Vol. XXIII OCTOBER—DECEMBER, 1948

197

The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

PUBLISHED QUARTERLY

1-49

Editor

Dr. GEORGE KURIYAN, B.A., B.Sc., Ph.D., (Lond.)

THE INDIAN GEOGRAPHICAL JOURNAL
Wellclose Cathedral P.O., Madras, 6.

CONTENTS.

The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

Vol. XXIII OCTOBER—DECEMBER, 1948 No 4.

The Editor takes no responsibility for the views expressed in the Journal Authors alone, are responsible for their respective statements.

Physiographic Divisions of India - A Reconsideration.

BY

Professor MANECK B. PITHAWALLA, D.Sc., B.A., F.G.S.,

Postgraduate Department of Geography and Geology,
University of Sind, Karachi.

In the April-June issue of the Indian Geographical Journal for the current year, Dr. O. H. K. Spate has revived the old question of a suitable division of the Indian subcontinent into regions, which essay no doubt gives a fresh stimulus to the solution of this difficult problem. It is, indeed, one of our most urgent geographical topics and deserves the sympathy and co-operation of all those who are interested in the welfare of the whole country. For, although partitioned into two independent States, India is geologically and geographically *one*. I have been patiently studying this subject for over a decade now and have discussed and revised my scheme of a physiographic division several times. On my part, I must assure my readers that there is *no* dogmatism as my critics would like to suggest. All I have attempted to do is to convince our geographers that if we can make *suitable physiographic divisions* of the landmass within our limits, most of our national problems would be solved to a great extent. Such divisions would satisfy the largest number of criteria in my opinion, and would afford a solid background for all other kinds of surveys, and luckily *a most frequently occurring pattern* in the physiography of our country is the triangle.

Earlier Attempts:—This question of dividing India into regions was last discussed by me in this journal,[1] while giving a reply to Dr. Kazi Ahmed of Aligarh. A little later during the same year, I presented a revised scheme and a working approximation of the solution in an elaborate paper published in *Science and Culture*, with a revised map, a concise table of classification and brief-notes on the physiographic characteristics of every division and sub-division, comprising:—

3 Major Divisions 16 Provinces	Generally accepted by geologists and geographers.
54 Sections 57 Sub-Sections	Tentatively drawn and subject to the confirmation of local geographers.

In the first place, it has to be confessed that this problem is by no means as simple as the other geographers have taken it to be. We have here to deal with a vast region of sub-continental dimensions. At the same time, two stumbling blocks have hindered our progress, *viz.*, (1) *very little research work* of a geographical character is done in our country and (2) *very little co-operative effort* is made for the solution. So far there has been no agreement forthcoming either upon the *very method* of division, physiographic etc., or even the *main* divisions, which I have called Provinces.

New Proposals:—Now Spate has proposed a *Regional* Division, which to my mind means nothing. What we no doubt want are the *regions* of India, but of what kind and by what method are they to be arrived at? As Spate himself has put it, a "mere verbalistic approach" will not do for us. He admits *several times* in his article that "physiography is *the* thing" in such a matter, and "*the physical basis* is of the very first importance", but he is not sure what his actual method will be

1. Indian Geographical Journal, XVII, 1 (1942) pp. 72-74.

and he has unfortunately not made his own proposals for counter-criticisms for the time being. *Regions* there must be, but there must be *one fundamental principle* for making them, *viz.* physiographic. Spate is also not consistent in his criticism. In one place he says, Ahmed's proposals are "quite sound" and realistic, but in another place he bitterly complains of his "lack of any hierarchical order" or any method in the division in general and particularly in his 4th major division of the peninsular littorals"! Other critics want to adopt a heterogeneous method of division, neither physiography, nor climate, nor vegetation-cover alone, to be the criterion. Some have acutally suggested linguistic or cultural regions straight away. But it has to be admitted that most, if not all, such regions will coincide with the physiographic divisions, which we can make of the country.[2] It is true we cannot transfer the concept of one country automatically to another. But I feel that the American geographers have done well in this direction and not only are the physiographic divisions of the United States of America[3] ready for use but also a good deal of national planning has been done by them with this *physical basis* provided by them. It is only the unwillingness on the part of Indian geographers to accept this principle of *physiography* that has delayed the solution so long. For one thing such divisions as we are proposing would be most useful today, since there is a cry for a realignment of territories in the different presidencies and states in India. Mere linguistic divisions will not do for their prosperity.

Value of Physiography:—Physiography is really a scientific study of the physical geography of a land. Although it deals with the morphology of the land forms and how they come about, that is, geomorphology, it takes stock also of the atmosphere and the hydrosphere, which makes the science quite comprehensive. Physiography takes account of geology in so far as the various processes and laws of the earth are concerned

2. Science and Culture, IX, II (1944) pp. 466 — 475.

3. Fenneman M.N. — Physiography of Western and Eastern United States, New York, 1938 and 1942.

and of geography in so far as the distribution and space relations are concerned. Most of the data are of geological investigations, and in this matter our country is particularly lucky. Quite a rich store of physiographical information I have collected for my purpose from the numerous Records and Memoirs of the G. S. of India published since 1856.

Economic Physiography:—The landforms are actually the final products, the ends of geological processes and the effects of geological agencies working upon the earth, but at the same time, these land forms are *the beginning of everything in geography*, which helps us to clothe these land forms with life, as their influence on climate, natural vegetation, animal and human life, settlement and civilisation is very great. Even the mineral resources, including the water resources, upon which our country is particularly dependent, being largely agricultural, are products of the geological past. They are the chief economic resources of man for the future prosperity of the country. *Economic physiography*, therefore, plays a vital part for us geographers in national planning. So the physiographic units are most desirable for the welfare of the entire sub-continent of India and for giving the necessary background for workers in development schemes of all kinds. What we should virtually ignore for the time being, is *the details*, which, being vastly important to local workers, can be left to them for detailed surveys and minor adjustments of the boundaries. Such intensive local studies will reveal other physiographic facts, which will help us to make sub-sections in later years. But that should not deter us from carving out the *main divisions* in a scientific manner, even at this stage.

Main and Minor Divisions:—At the same time, while making minor divisions and sub-sections, we can easily utilise secondary criteria, such as climate, soil fertility, mineral resources, water resources etc. which are in their turn dependent upon the geology and physiography. If all the necessary divisions are to be made and if there are no proper physical features marked, such supplementary aids have to be sought by us. But this

should not mean that we set aside the fundamental principle of physiography and deviate from the main principle. Geology, of course, is the foundation, but the very mode of erosion and weathering, the types of rock formations and their structure, relief, mineral contents etc., are all needed to *finally secure a homogeneous natural background* for our regions and sub-regions. Actually geomorphology does take notice of climatic conditions and soils are the results again of erosion, transportation and redeposition. Then the natural resources born of geology and physiography, are also always a powerful physical environment for human activities. But when Spate introduces a new factor, *viz.* positional, instead of simplifying the matter he complicates it. There cannot be any hard and fast rules for dealing mechanically with the regions and giving their description, and there is nothing pedantic in our treatment of neighbouring areas separately, *if they really fall into different divisions*, inspite of their juxtaposition on the map. *e.g.* While describing the Indo-Gangetic Plain, some sort of system will have to be adopted, so that after dealing with the lower Indus valley, there will be the turn of the upper Indus valley, then of the upper Ganges valley and so on. Parts that fall into one sub-division cannot always be treated along with those which fall into another, *inspite of their positional value*. Dehra Dun and Mussorie really belong to *one* physiographic unit, that of the Siwaliks. At the same time, I have accepted the principle of treating the Peninsular littorals, not as the 4th Major Division of Kazi Ahmed, but as a Section of the 3rd Major Division of the Peninsular Area, due to their *oceanic position*, but *actually belonging to the Provinces*, into which this 3rd major division is subdivided. Whether I call them by " shore facies " or by some other geographical term, is beside the point.

Decisions to be taken: (1) **Method of Classification**:—So, the first thing for us to decide is whether we are going to divide India principally into *physiographic* regions[4] or some other kind of regions, climatic, vegetational, linguistic, etc. according to the

4. Science and Culture, VII, II (1942) pp. 534-543.

whims of the geographers. Will not the science of Physiography, taken in its broad sense, enable us to divide the Indian landmass into *suitable* "natural" regions? I object to the term "natural" being used in our case, as it means nothing, no definite principle on which we shall base our division. After all, what is the purpose of dividing India in this manner, unless it be for the purpose of national *planning on a scientific physical basis?* Are we not going to determine the *geographical values* of such regions for a national purpose? Why not, then, agree upon the *fundamental principle of physiography as the basis*, including the climate and the natural resources? Such a scheme would be *comprehensive* and *fundamental* to begin with. Let us follow the physiographic principle for our *main* divisions, but where physiography fails, or is vague, and a sub-division cannot be made for want of a definite physical feature, the next best plan, I have suggested, is to refer to other suitable criteria. *e.g.* the sub-division of the Ganges valley into upper, middle and lower. There is a distinct watershed between the Indus basin and the Ganges basin in the Ghaggar plain and this is helpful in separating the two basins but there is no physiographical feature between the upper and the middle Ganges valleys, to be sure. Climate and subsoil water condition would lead us to draw the dividing line *provisionally*. Human activities and natural environment in our regions have to be integrated. The economy of our country is closely related to its physiography and unless it is divided into suitable regions and a regionalism is developed, there is bound to be a confusion of facts, and planning cannot be done with advantage.

(2) **Systems of Nomenclature and Numbering**:—The next thing to be agreed upon is the *nomenclature* of the divisions and the subdivisions and the system of numbering them. The *main physical feature* should guide us for *naming* a division with all other features subjected to it, *e.g.* a mountain or river system, an upland or a desert land. As regards the system of numbering the divisions, the following plan has been suggested by me. The three Major Divisions are numbered (1) the Extra-Peninsular Mountains, (2) Indo-Gangetic Plain and (3) the Peninsular Area. coinciding more or less with the three major soil groups of India. Each one of these major divisons is then subdivided into parts called Provinces, numbered I, II, III etc. These Provinces again are subdivided into Sections, marked A, B, C, etc. and into Sub-sections called (a), (b), (c) etc., according to the *relative importance and dignity* of the sections and the sub-sections.

(3) **Physiographic Boundaries**:—As regards the boundaries, all that we can do is to suggest some *zones* but no actual lines on the ground, until the areas are intensively studied by *local* geographers. *e.g.* the boundary line between the sandy desert and the Indus alluvium and that between the steppe desert and the Rajputana uplands. For the present only indications of the boundaries can be given.

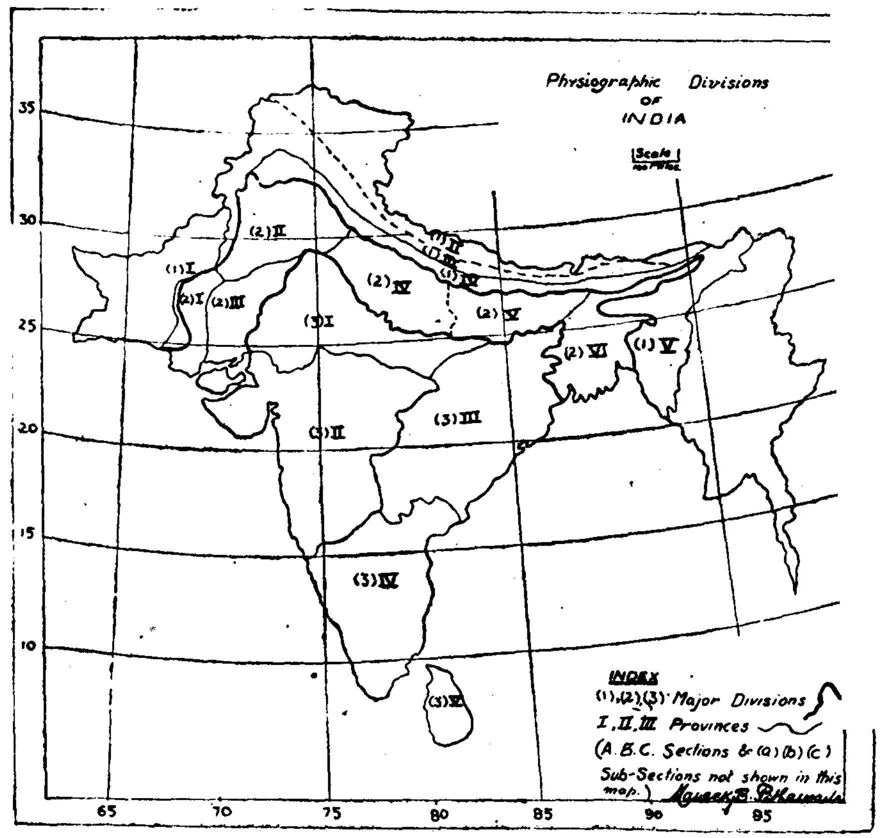
Kazi Ahmed's Scheme:—So far, no Indian geographers have made any sound alternative proposals. Kazi Ahmed's scheme,[5] supposed to be "quite new and sound", has, in my opinion, no system of classification, nomenclature and numbering. To me it is a conglomeration of divisions and subdivisions, virtually mixed up. There is no differentiation between a major and a minor division, no provision for rank and file. Of the 30 divisions, serially numbered, at least 22 are repetitions of our old divisions under slightly different names. No supplementary criteria, related to physiography, such as minerals, soils, water resources etc. are taken into consideration. The Salt Range (6) is left on a par with the mighty Himalayan Mountains (1). Tarai (9) and Chos (10) are fantastic divisions of the Indo-Gangetic Plain. The Ghaggar Plain (13) falls outside the Upper Indus (11) and the Ganges Plain (14). The Brahmaputra valley (16) is distinct from the Gangetic Delta country (15). The boundary between the Thar Sand-dune region (17) and the Aravalli Hills is arbitrary. The strangest division is that of Central Indian Ranges and Intervening Valleys (20), two distinct physiographic features, carried together by the same train.

5. Indian Geographical Journal, XVI, 3 (1941), pp. 257.

The Godavari valley (24) is separated from its very basin, included in the E. Central Plateau (23), while the Mahanadi valley and delta are ignored. The name Southern Plateau (25) has no meaning without emphasising any physical or natural feature. Although the Western Ghats are distinct features of the Peninsular Area (26), there is not much left of the Eastern Ghats (27), which are only relics left on account of subaerial denudation devoid of any of their former grandeur. And yet a very vast area is occupied by this division on Ahmed's map. If the West Coast (21) region is, as Spate points, different in structure, relief, etc. from the East Coast (30) region, there ought to be not four major divisions but five.

Pitfalls of geographical science :—Thus any attempt at presenting " an entirely new scheme " and that too " physiographic, " in such matters, will have its shortcomings, its pitfalls and discrepancies, which will only delay the solution of the problem and take us no where. This is a distinct loss both to India and Pakistan.

Wanted Regional Studies :—*Regional studies* are most urgently needed in our country, but before they are attempted a map showing *the main physiographic divisions* should be ready to avoid any overlapping of activities. A serious beginning must now be made and to simplify the solution, I give below a fresh preliminary table with a simplified map, showing only the three Main Divisions and the fifteen Provinces, into which they are physiographically divided, for general approval in the first instance. I shall work out the details in my next article.



MAIN DIVISIONS.	PROVINCES	INDICATIONS FOR SECTIONS & SUB-SECTIONS.
(1) **Extra-Peninsular Mountains.** (A complex series of highly folded and contorted mountains, including the two western and eastern flanks. Some powerful antecedent rivers, such as the Indus, flow here).	I. Western Highlands.	Includes the Himalayan off shoots, Kirthar - Suleiman ranges—and the plateau of Baluchistan.
	II. Greater Himayalyas.	Snow - covered ranges with high peaks. Himalayan watersheds.
	III. Middle Himalayas.	Bifurcations of the Main Himalayan Range. River gorges and Duns formed.
	IV. Sub-Himalayan Region.	Includes the Siwaliks, Salt Range, Potwar Plateau, as Sections. Oil fields.
	V. Eastern Highlands.	Includes the Assam ranges, Shillong Plateau, and ranges related to the Yomas, passing into Burma. Oil fields.
(2) **Indo-Gangetic Plain.** (Once a sagged area, now filled with alluvium. Many river captures here in the past. Some hidden ranges are also detected).	I. Lower Indus Valley.	With Sections of the Indus valley no more receiving any tributaries but aggraded and having delta growth.
	II. Upper Indus Valley.	Land of the Five Rivers, The Doabs (Bhangar lands) and submontane areas.
	III. Desert Province.	Including the old Sarasvati-Ghaggar - Hakra valley, now turned dry land and sand drift, Thar Section of sand hills and Pat Section of flatter land with Dhands or salt lakes.
	IV. Upper Ganges Valley.	Jamna-Ganges, Gogra - Ganges and other Doabs, a Piedmont zone in the north and Trans-Jamna tract in the south.
	V. Middle Ganges Valley.	Boundary cannot be defined here. But different in climate and a transition between the Upper and the Lower Ganges valleys.
	VI. Lower Ganges Valley.	Includes the Brahmaputra valley and many a Doab in the delta Section. Again Old Delta and New Delta Sections can be made, of dead, dying and living rivers.

