PAKISTAN GEOGRAPHICAL REVIEW

1959

VOL. XIV
NO. 2

ANNUAL SUBSCRIPTION :

INLAND	...	**Rs. 6**
FOREIGN	...	**Rs. 8**

All communications to be addressed to the Manager, Pakistan Geographical Review Department of Geography, University of the Panjab, Lahore

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THE PULSATING MONSOON IN SOUTH EAST ASIA AND ASSOCIATED FLOODS IN THE INDO-GANGETIC RIVER SYSTEMS*

BY

SYED SIBTE NABI NAQVI

Director, Pakistan Meteorological Service, Karachi

In our region, the southwest monsoon and its associated floods play an important role—rather a central role—not only as a factor in geomorphology, but also as a motive force in the anthropological drama, which has been played in this region by *homo sapiens* throughout the ages.

The pulsating character of this planetary phenomenon, while providing colour and romance in the life of the peoples residing in the region and bringing plenty and prosperity in normal years, brings misery, hunger, want and famine in years of deficiency, and raging torrents and devastating floods in years of excessive rainfall.

The monsoon rains wash down millions of tons of silt, debris and salts from the highest mountain ranges of the earth, the Himalayas, the Karakoram, the Hindukush, and the Sulaimans, and play the role of builders and creators of the entire landmass fed by them.

The economic importance of these monsoons lies in the huge amount of water-vapour which they transport from the ocean areas on to the continents, where the water-vapour precipitates out in the form of rain and snow, and, thus, provides a perennial supply of water to feed nearly one third of the human population of the earth. The rainfall received from June to September in association with the monsoon is given in Fig 2.

Before steamships came into existence during the last century, the monsoons provided the only motive power to the sailing ships for maintaining communications between the centres of civilizations in the Middle East, India and China. The monsoons have, thus, played a vital role in the development and maintenance of human civilization in Asia, and continue to play that part even now.

I would like to discuss, if I may, the physical causes of the pulsating properties of the southwest monsoon of the Indian Ocean basin with particular reference to associated floods in the Indo-Gangetic river systems and their forecasting.

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*Presidential Address, Section of Geography, Geology and Anthropology, Pakistan Science Conference, 1959.

BASIC CAUSES OF THE SOUTHWEST MONSOON

The basic causes of the southwest monsoon of our region, though usually claimed to be understood even by school children, are as yet not quite clear and fully agreed upon even amongst specialists. The simple explanation offered in school-rooms is that, during the summer months and due to continental heating, a trough of low pressure appears over the northwestern parts of the Indo-Pakistan sub-continent. The sub-tropical anti-cyclone over the south Indian Ocean is much intensified during this period, as it is the winter season there. The high pressure area over the south Indian Ocean extends northwards towards the equator, and the hydro-dynamical forces operating between these two systems—of low pressure in the northern hemisphere and high pressure in the southern hemisphere—drive the southeast Trade winds of the south Indian Ocean northwards. These reach Ceylon, India, Pakistan (East and West) and Burma as the southwest monsoon in the months of May, June and July and continue there up to the months of September and October. A similar argument for the extension of the northeast Trade into the southern hemisphere during the northern winter completes the whole story. Some bright fellow may even go to the extent of comparing the reversing planetary circulations over the Indian Ocean in the winter and the summer of the northern hemisphere to the land and sea breezes on a large scale.

These explanations, though substantially correct, do not satisfy scrutiny if we go a little deeper. Several anomalies can be pointed out in this simple argument, as has been done by others several times before, more recently by Palmers(1). For instance, the low-pressure area over the Indo-Pakistan sub-continent in the summer months extends far beyond this region, over Asia, where the monsoons do not reach. Or, again, the Doldrums of the equatorial region offer a hydrodynamical barrier to the passage of air across them.

The difficulties in the proper understanding of the monsoon in the past have been mainly due to our attention having been confined largely to the surface of separation between the atmosphere on the one hand and the lithosphere and the hydrosphere on the other. It was only during the last 50 years that we started the exploration of the upper atmosphere, where the directive forces reside; and it is only during the last 20 years that we have started getting a proper synoptic view of the phenomena in all the three dimensions. Vast areas of the Indian Ocean, however, still lack these data and many statements in the present survey, as in many others, are therefore based on inferences drawn from limited observations.

There is no doubt that the driving force of this vast system of reversing winds is the energy received from the sun. It can be compared to a vast irreversible steam-engine in which the boiler is the Indian Ocean, the cylinder is formed by the hill ranges starting from Tenasserim and Arakan in the east, the Himalayas in the north and the Sulaiman and Kirthar Ranges and the Western Ghats in the West. The front of every fresh pulse of the monsoon stream entering into this 'cylinder' acts like a piston; and the part of the valves is played by the isobaric system in the upper atmosphere at a height of 20,000 to 30,000 ft. above sea-level. The working substance is the monsoon air, which is fully charged with water-vapour from the Indian Ocean, and the land-masses over which the air passes in the last lap of its long journey.

The above simile becomes obvious if we look at a three-dimensional generalised diagram of the air-flow in the first 3 km of the atmosphere and the isobaric system at 6 km over the region in the months of July and August, shown in Fig. 1. If we try to understand the summer monsoon of Asia with this simple picture before us, many of its characteristics get explained easily.

The sub-tropical highs of the northern and southern hemispheres at the surface and in the troposphere are separated by areas of low pressure over the tropical regions. These isobaric systems and their associated wind currents oscillate towards the north and the south as the sun shines directly near the tropics of Cancer and of Capricorn, respectively.

When the sun shines directly over the Tropic of Cancer, the earth is at the apogee in its elliptic orbit round the sun; and when it shines vertically over the Tropic of Capricorn, the earth is at the perigee of its orbit. The difference in the distances of the earth from the sun at apogee and perigee is sufficient to produce changes in the amount of solar energy falling over the earth as a whole in the two seasons. In June it is much less than that received in December.

This difference in the energies received in June and December in the northern hemisphere would have produced rather milder conditions, but, because the northern hemisphere is dominated by land-masses and the southern hemisphere is covered mostly by oceans, the weather conditions in the northern hemisphere are subject to much larger extremes of climate in the summer and the winter than in the southern hemisphere.

In the Roaring Forties of the southern hemisphere the westerlies continue unabated throughout the year. To the north of this belt of westerlies lie the high pressure areas over the Pacific, Atlantic and the Indian Oceans. We are concerned in our discussion mainly with the anti-cyclone over the south Indian Ocean. In January, the Indian Ocean anti-cyclone does not extend towards the equator beyond 15° S, and a trough of low pressure extends from Australia to the centre of the Indian Ocean to the north of the anti-cyclone. In between these two pressure systems blow the south-east Trades of the south Indian Ocean and in this month their northern limit is about 10°S.

As the season advances, the northern limit of the south Indian Ocean anti cyclone and the trough line separating the air masses of the northern and the southern hemispheres move northwards along with the whole system. This was called the Tropical Front in the past and is now termed the Intertropical Convergence Zone or Intertropical Front.

In January, this convergence zone is in the neighbourhood of 10°S. Moving northwards, it reaches the equator in April. The stage is now set for the onset of the southwest monsoon of southeast Asia.

The distribution of the main air-streams over the Indian Ocean from May to October is shown in Figure 2. The shaded areas in these maps show winds of 60% or more in steadiness, while in the blank portions the steadiness is less and even below 40%. In the tropics, these blank areas of unsteady winds are the Doldrums, and to the south of the Bay of Bengal they persist even at the height of the monsoon season.

The conditions prevailing over the Indian Ocean in May, like those in all the other months, are given in full detail in the Monthly Meteorological Charts of the Indian Ocean, published by the London Meteorological office.(4) The stream-lines in May at 3 km and 6 km are shown in Figures 3 and 4. It is evident that in May, although the trough of low pressure on the surface now lies over the land masses of South Asia with its centre over India and West Pakistan, the Arabian Sea is still dominated by the tropical air from the deserts of Africa and Arabia. However, the southeast Trades begin to reach the Equator and turn towards northeast due to the coriolis force. This is just the beginning, the birth of the southwest monsoon.

In June, the conditions over the north Indian Ocean begin to adjust themselves quickly. The sub-tropical anti-cyclone of the South Indian Ocean is now shifted westwards with its centre near 30°S and 60°E. The westerlies of the Roaring Forties sweep round this anti-cyclone towards the north and then towards the west. These and the subsiding air masses in the northern part of the anticyclone blow on steadily from the south-east till they reach the coast of Br. East Africa and Somaliland. Here, they curve again under the influence of orography and the coriolis force, and enter the Arabian Sea from the southwest as strong steady monsoons. A second branch of the recurved southeast Trades enters the Bay of Bengal and a third branch in the China Sea. All these three branches of the sw monsoon advance like tongues of cold air, with squalls and thunderstorms at their front. There are however, inherent differences in these three branches of the monsoon. The Arabian Sea branch is the warmest. The second branch reaches the Bay of Bengal after crossing the Doldrum area, where precipitation is most frequent. The China Sea branch is affected very profoundly in its passage across Northern Australia and the Indonesian Islands.

The advance of the monsoon front carries the Intertropical Convergence Zone to the foot of the Himalayas in the Indo-Gangetic plains. Its structure over w India and Pakistan has been discussed by Sawyer(6). The typical cross sections of the front given by him are reproduced in Fig. 5. The normal conditions of pressure and wind during July and August, when the monsoon is at its height are given in Figures 6, 7 and 8 respectively for the surface, and for 3 and 6 km above sea level. The stream lines in the upper atmosphere have been drawn on the basis of the windroses and resultant wind directions given in the Climatological Atlas for Meteorologists and Airmen(5) and the Climatological Atlas of the Indian Monsoon Area, 1945,(2) issued by the India

Meteorological Department, the Monthly Meteorological Charts of the Indian Ocean, 1949,(4) and the Weather in the Indian Ocean(3) 1943, issued by the London Meteorological Office, and in Climatological Atlas of the World, Volume III—Indian Ocean, 1957, of the U.S. Navy.

The monsoon current itself is not very deep. My investigations into the correlation between excess of air in the 'cylinder' formed by the mountain ranges round the Indo-Pakistan sub-continent and the associated rainfall, have shown that the air upto 3 km is responsible for most of the rainfall that we receive. Above this level even the pattern of stream lines changes considerably; and at 6 km the cyclonic circulation which was over the Middle East countries at lower levels is replaced by an anti-cyclonic circulation. Also, at this level the easterly stream starting from Malaya reaches the Gangetic plains over India and then turns southwestwards towards Somaliland; in the equatorial belt south of the Indian peninsula a westerly stream appears over the Indian Ocean. Still further south, the stream-lines over the south Indian Ocean are dominated at its eastern and western ends in the region of latitude 15°S by two anti-cyclones.

In September the retreat of the monsoon starts from West Pakistan; and by the middle of October the monsoon is practically out of the Arabian Sea and the Bay of Bengal.

The summer monsoon of the Indian Ocean is not an isolated phenomenon. It forms part of the general circulation on the earth, and in our region is associated with the southerly monsoon of the China Sea, while even on the Ghana coast in West Africa and over Central America southerly or southwesterly monsoons occur in the northern summer.

PULSATIONS IN THE MONSOON CURRENT

From the mean climatic charts given here it might appear that the conditions in this season are very uniform and steady. This is not at all the case. The monsoon is generally made up of spells of rainy and stormy weather followed by spells of dry and fair weather. This pulsation in the activity of the monsoon has been explained mainly on the basis of the depressions and cyclonic storms which form in this season mostly in the Bay of Bengal, and sometime in the China Sea and the Arabian Sea. This explanation is evidently not quite satisfactory, firstly because the pulsating character of the monsoon is not confined to the intermittent nature of the associated rainfall, but shows itself also in the variations of wind strength and flow-pattern, in the entire monsoon field; and secondly the fluctuations are also evident in the positions of the Inter-tropical Convergence Zone and entire systems of isobaric distribution over the Indian Ocean. Moreover, the cyclonic storms and depressions form only near the northern limit of the sw monsoon in the Bay of Bengal and the China Sea when it is strong, and therefore can only be the effect and not the cause of the pulsation. It is evident that in this search we have to go a little farther out.

As far back as 1897 Hildebrandson had shown an opposite trend of pressure oscillations between Sydney and Buenos Aires. In 1902, Lockyer confirmed the seasaw between the pressures around the Indian Ocean and over Argentine. Following these suggestions Sir Gilbert Walker(8) investigated and found significant correlation between the monsoon rainfall of June to September in the Indo-Pakistan subcontinent and the South American air pressures of April and May. After this discovery, which had aimed at forecasting the monsoon rainfall of our region only, Walker's study assumed a world-wide character, and he published a series of memoirs on World Weather from the India Meteorological Department and from the Royal Meteorological Society of London, which established the existence of an empirical relationship between the tendency of the amount of air to decrease in the whole of the Pacific area and its increase almost simultaneously in and around the Indian Ocean, and vice versa. Similarly, there is a certain association between the fluctuations of pressure in the northern Atlantic and the Pacific and those in the Indian Ocean. These have been called oscillations, and the correlation between those oscillations and the rainfall of Indo-Pakistan, Java, Australia, Burma(9) and China (10) and even the temperatures over China(11) have been established. The correlations used by Walker in 1924 for forecasting the Indian monsoon rainfall of June to September were the South Rodhesia rainfall of October to April, South American pressure of April and May, Dutch Harbour temperature of December to April, etc. Such empirical correlations have been used all along for foreshadowing the monsoon rainfall in our region with a fair degree of success, and go to show that the activity of the summer monsoon of South Asia is influenced by factors operating far away both in time and space. It seems unnecessary to discuss all of them in detail. I, therefore, confine my attention to the more immediate meteorological factors which appear to be physically responsible for the fluctuations in the activity of our summer monsoon.

These fluctuations are of two kinds. Firstly, the fluctuations that take place in the strength of the monsoon current as a whole from year to year. Such fluctuations have been clearly brought out by Dr. Ramdas in his diagram showing the floods and droughts in 30 sub-divisions of the former India from year to year since 1875. In this analysis a year in a particular sub-division has been termed a flood year if its positive departure of rainfall from the normal was equal to or more than double the value of the mean deviation, and a drought year if the negative departure from normal was equal to or less than double the mean deviation. For each year I have counted and added together the numbers of sub-divisions with floods and droughts and have plotted them in Fig. 10.

The number of sub-divisions with floods or droughts in a year indicates the strength of the monsoon in different parts of the sub-continent. For example, in years in which most of sub-divisions had floods, the monsoon was strong as a whole, and in years when most of the sub-divisions recorded droughts, the monsoon was weak. The vertical lines in Fig. 10 show the extents of the flood and drought conditions. It is evident that the years 1878, 1892-94 & 1917 were flood years over most parts of the sub-continent, and 1877, 1899 and 1918 were the years when the rainfall was scanty and the monsoon weak as a whole. In 1885, 1906, 1921, 1930, 1940 & 1943 the rainfall was within double of the mean deviation over the whole sub-continent.

The above distribution of years of excessive and scanty rainfall does not bring out any system or regularity. But if we look upon the dispersion of flood and drought years in a generalised way, it becomes apparent that two different oscillations, each with a period of about 18 to 23 years, tend to strengthen and weaken the monsoon current over the Indo-Pakistan sub-continent. They operate simultaneously but have a phase difference of about $\frac{\pi}{4}$. A discussion of the nature of these operative factors of increasing and decreasing the activity of the monsoon current in different parts of the sub-continent and their physical significance would be too long for this treatise. It may however be mentioned, in passing, that these factors must be associated with the activity of the sun and with the oscillations of air pressure in the Indian, Atlantic and the Pacific oceans.

The second type of pulsations of the monsoon current consist of its day to day variations over the north Indian Ocean. As already expressed, this variation is generally explained on the basis of the formation and movement of cyclonic storms and depressions in the Bay of Bengal. When a depression or storm is in the process of formation and development at the head of the Bay of Bengal, the Arabian Sea current also revives and usually causes heavy rainfall at Bombay, Mahabaleshwar and Poona. But this continues only so long as the depression or storm is developing, and the rainfall on the west coast of India actually decreases when the development of the storm or depression has reached its final stage.

The formation of many of these depressions and storms in the Bay of Bengal has been explained on the basis of easterly waves from the China Sea. But there are many which form in the Bay of Bengal itself. These are, in fact, associated with the pulses of fresh monsoon that enter the Bay of Bengal from the south. These pulses in the monsoon current can sometimes be traced to originate in the westerlies to the south of the sub-tropical cyclone in the south Indian Ocean, due to breaking up of these highs on account of the Polar Fronts interposing themselves in the South Indian Ocean. But that also is not always true.

It has not so far been fully explained why some of these pulses, on reaching the inter-tropical front over or near the head of the Bay of Bengal, develop into depressions and storms, while many others do not. This erratic behaviour of the monsoon current in our area, giving rise to depressions and cyclonic storms on some occasions and passing off without any further developments on others, is one of the basic problems of tropical meteorology yet to be solved satisfactorily.

To me the pulsation of the monsoon has always appeared to be related to the isobaric distribution at the 6 km level. The movements of cirrus clouds have for long been thought to indicate the movements of tropical storms. Six km is near about the height of these clouds, and I have found the stream-lines at this height over the

Indo-Pakistan sub-continent to be the guide and the controlling factor of the entire monsoon system in this region much more than the cirrus movements. This is perhaps due to the fact that the mountain ranges of Africa in the west and of the Himalayas and Tibet, the Hindukush and the Zagros in the north of the monsoon current are all as high as the monsoon current, if not higher. *Naturallay the escape level of the monsoon air accumulating over the north Indian Ocean* is thus about 6 km, *where the air streams steer not only the depressions and storms, but also govern the states of flow of the monsoon air towards the north.*

We have a long series of upper wind data available for this level for the Indo-Pakistan region. The stream-lines drawn for July and August for this level are based on the resultant winds published in the Climatological Atlas for Meteorologists and Airmen, 1943, and from the wind roses for the 500 mb level published in the U.S. Navy's Climatological Atlas of the World, Volume III for Indian Ocean, 1957. These are, no doubt, a very rough representation of the actual mean conditions over the area, but there is conclusive evidence to support their genuineness and validity. In the stream-lines chart for 6 km (500 mb), we find that there are two centres of anti-cyclonic circulation over the African and the Australian ends of the Indian Ocean in the Tropics and two anti-cyclonic circulations over the land-masses of the Arabian and the Iranian Plateaus in the Middle East and of Indo-China and South China to Tibet in the Far East. In between these systems of anti-cyclones there is a vast cyclonic circulation over the Indian peninsula.

All these systems are very active all the time, with inner cells revolving within the bigger systems with the circulation at the peripheries of the latter, and assuming different shapes and alignments as they move. In between the anti-cyclones of the Far East and the Middle East and the vast cyclonic circulation over the Indian peninsula, there is the current which occasionally strengthens into the easterly jet stream discussed by Koteswaram ([12]). Ramanathan also has drawn attention ([13]) to these high level easterlies over Hong Kong, Calcutta, etc. in the monsoon season.

