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GROWTH AND DEVELOPMENT OF LYALLPUR CITY[1]

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URBAN Development of Lyallpur can conveniently be considered in three phases—the Initial Stage (1896—1904), the Formative Period (1905—1946) and the Modern Period (1947—1965). During the first the town plan was designed and its main roads were laid out. A *mandi*[2] was created for the distribution of agricultural produce collected from the surrounding district. Some houses and shops were built within the inner ring road. The census of 1901 recorded the population of the town as 9,172.

TABLE 1—GROWTH OF POPULATION (1901-1961)

Years	Total Population	Total Increase	Percent Increase	Years Increase
1901	9,172	—	—	—
1911	19,578	10.407	113.4	1,040.7
1921	28,136	88,658	43.7	855.8
1931	42,922	14,786	52.5	1,478.6
1941	69,930	22,088	63.8	2,700.8
1951	179,144	109,214	154.5	10,921.4
1961	425,248	246,104	137.4	24,610.4

SOURCE : *Lyallpur District Census Report*, Karachi, 1961, Part IV, Table 5, p. 6.

During the second phase, which started with the establishment of Lyallpur District in 1905, Lyallpur was connected more closely with its region by roads and railways (Fig. 1). Its commerce and administrative activities increased, and its population grew to nearly 70,000 by 1941 (Table 1). The town expanded in all directions. The Factory Area, Civil Lines, and several residential localities were established beyond the Circular Road. A number of social institutions such as schools, colleges, hospitals, cinemas, clubs were established. With the creation of Pakistan in 1947,

[1] This article is a chapter from author's unpublished Ph. D. Thesis, *Lyallpur : A study in Urban Geography* (University of London, 1968).

[2] *Mandi* in regional language means market.

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Lyallpur entered upon a period of exceptional growth. Thousands of Muslims immigrated to the city from India, and by 1961, its population considerably exceeded 400,000. Many unplanned residential localities appeared and several planned colonies were constructed. Numerous factories were established all around, and the city sprawled in many directions (Fig. 1).

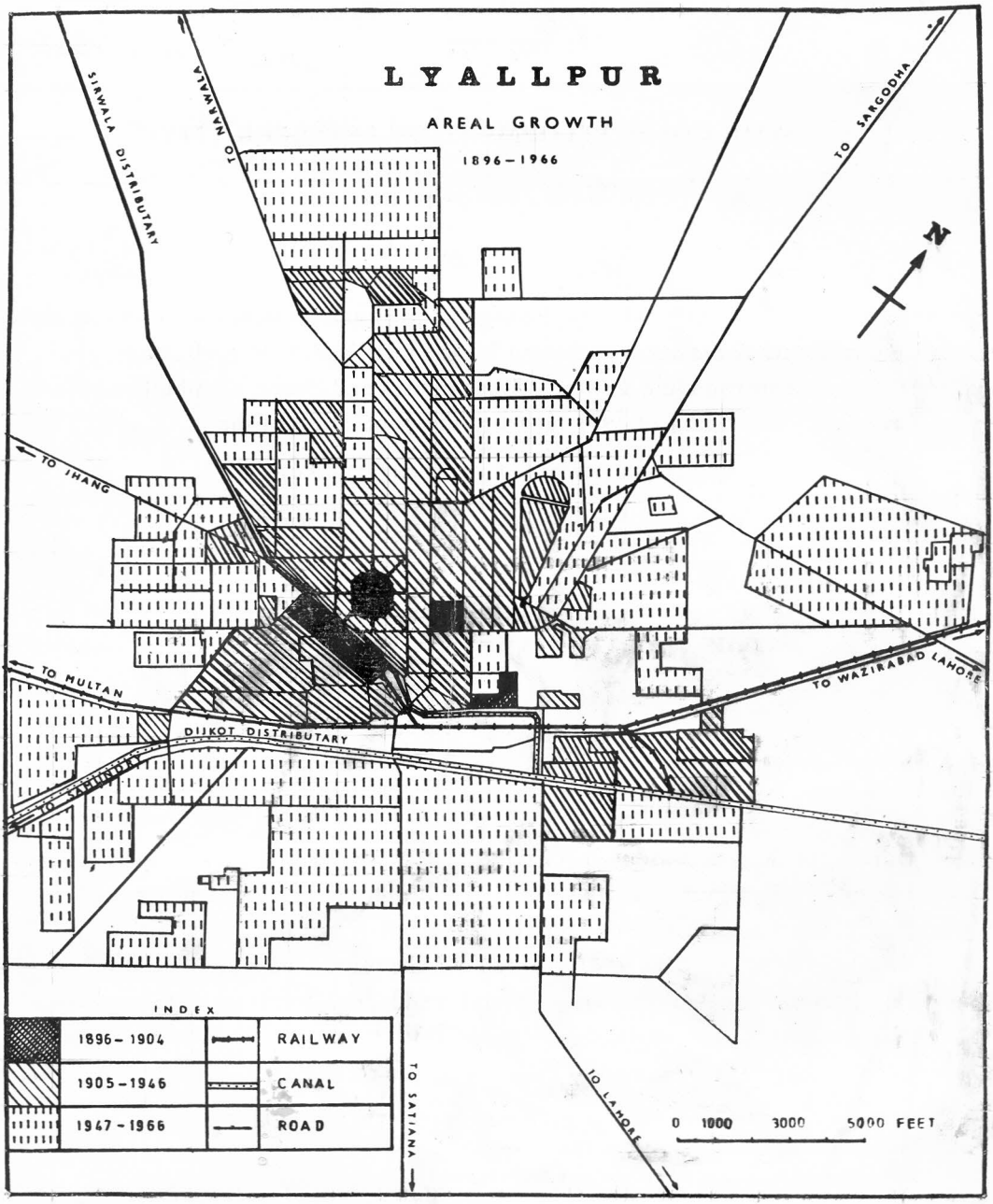

FIGURE 1

The Initial Stage (1896—1904)

The period between 1896-1904 marks the initial stage in the development of Lyallpur. The town was laid out in 1896, over an area of 110 acres. The salient features of this plan have already been described. A number of unmetalled roads radiated from Lyallpur in all directions towards Chiniot in the north, Jaranwala in the east, Samundri and Satiana in the south-east, Jhang and Bhowana in the west (Fig. 2).

The development started around the Clock Tower and remained confined within the inner ring. The buildings consisted of un-baked brick houses, which were constructed either by the business men or by those who came to Lyallpur as speculators, "at the Colonization Officer's invitation".[3] Several sites were purchased by capitalists, who resided elsewhere in the colony and who constructed houses and shops merely for letting. These buildings were looked after by their agents, who did not pay proper attention to their care and maintenance. As the pressing demand for housing enhanced the rental value the owners of the sites, looking to the rent which they could command, generally attached more importance to the number of houses they could build than to their quality. 'Consequently bad houses and the high rent became a rule'.[4] The authorities did not interfere because 'in His Honour's opinion they required fostering'[5] Otherwise they might go away.

Under these circumstances the town was developing in a settlement of kachcha (mud) houses and shops, with unpaved narrow streets without lighting or sanitary arrangements.

Feeling the urgency of management and improvement into the affairs of the town, the Colonization Officer wrote to the Deputy Commissioner, Jhang, 'Lyallpur is essentially a town of the future and to leave it to grow in a way natural to the oriental township would be analogous to leaving the whole body of colonists to irrigate as they pleased and cultivate where they chose and to invite every species of abuse'.[6]

Immediately after receiving these remarks from the Colonization Officer, Lyallpur was granted status as a second class municipality in 1898, and from then conditions began to improve. The municipal authority worked quite diligently and

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[3]Letters No. 107 dated 20th April, 1898 from W. Fenton, Esqr. Revenue Secretary to the Government of Punjab, to the Secretary to the Government of India, Revenue and Agriculture Department.

[4]Letters of K.M.B. Ghulam Bari, President, Municipal Committee, Lyallpur to A.A M.V. Michell, Esq , Deputy Commissioner, Lyallpur, dated 1927—29th March.

[5]Letter No. 107, *op. cit.*

[6]Letter No. 1207, dated 23rd December, 1897 from the Colonization Officer, Chenab Canal to Deputy Commissioner, Jhang.

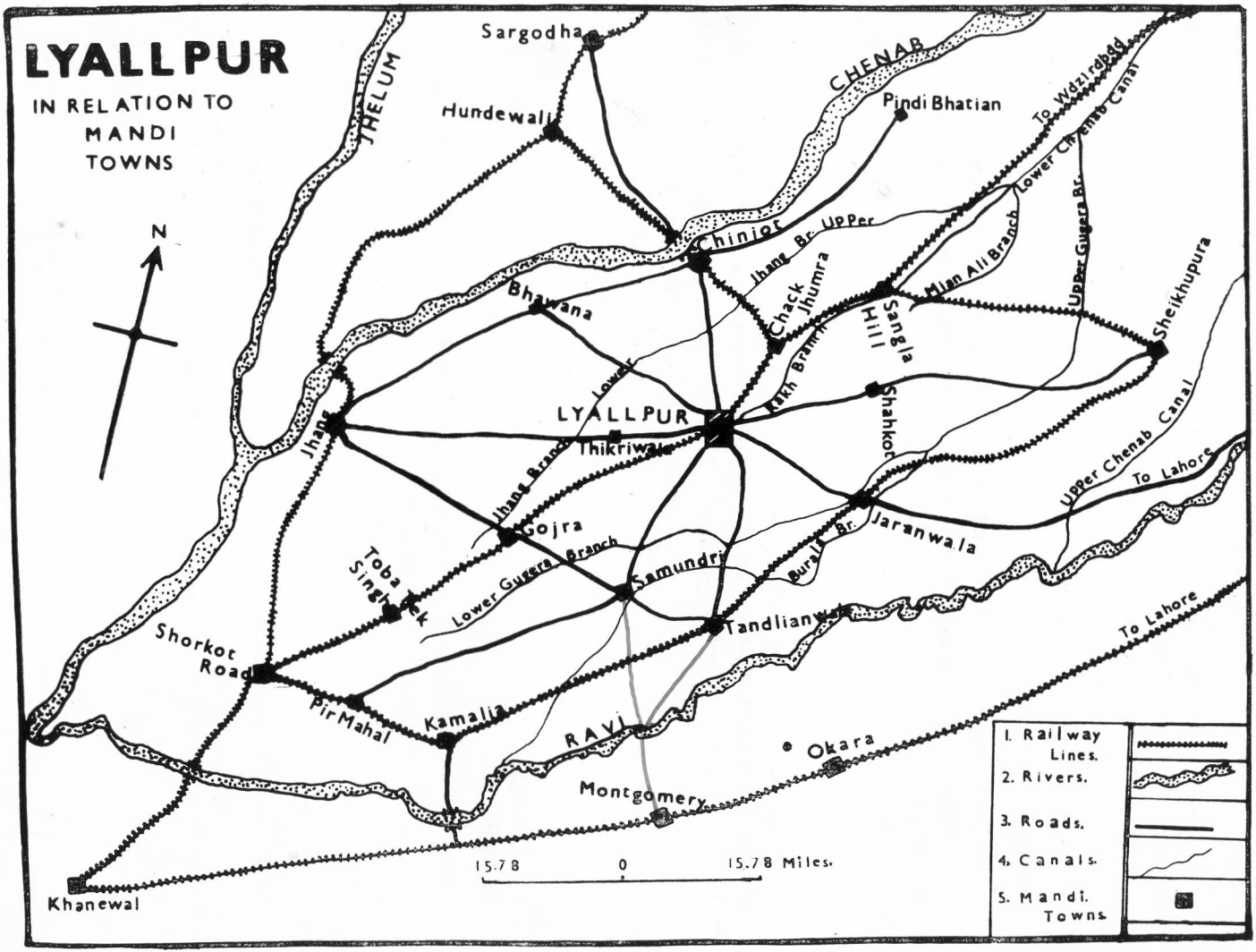
LYALLPUR
IN RELATION TO
MANDI
TOWNS
N
Sargodha
Hundewali
JHELUM
CHENAB
Pindi Bhatian
To Wazirabad
Lower Chenab Canal
Chiniot
Jhang Br. Upper
Upper Gugera Br.
Mian Ali Branch
Bhawana
Chack Jhumra
Sangla Hill
Sheikhupura
Lower
Jakh Branch
LYALLPUR
Thikriwala
Shahkot
Jhang
Jhang Branch
Upper Chenab Canal
To Lahore
Gojra
Jaranwala
Toba Singh
Lower Gugera Branch
Samundri
Burala Br.
Tandlianwala
To Lahore
Shorkot Road
Pir Mahal
Kamalia
RAVI
Okara
Montgomery
15.78 0 15.78 Miles.
Khanewal
1. Railway Lines.
2. Rivers.
3. Roads.
4. Canals.
5. Mandi Towns.

FIGURE 2

within a short period all eight radiating roads were metalled and proper lighting facilities were provided. The roads were named *Kutchery*[7] Bazar, Rail Bazar, *Karkhana*[8] Bazar, Montgomery Bazar, Jhang Bazar, Bhowana Bazar, Aminpur Bazar, Chiniot Bazar (Fig. 3).

A grain market was constructed between the Rail Bazar and Karkhana Bazar. On account of its proximity to the Railway Godowns, the place enjoyed adequate facilities for the collection and distribution of agricultural products. Shops surrounded it on all four sides. They were used as ware-houses. Some of them were occupied by the commission agents and *Artis* (Brokers) for displaying samples. A *sarai* (Rest-House) was constructed close to the markets to provide accommodation for villagers visiting the town to sell their produce.

Another notable construction was a gate, the Qaisri gate at the end of the Rail Bazar. Beyond the planned zone a few isolated buildings were constructed. In 1896 a railway line was laid between Wazirabad and Lyallpur, and it was extended to Khanewal in 1900 to join the main railway line between Lahore and Karachi. The railway station was established about one mile east of the Clock Tower on the Lyallpur-Lahore road. Close by a few bungalows for officers and quarters for the lower staff were built. Alongside a railway siding south of the railway station were established the railway godowns, sheds for the storage of grains and other produce. Further south were a few factories, for cotton ginning, cotton pressing, oil milling, and flour milling. Some unauthorized kachcha (mud) houses were also constructed here and there by the mill workers.

A large bungalow, about half a mile north-east of the railway godown on the Lyallpur-Chiniot Road, was shared by the Colonization Officer and Executive Engineer of the Lower Chenab Canal for their residential and official uses. It also contained a few servant quarters, where other employees of the canal department lived.

A water supply system was established by the municipality. Under this system two water reservoirs were built along the Rakh Canal with a storage capacity of 4,800,000[9] gallons. The water was distributed throughout the town and the railway station by means of stand pipes, which were also used to flush the drains.

The drainage system of the town was also completed by the municipality during this period. Under this scheme, the internal small drains of the central plan intercepted the major public drain of the town which passed by the side of the

[7] *Kutchery*—in local language it stands for court.

[8] *Karkhana*—means factory.

[9] *Chenab Colony Gazetteer, 1904*, Vol. 31 A-(Lahore 1907), p. 150.

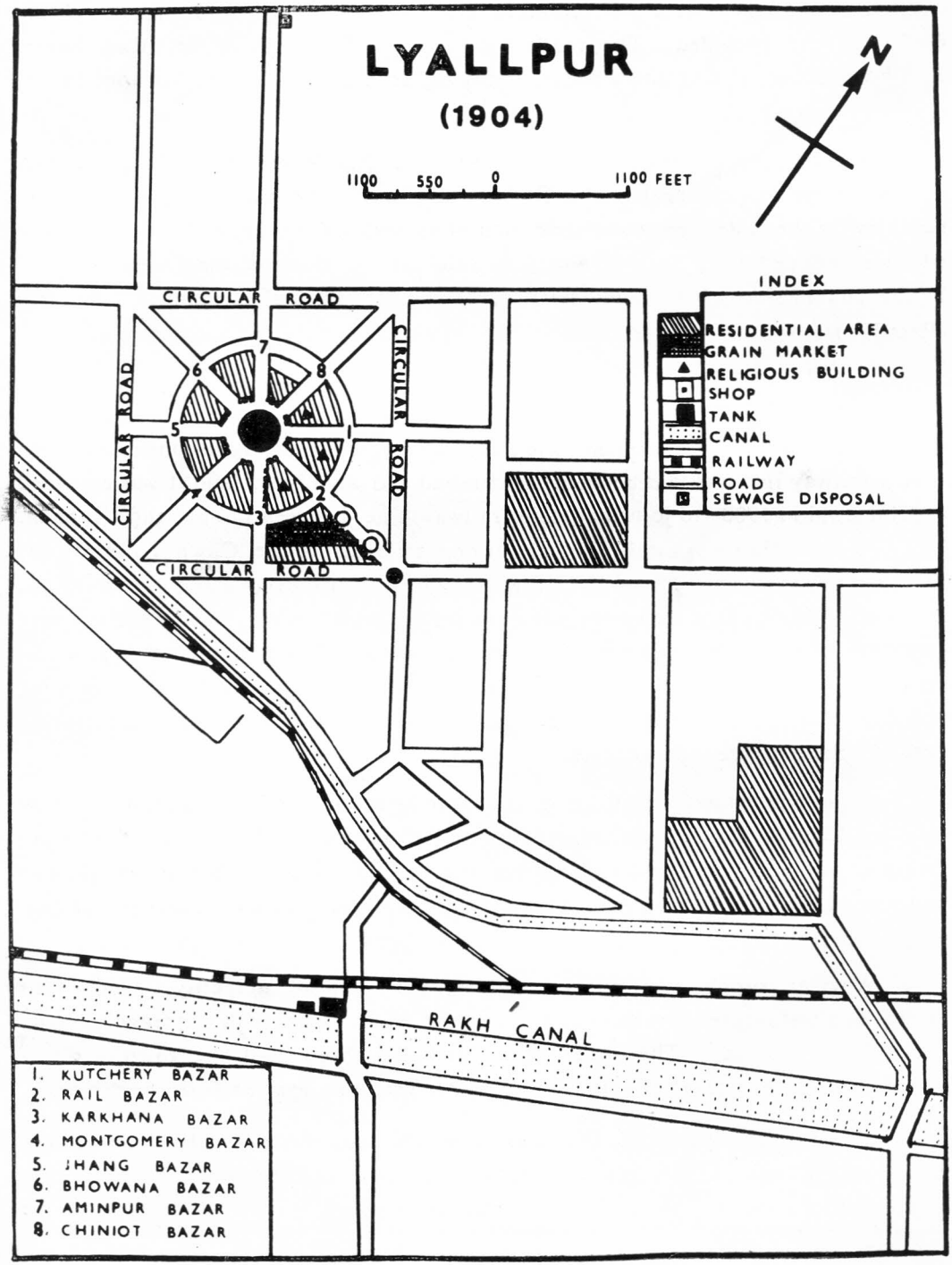
LYALLPUR
(1904)
1100 550 0 1100 FEET
N
INDEX
RESIDENTIAL AREA
GRAIN MARKET
RELIGIOUS BUILDING
SHOP
TANK
CANAL
RAILWAY
ROAD
SEWAGE DISPOSAL
CIRCULAR ROAD
CIRCULAR ROAD
CIRCULAR ROAD
CIRCULAR ROAD
RAKH CANAL
1. KUTCHERY BAZAR
2. RAIL BAZAR
3. KARKHANA BAZAR
4. MONTGOMERY BAZAR
5. JHANG BAZAR
6. BHOWANA BAZAR
7. AMINPUR BAZAR
8. CHINIOT BAZAR

FIGURE 3

circular road. This main drain deposited the sullage water in a tank on the Aminpur road. From here it was pumped out for irrigating the agricultural farms in the north-west of the town.