MAIN DIVISIONS.	PROVINCES.	INDICATIONS FOR SECTIONS & SUB-SECTIONS.
(3) **Peninsular Area.** (The ancient peninsular massif, a stable block left out of the old Gondwana land, sunk in the neighbourhood. A plateau,—relict type of mountains and many consequent rivers. Several triangular patterns found.	I. Rajputana Uplands.	Includes the Sections of the Aravallis, now greatly degraded, Marwar peneplain and Malwa plateau. A prominent N. E. drainage with bad land topography. The Kaimur Range the limit.
	II. Deccan Trap Region.	Many mountains of the relict type e. g. Western Ghats, also includes fault scarps, such as the Vindhyas and the Satpuras, and vast peneplained areas like Gujarat, Kathiawar, Cutch, Deccan Trap topography predominant. Konkan coast land a Section.
	III. N. E. Foreland.	Includes the Chota Nagpur plateau, the Mahanadi and Godavari river basins of Gondwana coal fields a portion of Eastern Ghats and the Golconda coast lands are belonging to this Province. Here are some prominent delta growths also.
	IV. South Indian Plateau.	Largely consists of crystalline complex, a Dravidian country with some prominent hills, such as the Nilgiris, Shevaroy and Javad Hills, Cardamom hills, Palni hills, Mysore plateau, etc. Malabar and Coromandal coasts belong to this Province and so is the island of Ceylon, — quite a pocket edition of S. I. plateau, which can be taken as a Separate Province.

The Ganges Canal Hydro-electric Scheme and aid to Agriculture in Western U. P.

BY

P. K. DUTT, (*Benaras.*)

The Ganges Canal which commands an area of about four and a half million acres in the north west of the United Provinces, was maintained only for irrigation before the installation of the hydro-electric scheme. The discharge of the canal varies in different seasons from a full capacity of 8,000 cusecs to 4,500 cusecs in the driest month. The slope of the country served by the Ganges Canal varies from 8 feet per mile in the sub-montane tract at Hardwar to 1 foot per mile near Aligarh, about 200 miles to the south. Thirteen vertical falls have been made to absorb the difference in level intercepted between the slope of the canal bed and that of the country. The distance between two successive falls increases with the gradual decrease of the slope of the country to the south. The total fall is 146 feet and the height of the falls decreases from near the head of the canal to the tail end.

Initiation of the Scheme :—

After the remodelling of the canal head works, it was decided to develop certain falls for power generation. In 1928 three independent schemes were started by the Irrigation Department to develop 3750 K.W. of hydro-electric power.

The first scheme combined the Bahadrabad and Salempur falls at mile 7 of the canal to generate 2,400 K.W. to supply electricity to the chief towns of the two agricultural districts of Bijnor and Moradabad, and the local railway stations.

The other two schemes put forward in 1928 were to develop the Bhola falls at mile 84 of the canal to energize Meerut, Ghaziabad and Hapur, together with intervening rural tracts, and Palara falls at mile 148 of the canal in Bulandshahar district to supply power to Khurja group of towns.

First grid :—

After the work had started, in 1929 it was decided to link these three independent schemes into a grid. This was done with the intention of supplying power to the intervening rural tracts for domestic, industrial and agricultural purposes. It was also foreseen that the connected power system could operate mutually at times of maximum load or of individual failure.

In 1931 the Palara falls were supplemented by a power station at Sumera (at mile 163) chiefly to pump 140 cusecs of water into the Ganges Canal from the Kali Nadi. Later on three more falls were developed and two steam power stations have been installed one at Chandausi and the other at Moradnagar.

Within the area served by the grid the demand for cheap power developed rapidly and many rural extensions were made to supply power to private tube wells and other agricultural activities. This demand for cheap power gradually extended to the adjacent areas of the original area of supply.

Grid Scheme Objectives :—

The main objectives of the grid scheme are the following :—

I. To supply power for pumping water to extend irrigation and aid agriculture within the grid area.

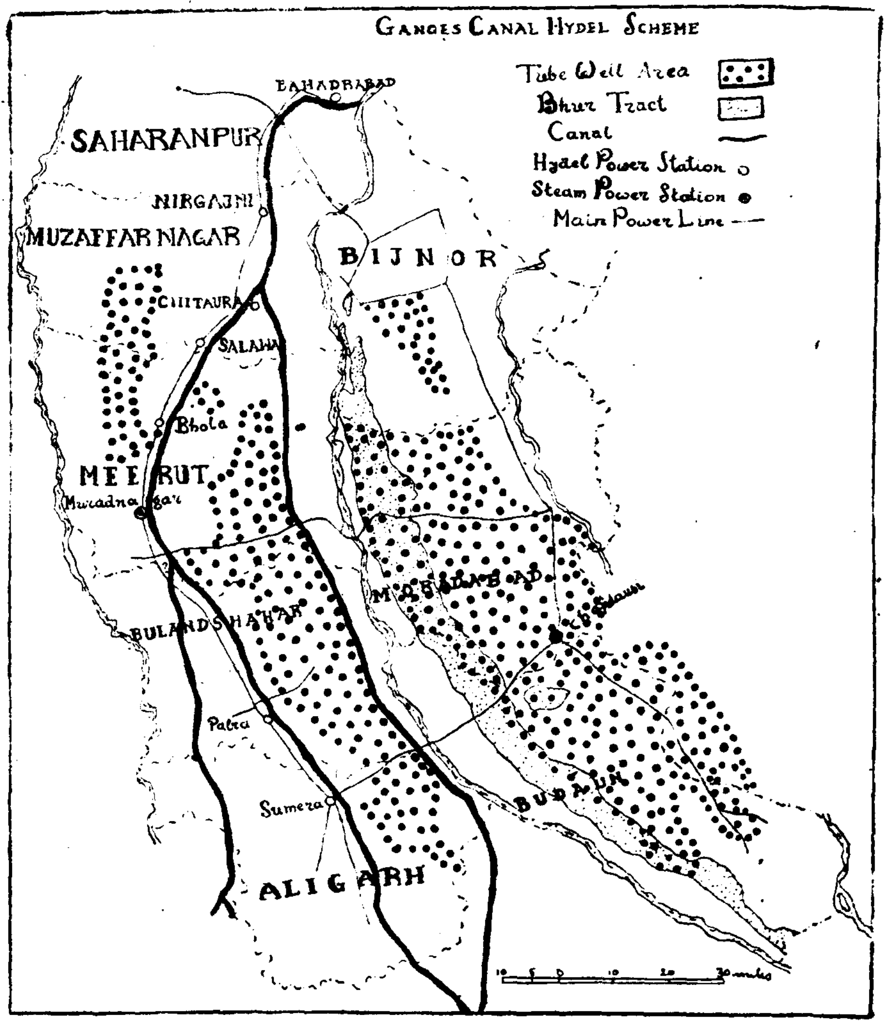
II. To supply electricity to all the towns within the grid with a population of 5,000 or over.

III. To supply power to the villages in order to develop agricultural and other cottage industries.

Here we shall discuss briefly how far the first objective has been achieved.

Extension of irrigation :—

The primary objective of the hydro-electric scheme is to provide irrigation water from tube-wells in the districts traversed by the hydro-electric grid which could not be commanded by the canals owing to the scarcity of river water. The



alternative possibility was to increase the canal flow by impounding the monsoon waters in reservoirs constructed in the Himalayas; but the unstable nature of the hill sides and the consequent difficulties connected with reservoir construction in such areas did not favour this proposition. On the other hand, the prosperity of this region depends mainly on the improvement of agricultural conditions and development of associated industries. This is because of local absence of raw materials for heavy industries and also the great distance of the region from the coal and iron deposits of India. The question of irrigation in this region is more acute than in any other part of the Province because of low and variable rainfall. Before the installation of the tube-wells, irrigation by well water was common in these areas, but due to adverse physical conditions at many places, it was not possible to construct shallow wells and these regions remained practically without any irrigation. The main difficulty was either that the subsoil was too loose and sandy to allow a shallow well to be dug, or that the water-bearing stratum was at such a depth that it did not pay to lift water by the help of bullocks. In those areas where irrigation was done by well water, it was more or less a seasonal affair, temporary earthen wells being dug whenever the rains failed. In order to supplement the scanty rainfall, many landlords installed tube-wells worked by oil engines, but the cost of water thus raised was much above that obtained from the canals in other areas.

The presence of good sub-soil water supply in many places encouraged the formulation of a scheme of tube-well irrigation. One economic feature in favour of tube well irrigation is that the system is flexible and wells can be constructed at points of intensive cultivation and omitted in the beginning in poor areas. Thus, the scheme could be gradually carried out without requiring much expenditure at the initial stage.

The starting of the grid scheme provided power at a cheap rate to raise water for irrigation. After the completion of the first stage of the grid scheme in 1931, preliminary experiments were carried out with a number of tube-wells which were already installed for the landlords by the Agricultural Department. These experiments showed that with electric power available at one anna per unit, irrigation could be economically effected, and also that if the number of such tube-wells was high, the rate of electric current could be reduced to 9 pies per unit.

In addition to investigations regarding the cost of irrigation water, the question of sub-soil water supply was also carefully studied.[1]

Originally it was aimed to construct only 1,500 tube wells, each commanding on the average 1,000 acres of culturable land in different districts, but the success of the first five years plan and demand for well irrigation have increased the number of tube-wells to 1619 at the end of 1942,[2] and the area irrigated by tube-wells has increased from 31,839 acres in 1934-35 to 750,767 acres in 1941-42.[3] It is certain that the number of tube-wells will still increase and provide irrigation facility to larger areas.

The hydro-electric scheme has also provided opportunity to utilize the water of the Ramganga river for irrigation. This river runs at such a low level that it is not possible to use its water directly for irrigation by canals. With the help of power the river water is now being raised by pumping for irrigation. The irrigation system consists of 62 miles of distributaries, including the main channel and 34 miles of minor channels, or a total of 96 miles. The total culturable area commanded by the system is 96,398 acres. Similarly the Kali Nadi pumping scheme is raising water to command 46,400 acres of culturable land. Then also the various conversion pumping schemes are raising water for irrigation.

1. Chief Engineer's Report on State Tube-well scheme United Provinces 1936.
2. Irrigation Administrative Report United Provinces p, 13, 1945.
3. Ibid, p. 32,

Increase in Acreage under Irrigation :—

The following table shows the average area in acres under irrigation in the districts affected by the tube well scheme. The first column shows the average for five years from 1924-25 to 1928-29, when there was no state tube-well scheme, and the second column the average from 1940-41 to 1943-44, when the tube well scheme was in full operation.

Irrigated area in acres

	Before Scheme	*After Scheme*
Muzaffarnagar	316,391	397,409
Meerut	485,272	648,934
Bulandshahar	387,018	494,724
Aligarh	448,959	506,146
Bijnor	40,505	95,404
Budaon	84,739	210,414
Moradabad	63,014	214,686

From the above table the large increase in the irrigated area in these districts, and especially in the last three districts, where there is very little canal irrigation is quite apparent.

Benefits from tube-well Scheme :—

The benefits from the provision of irrigation facilities have shown chiefly in :—

(*a*) increase of culturable area, and

(*b*) greater agricultural security.

(*a*) **Increase in culturable land :—**

The provision of irrigation facilities in the non-canalised districts has extended cultivation to areas formerly classified as culturable waste. This included large areas at comparatively higher elevation which were left under jungle grass cover, because of the difficulty of providing irrigation water. Then also the sandy upland, the "*bhur tract*", extending along the whole length of the western Moradabad district and also covering some portions of Bijnor and Budaon districts, was left without any cultivation. Only in a few small fields near village sides was cultivation carried out on these sandy areas. In Moradabad alone, the total *bhur* area exceeded 424 sq. miles. The hydro-electric scheme has provided irrigation facility to much of this *bhur* tract and more than 100,000 acres of *bhur* land are being cultivated every year. These areas with light sandy soil are quite suitable for the cultivation of cotton and sugarcane. With the further expansion of the tube-well scheme there is no doubt that much of the remaining *bhur* tracts in Bijnor and Budaon districts will be brought under cultivation. From the table given below it will be seen that before the hydel scheme was installed the area of culturable waste land remained almost the same from year to year; but with the gradual progress of the hydel scheme and extension of irrigation facilities to areas formerly without cultivation, the area of culturable waste has decreased every year:—

Culturable Waste in acres.

Districts.	Year 1924-25.	Year 1925-26.	Year 1927-28.	Year 1928-29.	Year 1940-41.	Year 1941-42.	Year 1942-43.	Year 1943-44.
Muzaffarnagar ...	142,854	144,868	142,456	145,284	127,363	127,971	123,674	120,733
Meerut ...	174,268	173,963	177,425	180,477	165,061	165,032	159,165	155,278
Bulandshahar ...	172,288	172,259	17[illegible],850	178,761	163,986	160,994	151,075	145,996
Aligarh ...	99,484	100,326	101,565	103,707	94,035	93,757	87,568	83,927
Bijnor ...	227,316	228,305	222,872	224,305	198,168	196,990	193,367	191,221
Budaon ...	180,604	188,527	197,764	205,327	135,250	133,934	129,437	126,960
Moradabad ...	202,475	209,236	219,344	230,939	190,648	187,095	183,981	181,910

(*a*) **Agricultural Security:—**

By the introduction of better facilities of irrigation a larger proportion of the crops are getting the benefit of assured water supply. Before the introduction of the tube well pumping scheme in the areas which were outside the command of the canals, water had to be procured from wells and tanks, but

because of the difficulty in constructing temporary wells in many places, irrigation was restricted to the more important crops. In the seven districts in which tube-well irrigation has been extended only 32·8 percent of the area under wheat used to be irrigated every year (average from 1924 to 1929) and with the introduction of the tube-well scheme this has increased to 58·9 percent (average of 1940-44).

Similarly in the case of other main cereals the irrigated area shows increase:—

	Before Scheme.	*After Scheme.*
Wheat	32·8 per cent	58·9 per cent
Barley	30·8 " "	45·5 " "
Maize	10·1 " "	26·1 " "
Grain	14·6 " "	23·9 " "

The chief effect of the provision of irrigation to new areas has been shown in the large increase in the acreage of sugar cane in all the districts served by the tube-well pumping scheme.

The following table shows the acreage of sugar cane before and after the tube-well scheme:—

	Before Scheme.	*After Scheme.*	*Increment.*
Muzaffarnagar	90,495	151,302	67·02 per cent.
Meerut	142,844	194,053	35·8 " "
Bulandshahar	51,376	63,597	23·08 " "
Aligarh	10,111	25,568	152·82 " "
Bijnor	91,443	110,353	31·61 " "
Budaon	28,160	38,556	36·90 " "
Moradabad	55,851	87,221	57·03 " "

Sugar cane is the main cash crop of these districts and wherever irrigation can be provided, sugar cane has become the chief crop. In many places it has replaced the cultivation of cotton, and thus the area under cotton has decreased much in these districts. Sugar cane is definitely a more dependable crop than cotton, mainly because in the case of cotton the crop is more susceptible to changes of weather.

The provision of irrigation has introduced variety in cultivation by providing water for growing root crops and other garden produce. Thus the areas under potatoes and vegetables have increased with the introduction of the tube-well pumping scheme.

The extension of *Canal* irrigation to these districts has considerably increased agricultural security. But, even then, in years of drought, the outlying areas, away from the reach of canals, suffered from lack of water and thus crop production used to be very low. The main sources of water supply in these areas were the wells and tanks. In years of drought the cultivators used to dig temporary wells and tried to irrigate as much as possible. On the other hand, due to dry weather the supply of water from tanks etc., used to be low. This will be clear from the following table which shows the irrigated area of a dry year 1918-19 and that of a year of normal rainfall 1916-17.

Area irrigated in acres.[4]

	Year	*Canals*	*Wells*	*Other sources*	*Total*
Muzaffarnagar.	918-19	284,938	81,528	4,165	370,631
	916-17	212,397	72,037	5,116	289,550
Meerut	1918-19	363,502	201,583	4,816	569,901
	1916-17	293,034	153,568	7,166	453,768
Bulandshahar.	1918-19	228,379	202,893	4,535	435,807
	1916-17	193,538	174,621	7,777	375,936
Aligarh ..	1918-19	186,863	237,311	4,502	428,676
	1916-17	165,502	260,689	10,691	436,882
Bijnor	1918-19	26,063	42,492	10,014	78,569
	1916-17	25,871	22,090	14,813	62,774
Budaon	1918-19	1,470	171,640	25,535	198,645
	1916-17	1,645	131,997	66,469	200,111
Moradabad	1918-19	2,822	152,018	19,822	174,662
	1916-17	3,656	89,214	46,472	139,342

4. Season and Crop Report of the United Provinces 1918-19 and 1916-17, p 20.

Thus in years of drought the well water is the chief source of irrigation in regions not commanded by the canals. The provision of tube-well irrigation in these areas has much increased agricultural security. This will be apparent from a comparison of the out-turn and produce of the principal crops in two drought years, one in 1918-19 before the scheme and another in 1941-42 after the tube-well scheme was well advanced.

The rainfall departure from normal in these two years during "kharif" (summer crop) and "rabi" (winter crop) seasons within the grid area is given below:—

Rainfall Departure from Normal.