The four inner cells L_1, L_2, L_3, and $L4$, inside the cyclonic circulation over the Indian peninsula and the east Arabian Sea revolve in an anti-clockwise direction and this is really responsible for the pulsatory character of the southwest monsoon in the lower levels over the Indo-Pakistan sub-continent. As the cell L_1 in Figs. 1 and 8 moves southwards it tends to retard the flow of the Arabian Sea current; but when it reaches the Lacadives, Maldives and Ceylon areas, it begins to favour an onrush of the Bay of Bengal current. Moving northward, each cell carries the fresh pulse towards the head of the Bay of Bengal. If, by the time this fresh pulse reaches there, the anti-cyclone over Tibet is able to cause subsidence of the continental air from the higher latitudes, across and down the snow-covered Himalayan ranges up to the vicinity of the fresh monsoon pulse, then a cyclonic storm or a depression is usually formed; and the state of this disturbance is much influenced if it happens to synchronise with a low pressure wave in the easterly current passing over that area at the time. The passage of western disturbances over the middle latitudes to the north of the anti-cyclonic circulation over South Asia has much to do with the state of these circulations, and, therefore, cannot be ignored while considering the pulsations of the southwest monsoon over Indo-Pakistan.

The factors controlling the future movement of depressions across India have also remained a subject of controversy. The monsoon depressions and storms from the Bay of Bengal in July and August travel initially in a northwesterly direction. But, some of these depressions recurve towards north then northeast on reaching the central parts of India or Rajasthan and fill up on coming up against the Himalayas. Other depressions continue to move westwards and generally merge into the trough of low pressure over Sind and Baluchistan. Some few of them, however, continue to move westwards and cause floods in Gujrat and Kathiawar, and then enter the northeast Arabian Sea and sometimes revive into cyclonic storms off the Sind coast and fill up over the Mekran coast or the Gulf of Oman. In the months of June and September the direction of movement of some of these storms and depressions is very irregular and difficult to explain.

The problem is, however, very much simplified if we keep in view the structure of these tropical cyclonic storms and depressions. Sawyer(14) after discussing the theory of the tropical cyclones has given the final stage of development of a tropical storm as shown in fig. 11. The model given by Riehl(15) in the Compendium of Meteorology, 1951, also agrees with this. Sawyer's diagram, while explaining the structure of the eye of the storm, shows clearly that the air participating in tropical storms escapes between 20,000 and 30,000 ft. above sea level. The mean flow of air near this layer, i.e., at 6 km in July and August, is shown in Fig. 8.*

While discussing the developments in the field of barometric pressure, Sutcliffe(16) has rightly said that "the popular conceptions of pressure changes due to simple translation or advection of existing fields of pressures, or to thermal effects of direct heating or by advection of air of a different temperature, are invalid without a discussion of the dynamical processes involved." He has further shown that "a fall of pressure requires divergence through the atmosphere above as the air must be removed. If this is obtained isallobarically it demands a persistent isallobaric high above the isallobaric low near the surface to set up divergence sufficient to compensate and to overcompensate the convergence at the lower levels". These considerations derived on theoretical grounds are fully borne out in the case of the monsoon depressions and storms. *The development of these pressure systems and their movements are completely controlled by the anti-cyclonic divergences and flows in the upper atmosphere.*

Specifically if the centre of a storm at the surface happens to fall under the western periphery of Far Eastern Anti cyclone, the storm recurves north and northeastwards

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*The flow pattern at this level for other months can be seen in the present writer's paper on the Zonal Currents as a Control Factor on Physical Climatology of South Asia, 1950.

on reaching the central parts of India. If the centre happens to come under the easterly current, the depression continues to move westwards towards Sind and Baluchistan. If the centre happens to come below the cyclonic circulation, it recurves slightly towards west-southwest and emerges into the northeast Arabian Sea either to continue its southward movement as a wave of low pressure to draw a fresh pulse of monsoon near Ceylon or to revive into a storm on getting a fresh supply of the monsoon air over the northeast Arabian Sea.

I have also noticed that the position of the cyclonic circulation over the Indian peninsula is very much influenced by solar activity. Although it has not been possible for me to analyse fully the available evidence to correlate the positions with sunspot maxima and minima, I have found it generally to move significantly northwards and southwards with them. And for the present I must leave it at that.

FLOODS IN THE INDO-GANGETIC RIVER SYSTEMS AND THEIR FORECASTING

The floods in the Indus and the Gangetic basins result from the depressions and storms which are steered by the western periphery at 6 km of the Far Eastern anti-cyclone and which cause heavy rainfall in the Himalayas after recurving north and northeastwards from the central parts of India. The number of floods in a season is also greatly dependent on the position of the cyclonic circulation over the peninsula at 6 km and the easterly current to its north at that level.

The forecasting of heavy rainfall in association with the tropical storms and depressions in the Indo-Pakistan region has been practised successfully for about 80 years now.

We know that the rainfall received in and around the Indo-Pakistan sub-continent during the monsoon period is orographic in the vicinity of the mountain range all around. Over the plains it is either due to the instability thunderstorms or to the uplifting of nearly saturated air in cyclonic storms and depressions. There is no doubt that the rainfall at Cherrapunji in the Khasi Hills or at Mahabaleshwar and other places in the Western Ghats is orographic. If we accept the rainfall resulting from the rise of air caused by the mountain ranges orographic, then, as I have already indicated, practically all the rainfall in the North Indian Ocean during the monsoon period should be regarded as orographic. For, in the ultimate analysis, it is the mountain ranges of Africa and Asia which guide the flow of the monsoon air both horizontally and vertically over this part of the Indian Ocean and the adjacent landmasses. But this would not be correct. It is the blend of the thermodynamic and the hydrodynamic causes superposed on the orography of the region which causes all the precipitation. Even the heaviest falls at Cherrapunji or Mahabaleshwar are associated with the development of cyclonic disturbances somewhere in those fields. It is thus evident that, while considering the hydrological factors, like the floods in any river basin, we must give due weight to all the factors involved, and it is only then that we can hope to forecast their onset and intensity with any degree of success.

Here, I must also discuss the effect of relief on rainfall. When the moist air rises against an orographic barrier, the rainfall increases with height *up to a certain* limit *and then begins to decrease.* In the case of Himalayas, whose general height is 16,000 to 18,000 ft., the southwest monsoon discharges its heaviest rainfall on the *outer* ramparts and the heaviest snowfall on the southern slopes of the *inner* ranges. The natives of those regions affirm(17) that Mount Everest and the great company of snow peaks above 24,000 ft. rise well above the level of heaviest rainfall and in fact little monsoon moisture crosses the chain into arid Tibet. The maximum precipitation is recorded at a level near about 10,000 ft. Consequently, it is the sections of the catchments of our river basins upto that height which make the most important contribution to the flood discharges of those catchments.

A study of 10 years' rainfall and discharge data in the catchment of various rivers in the Punjab carried out by me in 1950 and 1951 confirmed that the contribution of rainfall in the lower catchments was much less as compared to that of rainfall in the upper catchments. But, unfortunately the upper catchments of the Sutlej, Ravi, Chenab and Jhelum—all the rivers with which we are concerned—lie in India or in India-held Kashmir. It was, therefore, out of question to start the required number of precipitation-recording stations in those areas and to work out the unit hydrograph for issuing flood warnings like other countries. The problem of flood warning was, however, urgent so we had to decide to evolve some technique of flood forecasting which might use the data of the few available stations in the catchments in India which could be obtained. I, therefore, employed a statistical method for this purpose, and established correlations between the rainfall at the few available stations and the discharges at various sites along the rivers on the days on which the falls were recorded and on successive days till the correlations became insignificant. The rainfall stations selected for this purpose where those which had high and significant correlations with the contemporary rainfall of the whole catchment. The formulae so obtained enabled us to issue quantitative forecasts for flood peaks on the basis of very scanty rainfall observations. Good results have been achieved by this method over the years since 1953 and it is being developed further.

Happily for the catchments of the Ganges and the Brahamputra in East Pakistan where these warnings are much needed, it is not difficult to issue them reliably and well ahead. But here difficulties arise in assessing correctly the extent of inundation due to the floods. The extent of inundation is greatly influenced by tides and other oceanographic factors, the disssion of which would be out of place in the present treatise.

In this survey I have used the material and diagrams of a number of authors and organisations freely as it would have been impossible to explain the various aspects without these. All these are gratefully acknowledged in the Bibliography. I thank my former colleague, Dr. K. J. Kabraji, for going through the manuscript and for offering many useful suggestions.

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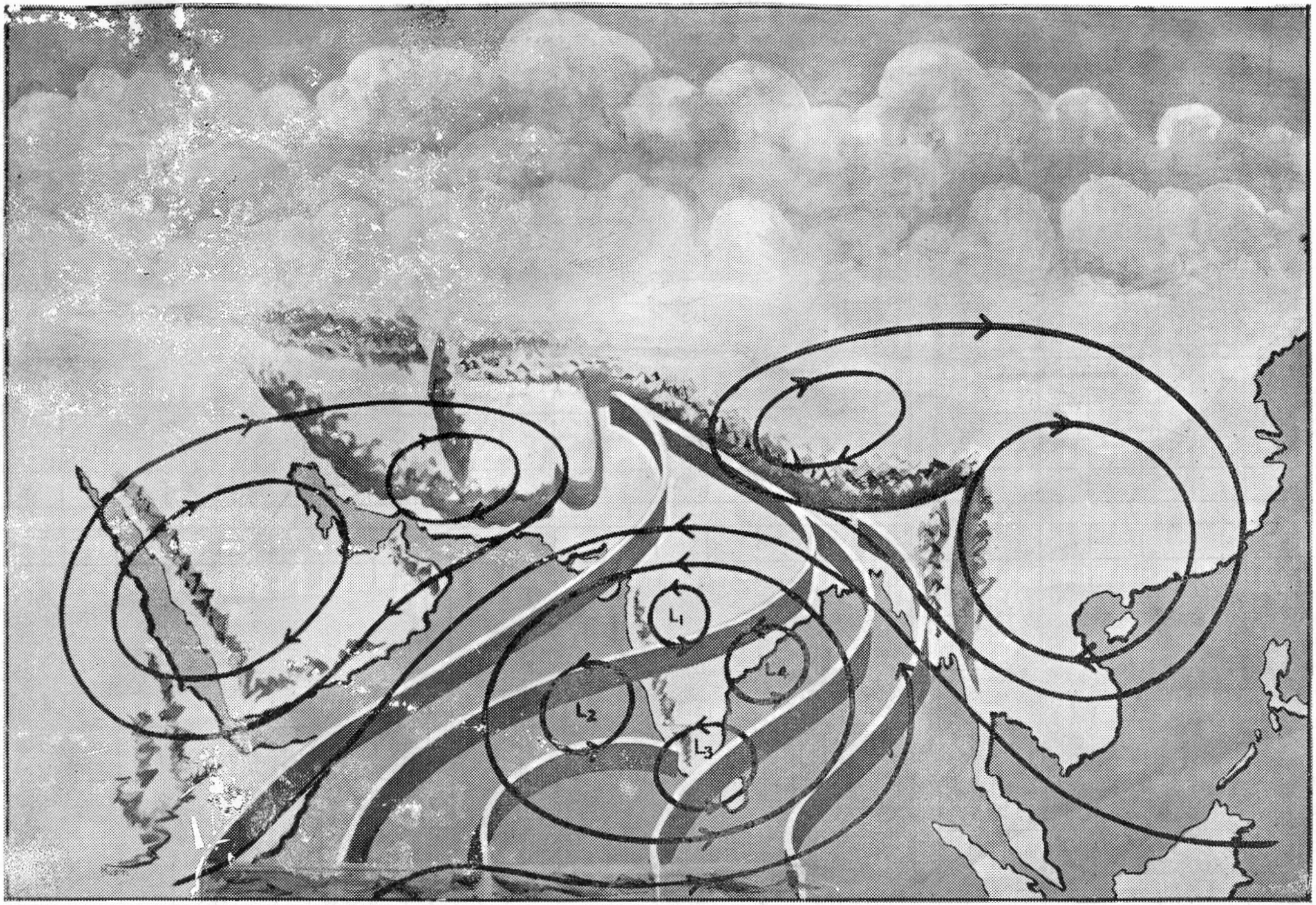

Fig. I:- Working of an Irreversible heat engine at the head of the Indian Ocean.
A generalised view of the Southwest Monsoon.

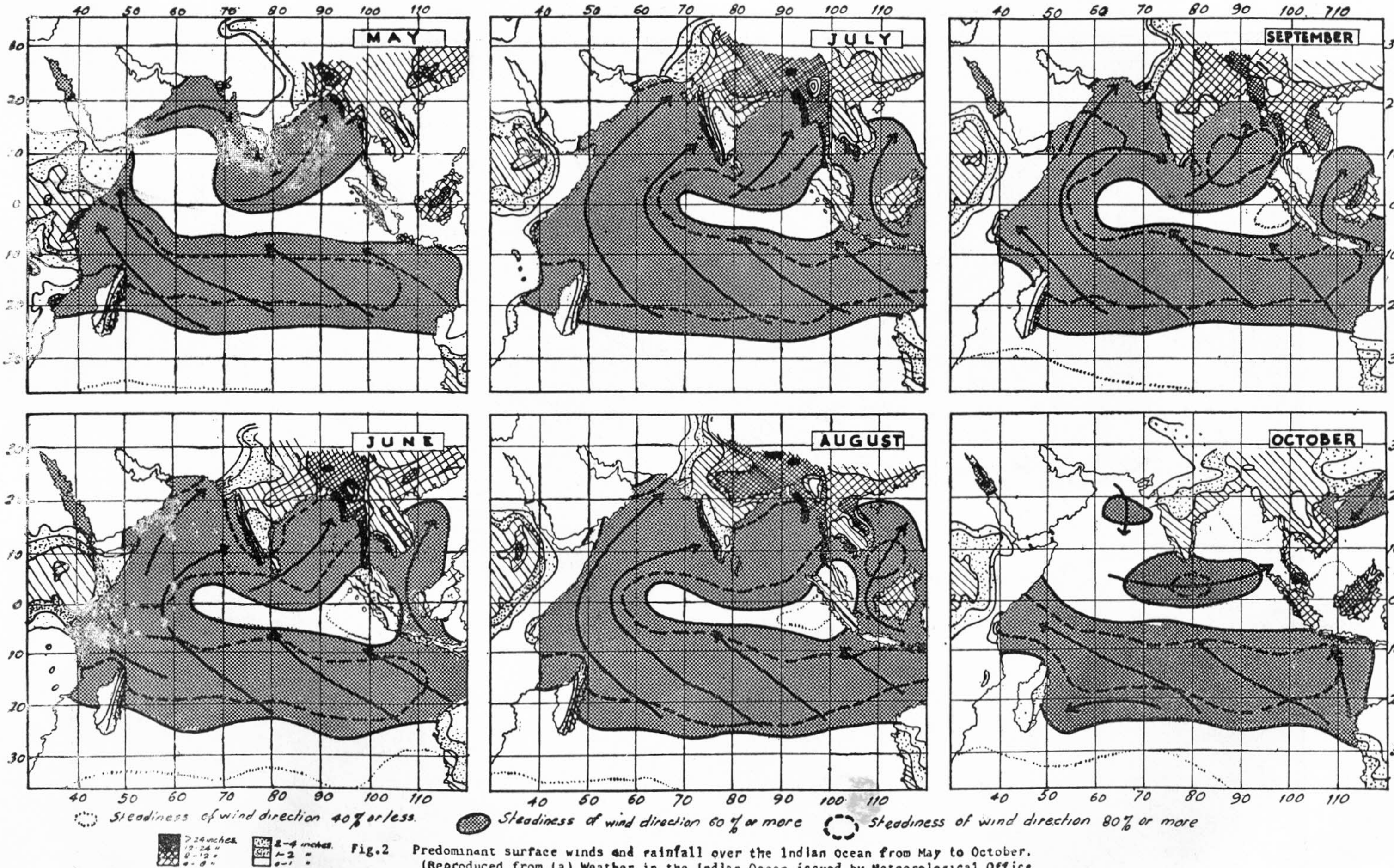

Fig.2 Predominant surface winds and rainfall over the Indian Ocean from May to October.
(Reproduced from (a) Weather in the Indian Ocean issued by Meteorological Office London 1943 (b) Climatological atlas of the Indian Monsoon Area 1945)

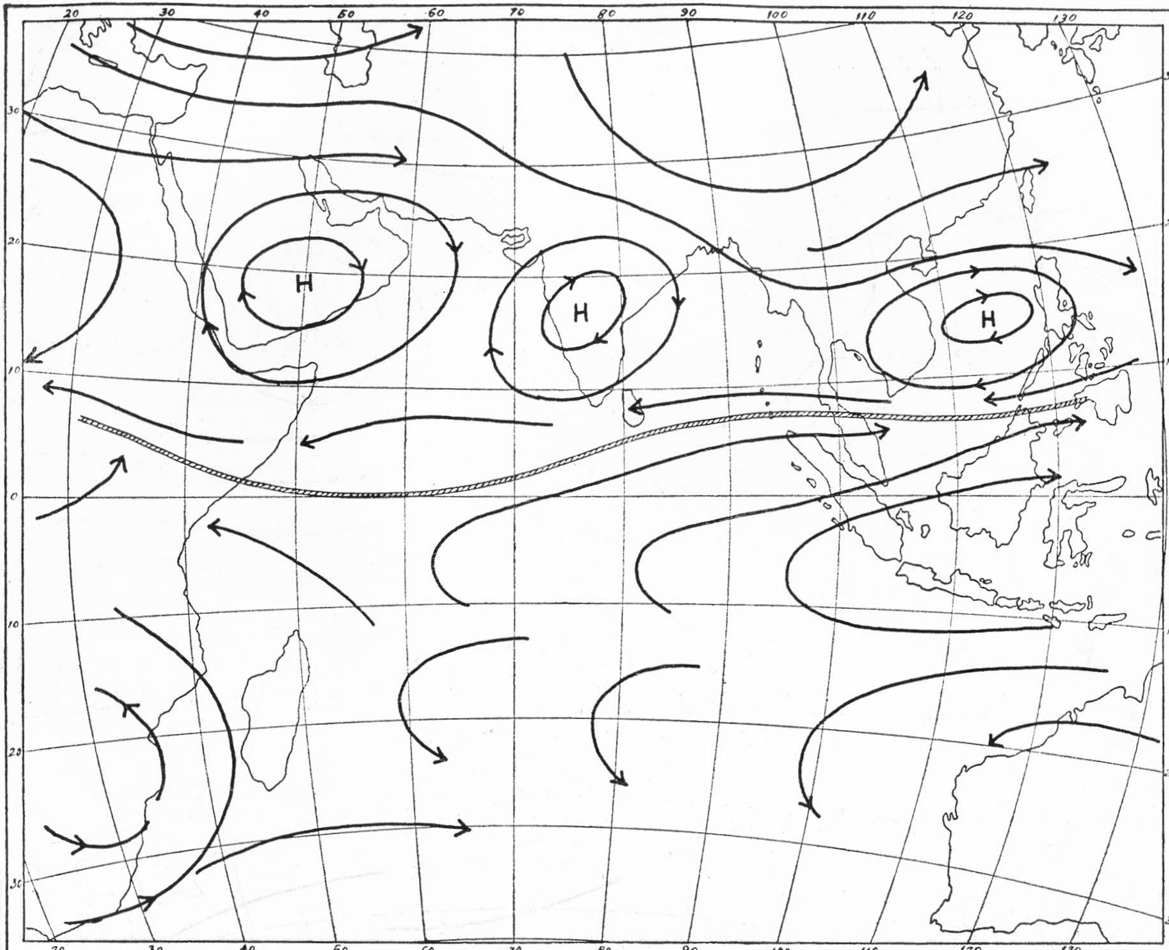

Fig.3 Streamlines showing mean flow of winds over the Indian Ocean in May at 3 Km.