According to the census of 1901, the town supported 9,171 persons, a large majority of them males (6,643).[10] They comprised three religious groups, Muslims, Hindus and Sikhs. They were Muslims 4,434 (48.4%), Hindus 4,240 (46.2%), and Sikhs 498 (5.4%). Each community lived in separate sections, as is evident by the location of their religious buildings. The Muslims lived in the sector formed by the Kutchery and Chiniot Bazars, where a magnificent mosque stands. Hindus lived in an area between the Kutchery and Rail Bazars and the Sikhs lived between the Rail and Karkhana Bazars. The Hindus' temple and Sikhs' Gurdwara were built in their respective sectors.

The Formative Period (1905—1946)

The constitution of the District of Lyallpur in December, 1904 enhanced the importance of the town, which was declared its headquarters. Various buildings housing the judiciary, administrative and civil departments were constructed and a marked rapid growth of residential bungalows and quarters for the Government Officers and subordinate employees took place.

To facilitate administrative control, the town was connected by roads with all the villages, *tehsils* and other settlements of the district, and the flow of agricultural products was thus greatly facilitated. Several industries processing the agricultural raw materials were established. There also came into existence certain social centres, such as educational institutions, hospitals, recreational parks, cinemas and a public library. More residential buildings and shops were built upon the area included within the central plan of the town. Retail shops were constructed on both sides of the roads radiating from the Clock Tower. A few sections of the inner ring road (locally called the *Gol*[11] Bazar) were developing as the centre for the wholesale business. As the already existing wholesale shops of wood, salt, hides and skins attracted more and more dealers in the similar trade, these sections of the inner ring road emerged as full-fledged wholesale markets. The *Lakkar Mandi* (wood market) grew in between the Karkhana and Montgomery Bazars. The *Namak Mandi* (salt market) is situated in between the Jhang and Montgomery Bazars, and the *Chamrah Mandi* (hides and skins market), between the Chiniot and Aminpur Bazars (Fig. 4).

The development of the administrative offices and houses for officers took place north-east of the town plan, in the area known as the Civil Lines. It covered

[10] *Census of India*, 1901, Punjab Province, Vol. 27, Parts 1 & 2.

[11] *Gol*—means circular.

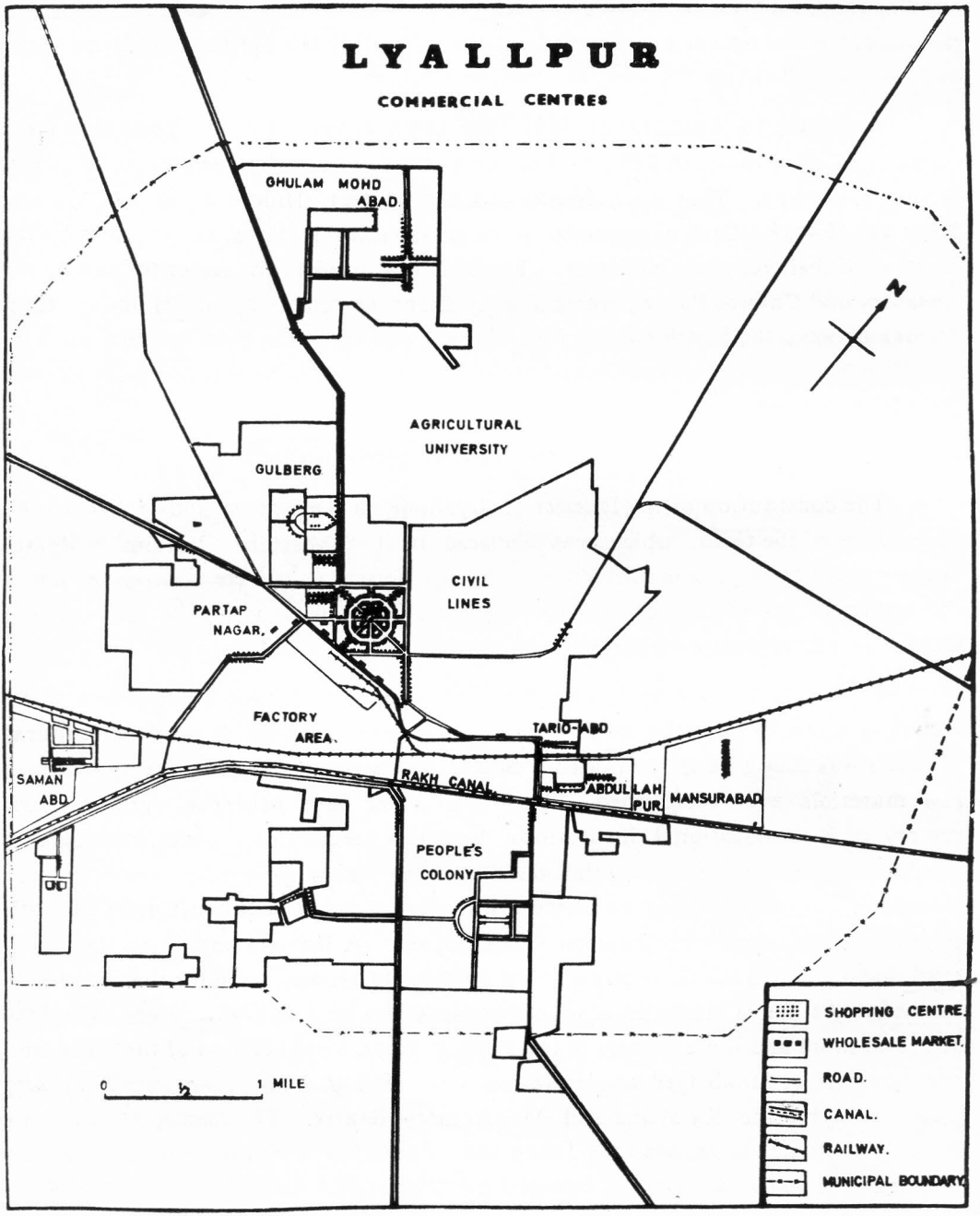
LYALLPUR
COMMERCIAL CENTRES
GHULAM MOHD ABAD
AGRICULTURAL UNIVERSITY
GULBERG
CIVIL LINES
PARTAP NAGAR
FACTORY AREA
TARIQ ABD
SAMAN ABD
RAKH CANAL
ABDULLAH PUR
MANSURABAD
PEOPLE'S COLONY
N
0 ½ 1 MILE
SHOPPING CENTRE
WHOLESALE MARKET
ROAD
CANAL
RAILWAY
MUNICIPAL BOUNDARY

FIGURE 4

an extensive tract, roughly bounded at the present time by the Jail, Circular and Chiniot Roads.

In the extreme north-west of this area were constructed the agricultural college buildings, consisting of a number of offices, departmental buildings, experimental centres, laboratories, hostels and bungalows for the teaching staff. Large playgrhunds and experimental fields were attached to the college. The Police Department and the District Jail were accommodated in two prominent buildings farther south. Adjacent to the former were a few barracks for the lower staff and recreational and parade grounds were also developed there (Fig. 5).

Next to it, were constructed the buildings of the Post and Telegraph Departments, which included an office and a number of officers' bungalows with some lower staff quarters. Adjacent to this was built the District Courts compound. Within this spacious compound were provided the separate office buildings for the Deputy Commissioner, Session Judge, Magistrates, Treasurer and a temporary prison house. In the centre were built a few sheds for lawyers and a small building for their social gatherings.

South of the District Courts were built a Central Police Station, Offices of the Tehsildar and his staff, a public library and a hospital with a few staff quarters. Further south were constructed the buildings of the Canal Irrigation Department, which included their office building and a number of quarters for the employees. Beyond the canal colony were constructed the offices and a rest house of the Public Works Department.

North of this administrative block ran a straight road beyond which were constructed the bungalows of the Civil Officers. The buildings of the Imperial Bank of India, the Minerva Club and the Chenab Club were the only non-residential buildings in this sector. Large open spaces were provided for recreational purposes.

Along the college road was developed a small park. About half a furlong north of the park was developed another park, which is presently known as the Company Bagh.[12] Further north was reserved a large open space as a Race Course Ground. To the north and east of the race cource, several sites were sold out for residential buildings. Some persons constructed their bungalows, but the majority left them unbuilt, in order to sell them with profit in the future. The entire sector was planned on a grid pattern with rows of trees along both sides of the roads, which added beauty and a new form to the town.

[12] *Bagh*—means garden.

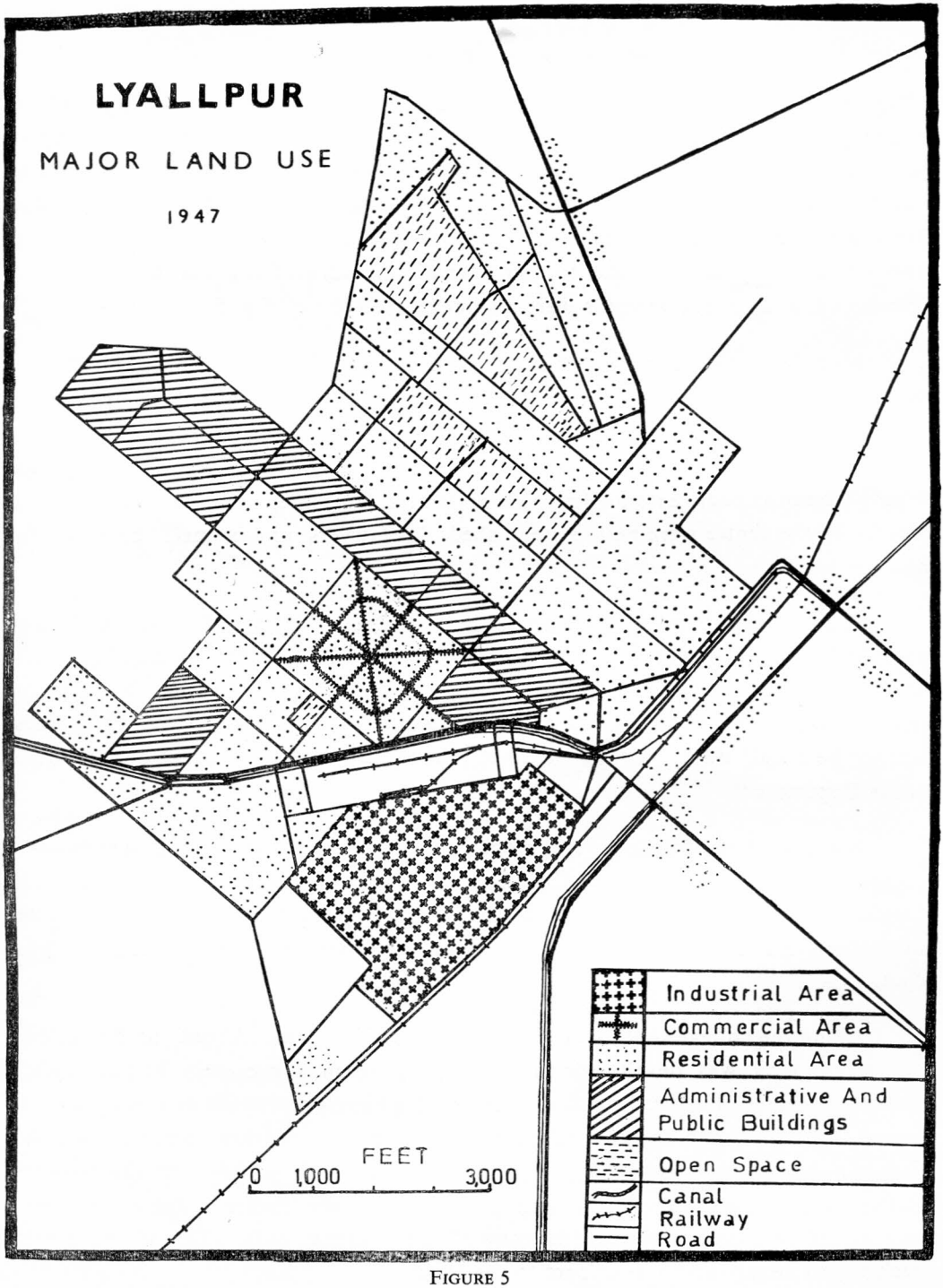
LYALLPUR
MAJOR LAND USE
1947
Industrial Area
Commercial Area
Residential Area
Administrative And Public Buildings
Open Space
Canal
Railway
Road
FEET
0 1,000 3,000

FIGURE 5

Contiguous to the Civil Lines and close to the Railway Station was the Railway colony, with bungalows for the superior staff, a rest house and a hospital with large open grounds, as well as some quarters for the lower staff, though most of these were constructed on the other side (south east) of the railway line.

Four cotton ginning, pressing and baling factories were already in existence south of the Railway Goods Yards. Several sites were vacant which were sold to the industrialists on subsidiary rates. They were "debarred from using them for any purpose other than that for which they were sold and more particularly from erecting on them dwelling houses, shops, etc".[13]

Thirteen new factories were established. The major one was a Cotton Textile mill, which is at present called the Lyallpur Cotton Textile Mills. The others dealt with flour milling, cotton ginning, pressing, vegetable oil and ghee mills. In addition to these factories a grain elevator was also erected near the Railway Godowns.

The town also expanded towards the west, with residential localities for the growing population. Close to the plan were established a few *mohallas*[14] called as Dauglaspura, Santpura, *Gujjar Basti*, Dhobi Ghat and Guru Nanakpura. The houses in these mohallas were double storeyed and were constructed with baked bricks, similar to those that already existed within the circular road of the plan. Further west were constructed Gobindpura, Madanpura, Chuhar Majra, Mohammadpura, Partap Nagar, Harcharn Singpura, and *Kachchi Abadi*.[15] In all those localities the houses were single storeyed and *semi-pucca*[16] in nature except Kachchi Abadi, where all the houses were mainly composed of mud walls.

Social institutions such as schools, colleges, health-services and cinemas were established in a scattered manner. The present M.B. School, Muslim School Tariqabad, M.B. Girls' School and College, Government College for Boys, Khalsa College, Coronation and Municipal libraries, Civil, Railway and Mission hopitals along with municipal dispensaries, Minerva, Nishat and Regal cinemas owe their origin to this period.

The Modern Period (1947—1965)

Following the establishment of independent Pakistan in 1947, Lyallpur grew as an industrial and commercial centre from 75,000 to 425,000 by 1961 (Table 1).[17]

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[13]Letter No. 2245, dated 31st August 1900, File No, 13, February 1902, Revenue (General) Department, West Pakistan Civil Secretariat.

[14]*Mohalla* and *Basti*—mean locality.

[15]*Kachchi Abadi*—means locality consisting of mud wall houses.

[16]*Semi-pucca*—mean the walls of the houses mixed with mud and brick.

[17]*Historical Development of the City of Lyallpur*, unpublished article, Town Planning Department, Lyallpur, p. 2,

In the four years after 1947 about 56,354 (seventy-four percent) non-Muslims left the city and went to India, but three times as many Muslims (160,359) came into the city from there. Thereafter the wave of immigration of Muslim refugees slowed down, but a large number of villagers came to the city in search of jobs. The total increase between 1951-1961, 350-109, was the highest percentage among the major cities of West Pakistan (Fig. 6).

The number of houses vacated by the non-Muslims was far too few to meet the demand, and a number of new residential areas were created and the municipal area was trebled in extent nearly to ten square miles and was further extended in 1958 to cover almost thirty square miles.[18]

The extension of the built-up area took place by encroaching upon open spaces within the city and especially by spreading over large tracts of agricultural land on the outskirts. Four types of residential area were developed :

1) Government planned colonies, where plots were allotted to individuals for building their own houses.
2) Government planned colonies, with houses constructed by the Government for the refugee families.
3) Private colonies, developed without any planning on agricultural land.
4) Unauthorized construction of mud-wall Kachcha houses and huts on the Government lands.

The first residential locality under category 1) established in 1947-48 in the west of the city along the circular road was named 'Model Town', the roads and other utility services being provided by the Government. Back to back houses, consisting of three or four rooms were characteristic. South of Model Town, Jinnah colony and Gulberg colony had more spacious, double-storeyed houses, with four or five rooms. One mile south-west of the Clock Tower, near the existing mohallah of Partap Nagar, was established Nazamabad colony.

Here individual allottees constructed their two room quarters. Along the Lahore Road, nearly two miles east of the city centre, the People's colony, a high class residential locality, was established, with spacious plots of various sizes containing bungalows of six or seven rooms and large grassy lawns. This colony was further extended in the south as far as the Cattle Fair Ground, with mostly double storeyed houses. In 'Batala Colony', joining this colony area in the south to the Samundri Road, the houses were either single or double storeyed and contained four to five rooms.

[18]Z.A. Khan, *Lyallpur : The Impact of its Growth on Urban Morphology*. A paper presented to the 16th Annual Pakistan Science Conference, p. 5.

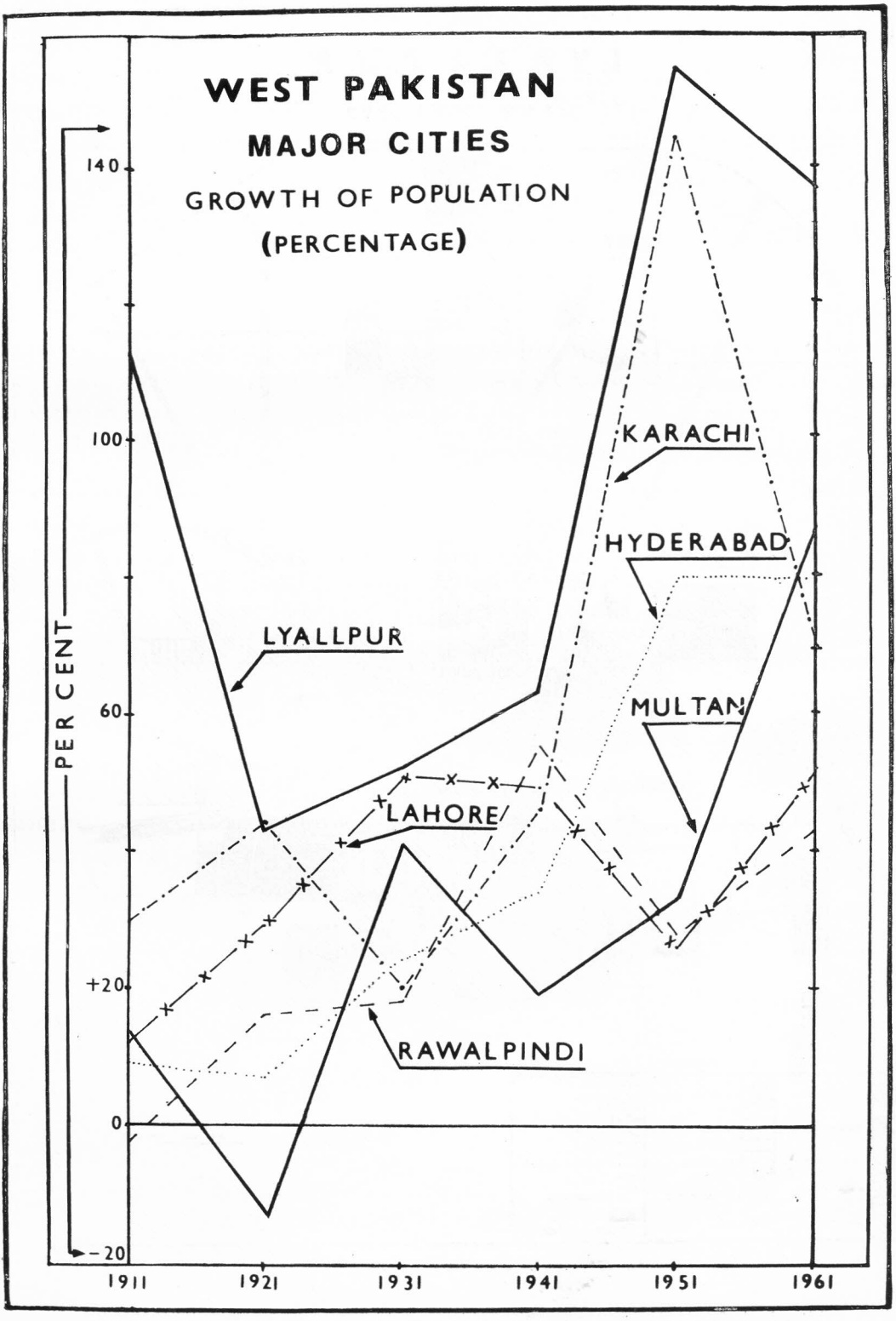
WEST PAKISTAN
MAJOR CITIES
GROWTH OF POPULATION
(PERCENTAGE)
PER CENT
140
100
60
+20
0
-20
1911
1921
1931
1941
1951
1961
KARACHI
HYDERABAD
LYALLPUR
MULTAN
LAHORE
RAWALPINDI