From :—	1918-19	1941-42
April 1st to August 31st.	—41·9 per cent	—38·4 per cent
November 1st to March 31st.	+28·9 ,, ,,	+30·0 ,, ,,

It will be seen that rainfall during kharif season was very low in both the years and crops dried up in many areas.

The following table shows the out-turn and total produce of the principal crops in terms of the percentage of normal production in two dry years 1941-42 and 1918-19.[5]

		RICE		WHEAT	
		1941—42.	*1918—19.*	*1941—42.*	*1918—19.*
Muzaffarnagar	...	50 p. c.	47.5 p. c.	81 p. c.	80 p. c.
Meerut	...	59 ,,	47.5 ,,	81 ,,	85 ,,
Bulandshahar	...	63 ,,	47.5 ,,	75 ,,	80 ,,
Aligarh	...	59 ,,	47.5 ,,	69 ,,	95 ,,
Bijnor	...	50 ,,	30 ,,	81 ,,	85 ,,
Budaon	...	41 ,,	35 ,,	69 ,,	80 ,,
Moradabad	...	44 ,,	32.5. ,,	75 ,,	85 ,,
		BARLEY		**JUAR**	
		1941—42.	*1918—19.*	*1941—42.*	*1918—19.*
Muzaffarnagar	...	81 p. c.	70 p. c.	50 p. c.	68 p. c.
Meerut	...	75 ,,	100 ,,	30 ,,	75 ,,
Bulandshahar	...	75 ,,	75 ,,	25 ,,	68 ,,
Aligarh	...	63 ,,	95 ,,	50 ,,	56 ,,
Bijnor	...	81 ,,	80 ,,	35 ,,	88 ,,
Budaon	...	63 ,,	90 ,,	25 ,,	68 ,,
Moradabad	...	88 ,,	80 ,,	35 ,,	68 ,,

5. Season and Crop Report, U. P. 1918-19 and 1941-42, p. 26

	BAJRA 1941–42.	BAJRA 1918–19.	MANDUA 1941–42.	MANDUA 1918–19.
Muzaffarnagar ...	73 p. c.	45 p. c.	75 p. c.	45 p. c.
Meerut ...	69 ,,	30 ,,	75 ,,	35 ,,
Bulandshahar ...	73 ,,	25 ,,	75 ,,	
Aligarh ...	56 ,,	20 ,,	73 ,,	
Bijnor ...	88 ,,	45 ,,	88 ,,	35 ,,
Budaon ...	73 ,,	25 ,,	73 ,,	20 ,,
Moradabad ...	73 ,,	30 ,,	73 ,,	35 ,,

	MAIZE 1941–42.	MAIZE 1918–19.	OIL SEEDS 1941–42.	OIL SEEDS 1918–19.
Muzaffarnagar ...	66 p. c.	45 p. c.	79 p. c.	40 p. c.
Meerut ...	75 ,,	35 ,,	79 ,,	43 ,,
Bulandshahar ...	66 ,,	45 ,,	79 ,,	40 ,,
Aligarh ...	56 ,,	45 ,,	77 ,,	40 ,,
Bijnor ...	75 ,,	35 ,,	79 ,,	46 ,,
Budaon ...	66 ,,	25 ,,	85 ,,	46 ,,
Moradabad ...	66 ,,	45 ,,	85 ,,	33 ,,

	SUGAR CANE 1941–42.	SUGAR CANE 1918–19.	COTTON 1941–42.	COTTON 1918–19.
Muzaffarnagar ...	50 p. c.	56 p. c.	56 p. c.	35 p. c.
Meerut ...	75 ,,	45 ,,	50 ,,	50 ,,
Bulandshahar ...	63 ,,	45 ,,	50 ,,	35 ,,
Aligarh ...	63 ,,	50 ,,	50 ,,	50 ,,
Bijnor ...	75 ,,	50 ,,	56 ,,	60 ,,
Budaon ...	69 ,,	35 ,,	50 ,,	30 ,,
Moradabad ...	69 ,,	50 ,,	56 ,,	55 ,,

The slight decrease in out-turn of wheat and barley in 1941-42 is in no way due to lack of water during rabi season but mainly due to damage done by frost, hail and white ants.[6]

There is no doubt that the better out-turn of the chief kharif crops in the drought years of 1941-42 is due to the provision of tube-well water in regions away from canal water supply.

The following table shows the area irrigated by wells in a drought year 1918-19 before the scheme, and in 1941-42 a drought year when the tube-well scheme was well advanced, and also in 1916-17 a year of normal rainfall.[7]

6. Season and Crop Report, U. P. 1941-42, p. 2.
7. Ibid, 1916-17, 1918-19 and 1941-42, p. 21.

Area Irrigated by Wells (in acres).

	1916—17 Wells.	1918—19 Wells.	1941-42 Other Wells.	1941—42 Tube-Wells.	Total
Muzaffarnagar ...	72,037	81,528	93,798	32,354	126,152
Meerut ...	153,568	201,583	208,499	93,725	302,224
Bulandshahr ...	174,621	202,893	220,113	62,790	282,903
Aligarh ...	260,689	237,311	283,189	14,029	297,218
Bijnor ...	22,090	42,492	13,525	61,830	75,355
Budaon ...	131,997	171,640	119,262	122,924	242,186
Moradabad ...	89,214	152,018	55,853	151,108	206,961

The above table clearly shows that the increment in well irrigated areas in 1941-42 is chiefly due to the construction of tube-wells in these districts.

Some Aspects of the Regional Geography of Tamilnad

BY

K. RAMAMURTHY, M.A., M. Litt., L.T.,

Lecturer in Geography, Vivekananda College, Mylapore.

(Continued from Vol. XXIII, No 3, July—September 1948, Page 64).

SOILS.

A systematic study of the soils of Tamilnad on a scientific basis has not yet been attempted. The settlement surveys have made a study of soils for all ryotwari lands, but the surveys were conducted by persons who had no scientific training. In the settlement records, the soils are mainly classified into the red and black "series", according to colour. The sandy soils of the coast are classified under a separate series called arenaceous. The alluvial and exceptionally good soils are also put under a separate series. These two latter series occupy only a small area in comparison with the former two. In the black series, strange as it may seem, no distinction whatever is made between the black cotton soil and the black soil formed in depressions, and river valleys.

These series of soils are again divided into the following "classes" by the proportion of sand and clay.

(*i*) Clay - containing upwards of 2/3 clay.

(*ii*) Loam - with 1/3 to 2/3 clay.

(*iii*) Sand - not more than 1/3 clay.

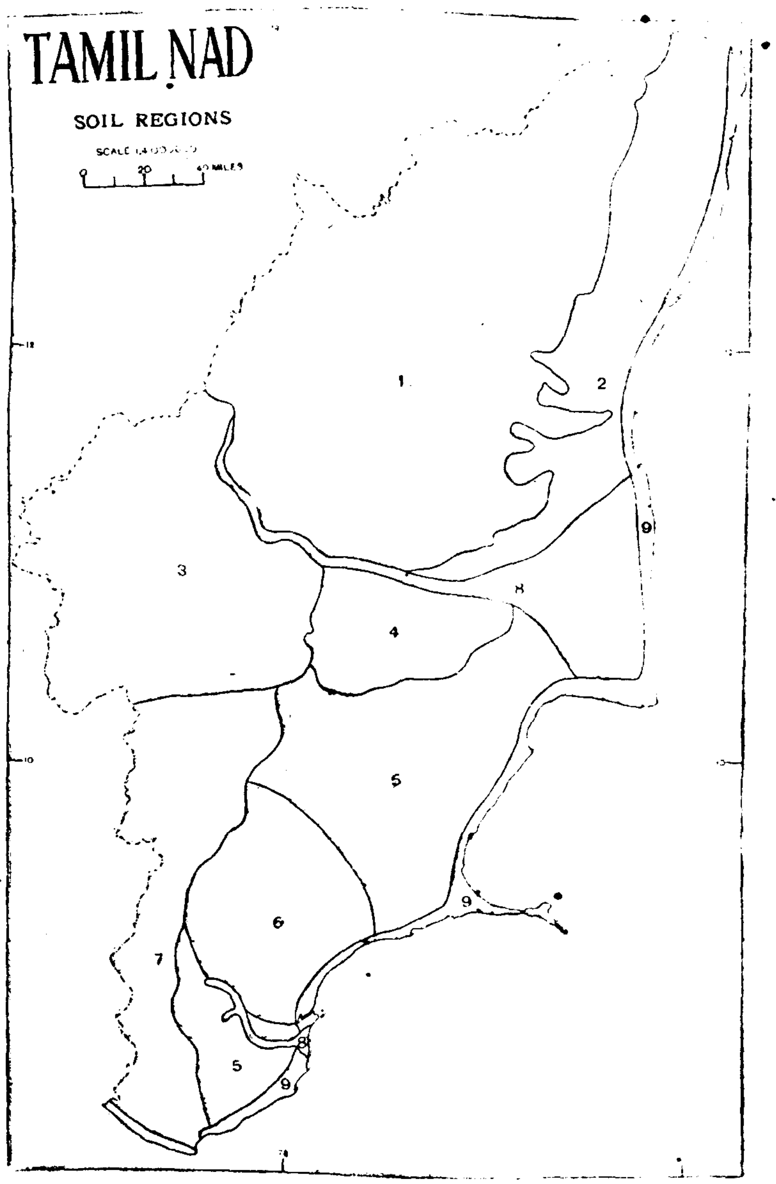
The above determination of the mechanical composition of clay and sand in soils is of great practical use, as it often distinguishes the soils according to the particular texture, suited for the several crops and also according to the relative cost of cultivation, including irrigation.

Each of these classes is again put into 5 sorts (best, good, ordinary, inferior, and worst) chiefly by the quantity of organic matter and the presence of other valuable or deleterious ingredients. The proximity of land to the village and irrigation sources, the facility of manuring, irrigating and guarding the crop are also considered in deciding the sorts. As these factors extraneous to the productive capacity of the soil are also considered in determining the sorts, they are of little scientific value.

Good descriptions of local soils are available in the Settlement Reports and also in the publications of the Geological Survey. These along with the classification of the soils in the different taluks as given in the Settlement Reports form the basis of the following discussion on soils and of the soil map of the region appended here.

The entire region may be divided into the following soil regions:—

1. The Western Upland Region north of the Cauvery river.
2. The Coastal Plain, north of the Cauvery delta.
3. The West Central Region.
4. The South Tiruchirapalli and North Pudukkottai Region.
5. The Coastal Plain south of the Cauvery delta excluding the black cotton soil region.
6. The Black Cotton Soil Region.
7. The Colluvial Belt at the foot of the Southern Ghats.
8. The Cauvery and the Tambaraparni alluvium.
9. The arenaceous soils of the littoral tracts.



MAP 8.

1. **The Western Upland Region north of the Cauvery river**:—This region comprises practically the whole of the North Arcot and Salem Districts and the western taluks of South Arcot and the northern taluks of Tiruchirapalli. The soils are either the product of the weathering of the local rocks or have been transported for trifling distances by pluvial action. The prevalent soils are red and of this the sandy variety is the most common[96]. The soils are sandy and gravelly in the uplands and loamy and clayey in the valleys and depressions. With rain water flowing down the slopes in the uplands and with good aeration oxidation proceeds rapidly, and the soils are therefore red, the ferrous compounds being oxidized into the ferric ones. In the depressions and hollows, with feebly permeable soil, where water can collect and stagnate excluding air, oxidation is held up and may be even reversed under the influence of organic matter. Compounds of ferric iron are then reduced again and the soil loses its bright red colours.[97] This fact explains the formation of black clays and loams in depressions and river valleys.

In some places, heavy rainfall has led to the extensive leaching and lateritisation of the soil. These lateritic soils are poor in lime and magnesia and deficient in nitrogen. These are therefore acidic in reaction and have to be treated for lessening this acidity.

The soils over the plateau formed by the the Cuddalore sandstones in South Arcot District are of very vivid red colour and very infertile and support scanty vegetation. Even these soils have been rendered commercially useful by cultivation of cashewnut, casurina and groundnut.

2. **The Coastal Plain, North of the Cauvery delta**:—The coastal plain of Tamilnad north of the Cauvery delta, lying roughly below the 250 ft. contour comprises practically the whole of Chingleput and the eastern taluks of the South Arcot

96. North Arcot Manual, Vol. I, p. 22.

97. P. Vagelar, An introduction to Tropical Soils, p. 124.

districts. The soils are generally loamy and clayey having received additions from time to time of fine soil from the sheet flows and inundations from the western uplands. This feature is specially well marked in the valleys of Palar, Cheyyar, Vellar and other rivers. The rainfall of this region is also heavy, the median of the annual totals exceeding 40". The amount of water covering the soil is greater than the western upland region as it is derived not only from the local rainfall but also by what flows from the west. Air is thus excluded from the soil to a greater extent than in the west. This causes the formation of a bed of humus with slow additions of organic matter, which in turn has resulted in the formation of black soils in several places.

This region has a higher proportion of red soils in the north and black in the south. In the taluk of Tiruvallur the soils are mainly of the red sand variety. Though the rainfall is good, even the *punja* (dry) crops are poor in this taluk on account of the high porosity of soils.[98] In the southern taluks of Chingleput and in the eastern taluks of South Arcot black clays and loams prevail in lowlying parts. The geologists are of opinion that the extensive black soils in the valley of the Vellar river in Chidambaram and Vriddachalam taluks (South Arcot District) and in Perambalur and Udayarpalayam (Tiruchirapalli District) have been formed in a huge inland lake caused by the backing up of the river by the line of high ground of which Mount Caper is the most prominent survival.[99] These black soils are very fertile, being very retentive of moisture and well suited for wet cultivation.

3. The West Central Region.

This region comprises the plain portions of Coimbatore District together with the Karur taluk of Tiruchirapalli and the Dindigal and Palni taluks of Madura, lying in the leeward side of the Palghat Gap. The rainfall here is so low that the

98. Settlement Report of the Chingleput Dt., 19.
99. Messrs. King & Foote; Mem. G. S. I. Vol. IV, Pt. 2, p. 30.

weathering has not kept pace with the erosion of the surface soil cover. The surface soils are, therefore, extremely thin and the subsoil often outcrops at the surface. This has resulted in the scarcity of vegetation which gives the region a barren appearance. But the soils are not generally as infertile as they appear to be. Owing to the hornblendic nature of the gneiss, they are rich in potash, lime and magnesia. Under proper irrigation they are capable of yielding excellent crops.[100]

4. The South Tiruchirapalli and North Pudukkottai region.

East of the above west central region, and south of the Cauvery river prevails sterile red soil which further south passes into soda soils almost entirely bare of vegetation.[101]

5. The Coastal Plain south of the Cauvery delta excluding the black cotton soil region.

This region consists of the eastern Pudukkottai state, the non-deltaic parts of Tanjore and parts of Ramnad, Tirunelveli excluding the black cotton soil region.

The soils belong to the red ferruginous type and are not so fertile as in the plain, north of the delta. The rainfall being much less and the rivers being also short the alluvia of rivers is a mixture of sandy clay with lateritic pellets and small debris of quartz and gneiss.[102] On account of the evaporation being in excess of rainfall, there are several places which are highly saline and hence barren and unproductive.

6. The Black Cotton Soil Region.

This region comprises the southern part of Tirumangalam taluk, the whole of Sattur and a greater part of Koilpatti, northern portions of Sankaranaiyinarkoil and Srivaikuntam taluks. The river Gundar forms roughly the eastern boundary

100. Coimbatore Settlement Report, p. 2.
101. Trichinopoly Gazetter, Vol. I, p. 12.
102. R. B. Foote, Rec. G. S. I., XII, p. 156.

of this black soil region.[103] There are patches of this kind of soil in the west central region also. These are the very areas of Tamilnad where rainfall is least and the weathering of ferruginous gneisses and schists under such a semi-arid climate has resulted in the black cotton soil.[104] It differs from the regur over the Deccan trap in that there is no transition between it and the underlying rock.[105] The regur of Tamilnad is less black, less retentive of moisture but more friable and more suited to irrigation.[106] In thickness also it is not so deep as in the trap area. Particularly in these regur areas of Tamilnad there is generally a layer rich in kankar nodules formed by the segregation of the calcium carbonate.[107] In common with the Deccan trap soils the regur of Tamilnad is highly argillaceous and very fine grained and very tenacious of moisture and extremely sticky when wetted. Both expand under the influence of moisture and contract on drying to an unusual extent. Hence in the dry season the surface is full of broad and deep cracks often five or six inches across and several feet deep. By means of these cracks considerable quantities of soil material are carried by wind and water from the surface to great depths within the soil. This in itself constitutes an energetic mixing of the soil. A more important and powerful factor, however is the displacement of deep-lying soil material which is necessarily set up by this introduction of solid matter when the soil is again moistened and when the cracks close up by swelling of the colloidal masses. This leads to a pronounced circulation of soil material upwards from below, and thereby to complete mixing of all soil layers up to the depth reached by the cracks.[108] This is the meaning of the saying that the black cotton soil ploughs itself. The great fertility of the black cotton soil depends upon this phenomenon as well as on the retentivity of moisture in such semi-arid areas where these

103. R. B. Foote, Mem. G. S. I., XX, p. 84.
104. Wadia, Krishnan &c., Rec. G. S. I., Vol. 68, p. 368.
105. P. G. Dowie, J. M. G. A. XV, p. 326.
106. Tinnevelly Gazetteer, Vol. I, p. 13.
107. Wadia, Krishnan &c. op. cit., p. 369.
108. Vagelar, Tropical Soils, p. 179.

occur. They contain much iron, and fairly high quantities of lime, magnesia and aluminium. They are poor in phosphorous, nitrogen and organic matter.[109]

The colour and the peculiar physical properties of the black cotton soil are associated with the compound particles of low specific gravity they contain. These possess the properties of ordinary clay and are derived from colloidal hydrated double iron and aluminium silicate. The black colour may be due partly to an organic compound of iron and aluminium.[110]

7. **The Colluvial Belt at the foot of the southern ghats.**— A very remarkable formation of deep red loamy soil several miles wide occurs along the foot of the southern ghats, especially in the bay-like recess formed by the great curve of the mountain range to the north and west of Kuttalam. This is a pluvial deposit washed down from the adjacent ghats.[111] These colluvial soils are very deep and generally have bulky rock fragments at the bottom. Into these soils water draining the mountain slopes penetrates very easily, and the soil climate is comparatively humid even in adverse seasons.[112] Moreover the rainfall also is much greater in the foothill region than further east. Hence oxidation proceeds rapidly and the soil is of deep, red colour, which becomes lighter towards the east. As the soil is very fertile and as water is obtainable at a slight depth, well irrigation is very common in this region and intensive agriculture is carried on.