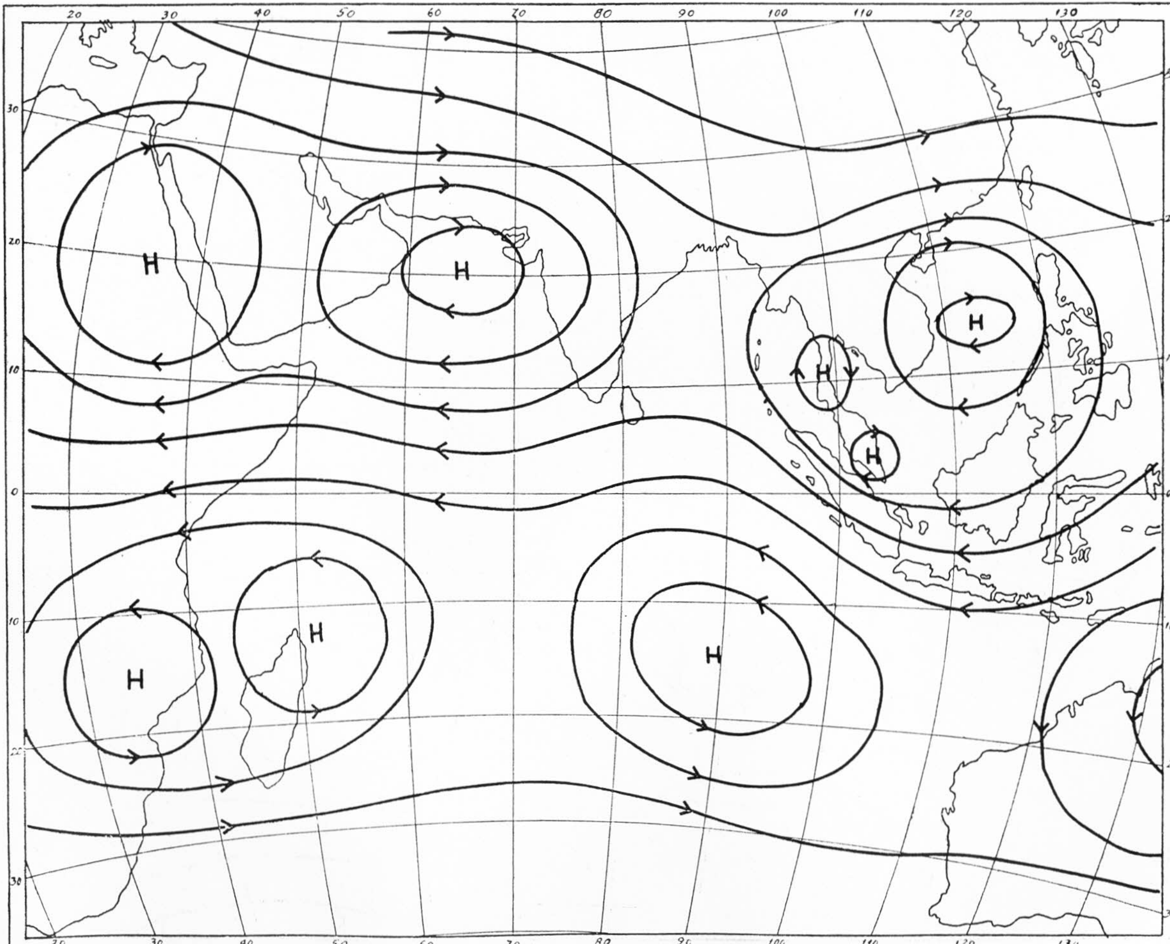

Fig.4 Streamlines showing mean flow pattern of winds over the Indian Ocean in May at 6 Km (500 mb)

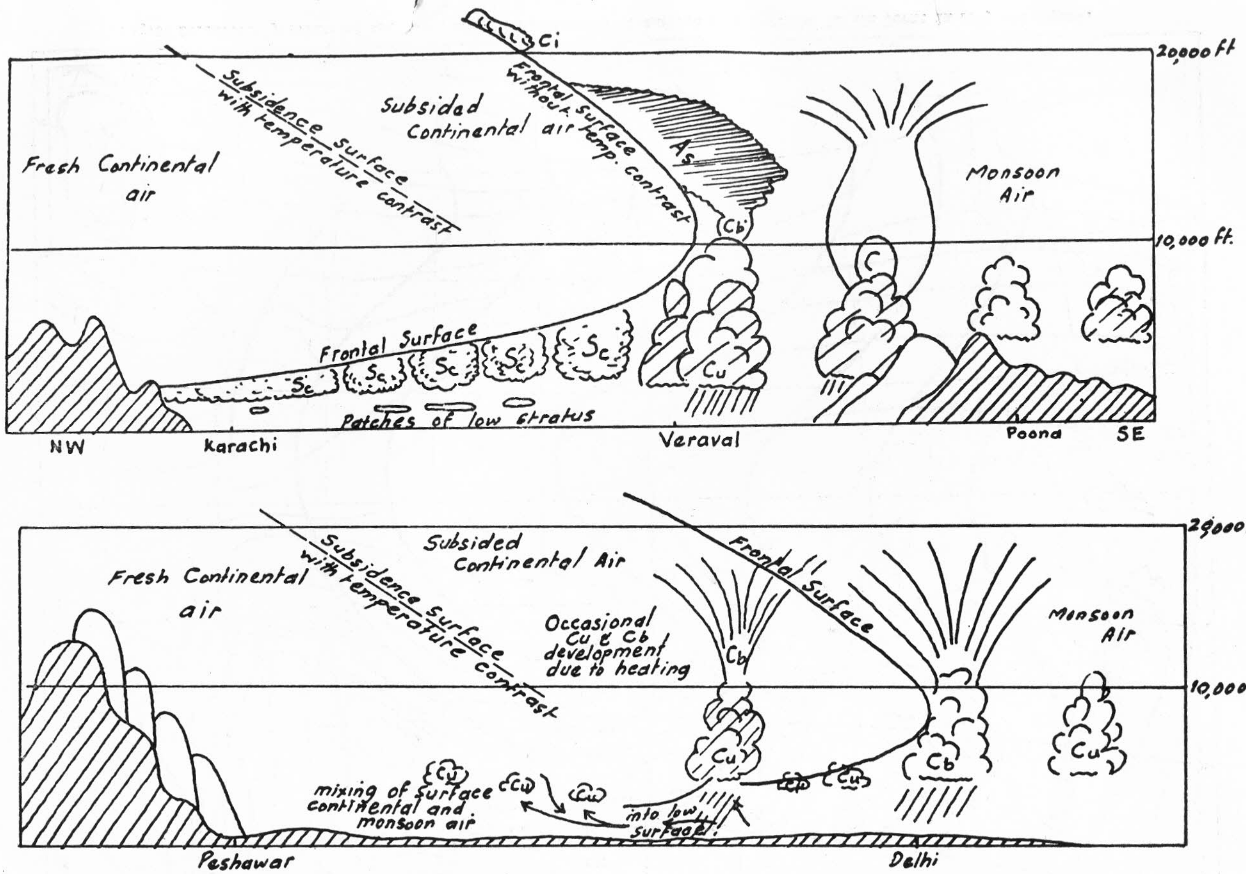

Fig.5 Cross sections of the Inter-Tropical front between Karachi and Poona and Peshawar and Delhi (after J.S.Sawyer reproduced from Quarterly Journal of Royal Meteorological Society, London, Vol.73, No.317 and 318, 1947).

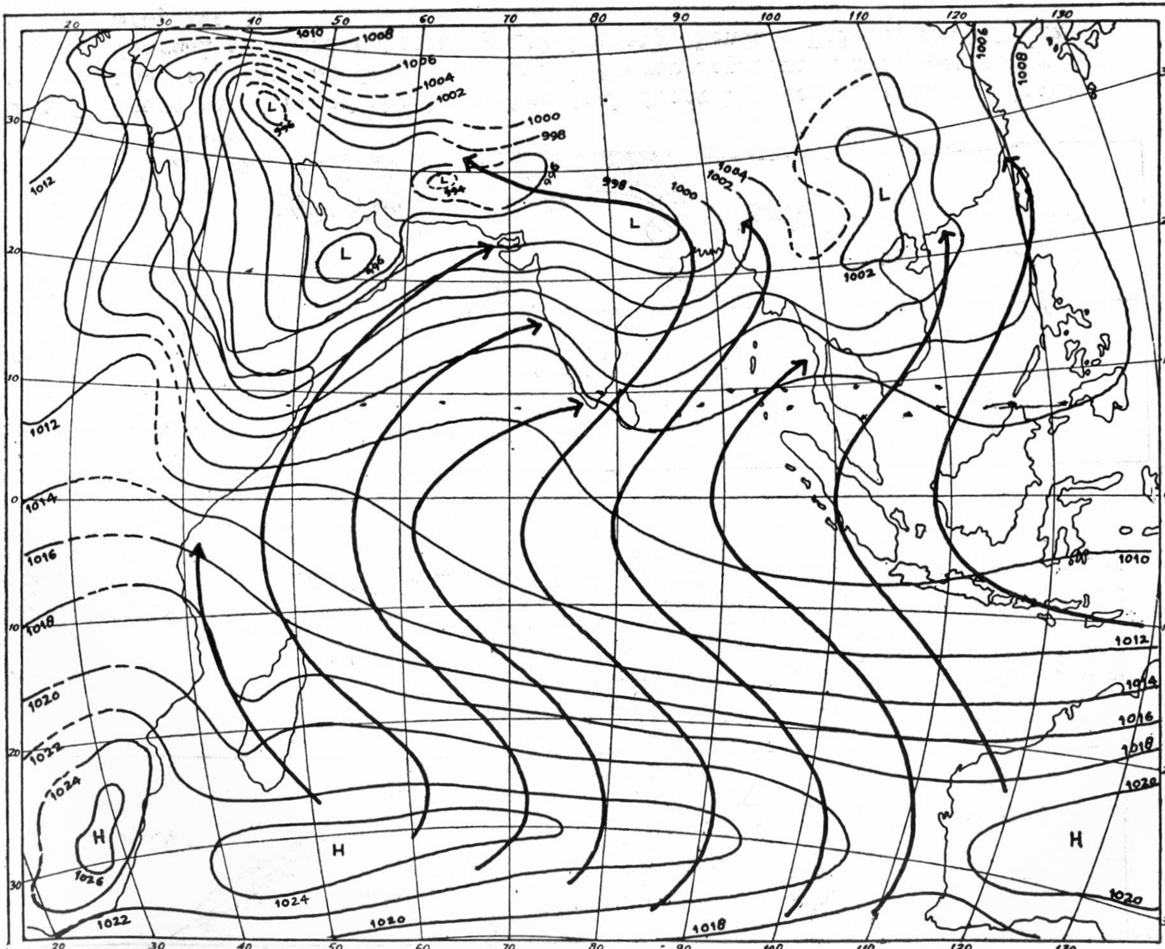

Fig.6 Barometric pressure at sea level and the streamlines of surface flow over the Indian Ocean in July and August.

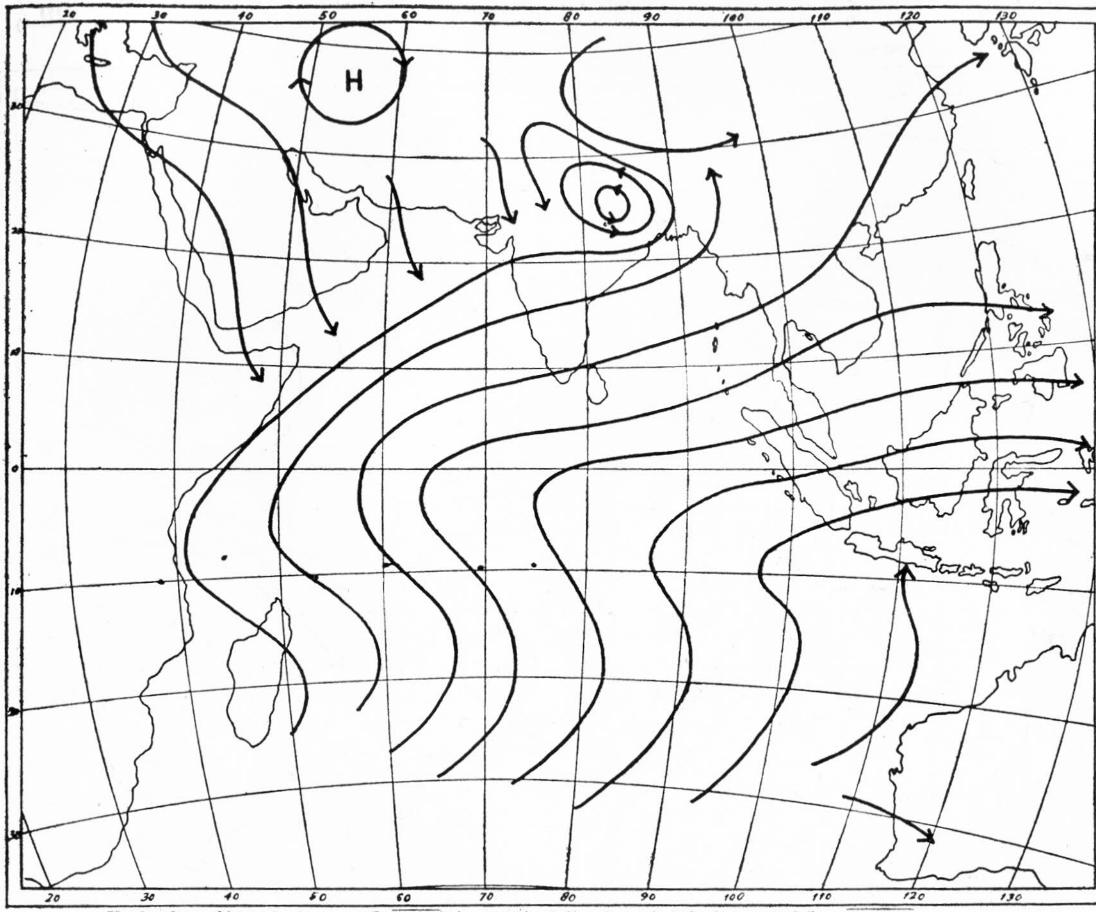

Fig.7 Streamlines showing mean flow of winds over the Indian Ocean in July-August at 3 Km.

(based on wind roses and resultant winds published in (i) Climatological Atlas for Meteorologists and Airmen, India Met. Dept. 1943 (ii)Climatological Charts of the Indian Monsoon area 1945 (iii) U.S.Marine Climatic Charts of the World, Vol.III Indian Ocean,1957).

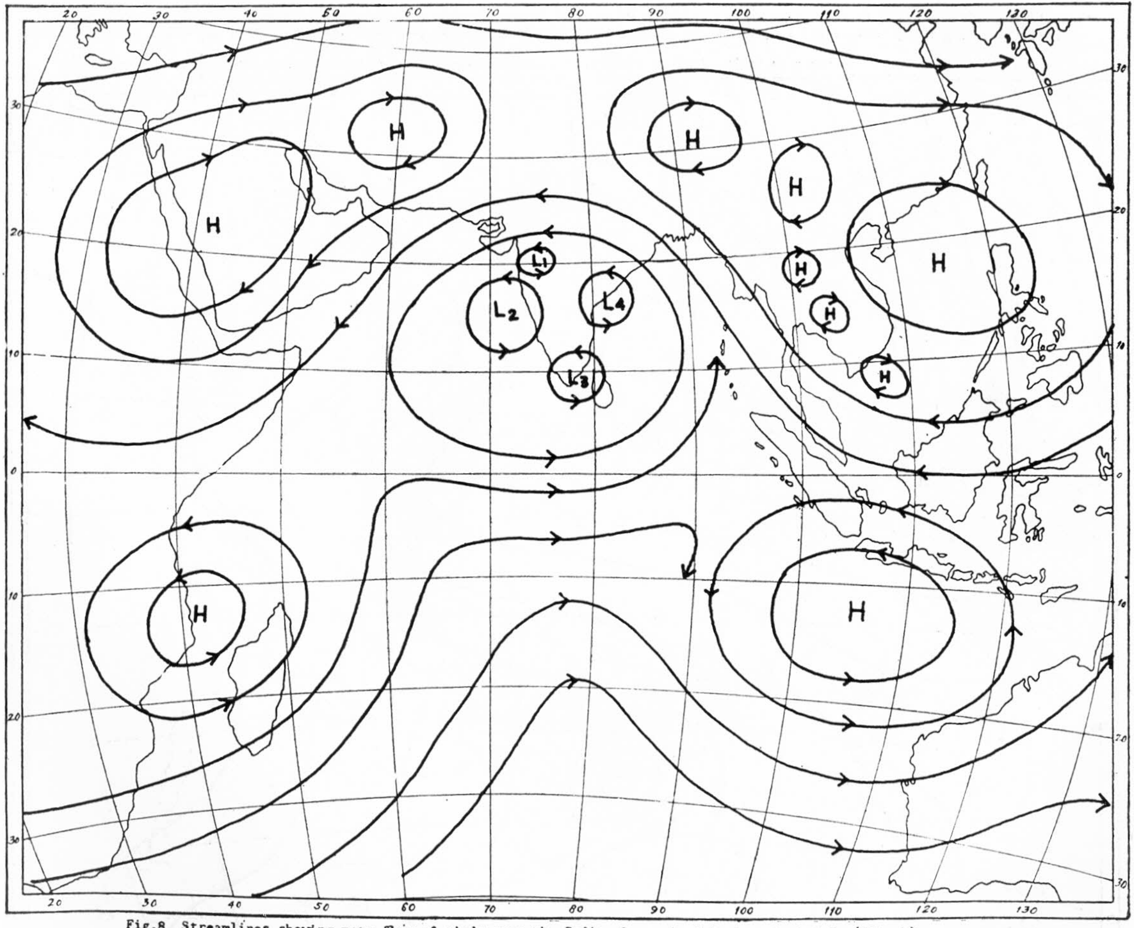

Fig.8 Streamlines showing mean flow of winds over the Indian Ocean in July-August at 6 Km (500 mb)

(based on wind roses and resultant winds published in (i)Climatological Atlas for Meteorologists and Airmen, India Met. Dept. 1943 (ii)Climatological Charts of the Indian Monsoon area 1945 (iii)U.S.Marine Climatic Charts of the World, Vol.III Indian Ocean,1957).