FIGURE 6

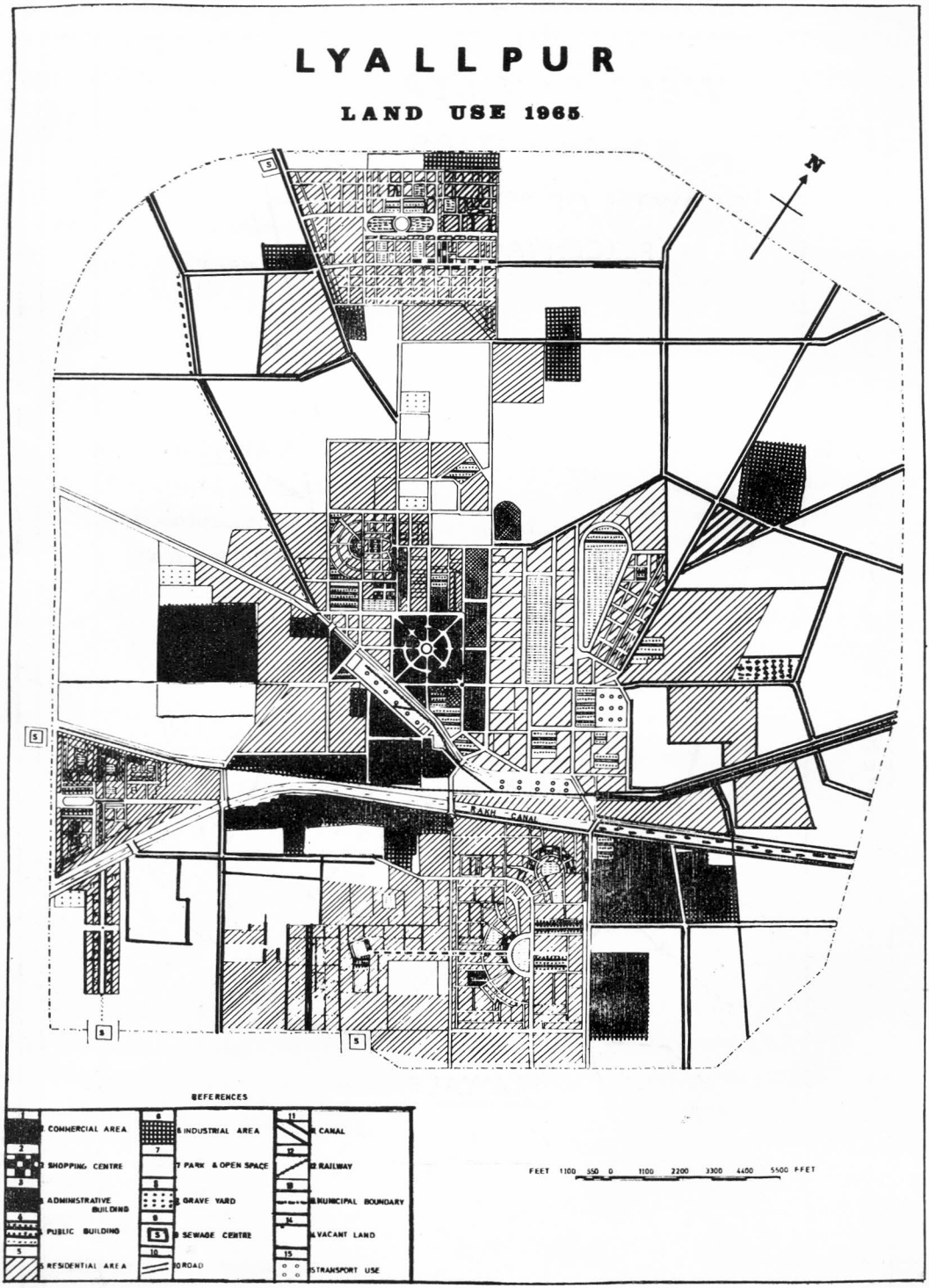
LYALLPUR
LAND USE 1965
N
RAKH CANAL
REFERENCES
1 COMMERCIAL AREA
2 SHOPPING CENTRE
3 ADMINISTRATIVE BUILDING
4 PUBLIC BUILDING
5 RESIDENTIAL AREA
6 INDUSTRIAL AREA
7 PARK & OPEN SPACE
8 GRAVE YARD
9 SEWAGE CENTRE
10 ROAD
11 CANAL
12 RAILWAY
13 MUNICIPAL BOUNDARY
14 VACANT LAND
15 TRANSPORT USE
FEET 1100 550 0 1100 2200 3300 4400 5500 FEET

FIGURE 7

The colonies of the second type also grew up in a scattered manner, the largest of them, Ghulam Mohammad Abad colony, about three miles north-west of city centre. Here the Government constructed two-room quarters for lower income group occupants. Colonies of similar type were Samanabad (Labour colony) and D-type were established about two and a half miles south of the Clock Tower.

Like the residential areas industrial development took place indiscriminately all around the city, but factory location was confined to the lines of the major highways, the Kohi-Noor Textile mills (the largest) and a few other silk and rayon and woollen mills, as well as dyeing, calendering and chemical works along the Lahore Road, some cotton textile, silk and rayon and nylon mills, a sugar factory, a hardboard factory and a few chemical, ghee and foundry establishments along the Sheikhupura road ; and some other cotton textile mills along the Chiniot and Jhang roads. The last named road also had some foundries (Fig. 7).

As a result of the proliferation of textile mills a number of wholesale cloth markets were established in the city. The largest was the 'Gol Cloth Market', situated along the inner ring road (between the Kutchery and Rail Bazars). Here the ground floors of older buildings were converted into wholesale shops. Other cloth markets were established elsewhere alone the inner ring road.

As the city grew rapidly after 1947 more administrative and social centres were established. Most of the administrative offices were housed in residential bungalows vacated by the non-Muslims chiefly in the Civil Lines area. The settlement and rehabilitation deparmental offices were housed on the College road and the taxation offices on the Chiniot road. Some offices were located in the new developing townships. In Model Town were established the offices of the Income Tax department, in Jinnah colony, Labour Settlements and Rehabilitation, Town Master Plan project offices, and in the People's colony, Income Tax, Town Planning and Settlement offices.

CROPPING PATTERN AND CROP ASSOCIATIONS IN WEST PAKISTAN

K. U. KURESHY

AND

M. K. ELAHI

THE study of agricultural regions and their crop associations has been one of the main trends in regional economic studies during the thirties of the present century and later.[1]

In the developing country of Pakistan, argiculture forms the back bone of its economy contributing 45.8 percent of the Gross National Product.[2] Greater agricultural efficiency in order to achieve self sufficiency in food has been the main drive in this sector of the country's economy for the last few years. The future of

[1]As noted by Whittlesey in his article of 1936. The first map of agricultural regions of the world was prepared by him in collaboration with Wellington D. Jones in 1926. This was later revised and published in 1932. According to Whittlesey agricultural type occupance has been classified on the basis of five criteria. Thirteen types of agricultural associations based on the predominent land use pattern have been mapped, of which seven are of primary importance. Quantitative and empirical values have been used to indicate the relative importance of crops.

Clarence F. Jones developed his series of seven articles concentrating on the Agricultural Regions of South America. Griffith Taylor, S. V. Valkenburg and Olaf Jonasson wrote a series of papers on the Agricultural Regions of Australia, Asia and Europe respectively. H.L. Shantz worked on similar lines on the continent of Africa.

In all these works, the acreage ratios have been used as the main index to the significance of predominent types of land use and cropping pattern. Generalisations in the cropping pattern have been made on the basis of prevalent land use in the region.

Richard Hartshorne and Samuel N. Dickens have closely followed Wellington D. Jones in selecting the limiting isopleths, based chiefly on crop acreages. Value of production according to Hartshorne could also be used as an index to determine the relative importance of crops, but these values fluctuate much more violently than acreages. Acreage as an index is even more significant in regions of stabilised agriculture, as in western Europe.

Works of this nature on Indo-Pakistan sub-continent are very few. M.K. Elahi has worked on Efficiency of Agriculture in West Pakistan on the basis of 10 year average yields of nine crops and cropping intensities on district basis. Among some of the recent works is the article on "Patterns of Crop Concentration and Diversification in India" by S. S. Bhatia. Acreage under various crops has been used as the main criterion. The author has been quite successful in showing the relative importance and degree of concentration of individual crops. The map showing crop diversification only depicts its degree. On the same basis, a final map showing the crop pattern could have been developed.

[2]*Pakistan Economic Survey, 1967-68* (Islamabad, Ministry of Finance), p. 3.

Dr. Kureshy is Professor and Head, and Dr. Elahi is Associate Professor in the Department of Geography, University of Punjab, Lahore.

agriculture poses a serious problem for the fast growing population as a source of livelihood, food supply and industrial raw materials. It is towards this measure of greater efficiency that it becomes useful to study the spatial distribution of various phenomena related to agriculture vis-a-vis land use and cropping pattern.

This paper seeks to record the cropping pattern in West Pakistan. For mapping this significant aspect of land occupance statistical approach along with field studies has been adopted. Multiple criteria have been used to depict the areal differences of degree of concentration of a crop in a unit area and its regional importance. The criteria selected for the present treatment are :

1) The acreage under a crop as percentage to total cropped area, by tehsils ;[3]
2) The acreage under a crop in a tehsil as percentage of total acreage of that crop in West Pakistan ; and
3) Yield per acre.

The first criterion establishes the relative importance of various crops in each tehsils, but in some cases fails to assign the correct relative status to an area in the total set up. For example Loralai and Quetta districts of Baluchistan plateau show exceptionally high ratios of 59—100 percent of cropped area under wheat and thus would fall in the highest category along with some of the best irrigated wheat producing areas of Lyallpur and Jhang. The high ratio in the former hilly areas is because, except in a few irrigated patches, no other crop is grown successfully. But in these areas the total acreage under wheat is very small. Similarly, this single criterion would depict the whole of Potwar more important than even the canal colonies. In order to rectify this false impression the second criterion on the basis of the share of each tehsil in the total acreage of that crop in West Pakistan has been included so that a *tehsil* as a producer of a particular commodity may as well be judged in the total regional context of West Pakistan.

The third criterion used is the yield per acre. In ascertaining the relative importance of a crop, intensity of production per unit area is a good indicator of the physical and cultural conditions prevailing in that area. In the event of non-inclusion of this criterion, certain anomalies will bound to crop up in our area of study. For example, all the Potwar districts, with large *barani* (unirrigated) acreage under wheat, and low production per unit area, will rank higher than some of the best irrigated wheat lands in West Pakistan.

The values obtained for a crop on the basis of each of the three criterion have been ranked[4] and the ranking coefficient calculated by dividing the total value of ranks by the number of criteria, namely three. For individual crops, these values have been grouped in quintiles. Thus a distributional map for each of the ten crops (wheat, rice, cotton, sugarcane, millets, gram, maize, barley, pulses and oilseeds) has been prepared depicting areas under five orders the lowest ranks showing the highest order (Figs. 1-10).

[3] *Tehsil* is an administrative unit of the fourth order after province, division and district.
[4] The highest ratio ranked as 1.

The number of unit areas for which data are available is 167 each quintile therefore includes 32-33 cases. This number is not strictly adhered to allowing deviations in special cases, as the dividing line is drawn after giving due consideration to changes in values *e.g.* in case of rice the ranking coefficients for the first thirty-three cases range from 7.6—16.6 but Ghorabari *tehsil* of Thatta district with a ranking coefficient of 17.6 has been included in the first rank for reasons 1) homogenity of the area around and 2) the ranking coefficient of the *tehsil* under discussion being 17.6 while the next value is 19.6. This *tehsil* therefore shows greater compatability in land occupance with areas included in the first order.

The values have been plotted on the sizable compact major cultivated areas as against the total area. Its main utility is manifest in hilly and desert regions where the extent of cultivated land is highly limited. In such areas if the total land is shaded on the map, the visual impression becomes erroneous, unduly inflating the importance of the areas of patchy cultivation, in the total complex. No statistics are available for tribal areas and northern hilly areas of Dir, Swat and Chitral. Therefore, these areas have been excluded from the area under study.

The final map depicting dominant cropping pattern has been prepared showing the two most important crop combinations. For the preparation of the final map of crop associations, based on the ten maps of individual crops, areas under different crops, falling under a given quintile are treated as of the same rank *e.g.* areas falling in the first quintile in the map showing cropping pattern of wheat and cotton are considered to be areas where both crops are of equal importance. In cases where an area under wheat falls in the first quintile, of sugarcane in the second quintile, of cotton in the third or fourth quintile the area is marked as wheat-sugarcane area, wheat being of primary importance. Similarly if in an area the order of the crops according to the cropping pattern maps (Figs. 1-10) is wheat 1, rice 2, cotton 1, sugarcane 3, the area is marked in the final map, giving dominant crop pattern, as wheat-cotton area.

In cases where more than two crops fall in the highest order due consideration is given to the value[5] of crops in the final crop association.

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[5]Value index has been prepared on the basis of five year average market prices of various crops (1959—64) calculated on the basis of five years average yield. Finally, value of wheat/acre has been considered as one unit. Accordingly relative indices have been prepared for various crops. Value has, therefore, been used in relation to both acreage and yields *e.g.* Tehsil Toba Tek Singh of district Lyallpur has wheat, cotton, and sugarcane in the first quintile with following acreage ratios:

Wheat	42.6% of sown area of tehsil	1
Cotton	10.8% of sown area of tehsil	2.24
Sugarcane	7.2% of sown area of tehsil	6.2

Obviously sugarcane would deserve preference over cotton for its high value and the tehsil would be showing a crop combination of wheat-sugarcane.

Though it is almost impossible to depict the total concept of reality on a map, the authors have been successful in mapping the cropping pattern of individual crops and the crop combination as near to reality as possible.

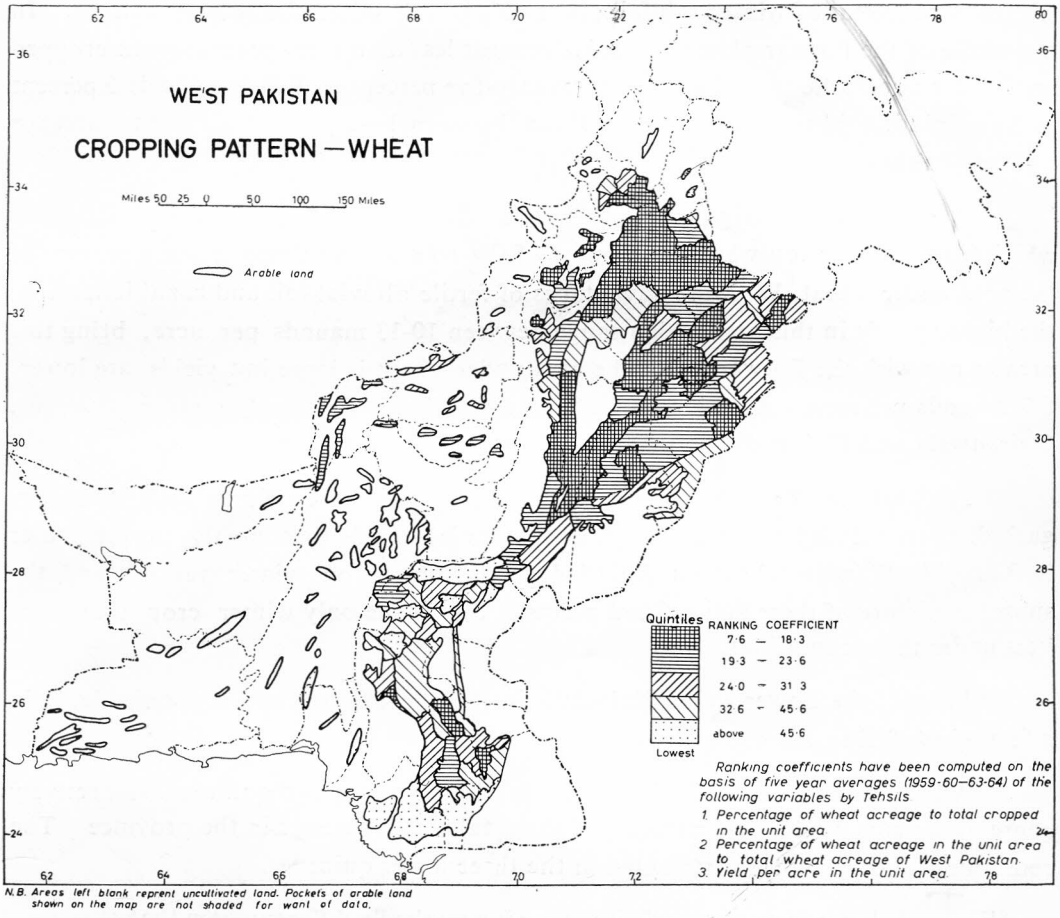


FIGURE 1

CROPPING PATTERN

Figure 1 shows the cropping pattern of wheat, with no generalisations applied at this stage. It brings out three prominent wheat areas in West Pakistan, all of which lie in the Upper Indus Basin :

1) Potwar and the adjacent area including parts of Mardan and Peshawar districts.
2) Canal irrigated areas in parts of Jhang, Sargodha, Multan and Lyallpur districts.
3) The non-perennial canal irrigated areas of D.I. Khan, D.G. Khan and Muzaffargarh districts.

1) Potwar and the adjacent areas of Swabi *tehsil* of Mardan, and Nowshera *tehsil* of Peshawar and parts of Bannu district form the major top wheat producing region in the north. This is mostly a *barani*[6] wheat area. This sub-montane region with a fair amount of winter rainfall (about 6″) is well suited for wheat culture. In the whole of the Potwar plateau no *tehsil* records less than forty percent of the cropped area under wheat, the range being from seventy-five percent in Tallagang to 41.3 percent in Rawalpindi. Most of these *tehsils* share between 1—2 percent of wheat acreage of West Pakistan.

2) In the canal irrigated areas of Jhang, Sargodha, Multan and Lyallpur which form another top wheat area, most of the *tehsils* have thirty to forty percent of the area under wheat. With the advantages of fertile alluvial soil and canal irrigation, the higher yields in this area which range between 10-13 maunds per acre, bring this area at par with the Potwar where the area under wheat is large but yields are lower, 6-7 maunds per acre. A major part of the rest of the former Punjab in Sahiwal, Gujranwala and Gujrat districts fall in the second quintile.

3) This area lies along the Indus in D. I. Khan, D. G. Khan and Muzaffargarh districts. It is irrigated through nonperennial canals that mostly supply water in *Kharif*.[7] Whereas wheat in *Rabi*[8] depends mostly on winter rainfall and the subsoil moisture of these active flood plains. This is the only winter crop that does best under these conditions.

Most of the Lower Indus Plain falls in the third, fourth and fifth quintile, only a few *tehsils* fall in the higher orders.

All the areas of West Pakistan that fall in the upper two quintiles respectively share 39.2 percent and 25.2 percent of the total wheat acreage in the province. The remaining 35.6 percent is distributed in the three lower quintiles.

Figure 2 shows the pattern of rice cropping markedly different from that of wheat. Rice with definite requirement of plentiful water supply shows a greater concentration in better rainfall and intensively irrigated parts. Three main compact rice blocks falling in the two upper quintiles are prominent on the map.

