24 hrs.	M.Max in June	M.Min in Jan.						
1.	Sub-Montane dry steppes	Peshawar	13.56	26.3	5.94	105.0	40.4	Rivers Kabul & the Indus	Padocals, clay and gravelly alluvial detritus, Surrounded by hilly country steep rocky slopes	Dry temperate forest, land merging into semi-desert.	Temperate broad leaved and conifers pine, deodar grass. Mulberry.	a. Wheat) b. Barley) Rabi c. Gram) d. Maize) e. Bajra) Kharif f. Jowar) g. Rice)	Olive Pomegranate Peaches Plums Apples Apricots Melons all kinds Almonds Fig
	plain dry steppes	Lahore	19.21	27.6	8.27	105.9	40.1	Rivers Chenab Ravi & Sutlej	Alluvium Saline Soils Silt Clay Local variations	Sub-tropical savanah	Shisham Babul Butea & willow Tamarix Mulberry.	a. Wheat) b. Gram) Rabi c. Barley) d. Rice) e. Bajra) Kharif f. Maize) g. Jowar)	Mangoes Melons Jaman Citrus fruits pears Guava
2.	Desert	Multan	7.05	12.5	6.87	106	42.0	River Chenab	Sandy Alluvium	Sub-tropical desert	Babul Kikar Acacia Xerophytic Adoptations	a. Wheat) b. Gram) Rabi c. Barley) d. Bajra) e. Maize) Kharif f. Rice) g. Jowar)	Mangoes Melons Citrus fruits Dates
	Desert	Jacobabad	3.60	7.3	4.00	113.9	43.8	Seasonal Streams	Sandy Alluvium	Desert	Cactai Thorn Bushes Xerophytic Adoptations	a. Gram) b. Wheat) Rabi c. Barley) *	Dates Mangoes Guava
	Semi-Arid High Land	Quetta	9.44	24	2.20	91.6	27.6	Under ground water & seasonal streams & winter snow	Padocals Loam in the valleys gravels stony surface scree-limestone	1. Dry temperate mixed forest 2 dry temperate coniferous forests	Pine Evergreen Oak Deodar Low scrub growth is common	a. Wheat) b. Gram) Rabi c. Barley) d. Rice) e. Jowar) Kharif f. Maize) g. Bajra) *Kharif Rice, Bajra Jowar, Maize	Grapes Apples Olive Fig Peaches Plums Pomegranate

Annual Mean No. of Rain Days.

Appendix -18

D[redacted]F PLANT PROTECTION SCHEMES FINANCED JOINTLY BY THE CENTRAL AND PROVINCIAL GOVERNMENTS.

Name of scheme.	Year of commencement.	Cost in rupees.	Crops and area treated.	Estimated Value of crops saved.
Black-headed cricket in Kashirpur Quetta and Kalat Divisions.	1949-50	1,18,800 (5 years)	Over 20,000 acres of wheat and oilseeds, annually.	62,90,000
Fruit pests in Tribal Area of Kurram Agency.	1949-50	42,000	About 84,000 trees treated annually.	4,00,000
Fruit pest control in Peshawar Division	1950-51	2,53,000	About 1,00,000 trees sprayed annually.	50,00,000
Fruit pest control in Quetta Division	1952-53	4,77,000	About 1,00,000 trees sprayed annually.	15,00,000
Insect pest control in East Bengal ..	1950-51	1,75,000 (5 years)	About 6,000 acres of paddy and jute and other crops treated.	Poor progress of the scheme due to lack of tech nical staff.
Insect pest control in Hyd. Div.	1954 55	6,95,000	Recently started.	..