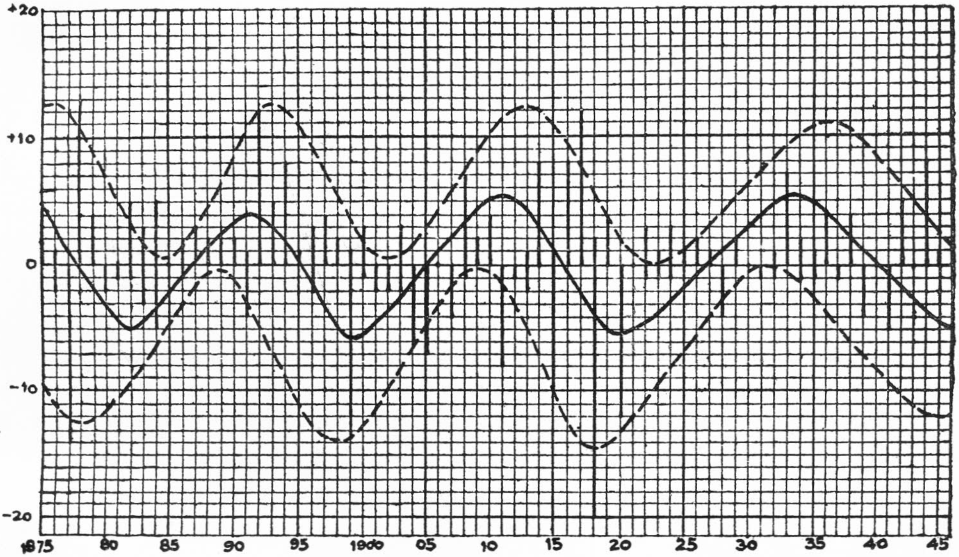

Fig.9 Fluotuations in the strength of the monsoon from year to different parts of the Indo-Pakistan sub-continent from 1876 to 1946 /The vertical lines show the number of sub-division (out of 30 in the whole region) which recorded flood and droughts in each year /

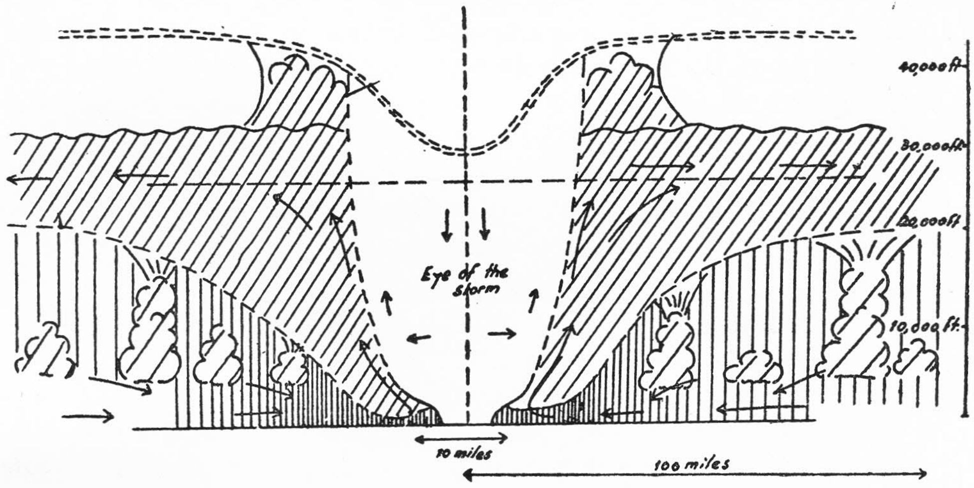

Fig.10 Final stage of development of a Tropical Storm (after J.S.Swayer - 1947).

HYDERABAD : A GEOGRAPHICAL APPRAISAL

BY

M. M. MEMON

Department of Geography, University of Sind, Hyderabad

The city of Hyderabad, headquarters of the district and division of the same name, is situated between latitude 25° 20′N and 25° 27′N, and longitude 68° 19′E and 68° 20′E, and covers an area of about 36 square miles. At its present site is supposed to have once stood the ancient town of Nerunkot or Nerun-i-Kafiri(1) which submitted to Mohammad bin Kassim Sakifi in the eighth century. However, the identification of the city with Nerunkot is not without controversy(2). This city was founded in 1768 by the saintly Ghulam Shah Kalhora, the ruler of Sind,(3) who erected a fort of burnt bricks on the southern edge of the ridge on which this city stands. He named the place in the honoured memory of the prophet's son-in-law, Hazrat Ali(4). Hyderabad remained the chief town of Sind till it was occupied by the British in 1843, who, after the battle of Miani, shifted the capital to Karachi.

Like many other towns in the country, Hyderabad too has undergone a gradual process of evolution. When the city was founded in 1768 there was at first a sporadic growth of tenements, shops and cattle-pens immediately outside the main entrance of the fort in the north. First of all a few crude huts or shelters made their appearance, huddled together, often on a slope. Later on a few more 'Kuchcha' and 'Pukka' houses sprang up. The whole city gradually developed in this unplanned manner resulting in a primitive tangle, with extremely narrow lanes. This process of development continued for more than 150 years till finally 3 to 4 storeyed houses made their appearance as land grew more expensive and the inhabitants wealthier. The old town is the congested hard core of the present city and presents the greatest need for improvement.

TOPOGRAPHY AND HYDROGRAPHY

Hyderabad stands on the most northerly portion of the limestone ridge called Ganjo Takkar which runs north and south, parallel to the Indus, for about 16 miles. The hill on which the city is built is 2 miles in length with an average elevation of 100 feet. It is separated by the major southern portion of the ridge by an alluvial gap of about a mile in length. Ganjo Takkar ridge is an outcrop of limestones of the Laki group. Its top, which is composed of a thick bed of white soft fossiliferous chalky lime-

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1. Cunningham, Sir A., The Ancient Geography of India I, 1871 edited by Majumdar 1924, p. 320.
2. Kureishy, K. U., *Urban Development in West Pakistan,* Unpublished Ph. D. thesis, University of London, 1957, p. 429.
3. Mirza Kalich Beg Ferdun Beg, A History of Sind (Chachnamah), 1900, p. 162.
4. Hazrat Ali is generally called "Haider."

stone, overlies a band of light yellow-colour clay. The whole ridge is more or less flat topped, escarped in general on every side, with the rock strata dipping to the east at a low angle from 2 to 4 degrees(5).

The highest point of the hill on which the city stands is 120 feet above sea level while the level of the surrounding plain is only 55 to 64 feet. The hill on which the city stands is roughly of the form of a parallelogram. The plain on the east, lying between this hill and the Fuleli canal, is about a mile in width, and that on the west between the hill and the Indus about 3 miles. The eastern plain has an elevation of 60 to 64 feet while the western one of 55 to 60 feet.

The Indus with its everchanging course and high incidence of floods has been the cause of abandonment and at times total destruction of many of the human habitations along its banks during the course of recorded history. Some of the old settlements that exist today in the lower Indus valley are those which are either beyond the reach of its flood waters or else are situated at a safe height. Ghulam Shah Kalhora was thus wise enough to locate his capital on the safe Ganjo Takkar ridge. At the time of Muslim conquest of Sind by Mohammad bin Kassim, the main stream of the Indus is said to have flowed to the east of the Ganjo Takkar. The Indus changed its course in the middle of the eighteenth century (1758)(6) and started flowing on the western side, while Fuleli, branching off from the parent stream about 16 miles north of Hyderabad, began to flow on the eastern side. Formerly there was a possibility that the Indus might get nearer the ridge by eating away the left bank and straighten its course, but this danger has greatly decreased since the construction of Ghulam Mohammad Barrage. Moreover, this side has been well protected by raising a strong embankment and reinforced by a loop bund about a mile east of it. It is hoped that Ghulam Mohammad Barrage together with its three left bank canals would play an important role in protecting the low lying areas of Hyderabad by regulating and draining of the flood-waters as it has hitherto done since its construction in March 1955.

CLIMATE

The climate of Hyderabad is the sub-tropical semi-desert type. It is comparatively less harsh than what is experienced in many other parts of the Hyderabad and Khairpur divisions particularly those that lie in its north. The weather conditions vary according to the three seasons, hot, rainy and cold. Summer conditions begin to appear from the month of April when mean maximum temperature rises to 102.32°F. May and June are the hottest months of the year, and of the two the mean maximum temperature of the former is higher (107.87° F). Mean minimum temperature is greatest in the month of June and is about 3.54° F greater than that of the previous month. In summer, temperature seldom rises to 120° F, and the mean diurnal range of temperature

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5. Blanford, W. T., Geology of Western Sind, *Mem. G. S. India*, 1889, Vol. XVII, pt. I, p. 154.

6. Smyth, J. W., Gazetteer of the Province of Sind, Bombay 1919-1920 B. vol. II. p. 40; Haig, M. R., Major General, The Indus Delta Country, London, 1894, p. 5 and map No. 2.

exceeds 30° F. The highest temperature ever recorded was 122° F on 14 th June 1900. Mean monthly maximum temperature oscillates between 96.91° and 107.87° F for about 7 months from April onwards, making the hot season long and unbearable. The prevailing wind is southerly or south-westerly during the summer. Nights in Hyderabad are invariably very pleasant during the summer months, on account of cool breeze which starts blowing about sunset. The sudden lowering of temperature on that account gives great relief to the citizens from the unpleasant heat suffered during the day. The inhabitants of this place have employed a very ingenious device of "Bad-girs" (wind-catchers or wind sails), which are fixed on the house tops to catch the sea breeze which blows with little intermission from the south-west throughout the hot season. The wind when it strikes "Bad-girs" is forced downward and enters the room by a slit. These "Bad-girs" give a very characteristic impression to this city which a visitor to this place would hardly, if ever, forget. Some essential climatic data are given in Table I.

Rainy season is short. It is of about ten days duration in summer and a couple of days during winter. The usual dates of arrival and withdrawal of the monsoon are 20th and 31st July respectively. Cyclonic storms visit this place as they do many other places in Hyderabad and Khairpur divisions on an average of 3 to 4 per month. The mean annual rainfall is 5.94″ mainly concentrated in the months of July and August, which together account for 4.64″. July is the rainiest month (2.84″) closely followed by August (1.8″). Winter rain is due to western depressions and is experienced during December-February. Total winter rainfall on the average is about 1.59″. February is the rainiest of the winter months (0.44″).

Unlike summers, winters are not so severe in Hyderabad. From November onwards temperature begins to fall substantially and nights begin to get cooler. January is the coolest month of the year and the lowest temperature ever recorded was 30° F on 31st January 1929. The mean maximum and minimum temperatures for this month are 78.3° and 50.15° F respectively, and the mean diurnal range is more than 25.33° F. General wind direction is northerly and northwesterly during the winter. Wind during this season is weaker than that experienced during the summer and rainy seasons. There are occasional spells of cold waves from the snowy mountains in the north and north-west which result in a sudden fall of temperature. Dust storms and squally weather are common at the commencement of winter season as is also the case at the commencement of summer.

Humidity varies to a considerable degree. It is highest in September (87%) and lowest in April (65%).

From the study of Table II, giving comparative figures of mean monthly relative humidity for Karachi and Hyderabad, it becomes clear that the climate of the latter city is less innervating during the hot months of April to August. It was probably on this account that the wealthy business man of Karachi preferred to build his home in the up-country centre of Hyderabad, which fact partly accounted for the past growth of this city.

WATER SUPPLY AND SEWAGE DISPOSAL

During the Talpur rule water supply was obtained from the Fuleli canal,(7) or from the Indus or from a few wells within the plain area. Before 1880 the city received its drinking water supply from the three tanks, which were fed with water from the Fuleli by means of a water course. These tanks had a combined holding capacity of 6,092,000 cubic feet. This arrangement had to be abandoned afterwards on account of unhealthy and unsatisfactory character of the water supply. The existing water-works were planned and designed by Mr. Robert Brunton, an engineer in 1870,(8) and opened after completion for the first time in 1878 for the cantonment and later for the city in 1880. It was afterwards improved upon in 1909.(9) At present water is drawn from the Indus with the help of pumps at Gidu Bunder, then stored into two large settling tanks nearby on the left bank. It is then brought through a conduit to the city and stored into a large tank near the foot of the ridge on the western side of the fort. From here water is pumped into a reservoir in the fort for distribution by gravity to the city. This arrangement was originally designed for a population of less than a lac, since then the needs of the city have more than doubled or perhaps trebled. According to the 1951 census the population has increased to 241,801 with the result that the city suffers from scarcity of water to a sever degree. Moreover, water that is had is not properly filtered and as such is not quite fit for human use. The present daily supply is under 15 gallons per head, which figure compares very miserably with 100 gallons per head in London and 150 in New York.(10) The water-supply in Hyderabad should be brought upto a reasonable minimum of 50 gallons per head per day. This would mean a total requirement of 121,00,000 gallons per day. Such a target can only be achieved provided water is had from the up stream side of the Ghulam Mohammad Barrage where water level is normally higher all the year round as compared with that at Gidu Bunder. Storage tanks can conveniently be located on the ridge near the Hyderabad Central Prison and settling tanks on its foot. It is also necessary that suitable arrangements be made for proper filtration, purification and disinfection of the drinking water.

The present drainage system of the city is the old fashioned "Sewage-farm method": a really primitive idea today. All the filth and sewage merely goes straight in open drains or channels, which run along the side of public streets, before being piped or channelled out of the city. This dirty sewage water is later pumped over the fields where vegetables are grown particularly on the eastern as well as the southern side of the town. The land can take only a certain amount of this dirty water per day or week and the excess is bound to stagnate. Such a condition is highly undesirable from the point of view of public health.

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(7) Hughes, A. W., *Gazetteer of the Province of Sind*, London (1876) P. 25.

(8) *Ibid*, p. 260.

(9) Smyth, J. W., *op. cit.*, p. 47.

(10) Thomas, G. S., *Hyderabad Master Plan*, Karachi, 1954, p. 53.

The present situation can be remedied by the installation of a modern sewage system and for this fortunately we have good levels, with plenty of slope or fall to work the drains particularly in the old town. If a modern system of sewage treatment or reclamation is installed, the final byproduct of solids, would form most valuable manure or fertilizer, clean and harmless, much in demand amongst intelligent farmers and cultivators. Its sale would bring in some thing on the profit side. The water-effluent flowing out from such a modern work is perfectly clear which can be directed into the nearest canal and from there ultimately it will find its way to the fields.

It is desirable that one sewage work may be sited by the Jamshoro Regulator, on the eastern bank of the Indus. The outflow from this would go direct into neighbouring fields outside the inner loop bund or Wadhu Wah, a small distributing canal, or into Fuleli or back in the Indus. Another should be located in the neighbourhood of the Power House, taking the outflow from that side of the city. This outflow can be directed into some large gardens that exist here at present and the surplus water can be made to run in the Fuleli nearby.

INDUSTRIES

Agriculture and fisheries have been the primary industries of this area ever since ancient times. Some small scale cottage industries like silver and gold work, ornamental silks and lacquer work flourished in the later half of the nineteenth century. During the Talpur rule Hyderabad was famous for its manufacture of weapons of war like daggers, shields, match-locks, but this industry decayed with the advent of the British for obvious reasons. By the close of the first quarter of the present century about 10 factories were working on the banks of the Fuleli for purposes of cotton ginning, pressing and rice husking, apart from some small scale industries as tanning, embroidery work, weaving, dyeing, camel saddle covers making, pottery, ivory carving and lacquer work. At the time of inception of Pakistan in August 1947 there were 23 cotton ginning and pressing factories, and one each of bone meal, oil, glass, tanning and carbon-di-oxide. Of these only a few are large units. All these factories are badly sited and scattered over the entire city and thus experience great difficulty in the transport of goods through the congested localities. It is only the Indus Glass Works, south of the Shah Makai Railway crossing, which is comparatively in a happy position in this regard. Since the establishment of Pakistan we find a growing tendency for the industrial development of the country, adequately shared by Hyderabad. By the close of 1958 there were six large and seven small size textile mills, twenty oil mills, seven cotton ginning and pressing factories, fifteen flour mills, three glass works, ten hosiery factories, two hume pipe factories and one each of cement, carbon-di-oxide and bone factory in the city.

The Sind Industrial Trading Estate

The Sind Industrial Trading Estate with an approximate area of more than two square miles planned to accommodate 43 factories is situated in the south of the city. It is bounded on its north by the N.W. Railway line, on the east by Fuleli canal, on the west by Latifabad township and on the south by the Railway stone quarries. Some of the advantages of its site are: (1) It is outside the limits of the city's habitable area, (2) wind direction is south-west in summer and north east in winter, thus the city's main residential area is saved from the harmful effects of smoke, associated gases and offensive smells, (3) plenty of labour is available from Latifabad, which is nearby, and the city proper, (4) raw materials like cotton, oil seeds, wheat, are easily available from the surrounding areas, (5) the Estate is well connected with the city by roads, (6) power is easily available in the form of natural gas from Sui and (7) Fuleli canal flowing nearby is a source of good water-supply.

The Sind Industrial Trading Estae is a well-planned industrial area, with planned factories, water-supply, power, good roads and many other facilities. The proposed autobahn (speedway) would pass through the Estate. It would also greatly relieve the narrow and congested Tando Mohd Khan Road as well as a great deal of rail traffic on account of its link up with the West Pakistan Highway. Ample provision has been made for the houses of the workers by fixing housing zones. About 3 acres of housing land has been fixed for every one acre under factory, and this is indeed a liberal provision. Latifabad Colony is situated on its west from where the Estate also draws a percentage of its labour force. Presently the total number of persons working in factories of the Estate which are in operation at the moment (April, 1959), is 5,051.(11)

POPULATION

The earliest estimate of the population of Hyderabad that could be available is that of 1808, when the population was 15,000 persons.(12) According to the first regular census of 1872 it was 35,272 out of which 13,065 were Muslims, 16,889 Hindus, 367 Christians and 4951 "all others". In 1881 and 1891 it was 48,153 and 58,048 persons respectively.