1) The submontane districts of Gujrat, Sialkot and the adjacent low lying flat areas of Sheikhupura, Gujranwala, Lahore and parts of Sahiwal districts form the major rice area in the Upper Indus plains. Monsoon rainfall (June-September) in the submontane area of Gujrat and Sialkot is higher (18.4″ and 23.4″ respectively) and wells, tubewells and canals are supplemcntary sources of water supply. Lahore,

[6]Barani area is the one that depends on rainfall, unsupplemented by irrigation.

[7]Summer crop sown in April-May and harvested in August-September.

[8]Winter crop sown in October-November and harvested in April-May.

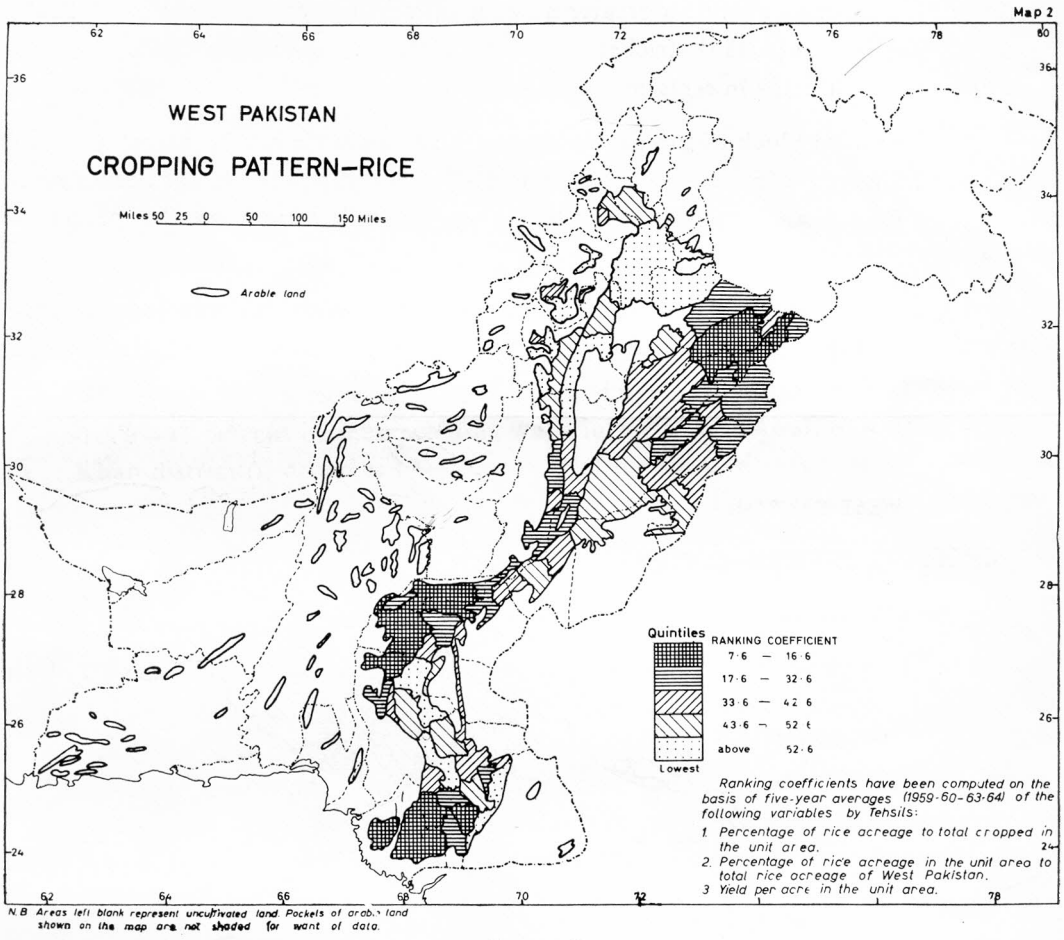


FIGURE 2

Gujranwala, Sheikhupura and Sahiwal where monsoon rainfall is 14.3, 14.7, 11.6 and 7.7 inches are dependent on perennial canal irrigation. Moreover it is a crop that helps in the reclamation of waterlogged areas, and therefore has been encouraged in parts of Sheikhupura and Gujranwala where some areas have been badly affected by waterlogging. In most of the *tehsils* of the above mentioned districts rice occupies 5—35 percent of the sown area.

2) Jacobabad, parts of Sukkur, Larkana and Dadu districts form a major compact rice producing area in the northern part of the lower Indus plain. Almost all the above noted area falls in the highest quintile. Only Usta Mohammad and Kashmore *tehsil* fall a little below the first order, but have been treated as part of the top rice producing area in the discussion to maintain the dominance of rice culture as the characteristic feature of the area. Whole of this area is well covered with Sukkur barrage canals. No where in this area the rice acreage falls below fifteen

percent of the sown area while a greater number of *tehsils* record a ratio of 25-45 percent. The area in parts is stricken with high salinity. Since rice fields are frequently watered, it helps in reclaiming the saline patches.

3) The third block of top rice producing area lies in the southernmost part of the Lower Indus plain in parts of Thatta and Hyderabad districts. It has been a non-perennially flood canal irrigated area but is now partially served by the perennial canals.

The *tehsils* in the two upper quintiles under rice in West Pakistan cover eighty-nine percent of the total rice acreage, thus showing its greater restricted distribution than wheat.

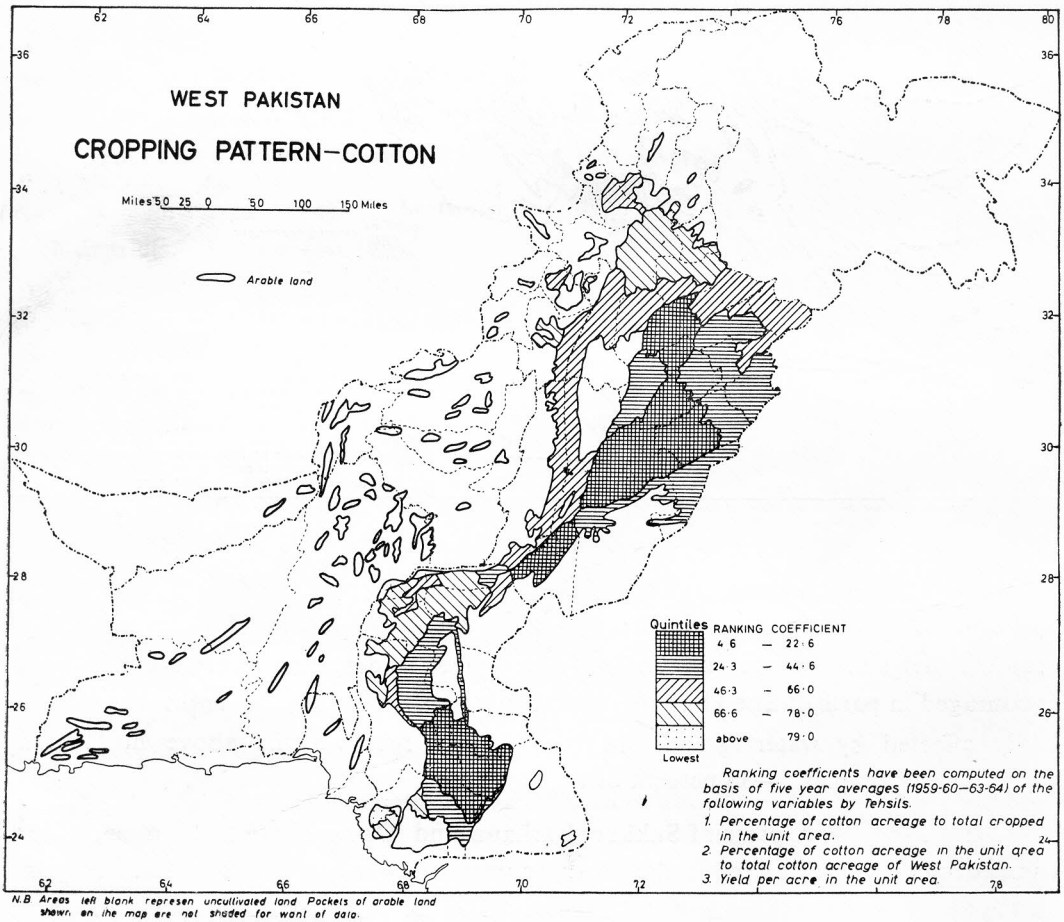


FIGURE 3

Figure 3 records the cropping pattern of cotton. A comparison of Figures 2 and 3 shows that rice and cotton show generally a complementary distribution, though both are *kharif* crops and require plenty of water. But unlike rice, cotton likes low

atmospheric humidity and thus seems to avoid the submontane areas which form the top rice lands. It is more concentrated in the lower parts of the doabs and parts of Lower Indus plain with plenty of sunshine and irrigation water, but rainfall during the period of growth generally under 10".

The following compact blocks emerge as top cotton areas :

1) Parts of Sargodha, Jhang, Lyallpur, Multan, Sahiwal and Rahim Yar Khan districts.
2) Parts of Sanghar, Tharparker and Hyderabad districts.

It is interesting to note that within these cotton producing areas, the ratio of sown area under cotton increases to the south and west. In parts of Sargodha, Lyallpur it shares 9—17 percent of the sown area while in parts of Sahiwal, Multan and Rahim Yar Khan districts it occupies 10—39 percent of the sown acreage, most of the *tehsils* recording above twenty percent. In parts of Sanghar, Tharparker and Hyderabad districts which have a still more southerly location, most of the *tehsils* have more than thirty percent of the sown area under this crop. This is due to dry atmospheric conditions better suited to cotton culture.

Areas that fall in the second category lie adjacent to the top cotton areas in both the Upper and Lower Indus Plains. These include Lahore, Sheikhupura, Gujranwala, and parts of Sahiwal and Lyallpur districts which form a compact block of secondary importance. Similarly, Khairpur and Nawabshah, districts in the second quintile, lie adjacent to the top cotton producing areas. All these areas that fall in the upper two quintiles account for ninety-three percent of the total cotton acreage in West Pakistan.

Both cotton and rice with the high concentration of acreage in the upper two quintiles indicate a high degree of specialization.

Figure 4 shows the pattern of sugarcane cropping in West Pakistan. The general overall pattern brings out the fact that with few exceptions it grows in almost the same areas as cotton and therefore it competes with cotton both for land and water during *kharif*. At the same time it forms much less compact blocks than cotton, although it is also a specialized crop. This is perhaps due to its expansion in recent years, especially in the Lower Indus Plain where it has yet to attain a high degree of stability. There are three top sugarcane areas :

1) The first conspicuous block of top sugarcane area consists of Peshawar and Mardan districts. Climatically this is the least suited area because of occasional winter frosts. But with facilities of irrigation specially from the Upper Swat canal and freedom from competition this area has acquired the advantage of an early start and continues enjoying the momentum.

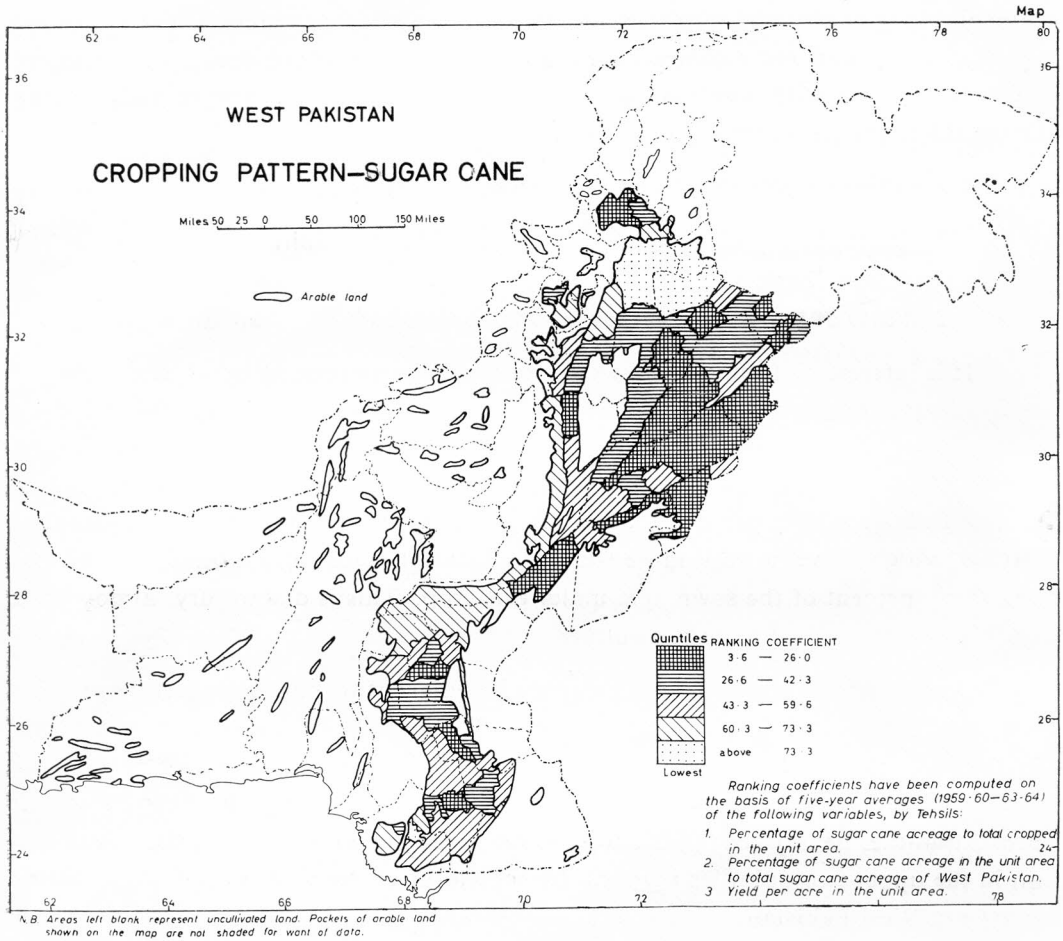


FIGURE 4

2) The second major sugarcane area in the top quintile is comprised of canal irrigated areas of parts of Sargodha, Lyallpur, Lahore, Sahiwal and parts of Multan, Bahawalpur and Rahim Yar Khan districts. All these areas are not only supplied with irrigation water from canals but also enjoy a generally frost-free winter.

3) In the Lower Indus Plain, districts of Nawabshah, parts of Sanghar, Tharparker, and Hyderabad form the top sugarcane area. Here the block is not very compact. This is the area where sugarcane culture, as expressed carlier, has recently been introduced. This block has the potentialities of becoming larger and a more important sugarcane area in future. In this area, because of mild winters along with the availability of irrigation water, sugarcane has a year round growing season, with the possibilities of sugar factories running for a longer period of time than elsewhere in West Pakistan.

The upper most quintiles of sugarcane in West Pakistan includes about ninety-five percent of the total area under sugarcane in the province. A comparison of land occupance of cotton and sugarcane clearly depicts that the ratio of sown area under sugarcane in the top sugarcane areas is generally less than that of cotton. With the exception of Mardan and Charsadda *tehsils* of Kabul valley where the area under sugarcane is nineteen to twenty-seven percent respectively, in other parts of top sugarcane areas the ratio of sown area under cane remains mostly below ten percent and in greater number of cases it remains below five percent. This is due to the fact that cotton while competing for land and water in the same areas gets a preference as its water demands are far less[9] than that of sugarcane, while it is highly lucrative crop, though not as paying as sugarcane.

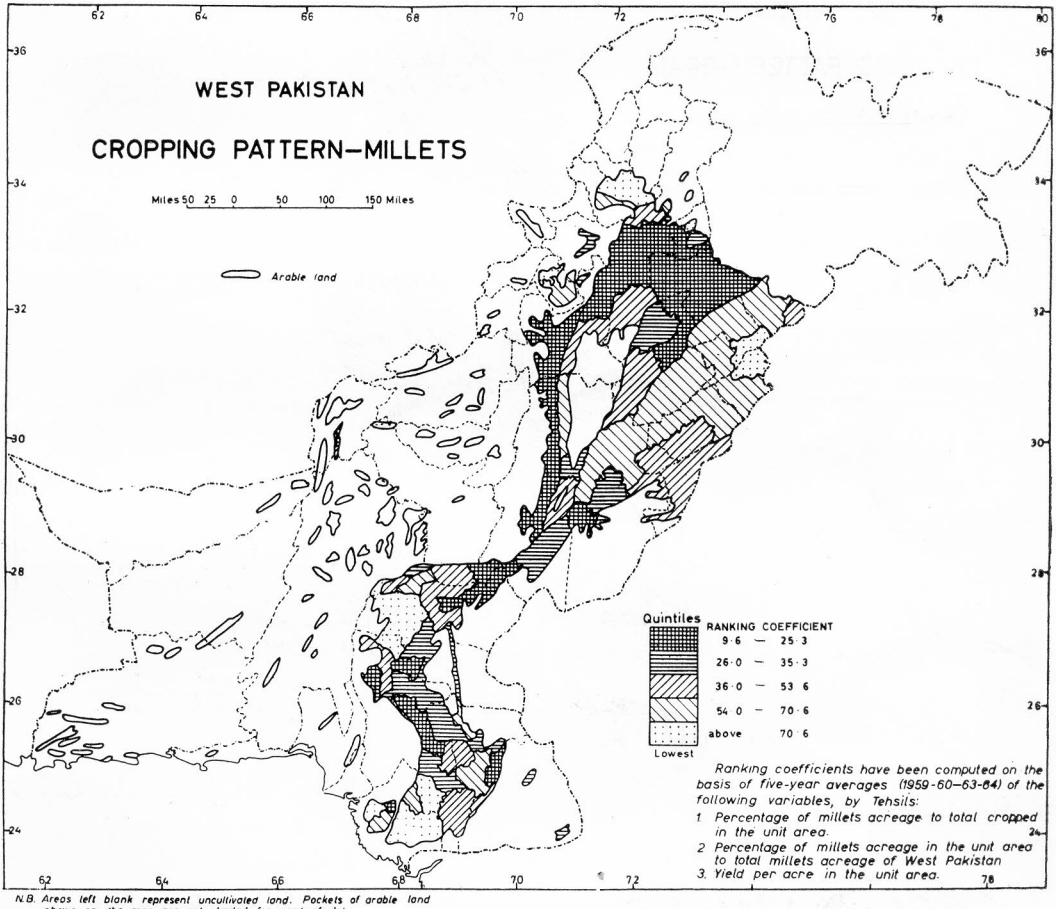


FIGURE 5

Cropping pattern of millets is shown in Figure 5. It is mostly a crop of unirrigated areas as its water requirements are not high. It includes inferior cereals of Jowar and Bajra which are resistant to drought, and, therefore, can grow in areas

[9]WAPDA Report.

of precarious agriculture. Although millets are *Kharif* grown these do not compete with rice, cotton or sugarcane for land and water for their poor yields and low price. The main millet producing areas are in the Potwar in the submontane torrent cultivated and riverain tracts of D. I. Khan and D. G. Khan. In all other parts it is much less important. The acreage under millets varies from 10—27 percent of the total sown in the top ranking areas. In the Lower Indus plain, the ratio under millets is even higher, varying in parts from twenty to forty percent.