A very striking feature about the southwestern part of the Tirunelveli district in this region is the occurrence of large heaps of termites. The brilliant red colour of the soils results from the activity of the termites, which influence their composition. In building their 'homes' which are from 5 to 8 feet

109. Wadia, Krishnan etc., Op. cit. p. 369.
110. M. R. Ramaswami Sivan, Ind. Dept. Ag. Chem. Ser. Vol. XX, p. 280.
111. R. B. Foote, Mem. G. S. I., XX, p. 85.
112. Vagelar, Op. cit., P. 110.

in height or even more, they expose large quantities of soil material to the air and thereby greatly promote oxidation. These termite infested red earths are considerably richer in plant foods than the surrounding soil.[113]

8. The Cauvery and the Tambaraparni alluvium.

In Tiruchirapalli district, rich alluvial soil has been formed for a length of about 50 miles along the course of the river Cauvery about a mile in breadth on either side of the river. These soils are exceptionally rich and very highly valued. The soil of the delta further east is entirely alluvial but varies greatly in quality. The long narrow belt between the Kollidam (Coleroon) and the Cauvery from the head of the delta up to Kumbakonam contains the richest alluvial soils of the delta and is popularly known as the breast of Tanjore. It is this very tract in the whole delta which is rich both in available phosphoric acid and potash and nitrogen and which requires no special manuring.[114] As one proceeds away from this tract eastwards and southwards, the alluvial soils get mixed up with clay and become less fertile and sometimes waterlogged. The soil between the Vennar and Vettar river is of very inferior quality as the sub-soil consists of limestone, which works its way to the surface and reduces the quality of the soil.[115] The soil near the sea coast is sandy in character and a considerable area of these sandy soils is cultivated with groundnut and Kullakar paddy.

The delta as a whole is in very great need of phosphatic manures. The nitrogen content is also low and the crops would benefit greatly by some cheap system of manuring for this ingredient. The soils of northern and eastern portions of the delta show an excess of magnesia over lime and would benefit greatly by the addition of lime.[116]

113. Ibid, p. 129.
114. Bull. of. the Madras Ag. Dept , Vol. III, No. 68.
115. Tanjore Sett. Report, p. 20.
116. Bull of the Madras Ag. Dept., Vol. III, No. 68.

The alluvium ot Tambaraparni consists of black loam, well suited to irrigation. This is not the black cotton soil but red loam which is reduced to black colour by constant flooding and manuring. The soils overlie a stiff yellow clay or marl, locally known as "*Karugai mann*". This effectively prevents all soakage and by keeping the water. vegetable matter and manure in suspension, is responsible for the greater fertility of the Tambaraparni valley as compared with the Cauvery valley, the sub-soil of which is mostly sand. The yellow marl is not deleterious though it produces nothing alone; but when worked up with the surface soil it strengthens and improves the light lands.[117]

9. The arenaceous soils of the littoral tracts.

The soils in the littoral tracts consist of grey sands, highly saline and porous and least productive. These sandy soils are useful in planting casurina, cocoanut and groundnut. Vegetation and cultivation have contributed much in places to the improvement of the composition of these soils, by introducing some fertile elements.

—(To be Continued)

Let India Use Her Geographers.

BY

V. S. MATHUR, *Rohtak.*

Geography is fast receiving general recognition in the Indian universities. It will, however, take some more time to give it an adequate place of honour in all the institutions devoted to both professional and humanistic learning, as is the case in U. S. A. and in some of the more advanced countries of Europe.

It is, therefore, a pity that not many persons who matter, seem to realise the importance and usefulness of this subject, and consequently there are very few positions available for those who specialise in Geography. There is, therefore, a grave danger of this really important subject getting very unpopular with the student community, purely on financial grounds. The only line that seems to absorb some of the qualified persons is the Education department and there too, the prospects offered are not very bright. I could only smile when a very high officer of the Government of India expressed his very great surprise when I told him that Geography is now a University subject. The authorities perhaps do not know what they are missing by this indifference to and their ignorance about the vast utility of Geography.

In the present era of speed and power, the geographical point of view cannot possibly be ignored. No geographical detail is unimportant; no area, howsoever, small and remote is to be neglected. An acquaintance with the total environment and an expert handling of relevant statistical, physical and social data are requirements of the first order in any progressive society. As such, the popular indifference to geography can only be called a strange phenomenon in India, a country of expanding ambitions. The 'dynamism of the modern age — power, production, trade and diversified cultures, warrants even a wider application of geographical principles to human life'.

As such, in every possible department of state and in every business house of the country, the services of trained geographers are indispensable. It is strange how the foreign Ministry and our embassies in foreign lands are functioning without geographical advisers. Our agriculture and our industries, our shipping and our trade will surely yield better results, if sound geographical advice is sought before a new adventure is launched upon. Such co-operation is an everyday occurrence on both sides of the Atlantic. In U. S. A., for instance, geographers are used in a wide variety of government offices, the departments of State, Commerce, Interior, War, Agriculture and the National Archives. Even the airlines, steamlines, chain stores, and large agricultural and business concerns, to name only a few industries, offer good jobs to trained geographers. In Australia, even the banks employ geographers trained in landuse problems. Experts in Geo-politics and inter-national affairs are everywhere kept as advisers in the various ministries.

Our knowledge of our own country both physically and in terms of her actual potential human occupance is very inadequate. A separate geography section may be added to the Agriculture department at the centre and in the provinces to carry on a 'land utilization survey' of the whole country and issue reports on the findings thereof. The Survey of India and the Meteorological department as also the Geological Survey of India have strangely enough been carrying on without any geographical help. Geography can do much in increasing the efficiency of these departments.

While concluding I can only hope that very soon the national importance of Geography and Geographers will be realised. All economic planning and all industrial schemes will achieve only dim results if they have no geographic foundations to stand upon.

———

Printed by Mr. R. Ravaimanickam, at Ravai & Sons, (Ravai Press), 148, Big St., Triplicane, Madras
and published by Dr. G. Kuriyan, Wellclose, Cathedral Post, Madras.

Vol. XXIII **JULY—SEPTEMBER, 1948** **No. 3**

197

The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

PUBLISHED QUARTERLY.

Editor

Dr. GEORGE KURIYAN, B.A., B.Sc., Ph.D., (Lond.)

THE INDIAN GEOGRAPHICAL JOURNAL

Wellclose **Cathedral P.O.,** **Madras, 6.**

CONTENTS.

The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

Vol. XXIII JULY—SEPTEMBER, 1948 No 3.

The Editor takes no responsibility for the views expressed in the Journal. Authors alone, are responsible for their respective statements.

The Physiography & Structure of the Bist Jullundur Doab.*

BY

OM PRAKASH BHARADWAJ, M.A.,

Department of Geography, University of East Punjab, Simla.

The Bist Jullundur Doab can be divided into two parts physically.

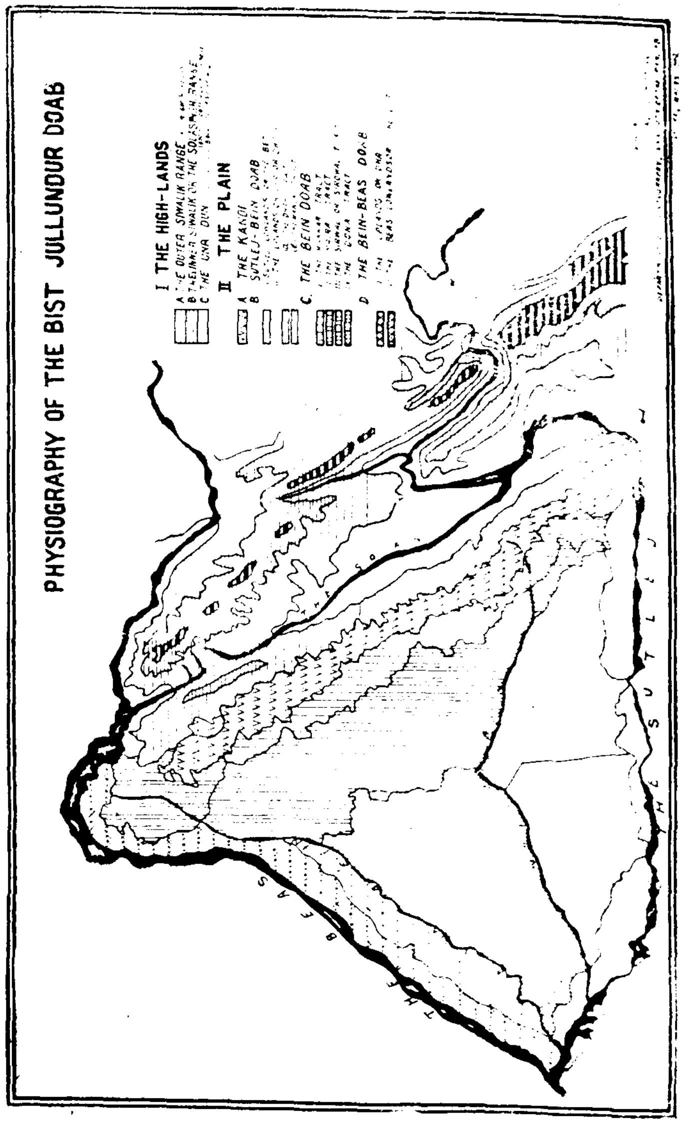
1. *The Hills* which run from south-east to north-west and from the north-eastern boundary of the Doab, separating it from the Kangra and Kulu Region.

2. *The Alluvial Plain* - sloping south-west from the foot of the Siwalik Hills and confined between the Sutlej on the south-east and the Beas on the north-west.

I. *The Hills*:—**General**:

The Hills are the continuation of the Siwalik ranges which run from Assam to the north-west, reaching the Punjab but they have been separated by the broad flat valley of the Jaswan or Una Dun which runs in between. The valley acts as a wedge between the Sola-Singhi range in the north-east and

* A paper contributed to the Indian Science Congress, Session 1947, Delhi.



MAP 1.

the outer Siwalik range in the south-west. The outer Siwalik range does not extend beyond the Beas in the north or Sutlej in the south. It is merely an outlier of the main Siwalik range. (Map 1).

The Hilly region falls into three sub-divisions:

(*a*) The outer Siwalik range or the outlier of the sub-Himalayan hills.

(*b*) The inner Siwalik or the Sola-Singhi range.

(*c*) The Jaswan or Una Dun.

(*a*) **The outer Siwalik range.**

It runs down the centre of the Hoshiarpur District, a little to the east, forming its back bone. It is locally known as 'Katar Dhar' meaning the edge of the sword, which it resembles in its curved form. It presents its convex edge towards the south-western plains. It is uniform in breadth except near 'Jaijon' in the south-east where it widens out. In the north-west as it approaches the Beas it takes a turn to the west and spreads into the cluster of round undulating hills near 'Datarpur'. The Government bamboo forests of Bindraban and Karanpur lie over them.

The outer Siwalik range has a lesser slope towards the Dun and it descends abruptly towards the south-western plain. As the range leaves Sutlej it consists mainly of stony and sandy hillocks and as it proceeds north the range becomes far more distinct in its out-line. By 'Jaijon' it spreads out into broad table lands, but on either side the ascent is steep and on the east it is precipitous. Passing beyond 'Jaijon' the table lands cease and the interior of the range becomes split up into a number of sharp steep ranges of the most irregular formation. For the most part they are barren, but here and there is found a patch of 'Chil Forest' and fields for cultivation. This lasts as far as the road from Hoshiarpur to Dharamsala, beyond which the hills begin to improve. The precipitous outline and sharp corners of the south change into broad undulations rising gradually from the valleys, and the barren sand gives place to a soil, stony indeed, but capable of cultivation. The improvement reaches its climax in the clusters of hills forming the end of the range already referred to above. The breadth of the outer Siwalik range is about 10 miles and the highest point 'Madhwani' above 'Garhshankar' is 2,018 ft. above the sea level.

(*b*) **The Sola Singhi or Chintpurni or Jaswan Dhar Range.**

It commences near 'Talwara' on the Beas where that river first touches the District. It runs south-eastward and its culminating ridge forms the boundary between Hoshiarpur and Kangra Districts. Passing southward from Talwara it increases steadily in width and elevation, until its highest point is reached at 'Bharwain' the summer hill station of Hoshiarpur District, 28 miles from Hoshiarpur city. At this point it is about 20 miles in width and 3,896 feet in height. Here the central range slopes in a series of undulating valleys to the Beas on one side and the 'Sowan Nadi' an important hill torrent, on the other. The range still runs towards the Sutlej and it has an abrupt fall of from 200 to 300 feet. Between the main range and the plain of the 'Jaswan or Una Dun' is a wide table land, thickly wooded and apparently level, but divided into natural blocks by numerous deep ravines. This area, some 15 miles in length and 8 in breadth, is thickly forested, the greater part being reserved under the forest act. At a short distance south of 'Amb' - a village, the Sola Singhi range recedes eastward, ceasing to form the boundary of the District and the plains at this point form a kind of bay in the hills, which is shut in by the Sola Singhi to the north east, and by another range commencing a few miles north of Una, in the south-west. The latter is Called Naina Devi ridge and runs south in a series of undulating hills of no considerable height with an even front towards the 'Jaswan or Una Dun'. Across the Sutlej the latter range breaks into a series of parallel ridges of no great height but rocky and in places precipitous, though their slopes are well covered with grass and brush-wood. This range is separated from the Sola Singhi by the Sutlej which for some 30 miles runs northwards between them until the Sutlej turns

westward into the Jaswan or Una Dun. The hill of 'Naina Devi' on whose summit is the famous shrine, from which the hill takes its name, is the highest point of the range and the temple is visible many miles around.

(*c*) **The Jaswan or Una Dun.**

In between the Sola Singhi and the outer Siwalik range runs the Una Dun. Its breadth is from 4 to 8 miles and the town of Una near the middle of the Dun is 1,404 feet above sea level. In the extreme north-west the surface of the valley is so high that it is almost level with the hills on either side. This forms a natural watershed and from it streams flow to the Beas, which is about 12 miles north of this place. To the south the valley slopes gradually to the Sutlej. It is traversed throughout by the 'Sowan Nadi', the main torrent into which the streams from the western slopes of the Sola Singhi and eastern slopes of the Siwaliks drain themselves. During the rainy season the Sowan Nadi covers almost the whole of the Una Dun but at other seasons it is a petty stream almost lost in its sandy bed which is from 1 to 2 miles in width. It abounds in quicksands but the water is not more than two or three feet deep. Due to its form as an elongated basin, the Sowan Nadi is flooded in no time after the rains in the rainy season. The torrents rushing from all sides flood the whole area and the flood does not even give time to the travellers to cross the bed of the stream which is more than a mile in width. The geological structure and form of the valley and its great height, almost level with the flanking hills in the south suggest that its final contours are the result of the vertical erosion by its principal stream the 'Sowan Nadi'.

Geological Structure:

(*a*) **The Siwaliks.**

Geologically speaking the rocks of the sub-Himalayan hills belong to the upper Siwalik stage of the Siwalik series in other words, they are Tertiary belonging to the Pliocene period. This is the first group which is met with in gradually from the valleys, and the barren sand gives place to a soil, stony indeed, but capable of cultivation. The improvement reaches its climax in the clusters of hills forming the end of the range already referred to above. The breadth of the outer Siwalik range is about 10 miles and the highest point 'Madhwani' above 'Garhshankar' is 2,018 ft. above the sea level.