From the study of Table III a remarkable growth of population of this urban centre over the period 1881-1951 becomes apparent. During the decade 1911-1921 the percentage variation was the lowest i.e. 7.8%. According to Lambrick(13) it was in the main due to heavy mortality on account of influenza epidemic of 1918-1919. In the succeeding years we find a great increase in population. Increasing percentage variation in population much so between 1931 and 1941 may be mainly attributed to greater economic development that took place in the city during this period. Comparatively less harsh climate than what is experienced in the north of Hyderabad, central position with regard to rail and road communications, industrialisation and favourable location are some of the many factors which may be said to be responsible for the rapid increase in population. The city's population nearly doubled between 1901 and 1941 and has risen from 69,378

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(11) Figures obtained from the Labour Welfare Office, Hyderabad.

(12) Pottinger, H., *Travels in Baluchistan and Sind*, (London 1816) p. 370.

(13) Lambrick, H. T., *Census of India*, 1941, Vol. XII., Sind p. 5.

in 1941 to 241,801 in 1951, the first census after the establishment of Pakistan. The percentage variation works to 78.7%. The abrupt rise of 107,108 souls in the city's population is a unique and memorable feature of the census history of the former Sind Province. It is obviously due to the influx of refugees from the other side of our border which now number 159,805. The refugee population of Hyderabad constitutes 30% of their total population in the former province of Sind.

The proportion of females to males is less and varies greatly from decade to decade (see Table IV). The latest recorded proportion of females per thousand males is 858. This type of disparity in the sex ratio is found in all the large urban centres of Pakistan. That of Hyderabad, therefore, needs no special explanation.

From the study of Table V it becomes clear that the majority of the city's population before the establishment of Pakistan consisted of the Hindus. Muslims ranked second and this was mainly due to the fact that they were educationally not so advanced as the Hindus; were more interested in agriculture and were too poor to afford city life. In 1951 Hindus were reduced to 2501 in number as a consequence of the Partition and migration to Bharat, while Muslims swelled by 198,528. The new Sindhis account for 159,805 or 66% of the total population of the city. Though the city's present population was estimated by many as 500,000 but on the basis of the ration cards as checked after the Martial Law it comes to 391,963.

From the foregoing discussion it becomes clear that Hyderabad has been growing at a rapid rate in later decades, and there is every likelihood of its further growth in future. There is plenty of space for accommodating the growing population in Latifabad, Sind Industrial Trading Estate, Barrage Colony and the Sind University Campus. There is still much land left for further settlement between the main ridge and the Indus, Fuleli and Pinyari, and Latifabad and Sind Industrial Trading Estate. There is enough room for accommodating a few more industries particularly in the south of the Sind Industrial, Trading Estate, where expansion is already taking place. A portion of the proposed autobahn encircling the town has also been completed. When available for traffic it would go a long way in relieving congestion, particularly on the Kali Road, thus ensuring a smooth vehicular traffic for the incoming and outgoing goods to and from the Sind Industrial Trading Estate. Nearness to Karachi, healthy and favourable climate as compared with other areas in its north and easy availability of raw materials of varied description are a few of the many factors that have contributed to its speedy growth. In view of the size the city has attained, its water supply, and drainage and sewage systems call for immediate attention and improvement.

TABLE I

*Climatic Data of Hyderabad**

Months	Mean monthly minimum temperature in degrees F.	Mean monthly maximum temperature in degrees F.	Mean monthly range of temperature in degrees F.	Mean monthly Relative Humidity in percent.	Mean monthly rainfall in inches.
January	50.15	78.3	25.33	68	0.25
February	55.6	82.77	26.71	66	0.44
March	63.6	93.18	28.74	69	0.07
April	72.77	102.32	30.5	65	0.05
May	78.82	107.87	29.44	77	0.12
June	82.36	104.6	23.6	73	0.25
July	81.22	99.33	17.14	79	2.84
August	79.35	96.91	17.36	81	1.8
September	76.77	98.53	21.82	87	0.07
October	70.8	99.87	29.77	70	0.01
November	61.44	91.42	31.88	77	0.0
December	52.40	79.36	26.92	68	0.9

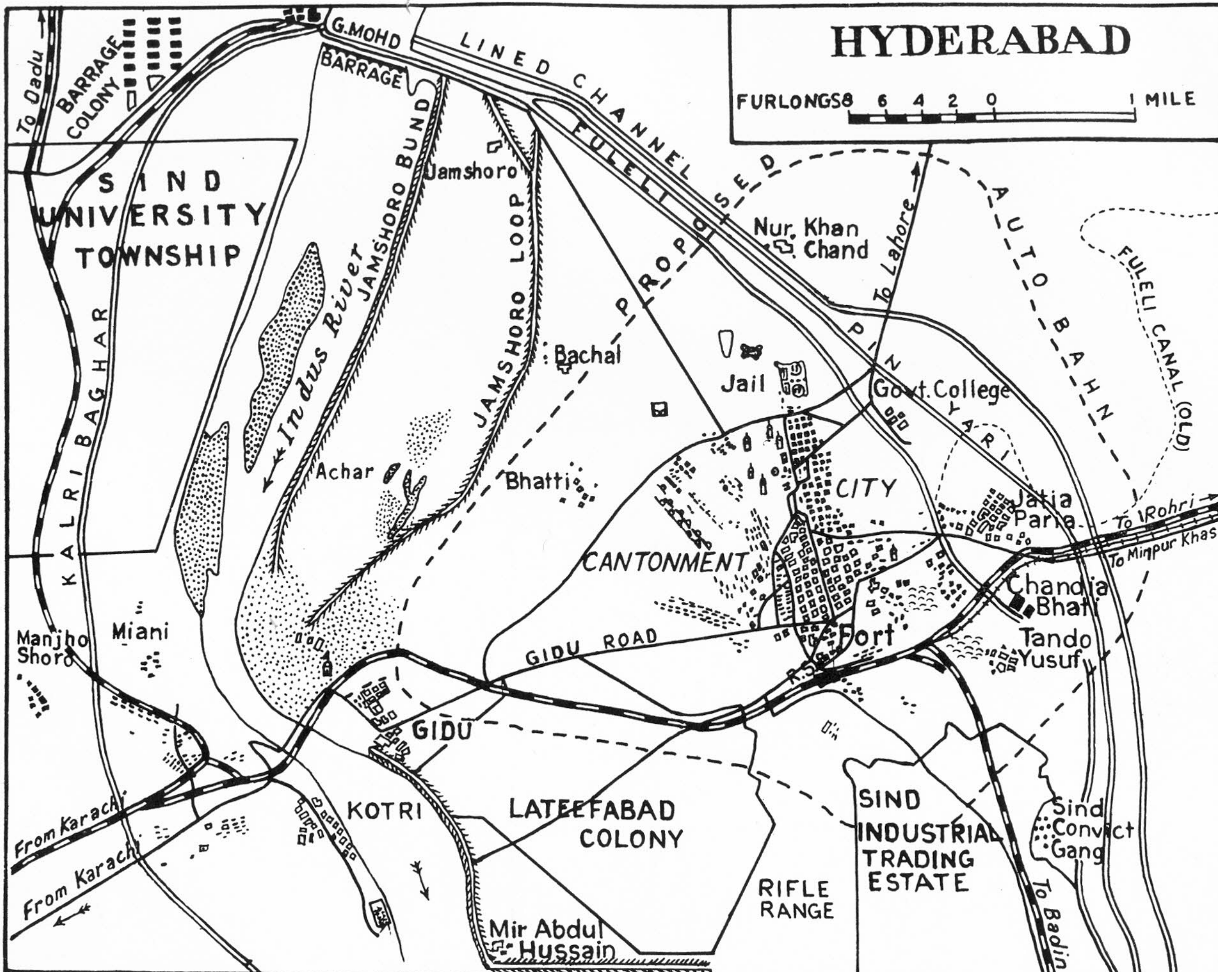
*Data taken from *India Weather Review*, 1936—45.

TABLE II

*Mean Monthly Relative Humidity**

Month	Karachi %	Hyderabad %
January	60	68
February	68	66
March	70	69
April	77	65
May	78	77
June	80	73
July	81	79
August	83	81
September	82	87
October	73	70
November	62	77
December	59	68

**India Weather Review*, 1936—45.


HYDERABAD
FURLONGS 8 6 4 2 0 1 MILE
To Dadu
BARRAGE COLONY
G. MOHD BARRAGE
LINED CHANNEL
FULELI CHANNEL
JAMSHORO BUND
Jamshoro
JAMSHORO LOOP
SIND UNIVERSITY TOWNSHIP
PROPOSED PINYARI
AUTO BAHN
Nur. Khan Chand
To Lahore
FULELI CANAL (OLD)
Indus River
JAMSHORO BUND
Bachal
Jail
Govt. College
KALRI BAGHAR
Achar
Bhatti
CITY
Jatia Paria
To Rohri
To Mirpur Khas
CANTONMENT
Chandia Bhatti
Manjho Shoro
Miani
GIDU ROAD
Fort
Tando Yusuf
R.S.
GIDU
From Karachi
From Karachi
KOTRI
LATEEFABAD COLONY
SIND INDUSTRIAL TRADING ESTATE
Sind Convict Gang
RIFLE RANGE
To Badin
Mir Abdul Hussain

TALBE III

Total & percentage variation of Population of Hyderabed, 188—1951

Year	Population		Total	Percentage variation of total population
	City	Cantonment		
1881	45,195	2,958	48,153	..
1891	54,569	3,479	58,048	20.6
1901	64,790	4,588	68,378	19.5
1911	69,140	6,812	75,952	9.5
1921	73,051	7,887	80,938	7.8
1931	96,021	5,678	101,699	24.3
1941	127,521	7,172	134,693	32.2
1951	229,412	12,389	241,801	78.7

TABLE IV

Variation of Population of Hyderabad by sex, 1921—1951.

Years	Males	Females	Male variation	Female veri-ation	Females per 1000 males
1921	46,387	35,451	..	..	764
1931	56,790	44,899	+10.403	+9.448	790
1941	74,426	60,267	+17.636	+15.368	810
1951	132,463	109,338	+58.037	+49.071	825
Net variation from 1921 to 1951			+86.076	+73.887	858

TABLE V

Population by religion, 1941—1951

Year	Caste Hindus	Scheduled castes	Muslims	Christians	Sikhs	Others
1941	93,032	3,571	36,069	355	1,528	138
1951	2,501	4,360	234,597	..	..	343

LAND UTILIZATION IN BEKASAHARA

BY

NAJMA RIZVI

Advanced Graduate Course student, Cornell University, New York.

The present study attempts to bring out the salient features of land utilization in Bekasahara, a small village situated in the southern and gently sloping section of the Pleistocene terraces in the northern part of Dacca district.

GEOGRAPHIC SETTING

Bekasahara is a *mauza* (village) in the Sripur Thana of Sadar subdivision in Dacca district of East Pakistan. The term *mauza* is defined as an "inhabited rural locality with its adjoining land constituting a survey unit in East Pakistan".([1]) Bekasahara is situated at latitude 24°30′ N. and longitude 90° 29′E.

Climate

Climatic data are not available for Bekasahara but as it is situated only about 35 miles from Dacca, its climate does not differ substantially from that of the city. It is characterized by heavy monsoon rains and dry winters. The average rainfall during the monsoon months (June to October) is 60—70 inches. About 12 inches of rainfall is received through Norwesters during the months of March, April and May. Highest temperatures occur at the end of short Norwester period in April-may, which sometimes exceed 100° F. Absolute maximum of 104° or 105° F are not uncommon. During the monsoon months the daily temperature varies between 68°—70° F (minimum) to 90°—95° F. (maximum). Winters are mild and dry. Lowest winter temperature does not go much below 55° F, though the daily average is generally above 65° F. Since Bekasahara remains above the highest flood level, the supply of moisture to the soils is directly from the rainfall. Unlike many other parts of East Pakistan which are annually inundated and which retain moisture for a considerable time, the village experiences a long period of evaporation, which begins immediately after the end of monsoon and lasts until the beginning of Norwesters.

Surface Features

Bekasahara, being situated on the southern slope of the Madhupur Tract, exhibits surface features which are distinctly different from the characteristic topography of the flood plains in East Pakistan. Here the topography consists of abandoned stream channels and a higher flat surface with a slope gradient steeper than the one in the flood plains. The Madhupur Tract as a whole consists of various levels of land (Pleistocene terraces). Bekasahara and other adjoining villages probably represent the lowest of these levels, just above the Recent flood plains. The two basic levels of land in the Sripur area are the flat surface with the general southward direction of the slope, locally called *Chala*, and the cultivated bottoms of the ancient streams called *Baid*. There are

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1. Naqavi, S. H. H., Govindpur—A study in Land Use, *Oriental* Geographer, Vol. I (No. 1), 1957, p. 18.

several intermediate levels with various local names. The *Chala* level does not occur in Bekasahara. The levels represented in this village are *Shota*, *Ukhai* and *Baid* (See Fig. 1).

TABLE I: LAND USE

Levels	Area in acres	Percent of the total area
Baid	15.40	7.00
Ukhai	2.10	1.00
Shota	201.50	92.00
Total	219.00	100.00

Shota which like *Chala* is a flat plain surface, is the most extensive level of the village and occupies 92.0 percent of the total area. It differs from *chala* only in terms of relative elevation.

Baid. The *baid* represented in Bekasahara is typical of its category, with its characteristic stream form, and represents 7.0 percent of the total village area.

Ukhai is a transitional level between the *shota* and *baid*, and represents only 1 percent of the total area. *Ukhai* is lower than *shota* and higher than *baid.* It has a much steeper slope. It would normally represent an area of excessive erosion but for the fact that it has been carefully terraced into three or four descending levels each one being 4—6 inches lower than the other.

Drainage

The area surveyed was classified into 'excessively drained', 'well drained' and 'poorly drained' tracts. There being no hard and fast criteria to determine these categories, somewhat arbitrary definitions were used. The term 'excessively drained' implies considerable slope of the land which allow soil wash under natural conditions. Lines of erosion will be visible in the form of small gullies if remained unchecked. In Bekasahara only the *Ukhai* level could be called 'excessively drained', but soil erosion has been checked there by terracing. The term 'poorly drained' could be applied to the areas where the water remained standing throughout the rainy season. A small part of *baid* falls under this category. The entire *shota* level and considerable part of the *baid*, which are classified as 'well drained', do not have any accumulation of water even in the rainy season nor do they show any signs of extensive soil erosion.

Soils

Since the village forms a part of the Madhupur Tract, which has been subjected to considerable erosion, the soils are deep and yellowish to red in colour. These soils present a marked contrast to the soils of the flood plains. Two different types of soil can be distinguished: those of *shota* and *baid.* The *shota* soil is *a doash* or loam with predominance of silt whereas the *baid* soil is *entel-doash* or clayey loam. The *baid* soil is somewhat darker in shade. The *shota* soils are not very fertile. The *baids* are comparatively fertile areas and give higher yield of crops.

Although no accurate soil survey has been done in the area, there are reasons to believe that the soils of Bekasahara are not very fertile. The soils are derived from the lateritic Madhupur Tract, and contain considerable amount of iron-oxide, which makes the soils poor.

LAND USE

Salient Features.—The most significant feature of the land use of Bekasahara is the predominance of crop land which accounts for 92.0 percent of the total area. Vegetables and other minor crops, which grow on land close to houses (*baris*), occupy another 0.5 percent, raising the total of land under all kinds of crops to 92.5 percent. Less than one percent of the land can be classified as 'non-agricultural land'. The latter includes embankments of ponds and graveyards (See Fig. 2).

With the exception of a small part of *baid* land, where considerable water accumulates during the rainy season, the entire crop land yields more than one crop every year. The vegetable gardens around the *baris*, which receive special care and attention of the farmers, generally give three crops in a year. The rest of the crop land is a double-cropped area.

No chemical fertilizers, like ammonium sulphate, are in use. The only fertilizer used by the farmers is the cowdung which is spread over the *shota* level before ploughing the field. The *baid* which is more fertile than *shota*, is completely ignored, and no manuring is done there.

The scarcity of water is the main drawback of the area. As stated earlier, unlike other parts of East Pakistan which are comparatively lower, the area stands high above the flood level. As it escapes inundation by the yearly floods the only water it receives is through the rains. There are a few ponds in the village but they are not used for supplying water to the fields at the time of scarcity, as they are meant to store only the drinking water. Irrigation seems to be the great need of the area for which no facilities exist at present.

The agricultural implements used by the cultivators are the same old implements which are being used in East Pakistan probably for thousands of years. They are crude and primitive implements which include plough, spade, *chango*, sickle and *dao*. A simple wooden plough with an iron point is used for tilling the small plots. This plough only furrows the land and does not turn it over. The plough is pulled by a pair of bullocks or buffaloes. Spade is used for digging, *chango* for harrowing, sickle for harvesting and *dao* for cutting.

TABLE II : LAND USE

Uses	Area in acres	Percent of the total area.
Settlement	4.80	2.20
Cropland	201.50	92.00
Vegetables	1.20	0.50
Ponds	3.40	1.60
Roads & Footpaths	6.00	2.70
Other non agricultural land	2.10	1.00
Total	219.00	100.00

Cropland

The cropland is the largest single category of land use in the village. It accounts for 201.5 acres of land out of the total acreage of 219.

The village is divided into a number of plots of unequal sizes and irregular shapes, each plot being less than an acre in area. Generally the plots are four sided figures, though the sides may not be of the same length. The boundaries of the plots were fixed at the time of Land Settlement in 1911—14. These boundaries do not necessarily coincide with the ownership boundaries existing today and thus are sometimes difficult to be recognized in the field.

The entire cropland is given to the cultivation of paddy. The two most important varieties of paddy are *Aus* and *Aman*. *Aus* is sown in April-May and harvested in July-August. The sowing of *Aus* begins when Norwester rains have supplied the required moisture to the fields. The particular variety of Aman which is grown in this area is locally called *shail*. The sowing of *shail* begins in the months of July-August, with the advent of monsoon rains. It is transplanted in September-October and harvested in December-January. From the end of January to April, when the next sowing season begins, the entire cropland remains uncultivated due to insufficient moisture in the soil and lack of artificial irrigation.

The yield of paddy varies with levels. The *baids* with comparatively more fertile soils, give a higher yield per acre than *shota*. The yield of paddy on *shota* land hardly exceeds 3-4 maunds per *pakhi*(2), whereas the *baid* land may produce upto 12 maunds per *pakhi*.

Vegetables and Other Minor Crops

About 0.5 percent of the total area of the village is given to vegetables of various types and some minor crops, including jute. Inspite of the importance of vegetables within this small area it cannot be classified as horticulture, as they are grown for home consumption and not for marketing. The vegetable plots are invariably associated with *baris* (homesteads) and receive the attention of the whole family. Inspite of its smallness it is the most interesting cultivated area. A variety of vegetables, including pumpkins, brinjals, sweet potatoes, are grown together with chillies, onions, pulses and a little quantity of jute, and all on a few square yards of land near the houses. None of these produces, including jute, is ever sent to the market.