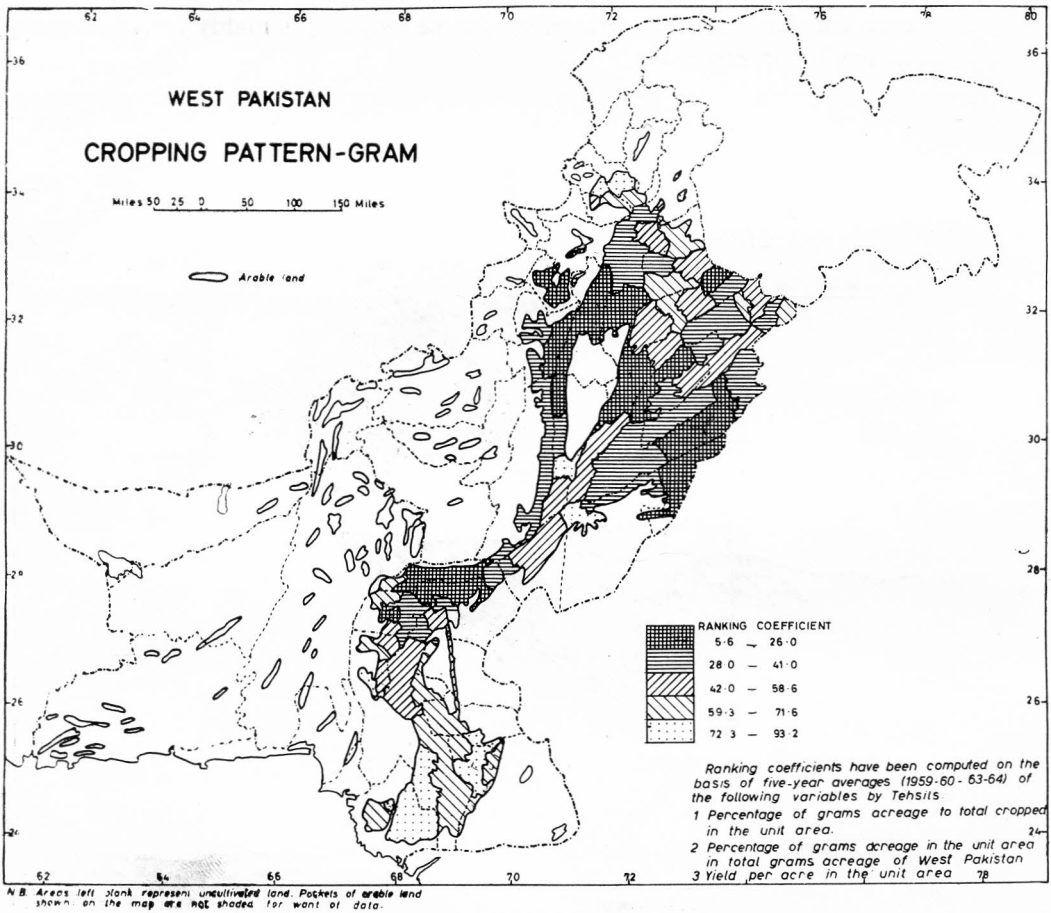


FIGURE 6

Figure 6 shows the cropping pattern of gram. It is a minor Rabi food crop. Parts of Sargodha, Mianwali, Bannu, and D I.Khan districts, parts of Jhang, Lyallpur, Lahore, Sahiwal, and Bahawalnager districts fall in the first quintile. Here, mostly it occupies under ten percent of the sown area except in Mianwali and Bhakkar *tehsils* of Mianwali district and Khushab *tehsil* of Sargodha district where it occupies exceptionally high ratio of sown area 24.9 percent, 72.2 percent and

forty-eight percent respectively. The second important gram producing area lies in the Lower Indus plain in Jacobabad, parts of Sukkur and Larkana districts. Here with rare exceptions, in most cases it occupies more than ten percent of the sown area, whereas many of the *tehsils* record a ratio of above twenty percent the highest being 33.7 percent in Kashmore *tehsil* of Jacobabad.

It is noteworthy that this rabi crop seldom falls in the top quintile where wheat is most important. With better conditions of soil and water supply wheat is given preference, and therefore, in the major wheat producing areas it is of minor importance.

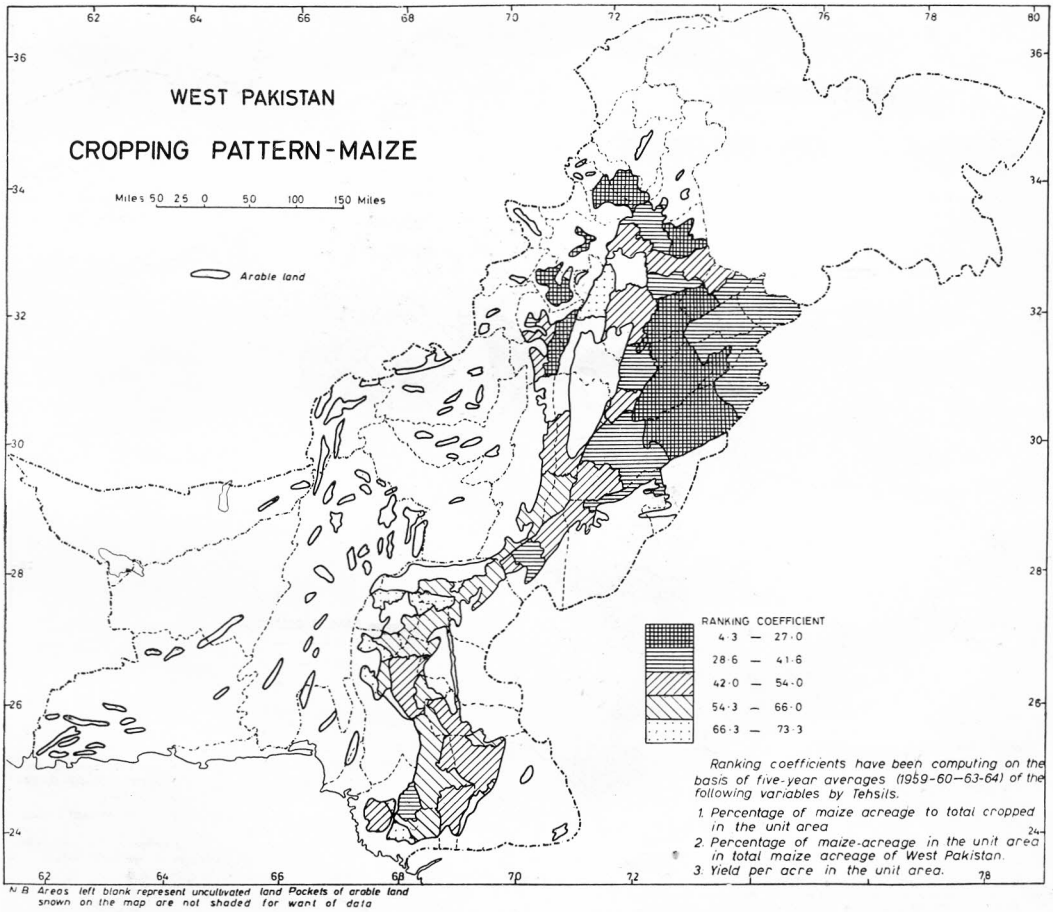


FIGURE 7

Cropping pattern of maize is shown in Figure 7. It is a *Kharif* crop and does not compete successfully with other more paying Kharif crops like rice, sugarcane or cotton in many parts of the irrigated plains.

Peshawar, Mardan, Hazara and Rawalpindi districts form one northern block of important maize areas where the ratio of sown acreage under this crop is generally above fifteen percent whereas in parts of Hazara and Rawalpindi this ratio exceeds fifty percent. In the former two districts it is an irrigated crop while in the latter two it is partly irrigated partly dependent upon monsoon rains. In the Upper Indus plain it is of some importance in parts of Gujrat, Sargodha, Lyallpur and Sahiwal districts. Here, its share in the cropped area rarely exceeds ten percent, because these are the areas where more paying crops like cotton or sugarcane become quite important. In major rice producing areas of Sialkot, Gujranwala, Lahore and Sheikhupura, again it is less important.

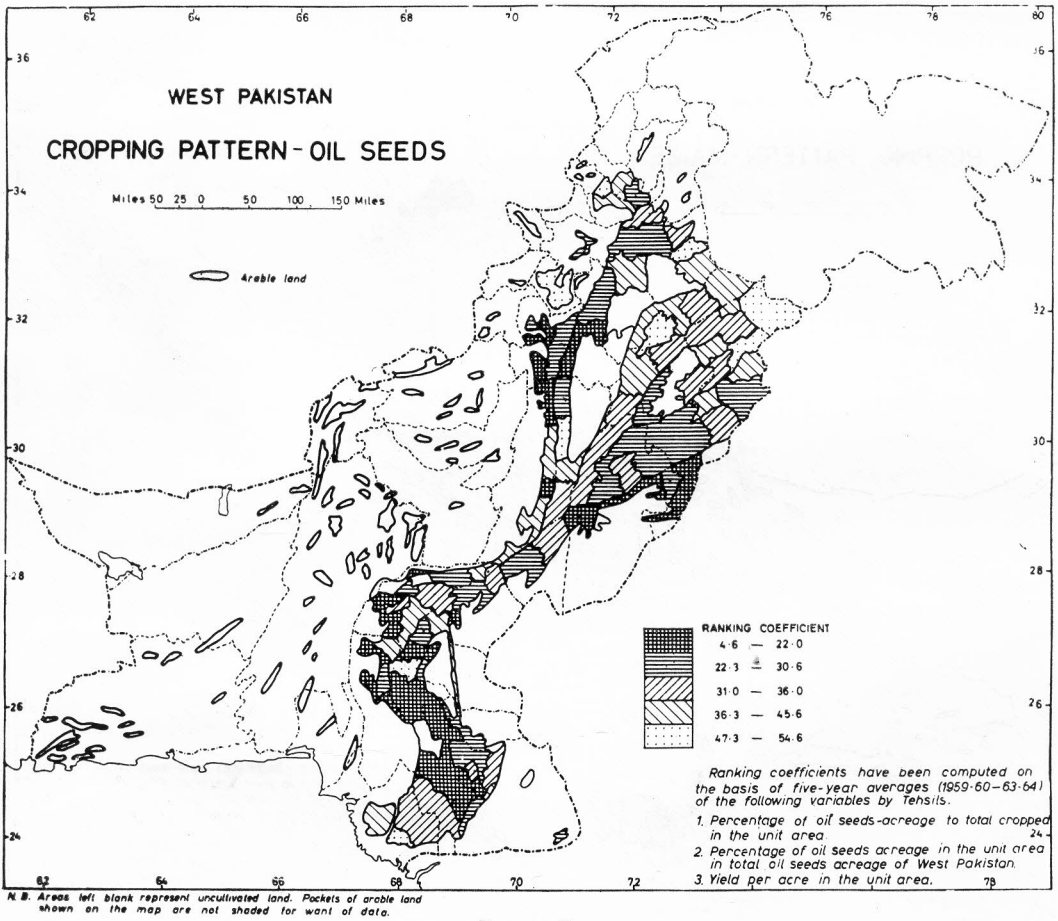


FIGURE 8

Oilseeds (rape and mustard). This is also a relatively less important crop. There are very few areas in the Upper Indus plain where it attains some importance. Bahawalnagar and Bahawalpur districts show a contiguous block of oilseeds in the 1st quintile and have a 5—10 percent of the sown area under this crop. Oilseeds

appear to be relatively more important in the Lower Indus plain specially in parts of Nawabshah and Hyderabad where the ratio varies between 10—25 percent.

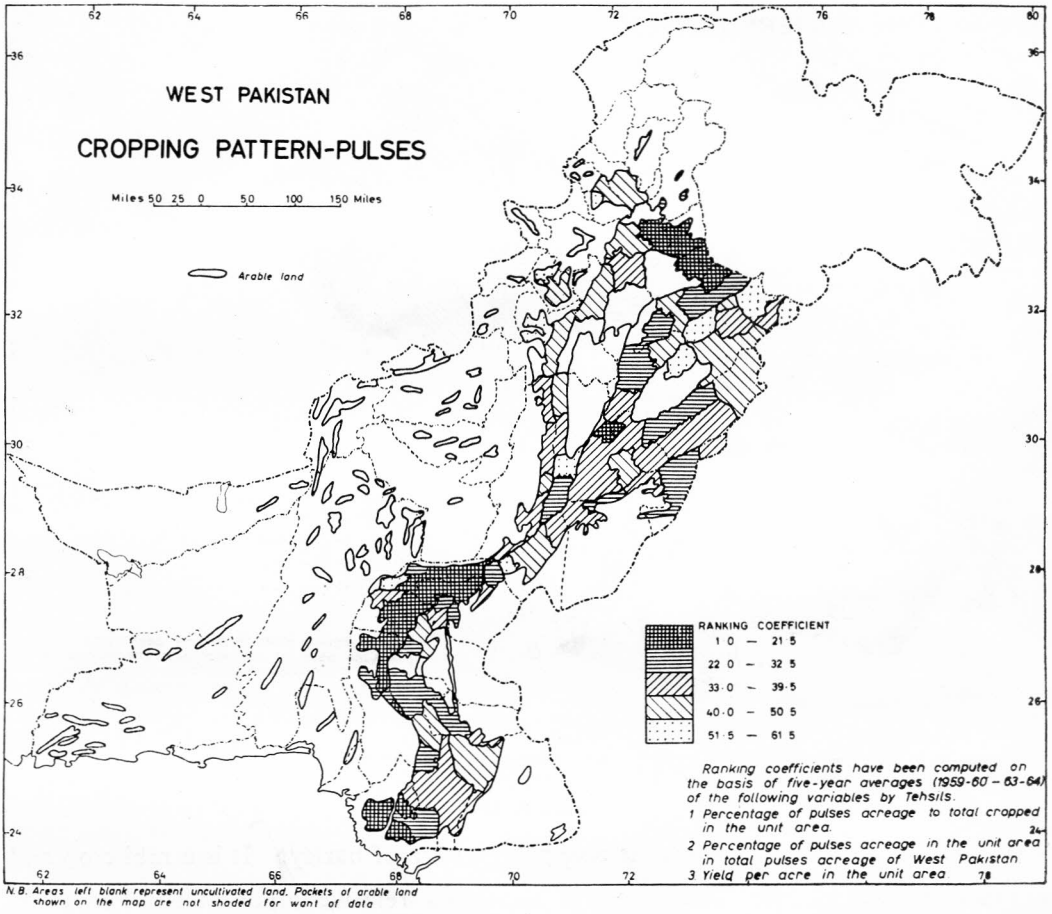


FIGURE 9

Pulses. 'A poor relation' in the general cropping pattern, show two areas of relatively greater importance. In the submontane areas of Rawalpindi district, Fatehjang *tehsil* of Campbellpur, Jhelum and Kharian *tehsils* area under this crop varies from 5—26 percent of the sown area.

Another important area under pulses appears in the Lower Indus plain in Jacobabad, Larkana and parts of Sukkur and Dadu districts occupying in a majority of cases more than ten percent of the sown area. In the southern most *tehsils* of Thatta district it appears again in the first quintile.

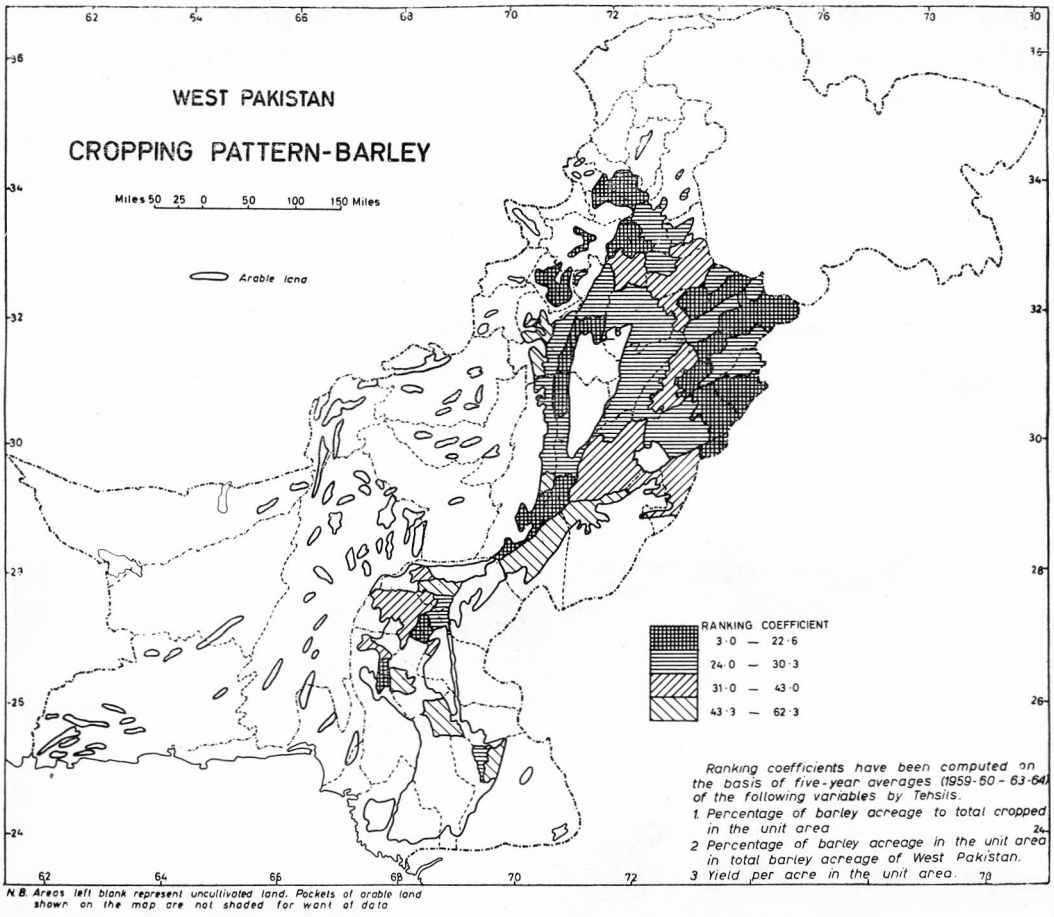


FIGURE 10

Barley. Figure 10 shows the cropping pattern of barley. It is a rabi crop and shows dispersed pattern. However, it shows its relative importance in Peshawar, Mardan, Bannu and Kohat districts. It is again more important in the eastern parts of the Upper Indus plain. In these above mentioned areas its land occupance generally varies from below two to five percent of the sown area.

Barley for its requirements of low winter temperature is almost absent from the southern parts of the Lower Indus plain.

CROP COMBINATIONS OR ASSOCIATIONS

Applying the method discussed earlier, Crop Associations have been established on the basis of the cropping pattern emerging from Figures 1—10. Various associations of cereals and non-cereal crops have been depicted. In doing so the

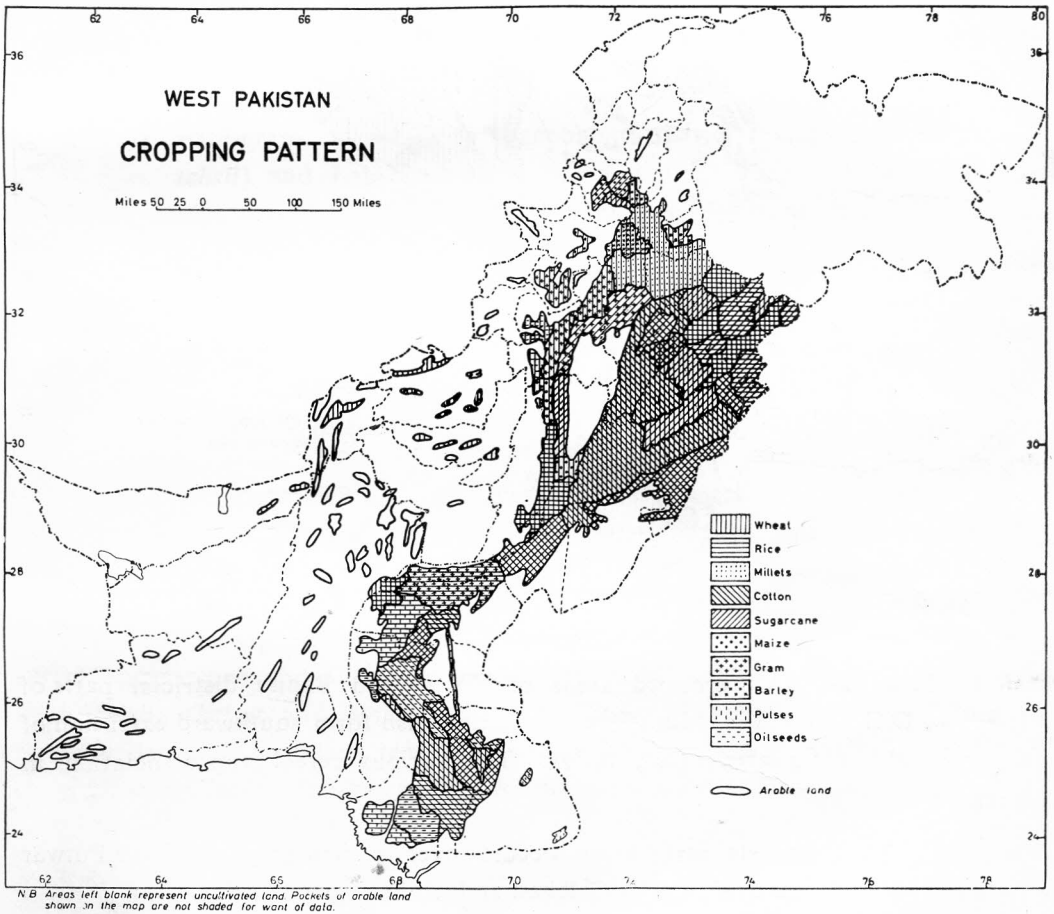
cropped areas of West Pakistan have been grouped under three main categories :

I. Areas where only cereals form the predominant crop associations.

II. Areas of cereal-cum-non-cereal crop associations.

III. Areas where non-cereal crop associations predominate.

The detailed crop associations have been shown in Figure 11. Figure 12 only shows the three major categories as such.