(*b*) **The Sola Singhi or Chintpurni or Jaswan Dhar Range.**

It commences near 'Talwara' on the Beas where that river first touches the District. It runs south-eastward and its culminating ridge forms the boundary between Hoshiarpur and Kangra Districts. Passing southward from Talwara it increases steadily in width and elevation, until its highest point is reached at 'Bharwain' the summer hill station of Hoshiarpur District, 28 miles from Hoshiarpur city. At this point it is about 20 miles in width and 3,896 feet in height. Here the central range slopes in a series of undulating valleys to the Beas on one side and the 'Sowan Nadi' an important hill torrent, on the other. The range still runs towards the Sutlej and it has an abrupt fall of from 200 to 300 feet. Between the main range and the plain of the 'Jaswan or Una Dun' is a wide table land, thickly wooded and apparently level, but divided into natural blocks by numerous deep ravines. This area, some 15 miles in length and 8 in breadth, is thickly forested, the greater part being reserved under the forest act. At a short distance south of 'Amb' - a village, the Sola Singhi range recedes eastward, ceasing to form the boundary of the District and the plains at this point form a kind of bay in the hills, which is shut in by the Sola Singhi to the north east, and by another range commencing a few miles north of Una, in the south-west. The latter is Called Naina Devi ridge and runs south in a series of undulating hills of no considerable height with an even front towards the 'Jaswan or Una Dun'. Across the Sutlej the latter range breaks into a series of parallel ridges of no great height but rocky and in places precipitous, though their slopes are well covered with grass and brush-wood. This range is separated from the Sola Singhi by the Sutlej which for some 30 miles runs northwards between them until the Sutlej turns westward into the Jaswan or Una Dun. The hill of 'Naina Devi' on whose summit is the famous shrine, from which the hill takes its name, is the highest point of the range and the temple is visible many miles around.

(*c*) **The Jaswan or Una Dun.**

In between the Sola Singhi and the outer Siwalik range runs the Una Dun. Its breadth is from 4 to 8 miles and the town of Una near the middle of the Dun is 1,404 feet above sea level. In the extreme north-west the surface of the valley is so high that it is almost level with the hills on either side. This forms a natural watershed and from it streams flow to the Beas, which is about 12 miles north of this place. To the south the valley slopes gradually to the Sutlej. It is traversed throughout by the 'Sowan Nadi', the main torrent into which the streams from the western slopes of the Sola Singhi and eastern slopes of the Siwaliks drain themselves. During the rainy season the Sowan Nadi covers almost the whole of the Una Dun but at other seasons it is a petty stream almost lost in its sandy bed which is from 1 to 2 miles in width. It abounds in quicksands but the water is not more than two or three feet deep. Due to its form as an elongated basin, the Sowan Nadi is flooded in no time after the rains in the rainy season. The torrents rushing from all sides flood the whole area and the flood does not even give time to the travellers to cross the bed of the stream which is more than a mile in width. The geological structure and form of the valley and its great height, almost level with the flanking hills in the south suggest that its final contours are the result of the vertical erosion by its principal stream the 'Sowan Nadi'.

Geological Structure:

(*a*) **The Siwaliks.**

Geologically speaking the rocks of the sub-Himalayan hills belong to the upper Siwalik stage of the Siwalik series in other words, they are Tertiary belonging to the Pliocene period. This is the first group which is met with in passing from the plains into the Himalayan foot hills and takes its name from the Siwalik hills. These hills consist entirely of vast beds of sand alternating with loams and clays in much smaller proportion, with extensive beds of loose conglomerate or gravel. The pebbles vary from the size of a pigeon's egg to twice the size of a large ostrich egg, but not as a rule bigger. They consist of metamorphic and quartzitic gneiss and granite rocks drived from the older Himalayan formations. They are the result of aqueous action but the strata so deposited have been upheaved. Most of the strata are soft and ill compacted, but there are extensive strata some varying from a soft and brittle greystone as at 'Chohal' at a distance of five miles from the city of Hoshiarpur, to a real hard building stone found beyond 'Pamrah' which occurs in masses of a grey colour, much resembling the sandstone found below Murree and Dharamsala. The beds of this hard sandstone often enclose small rounded pebbles of older rocks. Their structure seems to be the same, but they contain some mica agglomerated with lime.

On the north side of the outer Siwalik range and especially below 'Mansawal', there are beds of calcareous tufa alternating with gravel and clay. It is almost a pure limestone and is burnt for lime. Fossil remains are fairly common, a good many large fossilized bones of extinct species have been found.

(*b*). **The Una Dun.**

There is a well raised plateau of what appears to be upper Siwalik conglomerates, in the Dun, between Nalagarh and Kiratpur, against which the Sutlej runs southward.

Immediately to the west of this we find a great change in the arrangement of the rocks. Near 'Anandpur' just north of 'Nanowal', the strata of the dun are *Kunkury*, calcareous, clayey and sandy with irregular patches, hardened by tufa, and occasional strings of small boulders Here at the base of Naina Devi a sudden change to dirty red clays, and yellowish brown

sandstones occurs. Passing on to 'Bubhor' we find the same section but the upper beds here consist of thick beds of massive conglomerates. Further still, near Una, we find the yellow, marly clays. The conglomerates are subordinate and rapidly pass into pebbly grey sandstones. Structurally the Bharwain ridge is a representative ridge and in a manner the continuation of the Naina Devi ridge, but the physical features are altogether changed. It is a broad flat ridge of the ordinary Siwalik Type. Thick boulder conglomerates reach upto the crest, sandstones and clays cropping out along the south-western slopes towards the Una Dun. In the gorge of the Beas, through the Bharwain ridge there are excellent sections showing rather complicated disturbance. The upper rocks are grey pebbly sandstones, and the bottom is of the beds of conglomerates.

The Plain.

The plain beginning from the Siwalik foot hills has a gentle slope south-westwards and is mostly composed of the sand and the silt from the torrents which carry down the drainage. Hill torrents or 'Choes' which come down from the western slopes of the outer Siwalik range bring a good amount of silt in the rainy season which is spread over the fertile soil thus making it infertile. They have become a source of great menace to the fertility of the soil and have presented us a grave problem.

In their upper courses the 'Choes' do not have well defined channels. In the second stage they have well defined channels and damage is chiefly done by erosion and sand drift. In the third stage 'Choes' pass out of their well defined banks and here the worst damage is done. The water spreads out into a net work of small channels carrying with it a deposit of sand which aided by wind action spreads far and wide over the soil. As the 'cho' increases in length this action is carried further and further from the hills.

The plain can be sub-divided into the following Geographical Regions :

(*a*) The 'Kandi' or the gravelly fringe of land to the south-west of the Siwalik Range.

(*b*) The Sutlej-White-Bein Doab.

It can be sub-divided into

i. the Sutlej lowlands or 'The Bet'

ii. The uplands or 'Dha', which can be further sub-divided according to the nature and productivity of soil.

(*a*) The Dhak Tract.

(*b*) The Manjki Tract.

(*c*) The Bein Doab-between white Bein and Black Bei n It can be sub-divided into the following tracts.

i. The Maira Tract.

ii. The Raker Tract.

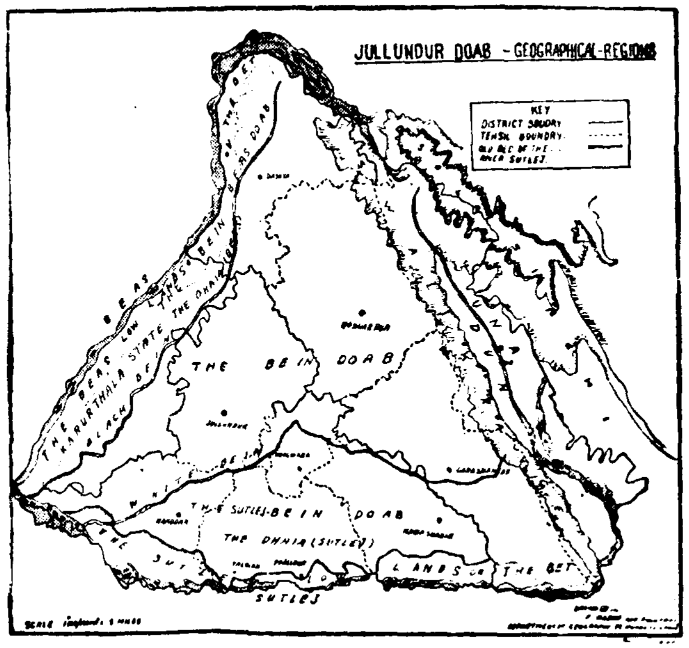
iii. The Sirowal or Sirwal Tract.

iv. The Dona Tract.

(*d*) The Black Bein-Beas Doab.

i. The Dha or Uplands.

ii. The Beas Lowlands, or 'the Bet.'



MAP 2.

(*a*) **The Kandi or the gravelly fringe of land to the south-west of the outer Siwalik Range.**

197

The sub-mountain belt at the foot of the outer Siwalik range extending in the form of a horse shoe around the outer Siwalik range is known as the 'Kandi', meaning border or fringe. The soil is generaly gravelly and sandy, but receives good rain to bring the crops to maturity. Some of the villages in the north have springs of water which are used for irrigating the land. It may be compared to the 'Bhabar tract' running along the Himalayas in the north of the Gangetic Valley. On account of comparatively lower rainfall it is not as much forested as the Bhabar zone.

(*b*) **The Sutlej-White Bein Doab.**

(*i*) **The Sutlej Lowlands or The Bet.**

This region is situated between the old bank which lies to the north and the present bank of the river Sutlej. Beyond the old bank starts the uplands or the Dha. Each of the three Tehsils of Jullundur District (*i.e.*) Nawahshehr, Phillor and Nakodar and the Garhshankar Tehsil of the Hoshiarpur District are divided into two parts locally known as 'The Bet' or the 'Low Lands' and the 'Dha' or 'Dhaia' or the 'Uplands'. The fall from one to the other is in some places almost perpendicular and in others very gradual and gentle. The bank is cut up by ravines (Ghag) through which the drainage water of the uplands pours down into the bet, often carrying sand with it and forming miniature 'Ghos' or sand torrents, and in many places forming swamps and marshes in the vicinity of the bank, where probably the deep stream of the Sutlej formerly ran, and where the depression so caused has not yet been silted up to the level of the adjoining country. The ravines are cut out almost vertically and afford facilities for studying the formation of the ridge; layers of clay or sand alternating with thin seams of Kankar (calcareous concretions) are usually found. The extent of bet lands in the four Tehsils is far from equal, as it depends on the amount of change that has taken place in the course of the river. In Nawahshehr Tehsil the bet is about four miles broad on an average; in Phillor Tehsil except in two places it is rarely more than a mile to a mile and a half broad, but in Nakodar Tehsil the present stream is for a part of its course eight miles from where it formerly ran, and its course now is very nearly parallel to what it was of old. At only three places does the main stream of the Sutlej now touch the uplands; at Kariana; at the junction of the Nawahshehr and Phillor Tehsils; five miles further west, at the town of Phillor; and below 'Talwan' a couple of miles to the east of where Nakodar and Phillor meet.

The Soil of the Bet.

The predominant soil of the Bet is a grey alluvial loam of fair quality. It generally contains more or less 'kaller', a saline substance consisting chiefly of sulphate of soda. A good deal of land is rendered quite unculturable by the presence of this salt. But as compared to the total area of the bet, the extent of land seriously affected by 'kaller' is trifling. In some places clay takes the place of loam. In the extreme east of Nawahshehr stiff brown clay is found. In the far west of Nakodar there is much hard black clay, while in the middle of the same Tehsil a grey clay, containing a good deal of kaller is met. Sand is not very common except where the river has been flowing recently, but still it is found, and generally covered by a very thin stratum of better soil. Hillocks of pure grey river sand may be seen at places in Nakodar.

The bet land may be further sub-divided into:

(*i*) Tracts affected by the river.
(*ii*) Those not so affected.

The area quite close to the river is flooded by the Sutlej during the rains and parts of it are kept permanently moist owing to their situation and proximity to the stream, even if not actually flooded. Almost all the Nawahshehr and Phillor bet belongs to the first class, the greater part of the Nakodar bet and a few of the western villages of Phillor form

the second class. Numerous shallow depressions in the bet show where branches of the river once ran. But most of them have been silted up. The eastern one third of the Nawahshehr bet is remarkably fertile, and produces admirable crops of sugar cane and wheat without any irrigation. The central portion is full of kaller and produces little but poor quality wheat. The western one third is good, but grows little cane. Passing into Phillor we find about three miles of bet quite equal to that in Nawahshehr. Then up to Phillor the soil is only middling, being decidedly saline. From Phillor to the end of the district the bet lowlands are fair but except in rare cases, almost exclusively in Phillor, cane cannot be grown without irrigation. There is but little dense jungle.

(*ii*) The Uplands or 'The Dha'.

It presents the appearence of an un-broken plain excepting in the west of Tehsil Nakodar where low sand ridges are not uncommon. The eastern portion has sandy soils and is followed by Sirwal and Rakkar tracts.

(*a*) The Dhak Tract.

It can be sub-divided into two tracts. The Dhak tract extends from the western slopes of the 'Kandi' tract to the middle of Phillor Tehsil, or to about the grand trunk road. It derives its name from the fact that it was formerly over-grown with the Dhak trees (Butea-frondosa). The great jungle has been mostly cleared away but there are still to be found trees which attest the justness of the designation. In Nawahshehr the soil is stiff loam, often clay. But the middle of the western half is sandy. In Phillor the soil is moderately fine and firm loam. North east and south west of the Phillor Tehsil is a little sandy.

(*b*) The Manjki Tract.

The Manjki is bounded on one side by the Dhak and on the other by the Bein. It is named after the Rajput Clan 'Manj' which was once powerful in these parts, but has now no special importance. In this tract the eastern parts consist of reddish loam but lighter in colour than that of Phillor. In the west sand predominates and low sand hillocks are numerous.

(c) **The Bein Doab.**

It comprises the land between the two beins or hill streams. It gradually slopes away from the outer Siwalik range. As we come down from the western slopes of the outer Siwalik range the gravelly and sandy patch of land known as Kandi gives place to :—

(*i*) The Rakker tract which is a ribbon shaped tract of land running longitudinally from north to south. This area is away from the outlying spurs of the outer Siwalik Range and contains more loam and less sand than the Kandi. In this tract the 'Urar Ret' *i.e.* the moving dunes of sand are less extensive. It runs through the middle of all the Tehsils of the Hoshiarpur District except the northerly Tehsils of Dasuya where it runs to a little south east *i.e.* near the foot hills of the outer Siwalik range. In the other two Tehsils of Hoshiarpur District *i.e.* Garhshankar and Hoshiarpur it denotes the strip of sloping undulating country intersected by torrents lying between the Kandi and the level fertile plain.

(*ii*) The Maira Tract. The villages of the Dasuya Tehsil which are irrigated by the Shah Canal have Maira soils - a fine mixture of sand and loam with a predominance of sand.

(*iii*) Away from the Rakkar tract the exceptionally fertile belt called the Sirwal or Sirowal is situated. It runs as a broad belt and covers a part of Hoshiarpur District and the north-east section of Jullundur Tehsil. Numerous streams coming from the Hoshiarpur District keep the soil sufficiently moist all the year round to render artificial irrigation unnecessary, though they themselves flow after heavy rain. The streams bring sand and have covered the soil with it, thus doing great damage. Much is being done to check this menace of soil erosion and sand disperson. The eastern portion of this tract is more fertile than the western.

(*iv*) The country to the west of Sirwal tract is known as the 'Dona'. The word Dona means that the soil is formed of two constituents, sand and clay but the term is now applied to that part of the country where there is much sand and little clay in the soil. The soil is sandy and certainly inferior but the places where it is very bad are comparatively few and are found in the north and south-west. Scattered sand hillocks are plentiful. Wheat, grams, millets, sugar cane and cotton are grown. Most of the Kapurthala State territory falls in the Dona tract.

(*d*) **The Bein-Beas Doab.**

(*i*) **The Beas uplands or Dha or Dheia.**

The upland Region continues west of the Bein. It runs between the western Bein and the low bet lands of the Beas. The soil is a mixture of sand and clay and becomes inferior still in the south.

(*ii*) **The Beas Lowlands or Bet Lands.**

The left bank of the Beas is uniformly low and on Kapurthala side there is a stretch of moist alluvial land running back several miles into the interior. It is fertile, well wooded and liable to inundation. There is a tradition that about a century ago, the river ran under the village of Hamira in Kapurthala territory, seven miles distant from its present course. The depression is still clearly traceable. At present the stream hugs the high western bank, more or less closely throughout the whole of its course. Cultivation is carried on between the foot of the cliff and the normal cold weather stream, or in the bays of land which lie back where the cliff recedes. At places there are openings in the cliff, where surface drainage from the uplands discharges into the valley bringing with it a deposit of sand. The high portions of the inundated land are sown with course rice and pulses.

Regional Planning of our Transport System.

BY

UJAGIR SINGH, M.A.,

U. P. College, Banaras.

Any region is an area with distinctive physical and therefore of cultural unity. It has definite geographical personalities-its physical features, climatic conditions, natural vegetation, pattern of settlements and communication are of definite character and designs. A region, therefore, presents communication problems quite different from another; the problem of communication in a hilly region like Nainital and Simla is quite different from those of the Bengal delta. Communication patterns in the Deccan table land has little in common with those of the Gangetic plain; Kashmir has its own problem quite different from Rajputana.