Tree and Other Perennial Crops

There is no separate area given to the trees. Almost all the trees of the village are grown around or near the *baris*. Some of the most common trees associated with the *baris* are the jack fruit, mango and olive. There used to be a few patches of bamboo groves scattered over the village but with the exception of one or two, they have all been cleared for cultivation.

Settlement

Like elsewhere in Bengal, the settlement in Bekasahara is n. nucleated. Flood being no problem in any part of the village it could well be compact, the influence

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35/100 of an acre, is a term generally used in the villages of Sripur Thana.

of traditions seems stronger than the factors of immediate environment. The settlement exhibits a linear pattern in the middle. In other parts of the village, however, the *baris* are scattered.

Like the traditional *baris* of Bengal, the homesteads in Bekasahara consist of four blocks arranged in a rectangular pattern, with a courtyard in the middle. Some of the *baris* have a separate cowshed for keeping cattles while the other three blocks consist of living rooms, kitchen and store rooms. The houses are made of mud and have thatched roof. Bamboo, jute stems and sungrass are used for thatching the roof. Ponds occupy a total area of 3.4 acres which is 1.6 per cent of the area of the village. Locally the ponds are differentiated into two types called *Pushkani* and *Doba*. *Pushkanis* are artificially made ponds in which the rain water is stored for domestic consumption. *Dobas* on the other hand are unintended depressions, generally made as a result of removal of earth for the construction of houses. *Dobas* are small and shallow, and contain muddy water. Mostly they are used for retting of jute but sometimes for domestic purposes also.

On the four sides of some of the *Pushkanis* are artificially raised embankments of considerable width which are made to increase the storing capacity of the *pushkani* and to stop the entry of the water from the near about lands into the pond. These embankments and the graveyards form the non-agricultural lands in the village and account for 1.0 per cent of the total land.

Roads

Roads in Bekasahara account for 2.7 percent of the village area. The roads are unmetalled and are used by bullock carts for carrying the surplus rice to Barami *hat* which is about four miles from Bekasahara. Inspite of the fact that these *kuchcha* roads play a significant part in the economic life of the village, the people do not make any cooperative effort to improve the most unsatisfactory condition of these roads.

POPULATION

According to the 1951 census Bekasahara has a population of about 500 people. This gives an average density of 1,461 persons per square mile which is equivalent to 1,579 people per cultivated square mile. The average density of this area is much lower than the density of parts of the flood plain areas. This becomes more evident when compared with the Rampal, Ramsinha and Kalanjipara villages of Munshiganj subdivision which have an average density of 3,544 persons per square mile and a density of 3,667 persons per cultivated square mile.(3) This "low" density is probably due to the scarcity of water supply in this area which greatly hinders cultivation.

The majority of population consists of Muslims, and Hindus are very few in number. The working group ranges from 10 to 50 years or more. Womenfolk do not form a

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3. Haq, Lutful, Rampal, Ramsinha and Kalanjipara—A study in Land Use, *Oriental Geographer*, Vol. II (1958), p. 118.

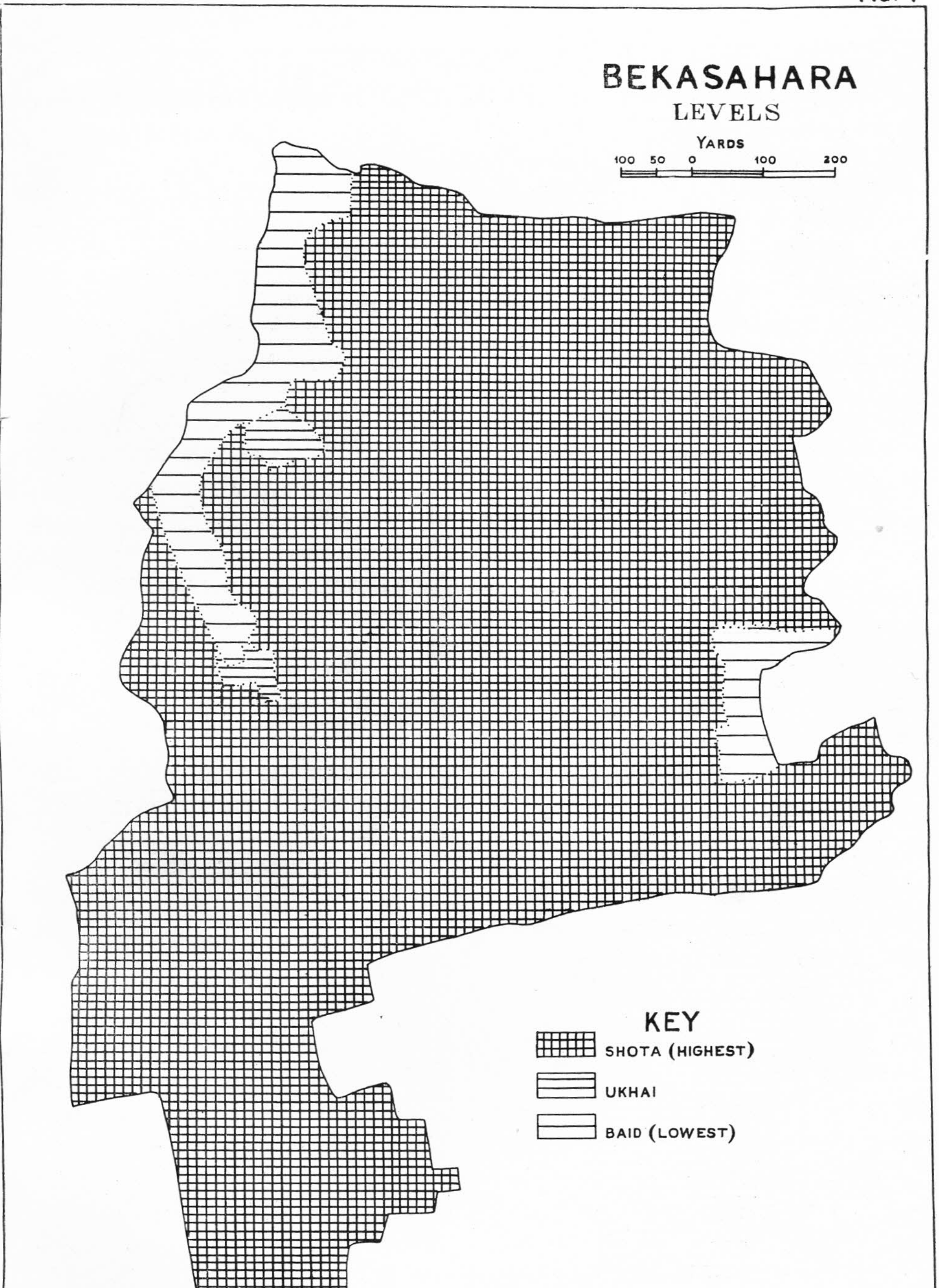
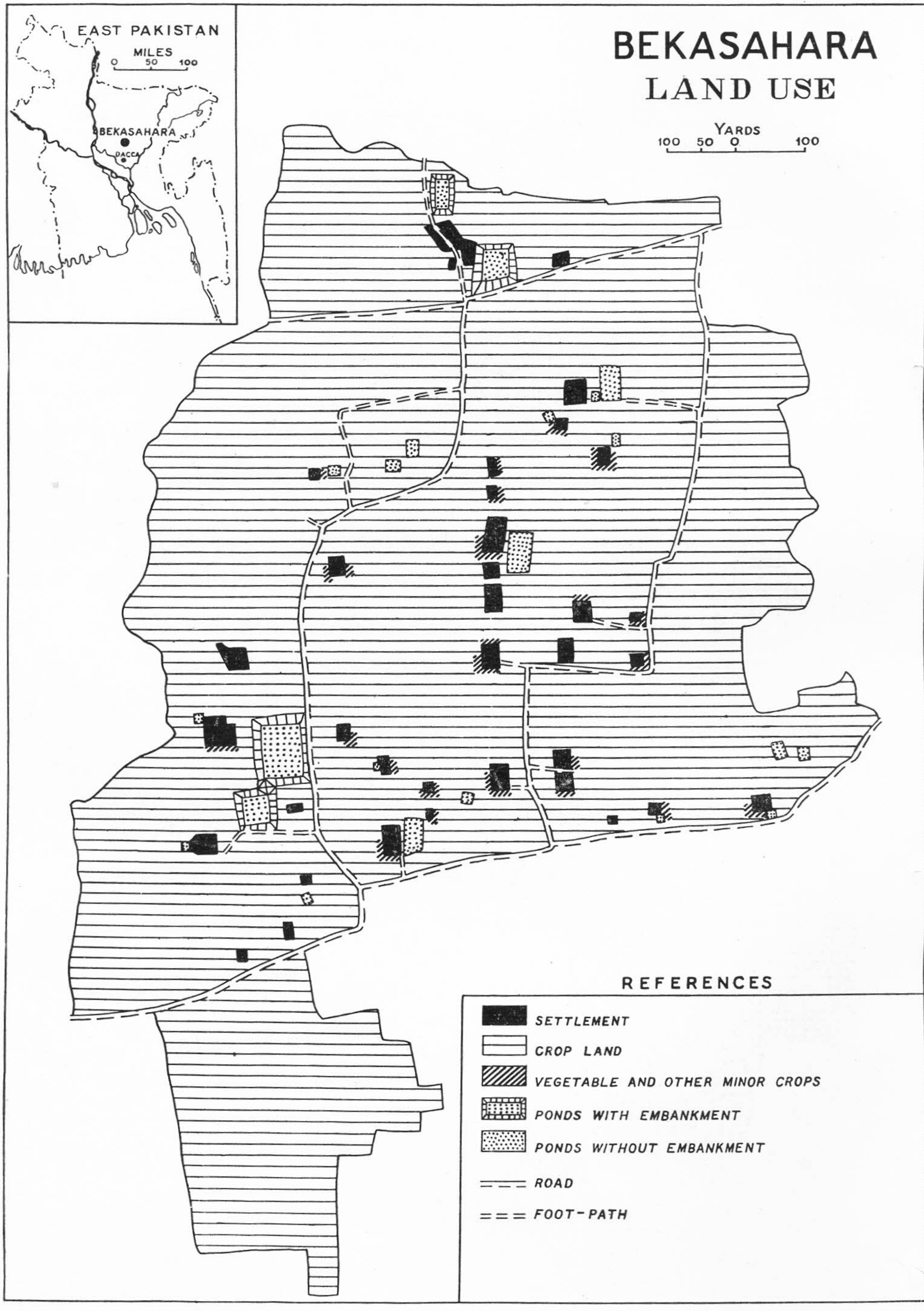

BEKASAHARA
LEVELS
YARDS
100 50 0 100 200
KEY
SHOTA (HIGHEST)
UKHAI
BAID (LOWEST)

FIG. 2


EAST PAKISTAN
MILES
0 50 100
BEKASAHARA
DACCA
BEKASAHARA
LAND USE
YARDS
100 50 0 100
REFERENCES
SETTLEMENT
CROP LAND
VEGETABLE AND OTHER MINOR CROPS
PONDS WITH EMBANKMENT
PONDS WITHOUT EMBANKMENT
ROAD
FOOT-PATH

part of the working group. Women only look after the household. Thus the working group forms a small part of the total population.

CONCLUSIONS

The land use pattern of Bekasahara exhibits considerably backward conditions. Physical conditions, like infertility of the soils and lack of sufficient water, have no doubt played a part in keeping the village underdeveloped, but the most striking of all the features is the traditional way of thinking of the people and lack of effort to improve conditions. Sufficient amount of good water could be available for irrigation as well as for domestic use by digging *kuchcha* wells but the aversion to hard manual labour has compelled the people to accept the backward conditions as unalterable and fixed.

The dependence of the entire economy on a single crop does not ensure stability. Any possible failure of crop is bound to be followed by famine and strarvation.

Irrigation, which has been experimented with success elsewhere, can be safely recommended to these villages. Most intensive use of the natural manures available to the villagers in addition to the artificial fertilizers which may be supplied to them on loan by the Department of Agriculture, is likely to improve the yield of crops.

AGRICULTURE IN SOUTH EAST ASIA

BY

(Miss) M. K. ELAHI

Department of Geography, University of the Panjab, Lahore

South East Asia, as defined for the purposes of this Symposium,* includes Burma, Indo-China (Vietnam, Cambodia and Laos), Philippines, Thailand, New Guinea, Indonesia, Timor, Brunei, Malaya, Northern Borneo, Sarawak and Singapore. It covers about 1,889,390 square miles or 20% of Asias' surface, which has 36% of the world area, and it inhabits about 203,648,000 persons, which form 13.7% of Asia's population and 7.9% of the world population.

The physiographic map of S. E. Asia presents a mosaic with mountain ranges, broken hills, valley flats and coastal plains. In some of the coastal areas like eastern Sumatra and Southern and Western Borneo considerable areas are swampy. Valley plains, deltas and coastal plains are of great agricultural value, and it is these plain areas that form some of the most densely populated parts of Asia.

CLIMATIC CONDITIONS

The climatic conditions in S.E. Asia, lying between latitudes 28° North and 11° south, are dominated by the heat and humidity of the tropics, with altitude and insularity as the chief modifying factors.

The most important feature of the climate is the uniformity of temperatures, which remain between 75-85° or so at most places and at all seasons, except in eastern Thailand and northern Burma. The uniformity of temperatures, except in the interior parts of northern Burma and eastern Thailand, is the result of small size of the islands, experiencing the ameliorating influences of the sea. The warmth allows the plant growth throughout the year, the rate of growth being controlled by the incidence and amount of rainfall, which is very much variable, depending upon the relief and aspect and the location in the northern or southern hemisphere.

The rainfall distribution in S.E. Asia follows the tropical regimes as one moves away from the equator, but the pattern of distribution is much too complicated by the varied relief of the region. Apart from local differences, most of the region receives rainfall above 80″. The seasonal distribution of rainfall depends mostly on the latitu-

*The Paper was contributed to the symposium on South East Asia, held at Lahore in 1958, under the auspices of the Pakistan Geographical Association.

dinal position. The distribution of rainfall varies because of the location in both the hemispheres and relief patterns which give orographic rains or create rain-shadow areas.

Diversity of relief is primarily responsible for the marked variations in the regional distribution of rainfall. Areas with heavy annual rainfall of over 250″ are western Sumatra and southern coast of Sumatra. Other areas with rainfall more than 120″ are the Cameron highlands of Malaya and the eastern coast of Malaya, coastal parts of Burma, western coast of Cambodia and central Vietnam. Areas with rainfall of less than 60″ are central Burma, central and eastern Thailand, western Cambodia and eastern Java.

Whereas the uniformity of temperature and great humidity give very secure ground for agricultural activities, thunderstorms and typhoons, the superimposed eddies in the general stream of air current, are a great hazard to crops. The greater frequency of typhoons is usually not experienced south of Cape of Cambodia. From July to September the maximum danger is to areas north of latitude 15°N—covering central and coastal parts of Indo-China and Philippines—while in October and November the path of typhoons shifts southwards, and Southern Cambodia and southern parts of Vietnam are in their grip. About 80 of such storms are experienced in the period from July to November. From February to May, the frequency is less, averaging only 4 to 5.

Sunshine is plentiful, with a distinct diurnal rhythm near the equator, and usually the rain falling in the afternoon. Areas with a distinct dry season have maximum sunshine in the dry period and continuous cloudy weather for days in the rainy season. Heavy incidence of rainfall within short periods causes heavy floods. Rivers carry heavy loads, and rapid deposition in the plains and esturial areas goes on. River deltas like that of Mekong and Solo are advancing due to the quick sedimentation.

The altitude and the insular effect have made human settlement possible in almost all parts of S.E. Asia.

SOILS

Lateritic soils are widely developed under warm and humid conditions, where chemical weathering goes on. Annual excess of rainfall over evaporation is experienced in most parts of S.E. Asia. This means a steady movement of rain water down-wards percolating through the soils, and there is a steady removal of the solubles from the upper layers of the soils. Where there is natural vegetation cover, the renewal of humus continues, but at other places the soil becomes less fertile—a factor that makes continuous agricultural activity a depleting force. In parts there are breaks in the leaching process as a result of a fair balance between evaporation and precipitation. In the central and eastern Java, central Burma, interior and eastern Thailand and adjoining portion of western Indo-China, the relatively dry season brings up the mineral contents to the surface layers, maintaining a balance between the leaching and capillary action. Hence, soils of these areas are of great agricultural value. The maintenance of fertility is, therefore, easy where the dry season exists than in a clearing in the more humid zone.

Apart from the residual soils, the rivers are a great transporting agents depositing huge amounts of silt and loam in the flood plains, deltas and the fresh water swamps. A continuous renewal, therefore, goes on in these areas of transported soils. So the flood plains and deltas function as the chief agricultural areas of S. E. Asia, with black or sticky dark brown soils, without signs of exhaustion.

CLASSIFICATION OF LAND

According to the classification of land-use adopted by the F.A.O., only 9.8% of the total area of S.E. Asia as a whole (excluding New Guinea and Timor, for which figures are not available) is cultivated. Indonesia on the whole has 15.4% land classed as cultivated, but the largest proportion of cultivated land is in Java, where it is approximately 70%. Here the rich alluvial plains of the north and the small valley plains of the south, with rich volcanoic soil, provide most of the agricultural land. Most of the area fit to be brought under cultivation has already been used. Singapore has 21.3% of its area cultivated, mostly catering for the large urban centre. Sarawak, a part of the British Borneo, shows 26.2% of the area as cultivated, mostly in Mujang and Relang river valleys. Malaya also has 16.5% of its area under cultivation. Burma, Cambodia, Philippines, Vietnam, have cultivated area ranging from 10 to 15%. (See Table I) In lower Burma, in the delta of Irrawaddy, Red river and Mekong deltas the proportion of the cultivated area is relatively high. Laos which is mainly hilly has only 4.2% of its area under crops. Thailand in the northern sections is hilly and relatively dry. Eastern part is also less moist and consists of a tableland. It has only 9.2% of its area cultivated, mostly lying in the deltas of Cha-Praya and Tachin. Northern Borneo and Bruni have also very little agricultural land, only 2.5% and 6.2% respectively.

The ratio of cultivable area (which can be reclaimed to agriculture) in the countries for which data are available, show a varying proportion from 0.9% in Northern Borneo to 26.9% in Cambodia. The very high proportion of land classed as cultivable in Cambodia lies in its lowlying area round lake Tonle and the basin of Mekong. At present only the delta area is intensively used. Philippines have about 20% of the total area cultivable—mostly lying outside Luzan. Laos has about 17% of the area awaiting development in the upper reaches of Mekong and valleys of small streams draining towards Vietnam.