N.B. Areas left blank represent uncultivated land. Pockets of arable land shown on the map are not shaded for want of data.

FIGURE 11

I—*Areas of Cereal Crop Associations*

There are fairly large and contiguous areas where cereal crop associations predominate. Three such major areas are noticeable in Figure 12.

(*a*) Whole of Potwar comprising of Jhelum, Rawalpindi and Campbellpur districts along with the contiguous areas of Swabi *tehsil* of Mardan and Mianwali

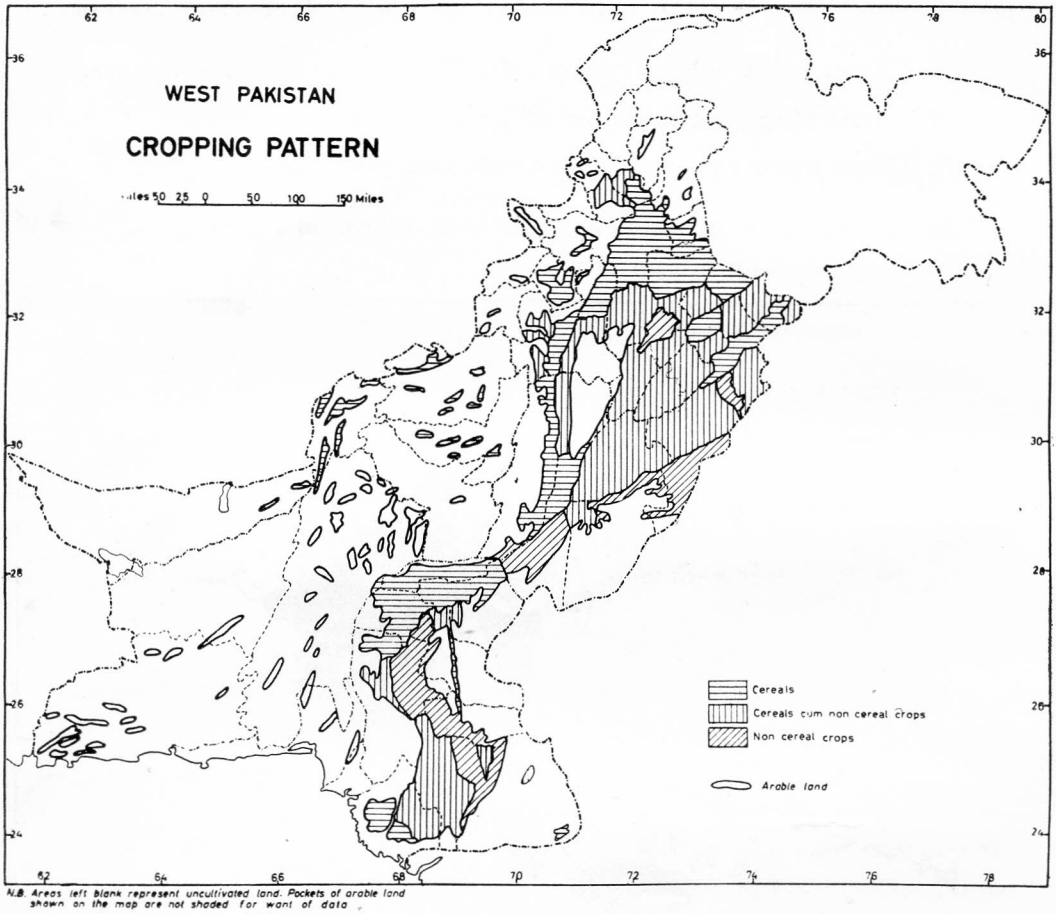


FIGURE 12

tehsil of Mianwali. All cropped areas of Kohat and Bannu districts, parts of D.I. Khan, D.G.Khan and Muzaffargarh districts also form southward extension of this cereal producing area along Indus. The various cereal crop associations in this region are :

i) Wheat-millets association occurs over a greater part of the Potwar and Taunsa *tehsil* of D.G.Khan and Kohat district.

ii) Wheat-maize association appears in Murree, Kahuta, Rawalpindi and Sawabi *tehsils*.

iii) Wheat-barley association in Pindigheb *tehsil* of Campbellpur.

iv) Wheat-gram association in Bannu district.

v) Wheat-rice association occurs in a small block in Jampur and Rajanpur *tehsils* of D.G.Khan district and Alipur *tehsil* of Muzaffargarh.

In most of the above mentioned parts wheat as *rabi* crop combines with one other *kharif* cereal. Only in Bannu district and D.I. Khan *tehsil* of D.I. Khan district both *rabi* cereals happen to form the more important crops. Most of these combinations reflect the existing conditions of water supply in the area—mostly a barani area, only irrigated in parts.

b) The second compact block of cereal crop association is in the upper part of the Lower Indus plain. It includes whole of Jacobabad and Larkana districts, northern *tehsil* of Dadu and the contiguous *tehsil* of Sukkur in the Cis-Indus area. A small block of cereal forming also occurs in the southern part of Thatta district. Following cereal associations are present in this region :

i) Rice-gram, in whole of Jacobabad district (except Usta Mohammad *tehsil*) and Larkana, Miro Khan and Kambar *tehsils* of Larkana district and Ghotki and Ubaro *tehsils* of Sukkur district.

ii) Rice-pulses in the rest of Larkana district and Mehar and Kakar *tehsils* of Dadu district. The second block of this crop association occurs in Ghorabari and Mirpur Sakro *tehsils* of Thatta.

iii) Wheat-rice in Shahdad Kot *tehsil* of Larkana and Usta Mohammad of Jacobabad district.

All these areas categorised under *b*) are irrigated areas well suited to rice culture in *kharif* while in *rabi* less water demanding crops like grams and pulses became more important.

c) In the Upper Indus plain in the Cis-Indus area only small areas show pure cereal associations and that too in some of the eastern parts of Rechna and Chaj doabs. The Gujrat and Kharian *tehsils* of Gujrat, Hafizabad *tehsil* of Gujranwala, Sheikhupura and Shahdara *tehsils* of Sheikhupura and Narowal *tehsil* of Sialkot district are included in this category. Wheat and rice form the most dominant cereal association here.

II—*Areas of Cereal-Non-Cereal Crop Association*

This category covers the largest area in West Pakistan. Large contiguous areas in the Upper Indus plain and the southern most parts of the Lower Indus plain form the major cereal-cum-non-cereal areas. A third and smaller block appears in the Mardan and Peshawar districts in the north.

a) Upper Indus plain cereal-cum-non cereal area. It covers the entire area between Sutlej and Indus south of the Salt Range except areas under 1-c, Sargodha

tehsil of Sargodha, Chunian *tehsil* of Lahore and Alipur *tehsil* of Muzaffargarh district. The following combinations emerge :

i) Wheat-cotton areas are quite extensive and perhaps the most common crop association in the Upper Indus plain. All *tehsils* of Sargodha district except Sargodha, whole of Jhang and Multan districts, Dipalpur, Pakpattan *tehsils* of Sahiwal, Ahmadpur East of Bahawalpur district form one major block showing this association. It covers a major part of the canal colonies in the agricultural heartland of West Pakistan.

ii) Wheat-sugarcane. This association does not cover as extensive areas as Wheat-cotton. Whole of Lyallpur district, Sahiwal and Okara *tehsil* of Sahiwal district form one contiguous area under this category.

iii) Rice-sugarcane association also occurs over less extensive areas in Upper Indus plain. It occurs in greater part of Sialkot and Nankana Sahib *tehsil* of Sheikhupura. Lahore and Kasur *tehsils* of Lahore also form one small block with this combination. A narrow tract along the right bank of Muzaffargarh also show wheat-sugarcane association.

iv) Sugarcane-Gram association occurs over a small part in Khushab *tehsil* of Sargodha and Bhakkar *tehsil* of Mianwali district.

b) Southern part of Lower Indus plains covering all *tehsils* of Thatta and Hyderabad districts, southern parts of Dadu district in Jobi and Dadu *tehsils* form the second most important contiguous block of cereal-cum-non-cereal crop associations. It shows various associations over small blocks :

i) Wheat-cotton in four *tehsils* of Hyderabad, Hyderabad, Hala, Tando Allah Yar and Matli. This combination also occurs in Somaro *tehsil* of Thatta district.

ii) Rice-cotton in southern parts of Hyderabad in Guni, Tando Bago and Badin *tehsils*.

iii) Rice-oilseeds in parts of Thatta in the Cis-Indus area and in Jobi *tehsil* of Dadu.

iv) Rice-sugarcane in Dadu *tehsil* only.

c) A small block of cereal-cum-non-cereal crop association occurs in Mardan and Peshawar districts. Two associations are found here :

i) Sugarcane-maize in Mardan, Charsadda and Peshawar *tehsils*.

ii) Wheat-sugarcane in Nowshera *tehsil*.

III—Areas of Non-Cereal Crop Associations

This is the least extensive of the three major categories and occurs in small blocks in the more efficiently irrigated parts of West Pakistan. There are two such conspicuous blocks one in the Bahawalpur region and the other in central Lower Indus plain.

a) Bahawalpur region includes all *tehsils* of Bahawalnagar, Bahawalpur and Rahim Yar Khan except one *tehsil* Ahmadpur East. This entire block shows cotton-sugarcane combination, both occurring in Kharif, and both form very important cash crops of West Pakistan.

b) Central Southern Indus Plain includes parts of Khairpur, whole of Nawabshah and parts of Sanghar and Tharparkar, It shows two associations :—

i) Cotton-sugarcane. This association appears over a greater part of III b, except in district Nawabshah and *tehsil* Shadadpur of Sanghar district.

ii) Sugarcane - oilseeds association occurs in Nawabshah district and Shahdadpur *tehsil* of Sanghar district.

c) Two detached areas in Sargodha *tehsil* of Sargodha and Chunian *tehsil* of Lahore also show non-cereal crop combination of cotton-sugarcane.

The above study shows that most common associations in the three major categories are :—

i) Wheat-millets and wheat-grams.
ii) Wheat-cotton and wheat-sugarcane.
iii) Cotton-sugarcane.

RESUME

1) The method applied to depict cropping pattern of individual crops in the first instance and the crop combination regions in the final stage appears to be quite satisfactory. The emergent distribution pattern is in agreement with the patterns as revealed by case studies on micro scales carried out by the authors.[9]

2) Where specialisation of agriculture is restricted, the determination of cropping pattern on single criterion of acreage under a crop as a ratio of total sown area in a unit area would have resulted in the dominance of one crop in almost seventy-five percent of the unit areas under study in West Pakistan. It is borne out by a comparison of top ranking wheat areas and the top ranking sugarcane areas. In the case

[9]Method worked out by John C. Weaver in his article 'Crop Combination Regions in the Middle East', *Geographical Review*, Vol XLIV, 1954, No. 2 was tested in case of West Pakistan. The results brought most of the areas under three or four crop combinations which fail to combine the two dominant crops in an area.

of wheat, ratio of sown area in most cases is above thirty-three percent with a majority of cases above forty percent. Whereas in the top sugarcane areas it seldom rises above ten percent. Had the top ranking areas of sugarcane been considered to be of lower status than the top ranking areas of wheat, the crop combination with sugarcane would not have been possible.

3) The price index has been used very rarely only in cases where more than two crops in a unit area are of equal rank. Such a restricted use eliminates the discrepancies arising out of fluctuating prices.

4) The method is used to bring out dominant bi-crop combinations only. If desired three or four crop associations can also be determined in any unit area with the position of

Wheat in the 2nd quintile.
Rice in the 1st quintile.
Cotton in the 1st quintile.
Maize in the 4th quintile.
Grams in the 3rd quintile.

The three crop combinations would be rice-cotton-wheat and the four crop combinations would be rice-cotton-wheat-grams.

The crop associations thus established, pave the way for further work to be done in the way of co-relating these associations with certain physical, cultural and economic phenomena *e.g.* land forms, size of holdings, availability and use of fertilizers, mechanisation and differential rate of supply of irrigation water. A cursory glance on the crop association map and the land form map gives somewhat consistent but general relationship of rice concentration in flatter areas in the districts of Sialkot, Gujranwala, Sheikhupura and Lahore, which lie in the meander and cover flood plains of the Rechna and Chaj doabs of the Upper Indus region. These areas, however, are also otherwise suited to rice culture because of favourable temperature, adequate water supply, fertile clay loam silt and labour requirements.

In the Lower Indus plain, the two areas of rice concentration covered by Sukkur and Kotri barrages show more response to plentiful water supply, and favourable thermic conditions.

In the crop associations in the Indus plains, water seems to be a more limiting factor than soil, especially in the final choice and ratio of arable land to be sown under sugarcane and cotton. It may however, be also related to other cognate economic factors if investigated.

In the crop associations in the cereal-cum-non-cereal associations, wheat in the Upper Indus plains and rice in the Lower Indus plains forms the base crop in greater part of the respective area. Pure cereal crops are generally found in the Potwar and northern and western hilly tracts.

For future associations to be developed on the basis of soil conservation and needs of the food and non-food crops for the growing population it may be suggested that :—

a) Increase in area under fodder crop in the irrigated tracts would be beneficial in improving the soil and maintaining its fertility. Simultaneous increase in area under pulses and oilseeds would help in increasing the milk and butter supply and cooking oils. More area under these crops would also reduce the fallow land and bring about a better rotation of crops.

b) Chances of a stronger cotton-sugarcane base in the south central part of the Lower Indus Plain are bright. Relative shift of sugarcane belt to the south with plentiful water supply would make a sound basis for low-cost sugar production, with prolonged crushing season and absence of damage from frost.

These general remarks are not final. Choice of crop is a function of complex and multiple factors and as mentioned above to establish relationship between the crop associations and these factors would require further detailed investigation.

CROP ECOLOGICAL ZONES OF THE INDUS PLAINS

CH. MOHAMMAD RAFIQ

1. INTRODUCTION

1.1 *General*

Recognition and delineation of crop ecological zones in the Indus plains can be of use in evaluation of cropping patterns and alternative crops ; of fertilizer trial results ; and in planning industries based on agricultural products. The first attempt to define ecological zones in West Pakistan was made by Papadakis 1965, Hamid and Hassan 1968 attempted to work out ecological zones for wheat.

Crop ecology is a young science and the limits of some of the climatic elements for various agricultural crops have yet to be worked out. Both detailed meteorological data and crop data are essential for the definition of crop ecological zones. In the Indus plains, the number of meteorological stations is insufficient for complete coverage, and this limits the accuracy of any attempt to delineate ecological zones. Also, crop conditions are changing due to the introduction of new varieties and modern management practices including the use of fertilizers and pesticides. Long-term crop data pertaining the past would, therefore, not be as meaningful as the data of the last few years which would reflect the present conditions much better.

1.2 *Crop yields : the basis of ecological zones.*

In this study an attempt has been made to define and delineate crop ecological zones on the basis of yield estimates for various localities in the Indus plains. The crop yields were estimated by assessment of standing crops on the best soils having no limitations for the crop. Information about the management practices including fertilizer application, was obtained from the farmers. Hundreds of interviews with farmers and thousands of crop observations made during the reconnaissance soil survey provided the data for this study.

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To take into account the variations in forming conditions two levels of management were used : traditional and modern. Traditional management implies the use of a country plough, local crop varieties, too low or too high a seed rate, some farmyard manure once in about three years, small doses of nitrogen fertilizer and no plant protection. These conditions are now changingbutat a slow rate. Modern management implies the use of a modern steel plough and other modern agricultural implements, seed of improved varieties, proper seed rate, balanced fertilizers, proper irrigation water management, control of weeds and adequate plant protection measures for controlling pests and diseases. Although modern management is practised by only a few farmers, crop yield estimates under these assumptions are essential to indicate the potential of the area.

Average yield estimates for each zone were made by the author in consultation with soil survey staff of the Soil Survey Project of Pakistan. Then the estimates were scrutinized by the Deputy Directors of Agriculture of the various regions. The crop yield estimates are presented in a table at the end.

1.3 *Crop ecological zones compared with climate zones.*

The various crop ecological zones were recognized on the basis of the estimated crop yields at many places in the Indus plains. Rough boundaries of these zones were drawn on a map. These were subsequently compared with the climatic zones of the Indus plains by various workers as reviewed by Ahmad 1951 (pp. 2—7). The climatic zones recognized by Ahmad were found to be in fairly close agreement with our crop zone estimates, so with a few minor changes they were adopted. These changes were made on the basis of information on soil characteristics and crop behaviour collected during soil surveys.

The boundaries of the climatic regions set up by Ahmad are close to the boundaries of the ecological zones proposed in this paper probably because Ahmad based his classification on more than a few variables. Instead of only one or a few elements of climate, factors considered were temperature, rainfall, humidity and wind velocity as well as, for example, nearness to the sea, altitude and latitude. The socio-economic conditions in different areas were also used to establish boundaries (Ahmad 1951, pp 9-10) Although this approach is empirical, it is more realistic and more useful for practical applications than any other climate classification for West Pakistan, such as those of Thornthwaite, Trewartha, Koppen, Blair, Kendrew and Miller (reviewed by Ahmad 1951 pp. 2—7).

2. DESCRIPTIONS OF CROP ECOLOGICAL ZONES

The crop ecological zones delineated on Figure 1 are described below.

Mapping unit 1, Thatta zone. On the south and west this zone is bounded by the sea, and on the east by the Thar desert. The limit of the Indus delta has been taken as the northern boundary on the basis of soil characteristics and hydrology. The climate is mainly arid marine, with moderate temperature and low rainfall.