Factors affecting communication pattern.

(1) **Physical Factors** :—Characters of the landscape presents a distinctive pattern of transport and communication. Hilly regions have human porters who carry you along the narrow. zigzag hilly path. Drainage pattern in the East Bengal has encouraged water communication. Indo-Gangetic plain provides an ideal region for rail-road constructions.

(2) **Climatic Factors** :—Climatic factors had little control on our transport system in the past. But since the development of air transport, the Department of Meteorology is playing an important part in directing the pilots in order to save them from future calamity. In the polar regions, no doubt, climate controls the system of communication and Eskimos of the northern colder region take the help of sledge drawn by white dogs. Even in civilized countries frozen rivers create some problems.

(3) **Regional Economic Activities** :—Economic activities of the region are also responsible for the development of some typical pattern of communication. Hooghly-industrial area, for

example, has its nucleus at Calcutta, but looks to the near west—Rani Ganj and Jharia—for power and to the northern plain for market. Thus it has to maintain connection between the water communication of Bengal and the rail-road communication of the west.

Agricultural regions of the northern plain present different problems. Here the need for connecting the villages with the adjacent town is greatly felt and a different type of pattern known as "ship-pattern" is bound to develop. We shall deal with this later on.

(4) **Demographic Factor** :—Regional differentiation in density of population influences the layout of the lines of communication. Larger towns like Calcutta and Bombay have different problems of communication, not only from commercial and economic points of view but also to solve the problem of congestion, rush hour traffic and so on.

Principles of Regional planning of Communication.

(1) **Development of Economic Relations** :—The main principle for the development of transport should be to join two or more different regions for developing their regional potentialities and not to connect only two points. An undeveloped region will probably gain by its association with the prosperous one. It may also aim at better distribution of population with in the country as has resulted in the U. S. A. by the construction of trans-continental railways. Population has now shifted to the west and further congestion in the east has been avoided. Utilization of mineral resources and power may be other criteria for developing communication as has been done in Russia where Russian Turkistan and middle Siberia have been connected with Moscow.

(2) **Various means of communication should not be competitive but complementary** :—In our country main roads and railways run parallel to one another and thus have not proved as beneficial to commerce as they aught to have been. Roads should serve as feeders to railways; there should be co-ordination between the two.

(3) **Development of Regional Types of communication** :—Each region should develop a type of communication that is economical in that region; for example, it would be quite unwise to suggest the development of road communication in eastern Bengal where water communication is more economical. Similarly road communication in the Deccan would really be more beneficial than the railways.

Regional Planning of communication in India.

It would be quite evident from the above description that lines of communication in India have developed without any planning, so to say. Its development is not based on some principle. No attention has been drawn for maintaining and developing water transportation. In Bengal instead of building roads we should develop water communication. Canals would serve the purpose better than roads. It would be also an economical proposition as road-building-materials like stones and pebbles are hardly found in the deltaic region and unmetalled roads would soon become useless in the rainy season. The presence of thousands of rivers and Khals create another trouble of building bridges. At the same time construction of railways and the roads in Bengal have created another problem. The high embankments over which the roads and railways run have checked the natural run-off of the rain water, and have thus created water logging. We, therefore, come to the conclusion that in regions like Bengal water communication would prove more successful than roads and railways.

Deccan Plateau.

The Deccan presents quite different problems of communication. The great northern plain due to its level nature is quite suitable for rail road transport while in the Deccan, the rugged nature of the land-scape makes the construction of railways difficult as well as uneconomic. The broken hill topography makes it essential to have tunnels at several places. At places we have to take the help of 'banking engines'.

Roads on the other hand have proved very economical in the Deccan. Here building materials for roads are found in abundance. Irregular topography does not stand in the way of buses that can run on steep surfaces.

Transport system in bigger towns.

Means of transport and communication have to serve two fold objectives in bigger towns like Calcutta, Bombay and Cawnpore — firstly to provide facilities for the movements of goods and passengers and secondly to shift the population of more congested areas to the out skirts or thinly populated parts of the town. The first object can be achieved by building several broad roads controlled by the city police and permitting only one way thorough-fare to avoid accidents. The second objective can be fulfilled by cheap and swift means of transport like tramways and motor buses. At present in all bigger towns housing problem has been acute especially in the centre of the town. Tramways and bus-services in Calcutta have been able to divert the population to the out-skirts and the city is growing fast towards Taliganj and Chitpur areas. Cawnpore can also solve its problem of congestion on Calcutta lines. Improvement Trusts with the help of the Government and the public should build houses in the out skirts. By the construction of the E. I. R. importance of the Ganges as means of transport has deteriorated; again roads running parallel to the E. I. R. have no commercial importance. The reason behind all these uneconomic phenomena was that the construction of railways and especially of the E. I. R. took place out of military requirements and for the movement of troops. Secondly British railway companies wanted to make money by joining the bigger cities and towns and did not think of the economic development of rural areas. This statement can be proved by the following statistics as an example.

	Punjab.	U. P.	C. P.
Total lengh of metalled roads	3900 miles	7776 miles	4760 miles
Total length of railways.	3700 ,,	4952 ,,	2200 ,,

	Punjab.	U. P.	C. P.
Total length of roads and railways parallel, within 10 miles of each other	1400 miles	3109 miles	1682 miles
Percentage of railway mileage that have parallel roads	38 ,,	63 ,,	35 ,,
Percentage of metalled road - mileage parallel to railways	36 ,,	40 ,,	73 ,,
Percentage of area more than 10 miles from any railway	25 ,,	28 ,,	55 ,,

From the above statistics it would be quite clear that 38 percent of railways in the Punjab, 63% in U. P. and 35% in C. P. run parallel to roads. Thus, it has gone against the main principle of communication, roads should not be competitive to railways. The best method would be to connect the rural areas with railway stations through roads; a main road cutting across the railways and local roads joining it from sides. As has been pointed out in earlier paragraphs, ship like pattern of communication would be greatly beneficial for our rural areas.

CASE IN BENGAL.

But such type of road communication will not be useful in East Bengal and the Municipal Board should provide cheap means of transport. This would go a long way in relieving the congestion in the town.

During rush hours at 10 A.M. and 4 P.M. when people go to and back from the offices, these towns have special problems. At such hours special buses and trams should run.

Need of Well planned Scheme of Transport.

From what has been said in earlier paragraphs it is quite clear that the transport system in India has not developed on any prethought plan. The reason is not far to seek. The British Government was more interested in the administration of the country than to see the interest of the public. Now India is free and our aim is to provide the best facilities to the public. But before doing any thing in the interest of the public, a scheme for the development must be chalked out on scientific lines. As far as our transport system is concerned the principle of regional planning should be followed. For this end in view the Government should seek the help of the Engineers and Geographers who should be provided facilities for making a survey for the development of transport systems on the principle of regional planning.

Electrification of railways:—I need hardly say that India possesses little coal in camparison to other leading countries of the world. We therefore, have to tackle some other source of power to run the railways and the factories. Hydroelectricity is the cheapest source of power of which India has a great potentiality. We hope that in the near future most of our railways would be run by electricity and the coal would be utilized in factories and mills and even as domestic fuel.

Nationalisation of High ways:—Services on the main roads like Grand Trunk road should be nationalised by the central government or different provincial governments for the sake of uniformity and the governments should start their own bus services on main roads joining several commercial and political centres. It would, on the one hand, lessen the rush into the train and on the other, would add to the Government-treasury a sufficient amount of money.

Some Aspects of the Regional Geography of Tamilnad

BY

K RAMAMURTHY, M.A., M.Litt., L.T.,

Lecturer in Geography, Vivekananda College, Mylapore.

(Continued from Vol. XXIII, No 2, April June 1948, Page 39).

CLIMATE.

Preliminary Survey.

Introduction :—An attempt is here made to describe the climate of Tamilnad as revealed by detailed data in the case of rainfall, of as many as fifty-four stations over a period of thirty-five years at half-monthly intervals, and in the case of other elements of climate, of eleven stations, for which alone data are available. To the ordinary cultivator in Tamilnad, rainfall is the most baffling problem in determining his agricultural pursuits. To him the ordinary arithmetic average is useless. He has to go by the actuals of weather and rain and immediate probables, for which he depends upon the traditional knowledge of the village *Panchik.* But to the Geographer, the climate is all important as the composite picture of the weather, and the average is his important instrument.

In recent years statistical methods have been evolved[66] to determine for Rainfall the 'average' so as to give an insight into the true features of climate. These methods have been adopted here. The probabilities have been made to depend on quantitative foundations and the results thus derived afford true bases for classification of Rainfall Zones; of Seasons; of Sub-Regions etc.

General Features :—The climate of Tamilnad is determined by its configuration and situation as well as relief and proximity to the sea. As already seen, this region is in the form of a rhomboid, extending from south to north and flanked on the

66. See Appendix II.

two western sides by the ramparts of the Eastern Ghats and the western Ghats and washed on the eastern sides by the Bay of Bengal. By its situation, the entire region is wholly within the tropics and is exposed for the greater part of the year to the full blast of the monsoon winds, both the advancing and the retreating, whose regime, accordingly, save for local variations, remains the prevailing force.

Of the determinative elements of climate, the sun's north and south movement which is cosmic and the monsoon which is planetary are common to all parts of the land. Individual variations of the several tracts from the torrid monsoon type, are found partly due to elevation which ranges both by gradual and abrupt changes from sea level to well over 2000 feet, and partly due to their distance from the sea which ranges from zero to two hundred and fifty miles. On account of the rapid rise of the land towards the interior[67] the influence of the sea stops short of a few miles of the coastal margin, giving rise to a broad contrast between the coastal and the interior type of climate and weather. Nevertheless, as the maximum distance from the sea always falls short of 250 miles, the continentality is not well marked.

There are no large lakes influencing the climate. Nor are there forests big enough to produce climatic reactions. But the green mantle of extensive area under cultivated crops as in the deltaic Tanjore, brings down the temperature, as for example at Kumbakonam, which is cooler than the sea coast town of Nagapattinam.[68]

67. While in Bengal, on the plains, a height of 300 feet is attained in the course of 300 miles from the sea, here that height is attained within forty to sixty miles of the coast.

68. From the records of thermometers kept by a civil surgeon at Nagapattinam and by an apothecary at Kumbakonam, which is more than 30 miles from the sea, Mr. Venkasami Rao has found that at Kumbakonam the temperature is generally lower (notably during the period of the southwest monsoon) than at Nagapattinam on the coast. At Nagapattinam the mean temperature of 1877 was 92° ranging from 101 5° in August to 82.4° in January and at Kumbakonam, it was 84° ranging from a maximum of 94.0° in July to a minimum of 78.8° in January. This anomaly, he says, is apparently due to the entire neighbourhood of Kumbakonam being covered with fresh water channels besides being thickly wooded with trees. (*Tanjore District Manual*, p. 37)

Messrs. King and Foote also refer to the cooling influence of evaporation from the vast area of the delta under water aided by the strong southwest monsoon wind blowing unimpeded through the Palghat Gap. *Mem.* G *S. I.* IV, Pt. 2, p. 10)

The climate is also affected by another feature. This region stretches as an extensive tract eastwards form the Western Ghats and is on their lee-side to the strong rain-bearing southwest winds. The Palghat Gap is the only marked break in the long range of mountains 3000 to 5000 feet high and the monsoon winds that blow through it greatly affect the climatic conditions. The topography of this region is also variegated by the hills of the Eastern Ghats, and places though on the plains, exhibit as a consequence, notable differences of climate due to their relative aspects to mountain, plain and sea, and to wind and rain.

These then furnish us with bases of sub-regional classification amid a general monsoonal uniformity. This uniformity is observable in the meteorological elements of temperature, relative humidity, amount of cloudiness, and also wind direction and velocity, its strength and steadiness, though there are sharp local variations in these following the distinction of Coast and Interior. On the other hand, marked differences are found in the incidence of rainfall. It varies not only in amount from tract to tract but also in the dates of occurrence, and the number of maxima attained and their dates.

Temperature:—The thermic cycle ranks this land among the very hot regions of the globe. The latitude being from 8° 4′ to 13° 15′ N. the sun passes vertically overhead at every place twice in the year and the length of day is never anywhere less than 11 hours. The sun parches; tracts are made arid; and prickly heat is often experienced, mitigated though by cloud and dust and rain, and varied by winds.

It is not possible to present a full statistical picture, as the temperature recording stations being but few, the data are scanty. Even upon such meagre data, some facts appear outstanding.

The diurnal variation is such that the heat becomes fierce an hour before noon and continues to be so for two hours after, so that the rhythm of life is sensibly lowered. Man and beast

then have their siesta and they have been off hours of office and business from ancient times, though the English hours are now kept from 10 A. M. to 5 P. M.

In general the temperature rises rapidly from January through the months of February and March to a maximum in April, May or June, after which it falls very gradually till the month of September. With the 'burst' of the retreating monsoon in October the temperatures begin to fall more rapidly and this rate of fall continues till December. The lowest mean monthly maximum temperatures are reached in December, when they vary from 81.7° at Vellore to 86.4° at Salem, but the lowest mean monthly minimum temperatures are reached generally in January, when they vary from 64.4° at Coimbatore and Salem to 74.5° at Pamban. During the hot weather the highest mean monthly maximum temperatures vary from 91.5° at Pamban in April to 101.7° at Tiruchirapalli in May, and the highest mean monthly minimum temperatures from 73.5° at Coimbatore to 81.2° at Madras and Pamban. These are from monthly averages. The mean annual range is lowest (10.4°) at Pamban on the sea coast and highest (22.1°) at Salem in the interior. There are, besides, spells of hotness for many days together at a stretch, even at places like Madras on the sea coast, with mercury rising to well over 100°. Heat waves then are not uncommon. But only very seldom does it rise to that degree of oppressive heat that obtains on Guntur-Hyderabad (Dn.) - and Agra tract.

The day temperatures during the hot weather are highest in the whole of Tamilnad at Tiruchirapalli (Max. in May 101.7°) in the heart of the region, probably due to the sun glare and reflected heat of the Tiruchirapalli rock. The hot season is very trying in this place, the range of temperature being very high (23.4° in May) and the atmosphere remarkably dry. The evenings are often rendered comparatively cool by a south-east wind, which sometimes blows with considerable strength; at times bringing up clouds of dust, but soon settling into a pleasant cool breeze.[69]

69. Lewis Moore, *A Manual of the Trichinopoly District*, p. 87.

On the coast the highest mean monthly maximum temperatures are less than 99°, but the highest mean monthly minimum temperatures are greater than 80°. In the northern part of the coast the highest mean daily maximum temperatures are reached towards the end of May and the beginning of June, while in the southern part of the coast (Pamban) they are reached towards the end of April and the beginning of May.[70]

At Salem and Coimbatore the maximum temperatures are highest in April, nearly a month earlier than at Vellore, Tiruchirapalli and Madura, and nearly two months earlier than at Madras, Cuddalore and Nagapattinam.[71] Thus the highest maximum temperatures occur earlier in the interior than on the coast. In the beginning of the hot season, a strong indraught from the sea sets up towards the hot interior, and these southerly winds bring down sensibly the day temperatures with decreasing effect from the coast. During May the westerlies blow down to the coast and overpowers the southeasterly indraught and lessens its cooling effect. These winds are descending winds from the plateau in the west to the sea level, and are therefore subject to compression which increases their temperature. Moreover these winds by the time they reach the coast will have blown over a vast stretch of heated land and their temperature effect is cumulative.[72] Thus towards the end of May and the beginning of June, the coastal places attain their highest temperatures. On the other hand in the interior the increasing heat regime brings about its own reduction by the formation of thunder-storm rains which occur earlier and are heavier than on the coast, so that in the interior places the maximum temperature curve reaches its highest much earlier than on the coast.

At Palamcottah, the heat attains a well defined double maxima once in May and again in September, but the interval

70 and 71. These conclusions are arrived at by a study of the five day normals of maximum and minimum temperatures contained in a special handbook issued by the India Meteorological Department. Unfortunately the temperature figures are given to the nearest degree and not to the tenths of a degree as in monthly normals. This fact has limited their use to a great extent.

72. R. Ll. Jones, *Ind. Met. Mem.* XX, p. 61.

is tempered by the summer winds made cool when blowing down the hills through the monsoon rains there. But the dryness at this place remains pronounced and there prevails an arid aspect.

Winds :—The Peninsula of which this region is the eastern part is the first land excepting Ceylon to encounter the S.W. Monsoon winds. The winds of the region are accordingly strongly monsoonic and are consequently regular and periodic; they blow with constancy of velocity and direction which may be availed of as a source of power if modern appliances are employed. Charged with moisture or dry, heated or cooled at places in their track, they play an all important part in determining the climate of localities.

Storms and cyclones sweep over from the Bay and at times move far into the interior; some have been known to cross the Palghat Gap and destroy shipping in the west coast.