In S.E. Asia as a whole a very large proportion, 58.5%, of the area is still covered with natural tropical rain forests. The forested area is specially large in less developed and more humid parts. Northern Borneo has about 91.2% of its land under forests. Malaya and Sarawak have 73.6% and 72.4% of the total area under forests respectively. In Malaya most of the central high lands, receiving heavy amount of rainfall throughout the year, have virgin forest stands. Sarawak, where development is still awaiting, has dense forests with rain at all seasons. Brunei has also large area under forests still untouched (67%). Only two countries, Vietnam and Cambodia, have forested area under 50%. In Indonesia the least area under forests is in the intensively cultivated land of Java, where it is only 23%. Here, the small proportion of the forested land is considered dangerous for the water balance of the country.

In these warm and humid environments a much larger proportion than 25% of the total area must be under natural vegetation cover of forests and woodlands. The heavy downpours of rainfall lead to very rapid erosion of soil if it is not otherwise protected. The laborious terracing of the upper slopes of the hilly area in many parts, especially in Java, are a protective measure to stop soil erosion and save the fields below in the plains and all along the lower slopes. Moreover, the heavy incidence of rainfall concentrated within a short period is of common occurrence in these parts, and the presence of forest stands with much undergrowth acts as a spunge in holding the water and reducing the frequence and magnitude of floods in the valley plains.

The agricultural activity continues in most parts throughout the year—a factor responsible for the high productivity of these areas. In some hilly parts agriculture is of subsistence type as in Northern Burma, but in most parts commercial farming goes side by side with subsistence farming. It is difficult to separate the area under subsistence farming from that under commercial crops.

MAIN CROPS

Rice

Warm and humid conditions in most parts of S.E. Asia have made rice the most important crop of the region, occupying 54.2% of the total cropped acreage and contributing the largest production tonnage. S. E. Asia has 23.6% of the world rice acreage and shares 19% of the world rice production. The total rice acreage remains between 22 and 23 million hectares. There has been an increase of about 11.2% in the rice acreage in S.E. Asia, keeping pace with the world increase of 11.2% between 1934-38 to 1952-53. The increase in production has been much more marked during the same period. In 1934-38 S.E. Asia shared 17.5% of the world rice production, and in 1952 it accounted for 19% of the world production. The increase in the world production has been only 6.5%, whereas in S.E. Asia it has been 11.7%. The increased share in world production is an index to the better returns per acre. A further increase of 7% in the production of rice has been recorded in S.E. Asia from 1952 to 1955.

Indonesia has the largest acreage under rice which accounts for 77.5% of its cultivated acreage and 29.5% of the total rice lands of S.E. Asia. The area under rice has expanded in S.E. Asia as a whole but the increase has been more marked in Indonesia. In 1934-38 it shared 18.9% of the total area under rice in S.E. Asia while it registered in 1952 an increase of 10.6% in the share of S.E. Asia's rice acreage and 70.9% increase in its own rice acreage. This increase is partly accounted for by the transfer of some area under rice from plantation crops and partly by reclaiming new lands to fulfil the growing demand of food supply for the fast growing population. About 60% of Indonesian rice acreage lies in Java. The new lands put under rice are in Sumatra and parts of Borneo. Most of the rice in Java is grown as wet paddy on the intensively cultivated river-transported alluvial soils, continually renewed by deposition. Hill slopes are also terraced for rice cultivation. All the rice is produced by Javanese themselves, and, as the climatic conditions allow, there is the planting or harvesting of rice going on in some district or the other throughout the year. In parts of Sumatra, shifting cultivation still continues in many parts. Wet paddy is confined to a few deltaic areas of Atjeh and Lampoenger and upper valleys of Moesi and Hari rivers. In the coastal areas of Atjeh and Lampoenger the rice acreage has expanded recently because of the Krakatau volcanic explosion, which spread fertile volcanic ash in southern Sumarta. Most of the rice produced in Indonesia is consumed within the country.

Thailand is the second largest producer of rice in S.E. Asia. It has 22% of the rice acreage, and produces 21.6% of the rice of the region. There has been an increase in acreage as well as in the production of rice since 1934-38, when it shared only 16.7% of the rice area of the region. In Thailand the importance of rice as a commercial food crop can be concluded from the agricultural statistics, which show the area under rice as more than the total cultivated area; the rice acreage includes double cropped area. All other crops like maize, sugarcane, tobacco and rubber are minor crops in terms of area and production. The extent of double cropped area under rice is difficult to ascertain, as relevant figures are not available for separate crops.

Almost all the commercial rice is produced in lower and eastern Thailand. Where the rainy season is shorter and the amount of rainfall smaller, the glutinous rice is produced for local consumption.

The deltaic plains of Thailand specialize in rice farming, and almost all the rice for export comes from this area. The deficiency of rainfall is made good by the flood waters from the rivers in the delta of Chao-Praya. The flood waters are distributed in the whole plain by flood canals. The time of floods is usually a month later than the rainy season. The nursery beds are sown in the rainy season and transplantings take place later. If the rains come late, almost coinciding with the floods, the sowings are broadcast. The times of sowing at various places vary with the times of floodings. The uncontrolled floodings without dykes or store-dams are risky, resulting in great variations in the production of rice, which is entirely dependent on rain and flood waters. The precariousness of rice farming has been cured by the construction of canals in the eastern part of the delta, as the river keeps on shifting to the east leaving the land on the west, with no soil renewal, as abandoned, a cause for the shifting of the favoured rice growing areas to the east. The maximum activity is in July for growing rice and in December for harvesting. In other parts of Thailand subsistence rice cultivation is carried on, with greater variety of crops than is practised in lower Thailand.

Burma is the third largest producer of rice with 18% of S.E. Asia's rice acreage and 19% of the production of the region. Rice occupies about 46.8% of the total cultivated area of the country. From the last quarter of the nineteenth century the area under rice in Burma has been expanding uptil 1941. The figures for 1934—38 show an average acreage of 4,931 thousand hectares under rice. In 1948—50 the acreage was 3,827 thousand hectares. It was 3,816 thousand hectares in 1951 and 4,000 thousand hectares in 1952. The post war decrease is partly explained by the disturbed conditions during the war and partly by the introduction of diversified agriculture, especially in lower Burma. The decline in production is well marked from a figure of 6,971 thousand tons in 1934—38 to 5,868 thousand tons in 1955. However, the production figures of 1955 show a recovery over the figures of the preceding years. Burma contributed 26.6% of the rice production of S.E. Asia in 1934—38, but in 1955 the contribution was only 18%. Most of the commercial rice of Burma comes from the wet paddy fields of the delta region of Irrawaddy, Sittang, Salween and the coastal plains. Irrawaddy delta contributes more than 90% of the commercial rice. The expansion of rice acreage in delta implied clearing and flattening and drainage mostly done by hand. Population migrations to southern Burma, therefore, were an accompaniment of rice cultivation.

Bulk of the deltaic rice comes from rainfall swamps; no flood water is received from the rivers. Local rains flood the area well in advance of the Irrawaddys floods and farmers have to protect their fields from the river floods.

All the rice is transplanted from nurseries to the fields. The activity in the fields starts from June-July, lasting till November and December. Most of the commercial rice of the country moves through the rivers. Without this water transport it would be difficult to keep the cost of production low.

Northern Burma produces a great many crop, depending on the local requirements. Mostly in this relatively drier zone subsistence agriculture is practised,with only a small production of commercial crops. Where rainfall is inadequte, large scale rice farming is a subsidiary industry.

In the hilly parts of Burma, shifting cultivation is practised with the hill rice cultivation. Such clearings when left unattended are a cause of rapid soil erosion. The government has made the replantation of forests compulsory for the hill tribes before they shift to a new clearing.

Indo-China has 17.1 of the total rice lands, and produces about 14.9% of the rice of the region. Indo-China, now comprising Vietnam, Laos and Cambodia, has registered a decline of 30.5% in its rice lands from 1934—38 to 1952. This is probably due to the disturbed political conditions during the post war period. Vietnam has shown some recovery since 1950 towards increasing its rice lands. Vietnam produces the largest amount of rice in Indo-China, and has about 96% (3,890 thousand hectares) of its cultivated area under rice, mostly lying in the delta of the Red river and small coastal plains.

Red river delta is thickly peopled and intensively cultivated with about 50% of the cultivated area as double cropped. Rice is the sole food crop as well as a commercial crop. This area grows more than 300 varieties of rice suited to different parts. The cultivation of rice is carried on in the flooded fields. High embankments have been constructed to control the floods, but sometimes the river level is higher than the flooded fields and the draining of water becomes a problem. To overcome the difficulty some modern irrigation works have been constructed.

Flood variations result in harvest fluctuations. Some wet rice is grown along the coastal plains of Vietnam. Laos produces very small quantities of rice, only about 500 thousand tons and the acreage has remained between 850 to 800 during 1948—52. Most of the area of Laos is hilly with small valley plains of the upper and middle Mekong.

Cambodia, mostly a low lying country, has about 1,168 hectares under rice, which forms 46% of its cultivated area.

The low areas of rice cultivation are in the Tonle Sap alluvial plain and the Mekong delta. Mekong delta has sticky mud with occasional belts of fluvial sands.

This area is also of relatively low rainfall and the cultivation of rice follows the flood rhythm as in lower Thailand. In the areas of deep flooding, floating paddy is sown in dry period of March and harvested in January when the floods subside. This type of paddy is usually more than 18 ft. tall to keep the head above flood level.

Philippines contribute about 10.2% of the rice produced in S.E. Asia. It has about 2,456 thousand hectares under paddy which covers 57.6% of its cultivated land. Philippines have patronised the rice culture and the area under rice shows a progressive increase of 23% from 1934—38 to 1952. During the same period the production increased by 44%, indicating an improvement in the yields per unit area.

The question of yield of rice is quite important in a region where rice forms a staple diet as well as an important article of commerce. The average yields in S.E. Asia have shown an increase from 15.3 to 16.9 maunds per acre, but it is lower than the average for the world, which is 18.8 maunds per acre. These yields in S.E. Asia are less than 1/3rd those in Italy and Spain. Highest yield in S.E. Asia are in British Borneo and second highest in Java, where the cultivation is very intensive. British Borneo has doubled its rice yields since 1934—38. Java shows a great constancy in this respect. Indo-China has also improved the yields from 12.9 to about 14.5 maunds an acre.

Maize

Maize is a very bad second as a food crop. It is only grown in areas of sparse population. S.E. Asia grows maize only on an area equal to about 1/5th that of rice. Since it is a lesser yielding crop than rice, it occupies a marginal position in the populated deltaic tracts, and is more favoured in hilly parts.

About 3/4th of S. E. Asia's maize crop is grown in Indonesia, Java alone sharing half of the total acreage of the region. Philippines grow some maize, but other remaining parts of S.E. Asia have very small acreages under this crop.

Rubber

Commercial farming in S.E. Asia, apart from the cultivation of commercial rice, revolves round the production of plantation rubber. Unlike rice, it started in big estates, after clearing the virgin forests, and filtered into the mixed farming system of the indigenous people. The acreage of rubber is not very large, as only about 5% of the total cultivated is under rubber, but it is a very valuable item of international trade. S.E. Asia produces about 87.1% of the world's rubber. The share has declined from 89.3% in 1934—38 to 87.1% in 1955. There has been an increase in the production of 805.4 thousand tons since 1934—38. The impetus was given by the development of transport and automobile industry in U.S.A. and Europe.

The largest producer of natural rubber in the world is Indonesia. It produces about 43.9% of S.E. Asian rubber and this share has increased from 39.8% in 1934—38.

Indonesia was the second largest producer of natural rubber after Malaya uptil 1950, after which the expansion of rubber cultivation in Java gave it the lead. Along with other plantation crops, rubber is still a very important commercial crop here, grown on large estates as well as on small holdings. Java and Madura have a major share of rubber acreage of Indonesia. Rubber estates of Java are widespread, with some concentration in eastern part of the island. In Sumatra, rubber growing started mostly on small holdings, fitting in the scheme of the indigenous farming. Large rubber plantations of later origin in Sumatra are in the vicinity of the old tobacco plantations near Medan and Palenbang and Djambi.

Malaya is the second largest producer of rubber in the world. It has lost its first place in favour of Indonesia since 1950. This has been due to the great damage done by II World War and the slow recovery in the post war period. It produces 38.3% of S.E. Asian rubber (41.9% in 1934—38). Rubber culture in Malaya, a country originally covered with dense tropical rain forests, very thinly populated, has been responsible for the economic and cultural revolution in the country. Before 1879, prior to the introduction of Havea rubber, Malaya was never concerned even with the collection of wild rubber. This rubber plant from Brazil adjusted to the warm and rainy climate and patriotic soils of Malaya. Moreover, other plantation crops like coffee, sugar and tea which were introduced earlier were abandoned partly because of the growing demand of rubber and partly because of the competition from other countries in the former commodities in the world market.

The larger rubber plantations are about 2000 acres in size. The rubber trees are grown in rows, with some undergrowth to stop soil erosion. Drainage channels have been constructed in lowlying areas. Other countries of S.E. Asia contribute a small share in the rubber production. Thailand produces about 7.8%, Indo-China 5.5% and British Borneo 2.3%, and very small quantities are produced in Borneo. In these countries rubber is not the main cash crop but only occupies important place in the diversified agriculture to ensure economic stability.

As rubber cultivation in S.E. Asia started as a plantation crop, much greater quantities were contributed by the large estates. In 1934—38 large estates contributed 52.4% and 62.3% in Indonesia and Malaya respectively, the rest was supplied by the small holdings. Gradually, as rubber fitted better in the economy of the small holders with mixed farming, the share of the large estates decreased to 39%in Indonesia and 58% in Malaya by 1952. The change has been mainly due to the fact that one-crop monopoly on the estates leads to economic depressions during the years of low prices. The diversified farming on the small holdings enables the growers to bear the low prices of rubber during critical periods. The decline in the share of production from the large estates is more marked in Indonesia as there the much capitalised rubber production on large estates was more vulnerable to the price fluctuations in the world market.

Sugarcane

Sugarcane production has been a speciality of many East Indian islands, mostly because of the transport facilities for export. It forms an important commercial crop. The production shows a slow and gradual recovery from the depression years in early thirties. In 1954-55 S.E. Asia produced 13.7% of the world cane sugar. The production by 1948-50 declined to only 982 tons, almost half of the pre-war years. It was partly due to the adverse effects of second world war specially on the trade and partly due to the pressure of population in Java where greater food production encroached upon the areas of commercial farming. Later years show a slow recovery in S.E. Asia as a whole which produced in 1955 about 8% or 1,611 thousand tons of cane sugar, still below the pre-war average of 1934—38.

The largest producer of sugar in S.E. Asia is Philippines, where the progress has been well marked. The stable political condition under American trusteeship has been one of the major contributive causes.

Sugarcane remains in the ground for a long period and requires a warm climate with rains at intervals and dry period for ripening. It does best where land may be relatively free of competition. In 1934—38 Philippines put 235 thousand hectares under sugarcane and produced 960 thousand tons, or 48.7% of the cane sugar of S.E. Asia. The production has increased to 1,105 thousand tons which amounts to 56.4% that of S.E. Asia. The increase is accounted for by an increased acreage put under sugarcane and by the increase in the per unit production by 60%. The only years when the production declined were the years of World War II.

Though for domestic use its growth is widespread, Luzan and Negros islands produce the major quantity of Philippines sugar. In Luzan sugar production is concentrated in Batangas, Torlac, Paupanga, Laguna, Pargasinan and Batuan. In Negros, western part of the island is devoted to its production; well drained loams of these areas are well suited to its growth. Heavy demands of labour are fulfilled by seasonal immigrants from other islands.

Indonesia is the second largest producer of cane sugar in S.E. Asia. It is an important commercial crop of the country. In 1934-38 it produced 913 thousand tons of sugar, a little less than that produced in the Philippines. The 1948—50 average figures show a decline in production to 182 thousand tons, or about 1/5th of the pre-war average. This ruin of the industry was mostly due to the unavoidable political conditions at home and the transfer of area from under commercial farming to food crops. The exports also fell to a negligible quantity in 1947-48. Gradually the recovery was made, increase being more marked between 52-55 from 458 thousand tons to 851 thousand tons (only on large estates). The fluctuations in the commercial farming of Java are better faced because of its farming methods, which could easily transfer the area from under one crop to another. Sugarcane is treated as an annual crop usually following a three-year rotation; in times of low prices land is easily transferred to other crops.

Java has been producing more than 4/5th of the total sugar of Indonesia. The labour demands are locally met with as it is a crop of very densely populated parts of Java. Bali and Lambok produce very small quantities.

The exports have also shown a recovery. Javanese sugar previously found a market in the Indo-Pak sub-continent, but since the production in India and Pakistan has expanded the market in the South Central Asia has been lost. S.E. Asia's other countries, and Japan are now the important buyers.

Other countries producing small quantities of sugar-cane in S.E. Asia are Indo-China, Malaya and Thailand. In Malaya the production of sugar shows a progressive increase partly as a measure of self sufficiency and partly as a step towards diversifying its agriculture to lessen the dependency on one commercial crop of rubber.

Other crops of the region, or its parts, which deserve mention are coffee, tea, coconut, copra, palmoil, pine apple and tobacco. Sesam, groundnuts, cassava, pepper and Kapak are some of the minor crops of the region.

LAND TENURE

Detailed figures are not available so far as regards the tenancy and the size of the holdings. As far as the information is available, we can have a general idea about different parts of S.E. Asia.

Philippines are essentially the islands with about 60% of the cultivated land in holdings between 35 to 2 hectares. About 37.9% of the tilled land is in holdings of 0.35 hectares. The area under large estates from 50 to over 100 hectares is only 0.4% About 77.8% of the land is ploughed by owners, 16.6% by tenants.

Indo-China generally is a land with small holdings. Vietnam, with the exception of Tonkin delta, has more than 60% of the land in holdings from 1—5 hectares. Holdings from 50 to over 100 hectares have only 2% of the total cultivated land.

Cambodia has greater percentage of its land in holdings of medium size. More than 45% of the land is in holdings from 5—10 hectares. The share of large estates from 10 to over 500 hectares is more in Cochin China delta area, being 13.4%.

In Thailand the deltaic area in lower Thailand has a greater proportion of larger holdings as it is the newly settled area for commercial rice farming.

Malaya is a land of large holdings and large rubber estates which are a land mark in the cultural landscape of the country. Small peasants with subsistence forming are small in number, mostly in Keddah, Kelantan and Perak.

In Lower Burma, where more than 50 % of the land is in the hands of non-agriculturists Indian and Chinese landlords own large estates. But in upper Burma one sees the mixed farming of indigenous type on small peasant holdings. These are the old settled parts of Burma.