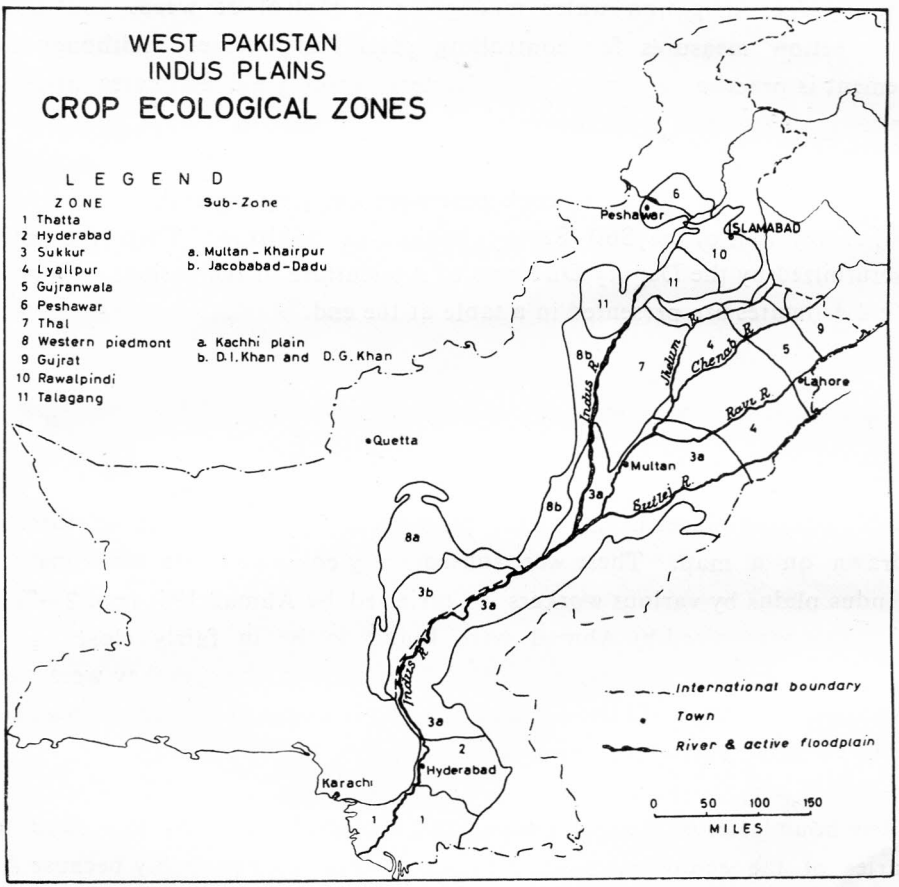

FIGURE 1

The outstanding feature is a steady sea-breeze from April to October, when the temperature rarely rises above 93°F or falls below 75°F. Humidity is high and both the annual and diurnal ranges of temperature are low. The average annual rainfall is about seven inches in the north-west and increases towards the south-east to about ten inches. Most of the rainfall occurs in summer, mainly in July and August. The winter is almost dry. The mean annual maximum temperature is more than 90°F. The mean monthly maximum temperature from March to October oscillates

between 82 and 89°F, and is 75.5°F in January, the coldest month. During December to January the mean temperature is 66 to 70°F. At Karachi the humidity is more than fifty percent throughout the year ; from May to September it is above sixty percent during the day and above eighty percent at night. In the northern part the mean maximum temperature in May and June is about 105°F. In winter the minimum temperature sometimes falls to within a degree or two of the freezing point, at Hyderabad the mean minimum for January being 50°F.

The general slope of the area is very small and the water-table is usually within eight feet in winter and within five feet in summer. Drainage is a great problem. Soils are mainly of three kinds : saline stratified silt loams on flats ; saline clays with weak structure in basins and channel infills ; and irrigated clays with weak structure, non-saline, having a thin layer of sweet ground water. Many basins become marshes in summer. Because of their very low permeability and very poor drainability the silty soils are not economic to reclaim. The clayey soils can probably be economically reclaimed if sufficient irrigation water is available and the non-saline basis are most favourable for development.

The soil-climate combination is most favourable for rice and sugarcane. Summer pulses will give high production with adequate plant protection. In winter, pulses and mustard are the best crop choices. Due to the short growing season wheat has a relatively low potential. Fodder, sorghum and berseem will give high yields. Among fruits, banana and guava have high potential.

Mapping unit 2, Hyderabad zone. In the south this zone is bounded by Indus delta, on the east by the Thar desert, and on the west by the Indus river. The northern boundary is the limit of the sea-breeze and of the frost-free area.

The range of temperature is greater, and the humidity is less than in the Thatta zone. May and June are the hottest months, with mean maximum temperatures of 107 and 104.5°F respectively. Normally there is a strong dusty wind from the south-west (the sea breeze) during summer. In winter a cold wind blows from the north and the temperature sometimes falls to within a degree or two of freezing point. Although frost does not occur, banana is affected by the near-freezing temperatures. The annual rainfall is about six inches, falling mostly in July and August. Continuous sunshine, moderate temperatures and sea-breeze in summer are the main features of the climate of this zone.

The main soils are silt loams with weak structure. Clayey soils with weak structure are sub-dominant. Saline soils are of very small extent. The water-table is generally deep, below fifteen feet, except along the Rohri canal. The soils are very favourable for crop production. The main limiting factor is the inadequate supply

of irrigation water. The ground water is generally saline and unfit for irrigation, except in narrow strips of land along old Indus courses.

The soil-climate combination is favourable for sugarcane, cotton, mustard and wheat. Sugarcane has a very high potential here, and sugar industry could be concentrated here and in the Thatta zone. This is probably the second-best zone for cotton, Sukkur zone being the best. Plant protection measures are needed to achieve high cotton yields. The incidence of disease is considerable in summer due to the effect of the monsoon, especially in the southern part. Mustard grows well in this area, and has low water requirements. It needs some plant protection for obtaining high yields. Maize and wheat have good potential. Mango and guava are the most suitable fruit trees, followed by banana and papaya. Banana gives good yields in the southern part, but the low winter temperature depresses the yield by about twenty-five percent in the north.

Mapping unit 3, Sukkur zone. On the east, this zone is bounded by the Thar desert, and on the south by the frost-free line and the limit of the sea-breeze effect. The irrigation boundary forms its western limit and the eight inches isohyet is the northern boundary, but the sandy Thal area is excluded (zone 7).

The main features of the climate are a very hot summer, low humidity, continuous sunshine and a great range of diurnal as well as seasonal temperatures. The mean maximum temperature in summer fluctuates between 105 and 110°F. On several days it is above 115 and occasionally as high as 120°F. In winter the nights are cold, the mean minimum temperature in January being between 42 and 45°F, but the days are warm with temperature of about 70°F. Frost is rare but the minimum temperature is near the freezing point. The annual rainfall is less than eight inches ; it is only about four inches in the centre of the zone. Dust storms are common in summer and hot dry winds blow from April to June.

In the *Multan-Khairpur sub-zone*, the soils are mainly silt loams with weak structure, and clayey soils with structure are sub-dominant. A small percentage of the soils is strongly saline or saline-alkali. The water table is generally deep but some areas have high water-table (along the Rohri canal in Khairpur).

Cotton is the most suitable crop, followed by gram and mustard. Continuous sunshine and low humidity are favourable for cotton and the incidence of disease is very low. Cotton yields as high as forty maunds per acre are obtained with modern management by progressive farmers. Late-sown mustard (especially raya) does well as it starts fruiting after the frost period is over. The near absence of winter rain and clouds is very favourable for gram. Onions also have a high potential. They keep well throughout the year as the incidence of rotting and sprouting is low due to

low humidity. Wheat also does well but gram is more suited for this zone. Lucerne (alfalfa) grows luxuriantly and would be very well suited for hay making for dairies in big cities. For dates this is the most suitable zone, especially the central part. Mangoes do well but are damaged by frost once in about five years. Suitability for citrus is low to moderate.

The *Jacobabad-Dadu sub-zone* has a generally high water-table. In other aspects it resembles the other sub-zone. Drainage is the main problem.

Rice, gram and mustard are the most suitable crops under present conditions but after proper drainage cotton is expected to replace rice. Among fruits guava is the only possibility. Onions have a high potential, especially because they keep well, the incidence of rotting and sprouting being low due to low humidity.

Mapping unit 4, Lyallpur zone. On the south and north this zone is bounded by the eight and sixteen inches isohyets respectively. On the east it extends to the Pakistan border. The sandy Thal zone (7) forms the western boundary but the Salt range piedmont is included in the Lyallpur zone.

The summer is very hot while the winters are cold. The mean maximum temperature in June is 108° F at Sahiwal and 106° F at Lyallpur. Dust storms are frequent from March to October. The minimum temperature in January is 40°F at Lyallpur and 42°F at Sahiwal. The mean annual rainfall ranges from eight to sixteen inches. The main difference from the Sukkur zone is the higher humidity in July and August and the larger number of cloudy days from mid-June to mid-September and from December to January. Frost may occur for a week or two, causing some damage to sugarcane and considereable damage to mango orchards once in four to five years.

The soils are mainly silt loams with weak structure, with some clayey soils. Saline-alkali soils are of very limited extent. Parts of Lyallpur and Sargodha districts have a high water-table causing salinity. Irrigation water is available for seventy-five percent cropping intensity, so shortage of water is a problem.

This zone has the highest potential for wheat, which should remain an important part of the cropping pattern. Cotton yields are about sixty percent of the Sukkur zone, but with intensive plant protection they could be raised to about eighty percent of Sukkur, the last twenty percent difference being due to climate, especially humidity and cloudiness. Maize is also a suitable crop. Sugarcane should have less importance.

Among the fruits this zone is most suitable for citrus. Mango should be less important as it is damaged by frost once in four to five years. Guava does quite well but needs intensive plant protection in summer.

Mapping unit 5, Gujranwala zone. The southern boundary of this zone is the sixteen inches isohyet, and the northern boundary the twenty inches isohyet. On the west the Salt range forms the boundary on the east the Pakistan border.

The summer is hot and winter is cold. The mean maximum temperature in May and June is 104°F aand 106°F respectively at Lahore. The mean minimum

temperature in January is 40°F. Frost occurs for a week or two. The rainfall ranges from sixteen to twenty inches. This is just sufficient for a few crops like millet, gram and oats.

The soils are mainly silty clay loams, and clay loams with weak structure and a kankar zone at three to six feet depth. Most of the soils are water-saturated in July and August by high-intensity rains, creating a seasonal drainage problem. A small percentage of the area has clayey soils which are imperfectly drained during the summer rainy season. Waterlogging is a serious problem in about one-third to one half of the area. Saline-alkali soils generally occupy a small but significant part, but a considerable proportion in Sheikhupura district.)

This is the basmati (high-quality) rice zone. Wheat is the second most suitable crop. Other crops in order of importance are fodders (sorghum and berseem) for the dairy industry, and sugarcane. Among fruits guava, mango and citrus are moderately suited to this zone. Guava suffers from insect attack during summer and needs intensive plant protection measures. Mango is damaged by frost once in about three years. Citrus is sensitive to soil saturation in July and August, but can be grown very well on well drained high lying loamy soils.

Mapping unit 6, Peshawar zone. It includes Peshawar vale where the rainfall is twelve to twenty inches. A small part along the northern fringe is subhumid with twenty to twenty-five inches rainfall. Winter rainfall is considerable due to the influence of western disturbances. At Peshawar the mean rainfall of the February-March period is four inches against three inches of July-August. Even January or April is rainier than July. Thunderstorms form a very important feature of this zone.

Annual ranges of temperature are great. The mean minimum temperature in January at Peshawar is about 40°F. Temperatures below freezing point are quite common. The mean maximum temperature in June is 105°F at Peshawar, the daily maximum temperature may rise to over 110°F.

The central, lowest part of Peshawar basin is subject to frost for about two to four weeks and crops including sugarcane are damaged. The higher sloping sides of the valley are frost-free. With irrigation, in the centre of Peshawar basin where damaging frost occurs, crops in decreasing order of suitability are maize, summer pulses, sugar-beet, tobacco and berseem. Sugarcane should be discouraged. Among fruits pears, peaches and citrus are suitable. The higher sides of Peshawar valley are not subject to frost and with irrigation the following crops are suitable (in decreasing order) : sugarcane, maize, potato, tomato and other vegetables, tobacco and summer pulses.

With irrigation the subhumid part is suitable for wheat and mustard.

Mapping unit 7, Thal zone. This zone comprises the sandy Thal area bounded by the Indus and Jhelum rivers. Its climate is like that of the Multan zone in the southern part and like that of the Lyallpur zone in the northern part, but it has quite different soils, mainly very sandy, with a small proportion of sandy loams.

Summers are hot and winters cold. Both the diurnal and seasonal ranges of temperatures are quite wide. The maximum temperature in summer ranges between 105 and 115°F. In December and January frost occurs for about two weeks. The mean annual rainfall ranges from six to fourteen inches. On the basis of rainfall it can be subdivided into two zones, with twelve to fourteen inches ; and six to twelve inches rainfall.

The most suitable crop without irrigation is gram. With twelve to fourteen inches rainfall it grows well on almost all soils. On the sandy loam valley soils between the sand ridges groundnuts can also be grown quite successfully with six to twelve inches average annual rainfall, gram is successful about once in three years on all soils. This part is better suited for development as grazing land. With small size tubewells, the sandy loam valley soils can be used for fodder as a supplemental feed for sheep and cattle. The ground water is generally suitable for irrigation.

Mapping unit 8, Western piedmont zone. This zone comprises the Kachhi plains south of Sibi, and the plains parts of D.G. Khan and D.I. Khan.

This area is influenced by the rain on the adjoining hills. Thus, the rainfall in the plains themselves is no measure for the hydrological conditions. When the rain falls on the hills, the torrents are suddenly in spate and water spreads over large areas. The torrents have cut deep beds for themselves dividing the area into blocks or strips of land. The torrent water is diverted into embanked fields by constructing earth dams across the torrents.

Temperatures are affected not only by insolation but also by radiation from heated rocks which serve in effect like radiators.

This zone can be subdivided into two sub-zones.

The *Kachhi Plain* is the hottest area of West Pakistan, with a mean maximum temperature of 114°F in June. The maximum temperature in summer often rises to about 120°F and even the night temperatures are above 90°F. Even in winter the sun is hot at mid-day, and crops are forced into quick growth and early maturity. The rainfall is very low. The mean annual rainfall at Sibi is only 4.6 inches.

The soils are loamy near the hills but clayey in the southern half. They are all strongly calcareous and laminated. Cultivation depends upon torrent water. Sorghum and millet are the only suitable crops in summer and gram in winter.

A part of the southern clayey region is irrigated and irrigation is being extended in most of this area. Rice in summer and mustard (raya) and gram in winter are the most suitable crops. For cotton the temperatures seem to be high, but since the winter sets in late it may still give good yields.

The *Dera Ismail Khan-Dera Ghazi Khan sub-zone* has higher rainfall than the Kachhi plain. The mean annual rainfall ranges between four and ten inches. The winter rains are more certain here than in the Kachhi plain. Agriculture is dependent upon torrent water. Sorghum and millet in summer and some gram and

wheat in winter are the only possibilities. There are no immediate plans for irrigation in this area.

Mapping unit 9, Gujrat zone. The twenty inches isohyet borders this zone on the south and the mountains of the Kashmir boundary in the north. In the west the Salt Range forms the boundary and in the east the Pakistan border.

In June the mean maximum temperature is 105°F and the mean minimum is 80°F (at Sialkot). The mean maximum temperature for January is 66°F and the mean minimum 42°F. Frost occurs for a week or two. Rainfall ranges from twenty to forty inches. It is quite reliable and sufficient for growing certain crops without irrigation. At Sialkot the mean annual rainfall is thirty-two inches, about three-fourths of which is received during the monsoon from mid-June to mid-September. The winter rains are usually sufficient for rain-fed winter crops. Each month from January to April has more than one inch rain. January and February together receive more than three inches. May, October and November are dry.

The soils are dominantly silt loams, silty clay loams and clay loams with weak subangular blocky structure. Clayey soils with weak structure are subdominant. About twenty percent of the area is occupied by noncalcareous soils with weak structure. Saline-alkali soils are of very small extent and occur only in the twenty to twenty-five inches rainfall tract. Generally the soils are non-saline and remain moist most of the time, being dry only in May and the first half of June.

With irrigation the most suitable and important crop is high quality rice (basmati) in summer and wheat and berseem in winter. In summer without irrigation the most suitable crops are groundnuts on silty and loamy soils, and sorghum and millet on clayey soils. Wheat and mustard (sarson) are suitable winter crops. Pulses, both summer and winter are also quite suitable. Among fruits, guava and to a limited extent mango are suitable. Citrus suffers from lack of root aeration during heavy monsoon rains. It can be grown only on high lying, well drained loamy soils in the twenty to twenty-five inches rainfall belt with special irrigation management. Mango is damaged by frost once in about three years.

Mapping unit 10, Rawalpindi zone. This zone comprises the subhumid part of the Potwar uplands, with rainfall ranging from about twenty to thirty-five inches. Rainfall is sufficient for rain-fed cultivation of crops. Summer rains are as heavy as in the Gujrat zone but the winter rains are slightly heavier. Rawalpindi has a mean annual rainfall of thirty-six inches, about seventy percent of which occurs during the monsoon season from mid-June to mid-September. January, February and March together receive a total of 7.6 inches. The summer is moderately hot but the winter is cold. The mean maximum temperature in June is 104°F.

A large part of the area comprises gullied land, bad land and rock land. About two thirds of the land has soils suitable for cropping. Mainly they are silty or loamy soils with weak structure or massive and calcareous. A small percentage of the area has silty and clayey noncalcareous soils with good structure.

The most suitable crops for this area are groundnuts for the loamy and silty soils, and sorghum and millet for the clayey soils. Summer pulses offer another possibility. In the thirty to forty inches rainfall belt maize grows quite well, and with proper fertilizing gives good yields. In winter lentils (pulses) are very suitable. Wheat should not be encouraged because the land has to be kept fallow during summer to grow it, and this practice increases erosion. The gullied land should be put under suitable species of trees and grasses. The management of this land should include grass cutting and controlled grazing. The rock land can be developed as grazing land by reseeding with suitable grasses and proper management including controlled grazing.

Mapping unit 11, Talagang zone. This zone comprises the semiarid part of the Potwar uplands and the Bannu basin.

Summers are moderately hot and winters are cold like in the Rawalpindi zone. The rainfall in the Potwar uplands ranges from about fourteen inches in the south-west to twenty inches in the north-east. In the Bannu basin the rainfall ranges from twelve to sixteen inches. This zone is distinguished from the Rawalpindi zone mainly on the basis of rainfall. Crops are subject to occasional failure.

The best land use is sheep and cattle production by concentrating on sorghum-alfalfa mixture or other suitable forage species. The gullied land and rock land can be used as improved range land mainly by controlled grazing and reseeding.

The most suitable crop would be gram, but gram blight has become a serious disease, resulting in complete failure of the crop. Wheat and mustard (taramira) are the other suitable crops. During summer groundnuts have some possibility besides sorghum and millet for fodder.

A small part of Bannu basin is irrigated. Here the crop suitabilities given for Peshawar are applicable.

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TABLE—CROP YIELDS IN VARIOUS ECOLOGICAL

(All figures in

Zone.	I		r		r		i		g		a	
	Thatta.		Hyderabad		Sukkur		Lyallpur		Gujranwala			
	1		2		3		4		5			
Management level	T[2]	M[3]	T	M	T	M	T	M	T	M		
Rice (IRRI) ...	30	80	40	80	40	80	35	60	35	60		
Rice (local, coarse) ...	10	20	15	30	12	25	20	35	25	40		
Rice (local, basmati) ...	...	...	...	...	...	...	25	40	25	45		
Wheat (Mexi-Pak) ...	15	30	20	40	20	40	35	50	25	45		
Wheat (Dirk) ...	...	...	...	...	12	30	20	35	15	30		
Wheat (local) ...	10	20	15	25	10	25	...	...	...	...		
Cotton (American) ...	6	12	12	20	15	30	10	20	...	...		
Sugarcane ...	500	1200	400	1100	400	900	400	900	400	800		
Maize (J-1) ...	15	30	25	40	15	30	20	35	20	49		
Maize (local) ...	...	...	15	30	10	20	...	...	10	20		
Mustard (raya) ...	5	10	8	12	10	15	8	10	...	...		
Mustard (raya after rice on residual moisture) ...	5	10	...	...	4	8	...	...	...	...		
Mustard (toria, sarson) ...	...	...	...	...	6	10	...	...	6	12		
Mustard (taramira) ...	...	...	...	...	...	...	...	...	...	...		
Gram[5] ...	...	...	10	20	15	35	10	25	5	15		
Gram (after rice on residual moisture)	...	...	...	...	6	12	...	...	4	8		
Summer pulses (mash, mong) ...	...	...	8	15	10	20	5	15	5	15		
Groundnuts ...	...	...	...	...	...	...	...	...	...	...		
Millets (fodders, mainly chari) ...	150	500	250	600	300	600	300	500	300	500		
Millets (grain) ...	5	12	5	12	8	15	...	...	...	...		
Guara (seed) ...	...	...	6	10	10	20	...	...	...	...		
Berseem (fodder) ...	250	400	500	800	600	900	500	800	600	1000		
Alfalfa (fodder) ...	...	...	500	700	600	900	400	600	...	...		
Mango ...	...	...	80	120	60	100	40	60	35	50		
Citrus (tangerine) ...	...	...	...	...	80	120	100	200	...	...		
Citrus (orange) ...	...	...	100	140	70	100	70	150	70	120		
Banana ...	300	400	250	300	...	...	...	...	...	...		