Along the coast the phenomena of land breeze and sea breeze are observed, but very often they are controlled by the force of the monsoons. In the winter months November to February, they are weak, increase rather rapidly in March and April and are strongest during the summer months May to September, when the differential heating between land and sea is at a maximum.[73]

The wind velocities generally attain a double maxima, once during the months of May-June-July and again in December, which fact shows close association with the monsoons. While there is no great difference between the two maxima at the coastal stations, in the interior stations of Tiruchirapalli and Coimbatore, the hot weather maximum is twice as great as the cold weather maximum. This is because the northeast monsoon winds at these places lose their force after having crossed over a vast stretch of land, and the southwest monsoon winds blow with full force direct from the Palghat Gap. The Tamil proverb 'ஆடிக்காற்றில் அம்மியும் பறக்கும்' (*i.e.*, in the

73. R. Ll. Jones: Op. Cit. p. 112.

wind of Adi month—July-August—the grindstone too will fly) aptly describes the force of the summer winds in these parts.[74]

Cloudiness:—Cloudiness is generally least in the spring months of February and March and greatest in the months of the southwest monsoon, though the actual rainfall is generally higher in the months of the retreating monsoon. On an average it is at a maximum in July (6.1)[75] and a minimum in March (2.8). In Nagapattinam and Pamban however, the maximum occurs in November (6.5 and 4.7 respectively) and close to it are the months of October (6.2 and 4.4 respectively) and December (6.3 and 4.4 respectively). Both these towns are very remote from the track of the southwest monsoon winds from the Palghat Gap, but being on the coast are in full sway of the retreating monsoon. The towns of Madras (July 7.1 and November 5.4), Cuddalore (July 5.7 and October 5.2), Coimbatore (July 6.1 and October 5.6), Madura (July 5.8 and October 5.2) and Palamcottah (July 6.8 and October 5.8), under the influence of both the monsoons have two maxima. On the other hand in the interior stations of Vellore, Tiruchirapalli, Pudukottai and Salem, away from the sea influence of the retreating monsoon winds, there is a single maximum of cloudiness in July.

74. The influence of the Palghat Gap over the wind force and the temperature regime is thus described by Mr. Frederick Nicholson in the Coimbatore Manual (p. 10). "In the months of June, July and August, the effects of the Palghat Gap are conspicuous: through the funnel-shaped opening some 16 miles broad, the cool southwest wind rushes with great violence, its course being visible from Coimbatore by a column of clouds and vapour. The cooling effect for many miles is very great, but it has its drawbacks; its violence is such as to overturn laden carts, and entirely to prevent the pitching of tents in the tract opposite to the gap; another drawback is in its tendency, especially in the evening to cause sudden and dangerous chills if the body is incautiously exposed without woollen protection Its violence and cooling effect are largely spent towards the east, (in Coimbatore district) where it is fitful hot and dusty, so that June, and July at Erode and Karur are not pleasant months". As regards its effects further east, Messrs. King and Foote observe, "the southwest wind meets with little or nothing in the Coimbatore district to oppose it, till, east of Cauvery, the Shevaroys and Kolamalais break its force, and receive in heavy showers a large share of its moisture then remaining... Southward of Kolamalais no obstruction is offered to the westerly wind, owing to the absence of mountains the nearest being the Dindigal mountains at a distance of some 40 miles; and in consequence, it blows very strongly across the delta of Cauvery to the east coast. This westerly wind added to the evaporation from the vast area of country laid under water in the delta, during the prevalence of freshes in the Cauvery, tends to cool very greatly the intensely hot climate of Tanjore district." (*Mem. G. S. I.*, IV Pt. 2, p. 10).

75. Cloudiness is measured as so many parts in tens of the sky.

Relative Humidity:—Relative humidity, as might be expected, is higher on the coast than in the interior and higher in the months of October to February than in the summer months. On an average it is at a minimum (68%) in June, and maximum (82%) in January. At the coastal stations a single maximum (in December or January) alone is reached. At these stations, as the dry season sets in later than December, the added effects of precipitation and low temperatures result in a maximum humidity in December and January. But at the interior stations double maxima, one in October or November and the other in January, are generally attained. At these latter stations the first maximum in October or November is due to the 'burst' of the retreating monsoon. This is followed by a minimum in December, when the dry season sets in at these interior stations. The second maximum in January is, of course, due to the night temperatures being lowest in January (Note: the figures of Relative Humidity are those at 8 A.M.)

Salem has a single maximum (81%) in October. The minimum both at Coimbatore (79%) and Salem (72%) falls in March and not in June. The minima here, it may be noted, is higher than the average of 68%. These wide departures from the normal are accounted for by their nearness to the Palghat Gap which serves as the surface gateway of the southwest monsoon.

Evaporation[76]:—Along the coast, evaporation generally increases from south to north. In the months of October, November and December, the rainfall is in excess of evaporation along the coast. In other months, evaporation is greater than rainfall, (except in September at Madras, when the rains of the southwest monsoon are greater than at the southerly stations), and this excess of evaporation over rainfall increases from north to south.

Both at Coimbatore and Madura the rainfall is in excess of evaporation only in the months of October and November.

76. Evaporation data are available for six stations only, *viz.* Madras, Nagapattinam Pamban, Salem, Coimbatore and Madura in the tables compiled by Messrs. P. K. Raman and V. Satagopan, published in p. 61, of Vol. VI of the Sc. Notes of the Ind. Met. Dept.

Owing to its elevation and the consequent low temperatures, Coimbatore has the lowest amount of evaporation, whereas in Madura the highest values for evaporation are to be found.

At Salem evaporation is at a maximum in April, the month of the highest temperatures. Rainfall is in excess of evaporation in the months of August, September, October and November, which are the rainy months of the station.

Excluding Salem, at the other stations, evaporation is at a maximum in June, when the direction of wind is off-shore. The long travel from west to east through the Palghat Gap and other routes following the lie of the land causes it to get superheated. These facts of hotness, strength, velocity and direction give the winds such high moisture taking and retaining capacity.

The Seasons of Tamilnad.

The weather cycle of Tamilnad consists of the following four seasons (For the basis of classification see Rainfall Rythm, p. 34).

(*i*) The Hot Weather season—from Mid-February to Mid-June.

(*ii*) The Southwest Monsoon season—from Mid-June to Mid-October.

(*iii*) The Retreating Monsoon season—from Mid-October to Mid-December.

(*iv*) The Cold Weather season—from Mid-December to Mid-February.

The variations in the wind velocity at Madras (for which daily data are available in 'the Madras Observatory Meterological Means') confirms the above cycle of seasons. There are two maxima and minima in wind velocity and their dates coincide very nearly with the dates which mark the commencement and the end of the four seasons. There is a uniform increase

during the hot weather and the retreating monsoon season and a uniform decrease during the southwest monsoon and the cold weather seasons.[77]

The Hot Weather Season:—The high pressure of the previous cold season in the north of Tamilnad weakens in February with the apparent northward movement of the sun and the consequent increase of temperature. On account of these changes the northeasterly winds of the previous season lose their strength and steadiness.

In March the temperature rises very rapidly in the interior and the hottest area is now shifted northwards. The pressure over land tends to be more and more uniform. At 8 A. M. it is slightly higher in the interior than in the surrounding seas. During the day, land becomes hotter and hence an area of lower pressure than the seas. The same is true of April. The morning high pressure almost disappears and the afternoon low pressure becomes marked over land (Climatological Atlas of India, Plates 13 and 14). The northeasterly winds of the previous season change to the southeasterly indraught from the seas towards the hot interior, and become very strong during the day. In April these winds become more southerly and damp and are known along the coast as the 'long shore winds'. In May the humidity is low and air movement is light being largely ascensional.[78]

During the hot season, the weather is generally fine interrupted occasionally by thunderstorms, whose frequency increases rapidly with increase of temperatures. The hot weather thunderstorms are due to the instability caused when the inflowing air up to a height of 2 kms. from the surrounding seas is overrun at 3 kms. and above by dry land air.[79] Their frequency increases from the coast towards the mountainous interior, owing to the increased convection on mountain slopes.

---

77. R. Ll. Jones, *Ind. Met. Mem.* XX, p. 83.
78. R. Ll. Jones, *op. cit.* p. 54.
79. S. P. Venkiteshwaran, *Ind. Met. Dept. Sc. Notes*, IV, pp. 144-151.

of the Bay. These conditions over the Bay favour the formation of cyclones.[88] The rainfall of this season is closely associated with this seasonal depression in the Bay, round which the humid current of the retreating monsoon blows towards the east coast of the region, and this current is vigorous, when the depression concentrates into a storm. These winds often recurve through the south and east round the seasonal depression in the Bay and appear on the Tamilnad coast as northeasterly winds. In the month of October the change of wind direction from the southwest to the northeast is almost sudden, occurring in a few days or even hours.[89]

The thunderstorms of this period are due to the retreating monsoon winds from the sea round the seasonal depression in the Bay, overrun by anticyclonic continental currents blowing from North India at higher levels.[90]

When the seasonal depression in the Bay develops into a cyclone, it moves into the land carrying heavy rain with it.[91]

As the season advances, though the direction of wind remains more or less the same (*i.e.* from the northeast) the winds tend to become cold and dry having their origin in the

88. The cyclones appear to form along the zone of contact between the continental air-mass on the one hand, and the oceanic air-mass on the other, when these possess the greatest contrasts of temperature and hmidity. It is obvious that temperature and the humidity differences will be at a maximum when these air-masses have been allowed to remain more or less stationary, the continental air-over the land area, and the oceanic air over the sea surface. Such a stagnation of air will occur only when the pressure differences are slight, over India and the adjacent seas, and such pressure conditions occur during the months of April and May, and again in October and November, which form the two transitional periods intervening between the southwest monsoon and cold weather months.

89. R. Ll. Jones, *Ind. Met. Mem.* XX, p. 68.

90. S. P. Venkiteshwaran, *Ind. Met. Dept. Sc. Notes*, V. pp. 63-68.

91. About the connection between the storms of this season and the rains Mr. K. P. Ramakrishnan observes as follows: -

(i) Rainfall often begins in the coastal districts when the storm is 200-300 miles of the coast ;

(ii) The rain area is generally more extended on the right side of the storm track than on the left ;

(iii) There are found two distinct separated areas of very heavy rainfall, one of which lies near the storm track and the other on its right,

(iv) The dissipation of a storm is usually accompanied by a divergence of these rainfall areas ; and

(v) There is a great tendency for one of these rainfall areas to move along north Madras coast and for the other to move northwestwards across the western half of the Peninsula. (*Ind. Met. Dept. Sc. Notes*, VII, p. 47).

north Indian High pressure area, when they are known as the northeast monsoon winds. This is the result of the gradual diminution of the incursion of the southwest monsoon into the Bay leaving the field clear for the cold dry northeast monsoon winds. Generally about the third week of December the south west monsoon disappears altogether in the Bay and the northeast monsoon and dry fine weather prevail throughout. Thus this period of increasing wind velocity is the transition period between the southwest monsoon and the cold weather periods, during which the southwest monsoon retreats leading to the establishment of the northeast monsoon over southern India with steeper gradients.[92]

Sometimes it may so happen that the high pressure of North India extends southwards quicker than usual with the result that the seasonal depression in the Bay is forced away from the coast of Tamilnad resulting in a premature ceasing of rains. In such a case, the cold winds of the northeast monsoon set in quicker than usual resulting in the cold dry weather with dew falling in early mornings. This has given rise to the saying that there will be no rain if there is dew.[93]

The Cold Weather Season:—In the cold weather season, the temperature increases from north to south and the hottest area for the whole of India lies in the extreme south of the peninsula. The cold weather pressure distribution may appear to be very similar to that of the retreating monsoon, and the difference between the two may not be quite clear. In the cold weather distribution, the area of lowest pressure is to the south of Ceylon and northeasterly winds consisting mainly of the anticyclonic continental air, prevail throughout. In the retreating monsoon season, on the other hand, the pressure is lowest in the southwest of the Bay and the southwest monsoon is still blowing into the Bay.[94] As the pressure becomes uniform during the cold weather season, the air movement falls off in

92. R. Ll. Jones, *Ind. Met. Mem.*, Vol. XX, p. 88.

93. *Ibid*, pp. 66-67.

94. Ibid, p. 55.

strength. This season is characterised by fine dry weather, warm days and cold nights.

Rainfall Rhythm.

Description of the Method :—Rainfall data have been analysed and studied in the light of statistical methods by Crowe, Matthews, Williamson and Mahalingam (See Appendix II for an outline of their methods). The procedure elaborated by them has been applied here with remarkable results to the statistical analysis of rainfall data of this region collected for 54 typical stations for thirty-five years from 1903 to 1937 at half-monthly intervals. Instead of the ordinary arithmetic mean, the median forms the basis of study. The figures of rainfall of a station for a particular half-month in all the 35 years are arranged in a descending order. In this sequence the median (M) is the mid-most term (here the 18th term of the descending series of 35 terms). This median is likely to vary with the sample of the years chosen for study. Dr. Savur has elaborated a method by which we can find out the probable range within which the median may vary with different samples. If 5% error is allowed in estimating this interval, it is called the 5% confidence interval *i.e.* an interval within which the variation of the median may be confidently expected to range with 95% probability. In this sample of 35 years, the 12th and 24th terms (Upper limit L_u and Lower limit L_l respectively) in the descending sequence give the limits of that interval. It so happens in this particular case of 35 years, a third of the years have rainfall below L_l, a third between L_u and L_l and the remaining third above L_u.

The year has been divided into twenty-four half-monthly periods. This is the base line of the graphs prepared. The off-sets represent the frequency and amount of rain with its Upper limit (L_u) and Lower limit (L_l) of the confidence interval for the Median (M). These three have been plotted; and standing side by side they afford means of comparing the rapidity of change between any two contiguous half-months.

The positions of L_u, M, and L_l of any at one half-month (say I) in comparison with the corresponding values of the immediate next half-month (say II) afford the criteria for the rapidity of change. Three degrees of significant changes (increases or decreases) are discernible. In all the three degrees of increases, the median of the following half-month (II) stands higher than the median of the preceding half-month (I) and in all the three, each of L_u, M and L_l of the following half-month (II) stands higher than the corresponding values of the preceding half-month (I).

In the increase of the third degree (the increase of the highest degree).

II L_l is higher than I L_u (II L_l > I L_u)

In this case the 5% intervals do not have a common part.

In the increase of the second degree

and II L_l is higher than I M (II L_l > 1 M)
and II. M is higher than I L_u (II M > 1 L_u)

In the increase of the first degree is included all other types of changes where each of the three values L_u, M and L_l show an increase.

In this increase it may be noted that

II L_l is not higher than I M (II L_l $\ngtr$ I M)
and II M is not higher than I L_u (II M $\ngtr$ I L_u)
simultaneously in the same instance.

Similar definitions hold good for decreases.

In the decrease of the third degree -

II L_u is less than I L_l (II L_u < I L_l)

In this case the 5% intervals do not have a common part.

In the decrease of the second degree

II L_u is less than I M (II L_u < I M)
and II M is less than I L_l (II M < I L_l)
simultaneously

All other types of changes in which three values show a decrease is defined as decrease of the first degree.

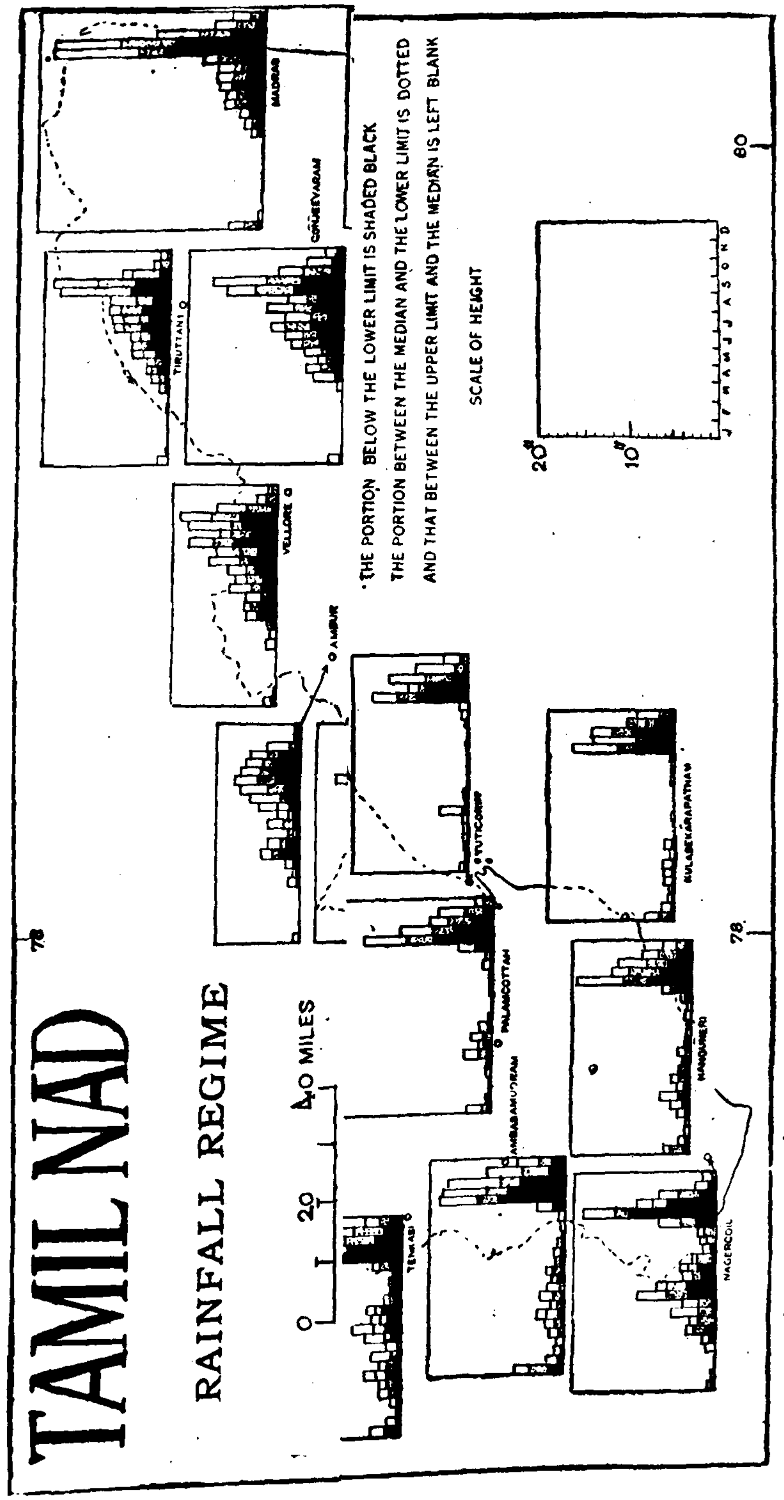
Rainfall of a particular station is considered to attain a maximum (here the term maximum is not used in the ordinary sense as the greatest of all the possible values of a varying quantity, but in the extended sense as the value of the varying quantity at the point at which it ceases to increase and begins to decrease) in a particular half-month if all the three values L_u, M and L_l are at a maximum *i.e.*, if it is preceded and succeeded by increase and decrease respectively of at least of the first degree.