In Indonesia very great contrast is met with in various islands. A greater proportion of agricultural land is in small parcels, the area held by large estates is very small, only about 7%. In Sumatra, which is much less developed than, Java, cultivated land is relatively samll. Reliable statistics for holdings and tenancy are not available.

WATER SUPPLY

The question of irrigation or drainage for the agricultural area in a warm and humid land is quite important, especially when the rainfall amount varies considerably due to the orographic effects. As far as the statistics are available, the highest percentage of irrigated land is in Indonesia, being 39.2%. For the intensively cultivated terrace fields of Java, for rice, and for sugar-cane, very regulated water supply is required, especially in the eastern part of the island which is less humid.

In Philippines only about 14.7% of the cultivated land is irrigated. In these islands the problem is more of a regulated supply to all the fields using the stream water directly, on the leeward side in the west.

Thailand has 18.6% of the irrigated area, mostly in central and eastern parts, where rainfall is lower and the dry period becomes well marked. Mostly there are small inexpensive water channels and temporary dams to hold the flood waters.

Malaya has its irrigated land (5.2%) in northern section for rice fields. Drainage of water is also important in deltaic parts and the coastal swamps along with the flood control schemes. Floods in many of the deltas are closely connected with the renewal and fertility of land and with the rice sowings, which depend on the extent, magnitude and duration of floods. Controlled flooding is needed to reduce the crop failures as well as for the renewal of soils.

AGRICULTURAL LAND AND POPULATION DENSITIES

The density on agricultural land is quite high in all parts of S.E. Asia. Leaving Singapore, which shows exceptionally high densities on account of urbanization, Indonesia shows the highest density of 1,931 persons per cultivated square mile (0.33 acres of cultivated land per head). Philippines, Thailand and Vietnam have densities of more than 1,000 persons per cultivated square mile. Cambodia, Brunie, Northern Borneo and Laos have less than 500 persons per cultivated square mile, with more than one acre of cultivated land per head.

The whole region has 1,272 persons per square mile, with about 0.5 acres of cultivated land per head. These high densities per cultivated square mile have become conspicuous due to the very great densities of population in Java, which has only 2.9% of total area of S.E. Asia and 40.2% of its population.

With such high densities of population in S.E. Asia it is still a surplus area in some food crops. These high densities are maintained due to intensity of land use, especially in Java, and due to plantation crops, which are a great source of income. Greater densities are also connected with the large-scale rice cultivation, which has a greater supporting value.

The population distribution in different parts of S.E. Asia shows greater maldistribution than over population. Various parts of Indonesia offer a case study where Java has 949 and Sumatra only 53 persons per square mile. The remedy lies in the development of land and dispersal of population from the densely settled parts, a sort of controlled migration as is taking place now in some parts of Indonesia. Similar is the case with many other parts of the region.

It is interesting to note that in the last quarter of the 19th century and early 20th century, many parts of S.E. Asia, like Malaya, Java, Burma and Philippines, did not have enough labour force for the land to be developed. With the growth of tree culture, rubber, coffee, and sugar cane plantations, the population was attracted from the densely peopled parts of China, Japan and Indo-Pakistan. The population figures in S.E. Asia show clearly the great contribution of Chinese, Japanese and Indo-Pakistanis in inhabiting and developing certain parts of S.E. Asia. Now the question of redistribution within S.E. Asia has arisen as a measure towards a balanced economy and for tapping the resources of those parts which are far less developed than the existing potentialities, like Sumatra, Borneo, parts of Thailand and Indo-China.

RECENT AGRICULTURAL TRENDS

The index for agricultural production in S.E. Asia shows that, as compared to the pre-war level, S.E. Asia made good progress. Yields of various crops, as discussed above, have improved progressively as compared to the pre-war averages. The agricultural index shows that, except in Burma, the agricultural production is more than that for 1934—38. The pre-war averages being taken as 100, Burma still has 87, while all others have surpassed the 100 figure. Philippines have improved with 148, Thailand with 133 and Indonesia with 114. The Malayan Federation shows 108,8 % higher than pre-war level. This small excess is due to much greater affects of war on plantation agriculture of Malaya the product of which depended entirely on foreign market for sale. The agricultural products in S.E. Asia show some change in the composition. It produces a great range of commercial crops, a fact which makes the whole region able to bear the price fluctuations better. The most important change in the trends of agriculture is marked by greater need for food crops with the increasing population. It has led to the change in the acreage more in favour of food crops. The commercial crops in S.E. Asia have had a serious set back due to disturbed political conditions during and after the war. Those centres suffered more which catered for the international market. Rice cultivation in Burma and Siam and Indo-China, rubber plantation in Malaya, pine apple in Singapore, sugar industry of Java, all show effects of the second world war, the difference is only of degree. Small holders with greater diversity of crops stood the adverse effects much better than areas dependent on other parts for their food supply.

As a result of greater food requirements and dangers of one crop monopoly, the large estates previously devoting to the production of one crop now show a greater diversity.

In keeping with the general agricultural trends, the trade figures also show a change. The balance of trade for the region as a whole is in favour of exports. In pre-war days it was one of the important regions of the world as a source of large quantities of food supply and industrial raw material. In 1934—38 the value of exports exceeded about 300 m. dollars. War gave a setback to the exports, especially to rubber. In 1948, figures again showed some increase in exports. In the year 1952-53 the balance was upset because of greater consumption of food at home, resulting from the growing population, and because of great imports of machinery and other goods, which were needed for post war reconstruction. In 1954 and 1955 a small surplus appeared.

It can be seen that S.E. Asia grows a wide range of agricultural products and has a surplus in food and cash crops. With 19 % of world's rice production, 87.1 % of world's rubber, a little less than half of world's copra, 8 % of world's canesugar and other minor crops, it is one of the world's richest agricultural regions. The encroachment of food crops on the plantation crops under the impact of increasing population has already decreased the exportable surplus to a very great extent. The future, however, is not gloomy. With room for expansion of cultivated areas in Sumatra, Borneo, New Guinea, Thailand, Indo-China, and to a lesser degree in Burma, and with possibilities for the increased per acre production by imporved methods of cultivation, it can continue to have an exportable surplus in the above-mentioned commodities.

TABLE I

Classification of Land in S.E. Asia, F.A.O. Report, 1953.
Area in, 000 hectares

Countries.	Year	Total Area	Arable Land (including fallow and orchards).	Meadows and pastures	Forests and wood-land	Potentially cultivable	Built area and waste-land
Burma	1950	67,802	5,844	..	39,094	7,816	12,348
Cambodia	1951	17,600	2,500	1,000	8,000	4,675	1,425
Indonesia	1947	190,435	11,000	..	121,000	..	58,435
Laos	1951	23,680	1,020	940	14,200	4,200	3,320
Philippines	1952	29,968	4,262	1,524	16,318	5,944	1,900
Tha iland	1949	51,352	4,750	..	32,600	..	14,002
Vietnam	1952	33,000	4,042	..	13,500	..	15,458
New Guinea	1951	41,278	..	..	..	..	41,278
Timor	1947	1,899	..	..	..	..	1,899
Brunei	1952	577	35	..	388	..	146
Malaya	1952	13,129	2,178	..	9,714	892	345
N. Borneo	1952	7,611	207	159	6,968	61	216
Sarawak	1950	12,191	3,200	..	8,822	..	169
Singapore	1952	75	16	..	20	12	27

TABLES II and III

Area and Prcduction of Riee and Sugar in S. E. Asia.

Names of countries	Rice: Acreage, 000 hectares. 1934—38	1952	Rice: Yield, 000 tons 1934—38	1952	1955	Sugar: Acreage, 000 hectares. 1934—38	1952	Sugar: Yield of sugar 000 tons. 1934—38	1952	1955
Indo-China	5,590	..	6,498	..	..	37	10	50	6	4
Cambodia	..	1,166	..	1,494	1,100	..	..	..	..	..
Lars	..	80-	..	502	510	..	..	..	..	..
Vietnam	..	1,924	..	2,564	2,733	..	..	..	..	..
British Borneo	..	..	..	..	..	..	..	..	..	..
Brunei	2	4	..	..	..	..	..	..	..	..
Northern Borneo	33	31	..	..	50	..	..	..	..	..
Sarawak	241	212*	..	..	..	..	..	..	..	..
Burma	4,931	4,000	6,971	5,500	5,868	21	..	23	18	..
Indonesia	3,843	..	6,081	..	..	..	..	913	458	851
Java and Madura	..	4,082	..	6,020	6,900	..	..	..	..	..
Others	..	2,450	..	3,159	4,217	..	..	..	..	..
Malaya	297	334	513	550	671	..	1	30	82	..
Philippines	1,990	2,456	2,179	2,832	3,237	235	391	960	1,020	1,105
Thailand	3,370	5,130	4,357	7,325	7,712	..	74	19	27	..
Total	20,297	22,589	26,599	29,945	32,998			1,995	1,611	1956

Statistics for this Table are obtained frcm F.A.O. Report 1953 and U. N. statistical year book 1956-57.

*Figures relate to 1952.

TABLE IV

Production of Rubber in S.E. Asia

Name of the countr ies	Production in 000 tons 1934--38	1952	1955
Indones ia	38·9	18·5	94·1
Cambodia	..	..	..
Laos	..	..	..
Vietnam	..	..	..
Br itish Borneo	..	..	..
Brunei	1·5	1·8	1·5
N. Borneo	10·3	19·4	20·4
Sarawak	20·7	32·4	39·9
Burma	8·4	14·1	10·9
Indonesia	353·6	761·2	745·6
Estates	185·8	297·9	..
Small Holdings	167·8	463·3	..
Malaya	422·7	594·2	649·4
Estates	263·5	345·0	..
Small Holdings	159·2	249·2	..
Philippines	10·5	1·4	132·3
Thailand.	32·1	99·4	..
	880·7	1588·0	169·41

Figures for this Table are obtaincd from F.A.O.. Report 1953 and U.N. statistical year book 1956-57.

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GEOGRAPHICAL RECORD

NEW SITE FOR THE FEDERAL CAPITAL OF PAKISTAN

The Government of Pakistan accepted in principle on June 12, 1959, the recommendation of the Capital Commission in favour of a site north-east of Rawalpindi as the most suitable location for the capital of the country. The recommendation was made by the Commission after a thorough appraisal of the relative merits of a number of probable sites.

The recommended site of the federal capital is roughly a trapezoid, formed by joining: "Spot Height 5,264′ with junction of Lethrar Road/Soan River, along Lethrar Road (inclusive as boundary) and Malal Kas to junctions Malal Kas Gumreh Nala, with Gumreh and the Kurang (inclusive) as the boundary, north-west to village Kalanjar ; from Kalanjar via Saidpur back to Spot Height 5,264′. The Murree road runs roughly through the centre of the site."

The boundaries of the site of the capital on the map given here were interpolated from the above description.

The repetitive recognition by man since proto-historical times of the strategic and administrative importance of this part of the Indo-Pakistan sub-continent (the Taxila-Rawalpindi area) seems to refer to some geographical factors bearing upon history.

The Taxila-Rawalpindi area lay for centuries on the of pathway of commercial caravans, emigrant hordes and invading armies from Central Asia to the Indo-Gangetic plains. Owing to the difficult nature of the terrain of the western frontier of West Pakistan, most of the movements into Indo-Pakistan were channelised through the passes.

The most frequently negotiated of the historical routes was the one from Kabul via Jalalabad, and through the Khyber, to Taxila-Rawalpindi, Sialkot (or alternatively Lahore) on to Delhi. The historical evidence confirms that the outline of the modern Grand Trunk Road was sketched out in Chandragupta Maurya's Royal Road from Peshawar to Patna. The route was important partly because in its western reach it generally clings to the sub-Siwalik zone, where the rivers are easy to cross. The Taxila-Rawalpindi area has been one of vantage position and importance on the route.

Historico-archaelogical evidence points to the top-strategic and administrative importance of Taxila during the Bactrians, Scythians or Sakas and Kushans over the period 522 B.C.—A.D. 470. In its long history of 1,000 years the town is recorded to have occupied four different sites, with a number of structural 'phases' or 'strata of occupation', signifying successive periods of rebuilding. The number of strata of occupation recorded at the third site, Sirkap, is seven.

Another centre of antiquity in the area is Manikiala, about 14 miles south of Rawalpindi. Its antiquity is established by the recorded Buddhist ruins and the Buddhist legends connected with the centre.

Rawalpindi itself is also regarded as an ancient centre. A. Cunningham, a renowned archaeologist of British India, identified it with Gajipur or Gajnipur, the seat of the Bhatti tribe in the centuries preceding the Christian era. It came into the possession of Gakhars, by gift from Mahmud of Ghaznavi, in 995 A.D. The present name Rawalpindi, was given by Jhanda Khan, a Gakhar chief. The name was derived from that of Rawal, which was at one time a flourishing place a few miles to the north of the city on the present road to Murree. Rawalpindi grew into importance under Sardar Milka Singh, after 1765. After the British occuptaion in 1849, it became the Headquarters of the Division of the same name and the one time largest cantonment of British India.

With the acceptance by the Government of the aforesaid site for the capital of Pakistan, the centre of power is once again moving to the Taxila-Rawalpindi area, one of repetitive importance in the historical annals of our land.

Terrain

The environs of the site of the Federal Capital present diversified, broken and hilly topography of the submontane area. The submontane area in these parts of Rawalpindi District is divided into two tracts, (i) Kachha and (ii) Kandhi. The Kachha is the tract along and among the foot hills of Murree. This low submontane is characterised by copious rainfall and abundant springs. The Kandhi extends from about Rawalpindi eastward to about Kahuta. On the east it includes the low soft sandstone hills which run out from the main Murree Range. On the west it includes the rich plains near Rawalpindi, which are the most fertile spots in the whole District. But the general characteristic of the tract is the low hill outcrops of rocks from the Murree hills on the north, and this is reflected in the name, Kandhi, or bank, referring to the foot hills. Throughout this tract are level and sometimes very fertile valleys interspersed with spears of sandstone rock and cut up with pebbly ridges.

Between Rawalpindi and the hills is a comparatively level plain stretching from the Murree Road to the Grand Trunk Road, East of this plain, ridges of sandstone run down south from the Murree and Kahuta hills and split the country into valleys and plateaus of sandy soil. South of Rawalpindi ravines and gorges scar the country, and present a wild and desolate aspect.

The site of the capital is one of diversfied aspect, though the diversity is of a scale much smaller than that of the general environs described above. Diversity of terrain of the nature, if imaginatively utilised by the town planner, is most likely to enhance the beauty of the urban landscape.

The area of the site lies at the north-eastern extremity of the Potwar plateau and the southern extremity of the Murree hills and other sub-Siwalik ranges. The northern and western corners of the trapezoid are hilly. The land rises roughly from south to north from about 1,700 feet to 5,264 feet, the gradient of the land getting steeper upwards from the 2,000-foot contour. The area is cut up by numerous small dry torrents, containing water only in the rainy season. The torrents generally have narrow valleys with somewhat steep banks; the relative height of the banks above the bed is generally 20-40 feet and over. The area is presently traversed by two metalled roads connecting Saidpur with Rawalpindi and Nurpur Shahan with the Rawalpindi-Murree Road, south of the settlement of Rawal. Saidpur and Nurpur Shahan are also connected with each other by a metalled road.

The north-eastern part of the site, east of the Rawalpndi-Murree Road, traversed from west to east is an alternation of river valleys and hill ranges, forming the outliers of the sub-Siwalik ranges. The height of these ranges is from 1,700 to over 2,000 feet. The general slope of the land in this section of the trapezoid is from northeast to south-west.

The remaining southern area of the site, about one-third of the total, is an undulating plain, with patches of bad-land (broken topography) and sizeable stretches of comparatively level ground. The largest stretch of the comparatively level ground is to the northeast of Rawalpindi, containing, among others, the settlements of Khanna, Tarlai Kalan, Sahana and Dhok Hayat. The general slope of the land is roughly from north to south or southwest. A small portion of the plain, southwest of the settlement of Jaba Kel, is swampy, affording a snipe ground. The area is traversed by a few unmetalled roads, the only important metalled road is the Rawalpindi-Murree Road. The general alignment of the roads is from northeast to southwest. It seems to signify that the improvement of the intra-town communications of the Federal Capital will involve particular attention of the planner towards east-west communication.

The main perennial streams of the Federal Capital Area, Kurang River, Gumreh Kas and Malal Kas, belong to the Soan system, which these join as a combined stream, under the name of Kurang, a few miles southeast of Rawalpindi. Kurang River receives Gumreh Kas at a point near Dhok Gangal and is joined by Malal Kas a few miles downward.

The surface water resources of the area, in the presence of the above-mentioned perennial streams, seem adequate. The proposed Rawal Dam on the Kurang River designed to hold about 50,000 acre feet of water is likely to meet the water requirements of Rawalpindi and the Federal Capital Area. The underground water resources can be ascertained by a proper survey for the purpose. The number of existing wells in the plain areas of the site is not very large. It seems to suggest that the water-table in these areas is low. At the same time, a study of the moisture index shows that it rises markedly from minus 14.7 at Rawalpindi to plus 115.7 at Murree. Also, a number of springs are located towards north in the foot-hills It can, therefore, be expected that the underground water resources of the Federal Capital Area, replenished by seepage from the hills, shall prove satisfactory.

Climate

The climate of the area is its great asset. The winters are bracing, while the summers are not very hot. At Rawalpindi the temperature is low from Oct. to March. It begins rising from April to June, which is the hottest month, and remains high over July-September. The mean monthly maximum temperature in June is 1035. degrees and the mean monthly minimum temperature of the month is 75.9 degrees.

A comparative study of the termperatures of Rawalpindi and Lahore reveals that the mean monthly maximum temperature of Rawalpindi is lower than that of Lahore over the summer months by two to six degrees, and the mean monthly minimum temperature by 3 to 3.8 degrees. During the winter months, the mean monthly maximum and minimum temperatures of Rawalpindi are respectively lower than those of Lahore by about 5 degrees and over 2 degrees.

The average annual rainfall at Rawalpindi is 36.37″, while that of Lahore is 19.21″. Cloudiness and the number of rainy days are higher in the former than in the latter city. Winter rainfall at Rawalpindi, though less than that of the summer season, is quite pronounced. August is the rainiest month of the year, while January is the rainiest month of the winter season. The rainfall increases appreciably from Rawalpindi to Murree, where the average annual precipitation is 59.36. Each month of the year is rainier at Murree than at Rawalpindi.

The new site of the Federal Capital with the above-mentioned attributes is capable of developing into a fascinating urban centre. The services might well be obtained of some of the best town planners and architects of international repute, not excluding the top ranking but controversial architects. Sirkap (Taxila), the nearby ancient capital, presents one of the most impressive examples of town planning of its days. It can be reasonably hoped that the proposed capital of Pakistan will be an equally impressive specimen of contemporary urbanism.

K.U.K.

New Site For The Federal Capital