[1]On the most suitable soils for the crop except in Thal where the best soil is very limited

[2]T. Traditional management including the use of a country plough, little manure or

[3]M. Modern management including the use of an improved steel plough, recommended

[4]Only a small part of the area is cultivated with torrent water and the remainder is

[5]Disease is a serious problem in Hyderabad, Lyallpur, Gujranwala, Rawalpindi and

ZONES OF THE INDUS PLAINS[1]

maunds per acre)

t *e* *d*				*Torrent-watered*		*R a i n - f e d*							
Peshawar		Thal		Western[4] piedmont		Gujrat		Rawalpindi		Talagang		Thal	
6		7		8		9		10		11		7	
T	M	T	M	T	M	T	M	T	M	T	M	T	M
35	60	...	...	...	...	...	...	...	...	...	...	...	...
25	35	...	...	...	...	...	...	...	...	...	...	...	...
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...	...	12	30	...	...	8	18	8	18	6	10	4	8
15	25	10	20	8	12	7	15	7	15	4	8	4	7
...	...	8	15	...	...	...	...	...	...	...	...	...	...
500	900	300	700	...	...	...	...	...	...	...	...	...	...
30	50	...	...	...	...	12	20	12	20	...	...	...	...
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...	...	8	15	8	12	...	...	8	14	5	10	5	8
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...	...	6	15	4	7	5	12	5	12	3	6	...	...
...	...	8	20	...	...	15	25	15	25	6	10	5	8
300	500	250	500	200	350	150	300	150	300	75	150	30	70
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...	...	8	16	...	...	5	10	4	10	4	8	4	6
600	1000	400	700	...	...	...	...	...	...	...	...	...	...
500	800	300	600	50	100	150	250	150	250	...	...	...	...
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...	...	80	120	...	...	...	...	...	...	...	...	...	...
70	150	70	100	...	...	...	...	...	...	...	...	...	...
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and the extensive moderately suitable soil (sandy loam) is considered.

fertilizer, local seed and no disease control.

doses of fertilizers, quality seed and proper disease control.

barren.

Talagang zones.

SOME ASPECTS OF SCIENTIFIC GEOGRAPHICAL WORK IN CENTRAL ASIA DURING 9th TO 13th CENTURY[1]

NAFIS AHMAD

Central Asia like some other popular geographic expressions, *e.g.* Near East, Middle East, Far East, Southeast Asia, has a somewhat loose connotation. For the sake of accepting a traditional geographic concept, let us start by including in it a core area which stretches from beyond the borders of Khurasan (N.E. Iran and Turkmen SSR) across the River Oxus (Amu Darya or the Jayhun of Arabs) to Chinese Turkistan, embracing Kashghar and Yarqand The northern limits coincide with 50° N Lat. passing across the Aral Sea to Tien Shan mountains. While important fringe lands include Khurasan itself, Northern Afghanistan (North of Hindukush mountains in the present Wilayat-i-Shimali) and Tajikistan and Badakhshan. In the Soviet Union lie the Republic of Turkmen, Uzbek, Tadjik and Khirghiz and the central and southern parts of Kazakh SSR.

The climate of Central Asian regions is distinctly continental, with cold winters and hot summers. Both annual and daily temperature amplitudes are great ; most of the region has many hours of sunshine and very little precipitation ; even the mountains are arid. Most of Central Asia is part of the vast undrained interior of the Eurasian basin whose low arid plains surrounded by high mountain ranges, control the regime of the many large rivers within it. There is a broad development of arid soils. The flora and fauna are remarkably adapted to geographic conditions. The greater part of the region consists of deserts and semideserts; forests occupy a negligible area. In Central Asia crops have been irrigated for many centuries, and the construction of irrigation systems is still going on cotton and fruits are perhaps the most important agricultural products.

Advent of Arabs and Islam

It was into this regions that the Arab conquerors fired with the zeal of Islam swept like a rapid wave in the first 50 years of the 8th Century A.D. As early as 9th century Mawarannahr (Transoxiana) was regarded as a Muslim area, its population taking part in the holy wars against non-Muslims. Though sizeable other communities like Jews, Christians, Zoroastrians and Manichaeans continued to live there in peace.

The Arabs annexed the lands beyond Khurasan and the Oxus-Mawarannahr, that lies beyond the river (Transoxiana). Marv became the capital of the whole of Khurasan and Samarkand the capital of Mawarannahr. This was under Governor Qutaiba ibn Muslim (705-715 A.D.). Toward 730 A.D. Arab conquests spread beyond the Jaxartes (Syr Darya, Shash of Arabs). The Arab success over the Chinese in Talas valley (Auliya Ata) on 751 A.D. settled the fate of Turkistan as an Arab cultural area. The Arab conquests, thereafter extended to Kashghar, the Farghana valley and Tashqand and Khwarizm. They crossed the border regions between the cultivated and Steppe areas. Protection walls against the nomads were built by the Arabs. Remnants of these walls still exist. Khurasan attained great importance in the affairs of the Caliphate. And Ibn Muslim a Khurasani played a leading role in the fall of the Umayyad Caliphate and in installing the Abbasids.

Barmak the ancestor of the Barmakids and Samin Khudat the ancestor of the Samanids both were natives of the province of Balkh. The founder of the Samanid dynasty Ismail (892-907 A.D.) ruled from Bukhara east of the Oxus.

[1]The paper was read at the UNESCO Symposium on the Development of Science in Central Asia held at Islamabad, Pakistan, September 22nd to 30th, 1970.

Large parts of this region were also included into the dominions of the powerful Seljuqs, and the Ghaznavids also possessed large tracts of these regions. The great scientist Abu Raihan Al-Biruni (b. 972 d. 1050 A.D.) came from near Khwarizm. The astronomer, mathematician, philosopher, scientist and poet Umar Khayyam was a native of Nishapur in Khurasan (1038—1123 A.D.)

The 10 century A. D. during the heyday of Samanid rule was also the time when Arab geographical literature attained great height in this area. Among others, Abu Zaid Al-Balkhi (d. 934 A.D.) and Abu Ishaq Al-Istakhri (d. 951 A.D.) were great geographers and map makers, Al Jaihani though a top administrator produced a remarkably geography oriented work (Kitab al-Kharaj) and the anonymous writer of Hudud al-Alam (982 A.D.) wrote an outstanding world geography book in Persian. Abu Said of Jurjan the mathematician drew a meridian. Abu Ma'shar of Khurasan was born in Balkh and died in 886 A.D. Al-Farghani and Al-Khawarizmi were great astronomers and mathematicians. Farghani determined the diameter of the earth as 6,500 miles. Abu Dulaf (942 A.D) flourished at Bukhara and travelled over much of Central Asia and then went across Tibet to South India, Kashmir, Afghanistan and Sistan. He wrote the fascinating Ajaib-at-Buldan.

Well known Muslim geographers living in other areas, namely, Ibn Khurdadbeh (848 A.D.) Ya'qubi (897 A.D.). Al-Hamadani (902 A.D.), Ibn Rustah (903 A.D.), Ibn Fadlan (921 A.D.), Ibn Hawqal (977 A D), Al-Mas'udi (d. 956 A.D.) and Al-Maqdisi (985 A.D.) ; wrote on the geographical aspects of Central Asian areas. Of these, Al-Mas'udis' accounts of Khurasan, Caspian Sea areas, Transoxiana and Chinese border lands are remarkable for their clarity, Russian geographers have often used Mas'udi' text in Muruj aldhahb (meadows of Gold) on Central Asia and Turkistan, Mas'udi is truly called the Herodotus of the Arabs.

In the 11th century Nasir-i-Khusrau from Balkh (d. 1088 A.D.) produced a brilliant travel diary (Safar Namah, 1045 A.D.). But one of the most remarkable geographical works was produced by Yaqut Hamavi (d. 1229 A.D.). It gave a true picture of the culture of Islam in the area before the Mongol tornado swept over it. Yaqut's work Mu'jam ul Buldan (1224 A.D.) is an outstanding contribution to Arabic and Geographical literature during the Middle Ages.

The invasion of the Mongols and the destruction by Chingez Khan and Hulagu and their successors brought the 13th century to a sorrowful close in this period of Central Asian history. The amazing phenomena of the revival of Islam's glory under the Ilkhans and Timurids is the story of the succeeding generations.

Then what what about the development of science and material culture during this period ? The geographers are more concerned with the progress of urbanization, industrial advance, town planning, agricultural techniques, development of irrigation, trade and commerce, problem of desiccation and general economic prosperity.

Towns and Town Planning

It is a well known fact that the advent of the Arabs contributed much to the growth of towns and the progress of trade and industry. They learnt the art of making rag-paper from the Chinese, developed it, and then passed it on to the west. Textile manufacture in Transoxiana was introduced by the Arabs.

In Turkistan the Arabs did not build such large and new town as they did in Iran (Shiraz and Qum) and Transoxiana (Ganja). But existing towns grew in size. Barthold had observed that a comparison of literacy records with archaeological remains throws much light on the growth of such towns as Marv, Samarqand and Bukhara.

The main components of pre-Muslim towns were : *a*) A Shahristan or core area (modern down town) ; *b*) The citadel or fortress either inside or outside Sharistan ; *c*) The suburbs surrounded by an outer town wall. More research is needed in this direction.

Here the mention of the work of V.V. Barthold (1869—1930) is important. He was a great historian of the Muslim East who has been

rightly called the 'Gibbon of Turkistan'. As author of the 'Historical Geography of Iran', 'the History of Oriental Studies in Western Europe and Russia', 'the Caliph and the Sultan' and above all the most brilliant contribution. 'Turkistan down to the Mongol Invasion' and several articles in the earlier edition (Leiden) of the Encyclopaedia of Islam ; he established a great tradition in scholarship.

Tenth Century, the Classical Period

As is well known, 10th century A.D. was a classical period in the history of Arab (Muslim) geographical science which grew partly out of the influence of Graeco-Roman ideas, but largely due to the synthesis between older ideas and the new independent thinking. The conceptions of aneient geographers and philosophers were subjected to revision and often had to be abandoned by Muslim scholars as out of date.

In this general advancement of science in the lands of Islam, the scientist and scholars of Central Asian areas played a significant part. Especially, in the field of geography their contribution was outstanding. Some of these names have been mentioned already. These brilliant scientists became known in Europe and Russia comparatively late, in fact, many centuries after their magnificent contributions were made. But the western orientalists succeeded in focussing attention on their achievements to make the history of Science more understandable.

Orientalists and Other Scholars

In Russia—USSR were such prominent scholars as I.P. Minaev, V.V. Grigorief, V.V. Barthold and I. Yu. Krachkovsky who recognised and elaborated the works of Muslim geographers and encyclopaedists. Elsewhere were such men as Nalino, de Goje. Carra de Vaux, Ferrand, Sedillot, Reinaud, Brockelmann, Levy, Mez, Mayerhof, Huart, Schoy, Le Strange, O'Leary, Gibb, Barbier de Meynard, Sarton, Zaki Validi, Sulaiman Nadvi, Hitti, Minorsky and others.

However, in assessing the nature and extent of Science and Scientific thought in Mediaeval Central Asia as elsewhere in the lands of Islam, it should not be forgotten that the most important feature of the intellectual outlook in those days was the dominance of religion. It pervaded all aspects of life. In general, it may be said that religious attitude was manifest in the social and cultural fields. Therefore, scientific work also sometimes had to contend with uneven and difficult, orthodox attitudes, yet many brave and devoted intellectuals were produced under the Islamic impulse. Doubts and critical attitudes were developed but there was a lack of the development of a tradition of experimentation. That really had to wait till the advent of the industrial and scientific revolution.

In conclusion, it may be said that a good deal of work has been done in the general field of history of Medieval Central Asia. Though there is always room for more research. The works of the geographers have received considerable attention and achievements of science in other fields have often been enumerated. But geographers should still be interested in developing more knowledge about such matters as irrigation and agricultural land use, erection of windmills, theories about desiccation, manufactures and industrial activity, town life and urbanization, structure of new towns, patterns of trade and commerce and ethnic and cultural settings and Muslim cartography.

In my opinion, by these discussions on scientific thought in Central Asia in the past, we have emphasized the tradition of the exchange of knowledge and the internationalism of knowledge. I am sure, this gathering of scholars and scientists from several countries will promote this spirit.

BOOK REVIEW

Regional Geography of the World, Jesse H. Wheeler Jr., J. Trenton Kostbade and Richard S. Thoman, published by Holt, Rinehart and Winston Inc., New York, (1969, 3rd edition). xi, 799 pp., maps, diagrams, photos, bibliographies, indexes.

University of Missouri partnership has done a magnificent job, indeed. Their labour of many years has been well received and is in its third edition. Following the post 1945 pattern that became common in American regional geography, this world study maintains, in a large measure, its distinction of generally sustained geo-economic approach. The present edition appears with portions of the text having been enlarged, tables brought up to date and changes made in the development of themes and the arrangement of titles. Bibliographies, particularly, are usefully selective. A new chapter on geographic processes has been incorporated with the understandable objective of familiarizing students at different instructional levels, as well as the general reader, with the operation of forces that create a natural setting and the way human geography is adjusted to it. A detailed and instructive account of London has been added to the portion relating to the British Isles to initiate the students into the processes of urban development and expansion. The choice reflects appreciation of some of the unique historical and geographical factors whose interplay accounts for the growth of one of the largest metropolises in the world and, certainly, the largest commercial centre in the colonial era that now belongs to history. The book also represents new projections in modern cartography with all the excellence of line and colour. In essence, this edition is, by and large: a balanced thematic exposition and appears with enhanced value.

Some spots peeping out of this ambitious canvas, however, is not unusual. The concept and plan of treatment on which the volume is based has been set out in detail in the chapter on "Key Topics in the Geographical Interpretation of Countries and Regions". The regions conform more to the twentieth century's political mood than to the purely geographical variables. Even though the application of a "high degree of selectivity" (p. 38) of facts, as has been indicated, is the basis of classification, it is difficult to see the validity of regions like the Orient and Africa. The authors do not seem to regard environmental diversity of these vast areas as inimical to the 'homogeneity' that is the hallmark of a region; yet they draw a line (as will be discussed presently) between European Russia and East European countries in spite of the identicality of so much between them.

At places there appear interpretative references to matters that, strictly speaking, would seem to fall outside the ambit of geography. That, incidently, is a universal weakness with the modern regional treatments. Pigs having been forbidden in Islam could hardly be on the ground that "in a barrenland where all vegetable foods are needed to feed men, it would be anti-social to fatten a pig;" (p. 353). It is arguable if pigs consume more of vegetable foods than all other categories of stock put together; and the region (Middle East) has sustained countless millions of cattle, camels, sheep, goats, horses, donkeys and mules through ages. Dealing with the South Asian region, the authors refer to "Islam's uncompromising monotheism" and its "essential intolerance of other faiths" (p. 434). The relevance of such observations in a regional treatment by geographers is difficult to see. These could damage the scientific approach and objectivity that, indeed, is the basis of motivation in the preparation of this otherwise commendable study. The position is all the more regrettable because the authors themselves belong to a society that represents a definite religious persuasion. It is, however, satisfying that such derogatory comments do not appear

elsewhere in regard to the communities (and their religion and ideology), inhabiting other regions, although every region of the world has been, and still is, full of intolerance and bigotry of one kind or another.

In the chapter on Europe, a new concept of the continent's eastern boundary has been advanced. The traditional boundary has been shifted from the Urals to the western borders of the Soviet Union and Turkey for the delimitation of the European region. That, obviously, raises the issue of proper geographical perspective in which the generation, for which the book is intended, is to be instructed. Arguing for the shift, the authors emphasize "important differences in culture and environment" (p. 55). How much wider is the gap between (West) European and Soviet cultures than that between (East) European and Soviet cultures is a point on which opinions will differ. The part of the Soviet Union west of the Urals and stretching from the Baltic to the Black Sea consists of 'core' areas wherein the society, in general, is characterised by those some hues of modern industrial life that are a distinctive feature of the West European society. What differentiates one from the other is race and history. And if race and history be reckoned as the determinants of 'culture and environment' the environment and culture of the marginal buffer-zone countries like Poland, Czechoslovakia, Hungary, Romania, Bulgaria and Yugoslavia are only a shade different from those of Russia, but considerably so from western Europe's. These communities have had their origin in the Russian territory, the Slavs in the area between the Vistula and the Dnieper and others in the Asian Steppe, and their cultures and languages carry deep eastern impressions. In many of their traits they come closer to Ukranians and Byelorussians. The identicality of their traits is as much worthy of cognizance as the similarities in the English, French and German ways of life. That their boundaries, as also the western frontiers of the Soviet Union, have been changing is not distant history. After all, Alsace and Lorraine changing hands between France and Germany over the last fifty years did not affect the West European culture ! The new concept is likely to foster ideological bias and to blur true geographical perspective.

These instances apart, the book is a valuable contribution to the literature on regional geography. Finely got up and attractively printed, it should find favour with every student of regional and human geography.

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Tradition, Season, and Change, in a Turkish Village, John F. Kolars, University of Chicago Press, Chicago (1963), XV, 205 pp., tables, figures, maps, bibliography.

By and large all Chicago University dissertations are based entirely on personal research work. Of necessity the area of study is small and the information exhaustive, *Tradition, Season, and Change in a Turkish Village*, by John F. Kolars belongs to this group of publications.

Both the title and the author's words themselves clearly state the nature of this work, " the description of different systems of agriculture in several selected villages in Southern Turkey, and an account of the developmental processes which have resulted in the emergence of these systems constitute the body of this work. The approach is both historical and dynamic, and its aimed at showing how time change and development give distinct characteristics to at one time similar communities. Throughout this work, four topics appear to be critical to an understanding of the village agricultural systems. These are, (*i*) ingredients of the village agricultural organization, (*ii*) processes of transition during the last fifty years, (*iii*) relationship of village agriculture to the changing elements of the national milieu, (*iv*) importance of variations in explaining the current differences in the artificial landscapes and their accompanying agricultural activities. The author appears to have taken considerable pains to choose appropriate variables to prove the validity of his arguments. The region of Antalya is central to this research work and also a comparison of this region with a number of other villages chosen again on the basis of their fulfilling certain chosen criteria.

A glance at the contents shows that in the Introduction, the author explains in detail the method of determining the sets of variables used thereafter in this report. The main body of the work is divided into ten chapters. Chapter I deals with the main area of research which is the Antalya region. In Chapter II the need for comparison of the Antalya region with some other regions of Turkey is emphasised and on the basis of chosen criteria, the selection of an area referred to as the Boga Cay area is made for such comparisons. In the remaining eight chapters this comparison is dealt with in great detail which is indeed commendable. In conclusion, the author draws the attention of the reader to the fast changing relationships between once self-sufficient, subsistence level villages and the market economy of Turkey, resulting in the development of new sets of problems and the need to continue investigation and research.

Tradition, Season, and Change in a Turkey Village, is an excellent guide to the kind of research work which can be carried out in areas of similar conditions as the Antalya and Boga Cay regions. In particular, this work can be of immense help to persons directing planned programmes of regional development in Turkey especially the Antalya region. The detailed explanation of the methods used in evolving sets of variables on which the research work has been carried out, can be of great value to research students in their investigations. Besides the text, a large number of tables, figures and maps all contribute to the high research value of this work.

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