Rainfall of a period in this paper is taken to mean the sum of the medians during the different half-months of the period. Here it may be noted that the sum of the medians is not equal to the median of the sum. This does not mean that the sum of the medians is valueless. For most of the agricultural operations the effect of rainfall is but slightly cumulative. Rain must come at a period and a later excess will have but little chance of remedying an initial deficiency. From this point of view the ordinary seasonal total would also appear to be an abstraction and for descriptive purposes a summation of medians or mean monthly expectations would not be out of place.[95]

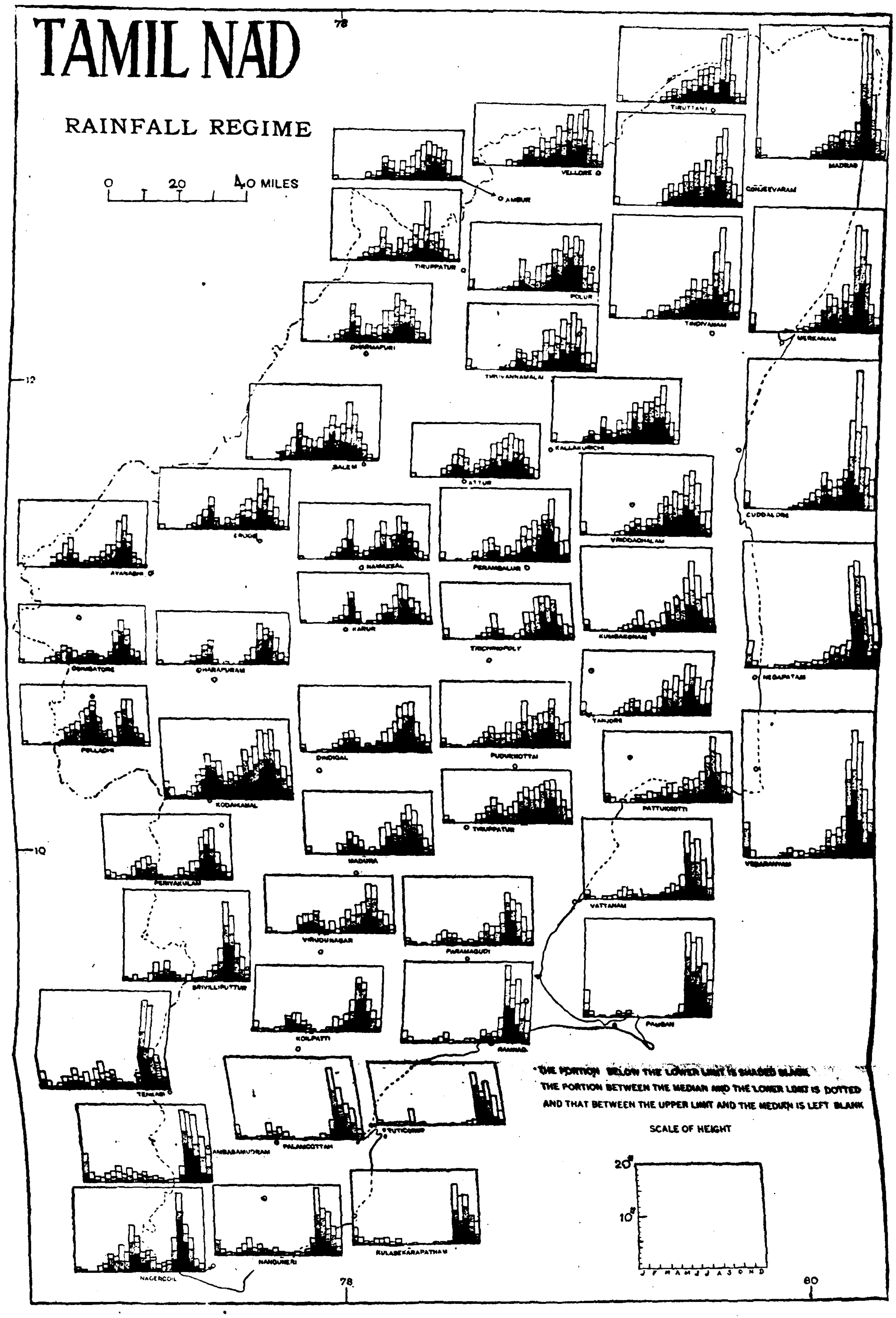
A period is taken as a dry period if the rainfall in the various half-months of the period is not significant *i.e.*, when the L_l's are all zero. In such a period in each half-month, at least in a third of the years there was no rainfall.

Advantages of the Method:—By these methods there has been obtained a statistical law of rainfall of each of the stations studied. Of each station we can predict the norm at which as at the bull's eye, nature tends more and more to hit. This in itself is a notable gain to be able to determine the normal features of rainfall of a particular station, amidst the seemingly arbitrary occurrence of rainfall.

95. P. R. Crowe, *S. G. M.* XLIX, p. 85.



MAP 6.


TAMIL NAD
RAINFALL REGIME
0 20 40 MILES
THE PORTION BELOW THE LOWER LIMIT IS SHADED BLACK
THE PORTION BETWEEN THE MEDIAN AND THE LOWER LIMIT IS DOTTED
AND THAT BETWEEN THE UPPER LIMIT AND THE MEDIAN IS LEFT BLANK
SCALE OF HEIGHT
20"
10"
J F M A M J J A S O N D
78
80
12
10
MADRAS
TIRUTTANI
VELLORE
AMBUR
TIRUPPATUR
POLUR
TINDIVANAM
DHARMAPURI
TIRUVANNAMALAI
SALEM
ATTUR
KALLAKURICHI
CUDDALORE
ERODE
AVANASHI
NAMAKKAL
PERAMBALUR
VRIDDACHALAM
KARUR
TRICHINOPOLY
KUMBAKONAM
COIMBATORE
DHARAPURAM
NEGAPATAM
TANJORE
POLLACHI
KODAIKANAL
DINDIGAL
PUDUKKOTTAI
PATTUKKOTTAI
TIRUPPATUR
MADURA
PERIYAKULAM
VIRUDUNAGAR
PARAMAGUDI
VATTANAM
SRIVILLIPUTTUR
KOILPATTI
RAMNAD
PAMBAN
TENKASI
PALAMCOTTAH
TUTICORIN
AMBASAMUDRAM
NAGERCOIL
NANGUNERI
KULASEKARAPATNAM

MAP 6.

In the second place, there is ascertained the law of its spread upon the time of the year - its date and intensity - a stable foundation for forecast.

Thirdly, the several distributions are susceptible of grouping and classification and the march of seasons can be followed in the station with accuracy.

Fourthly, through the study of rainfall we obtain the differential criteria for marking off one sub-region from another while the other elements such as temperatures are of small help only, the variations being small and the observations having been made at fewer stations.

Rainfall Rhythm :—In this section it is proposed to describe the features of rainfall rhythm such as the nature of the changes between two contiguous half-months and the several maxima and minima occuring in the course of the year. For the purposes of the study of the rainfall cycle, it is better to start the year with the middle of February instead of following the ordinary calendar year, as the month of February happens to be the driest month in the year. This departure from the usual procedure of beginning with the calendar year is also justified by the fact that the main agricultural operations do not close with the end of December as the harvest of the main crop generally takes place in the month of January or early in February.

Increase of the third degree at the end of March :—The early hot weather showers appear generally in the month of March in the western parts of Tirunelveli and Ramnad districts near the ghats, where the influence of the mid-day sun is felt first. The end of March witnesses increase of the third degree in three areas *viz.*, Madura, Virudunagar and Koilpatti belt in the south, in Dharmapuri, Yercaud, and Salem belt in the northwest and at Pollachi in the vicinity of the Palghat Gap. In the stations surrounding the Madura, Virudunagar and Koilpatti belt, the increase at the end of March is of the first or second degrees, as the hot weather rains appear earlier in the western parts near the ghats and they are later and much less in amount towards the coast.

The increase of the third degree in the northern area is due to their being in the midst of high hills facing the current of pre-monsoon air from the Arabian Sea through the Palghat Gap.

Mid-May increase of the third degree:—In the middle of May increase of the third degree is found in a central belt in the northern part of the Tamilnad similar to that at the end of March in the central belt of the southern part of the region, and the same explanation holds good for its being confined to the central zone (*i.e.*) outside this central zone the hot weather rains appear earlier in the south-western and western parts near the ghats and they are later and much less in amount in the north-eastern and eastern parts. Increase of the second degree in Mid-May is found in stations surrounding the belt of increase of the third degree on all sides except the plains on the southeast.

Maxima during the hot weather season:—In the Western parts of the districts of Ramnad and Tirunelveli and in the peninsular portion of the former district (*e.g.* stations of Ramnad and Pamban and at Tuticorin) the hot weather maximum occurs in the first half of April. The eastern parts of Ramnad and Tirunelveli do not generally show a hot weather maximum as the rains during this season are very small in amount. The hot weather maximum occurs in the first half of May in Kodaikanal, Periyakulam and Madura in the western Madura District, and also at Vedaranyam cape. The stations of Nanguneri and Ambasamudram in Tirunelveli also have this maximum in the first half of May in addition to the one in the first half of April. In the Sub-coast zone of Chingleput, South Arcot and Tanjore Districts the hot weather maximum occurs either in Mid-May to Mid-June period (Wandawashi, Tindivanam and Tanjore) or in the first half of June (Kanchepuram and Kumbakonam). West of this sub-coast zone over the whole of the northern and central parts of

Tamilnad the hot weather maximum prevails in the second half of May. Thus we see that the hot weather maximum occurs earlier in the southerly stations and later towards the north.

Decreases in Mid-May and Mid-June:—The rainfall decreases marking the end of the hot weather showers is of the third degree at the end of May just on the leeward side of the Palghat Gap and is of the second or third degree in Mid-June farther away from the Gap on the northeastern and the eastern sides. This decrease is not to be seen in the coastal and sub-coastal stations where the hot weather rains are poor.

Minimum in the second half of June:—In the second half of June there is to be found a general minimum of rains marking the transition from the rains of the hot weather to those of the southwest monsoon. The minimum is not well marked or even absent in three areas,—firstly, in the coastal and sub-coastal region of the northern part of the Tamilnad, where the hot weather showers are small and even these are late in occurrence and are in continuity with those of the southwest monsoon of the second half of June, secondly in parts of Tirunelveli and Ramnad coasts where very little rain falls during the early southwest monsoon period as also during the hot weather period; and thirdly in the sub-ghat region of Tirunelveli and Ramnad districts and also at Pollachi in Coimbatore, where the southwest monsoon rains appear early in continuation with those of the hot weather.

Increase at the end of July and in Mid-August:—Increase of the second degree at the end of July is found in a belt extending from Dindigal and Madura to Tanjore and Pattukkottai, and in the middle of August it is a feature of the Cauvery valley and delta and a few stations on its northern side.

Second Degree increase at the beginning of October:—The increase of at least of the second degree at the beginning of October is a feature of all the stations west of the longitude of Erode (excluding the hill-station of Kodaikanal). This is partly due to the fact that the September rains of the southwest monsoon at these places are poor and partly to the increase of thunderstorm showers in these sub-ghat sections before the burst of the retreating monsoon on the coast.

Maxima during the southwest monsoon season :—The maxima of rains during the southwest monsoon season occur in four periods *viz.*, (*i*) first half of July, (*ii*) second half of July, (*iii*) second half of August and (*iv*) second half of September. The maximum in the first half of July is found in all the stations lying in the latitude of Vedaranyam cape and in Tanjore and Perambalur to the north of this line and in Madura to the south. The maximum in the second half of July is confined to Coimbatore, Pollachi, Tenkasi and Nagercoil. The maximum in the second half of August is a feature of the sub-coastal region extending from Kanchepuram on the north to Tiruppattur (Rd.) in the south and is found in a few stations in the interior north of the Cauvery. The maximum in the second half of Sepember is a feature north of the latitude of Merkanam, excluding Madras in the northeastern corner and Ambur in the northwestern corner.

The October maximum is a feature of Namakkal and Karur and the maximum in the first half of October in Erode and Tiruchirapalli. These are due to the combined effects of both the advancing and the retreating monsoons.

Mid-October Increase :—The burst of the retreating monsoon in the middle of October is the most remarkable of all the changes taking place in the whole year. Out of the fifty-four stations, significant increases of the first degree are felt in eleven, of the second degree in eleven and of the third degree in sixteen of the stations. The increase of the third or the highest degree occurs in all the coastal stations (with the exception of Cuddalore) and in the sub-ghat zone in the extreme south of the peninsula (*e.g.* Srivilliputtur, Tenkasi, Ambasamudram, Palamcottah and Nanguneri). As we go into the interior from the coast, the gradient of change becomes less and less steep passing into

those of the second and the first degrees and finally becomes imperceptible. In some interior stations (Ambur, Uttankarai, Erode and Tiruchirapalli) there is even a decrease of the first degree at this time. These are due to the fact that the rains following the 'burst' are very heavy on the coast and decrease towards the interior.

Maxima during the retreating monsoon season :—The maximum rainfall of the year in Tamilnad generally occurs in the period Mid-October to Mid-November. Exceptions to this are however to be found in the western sections of the northern half of the region far away from the coast, where the southwest monsoon rains are heavier than the retreating monsoon rains.

It is a common notion of all writers on rainfall that the rainfall zone tends to move south with the advance of the year, with a November maximum at Madras and Nagapattinam and a December maximum in Ramnad and Tirunelveli coasts. This is the result of a study of monthly averages. It is very surprising to note that this is not the case when half-monthly basis is followed. The maximum occurs in the first half of November at Cuddalore, Nagapattinam and Vedaranyam, but in the second half of October at stations in the southern part of the coast. In the second half of October the seasonal depression is in the middle of the Bay and the air currents blowing round it reach the Tirunelveli coast through the Gulf of Mannar between the mainland and the island of Ceylon. But in November and December when the seasonal depression in the Bay is directly to the east of Ceylon, the air currents blowing round it to the Tirunelveli coast have to cross the landmass of Ceylon and hence there is a decline of rains in November and December. Unfortunately this is not borne out by maps of wind currents, as the recording stations are few and far apart. (It may be noted in this connection that there are two maxima at Kulasekarapatnam on the South Tirunelveli coast during this season. The maximum in the second half of October is followed by a minimum in the first half of November and again by a maximum in the second half of November. The decrease of rains in the early November is probably due to the same cause).

Decrease in the middle and end of November:—In the middle of November the decrease of the second degree is felt generally at the interior stations and of the first degree in the coastal and sub-coastal stations. No decrease of any degree in Mid-November is to be found at stations on the south coast. The end of November witnesses decrease at all stations with the solitary exception of Ramnad. This is of the second degree at 14 stations, and of the first degree at all others. Thus the decrease is a widespread occurrence during the second half of November.

Transition to the Dry Period:—In the first half of December the rainfall is significant (*i.e.* the lower limit L_l is above zero which means at least in two-thirds of the years there was rainfall) in all the stations except those five stations (Ambur, Tiruppattur, Salem, Namakkal and Karur) on the leeward side of the Javadis, Shevaroys and the Pachamalais. But in the second half of December and the first half of January in about half the stations rainfall is not significant. Hence this period Mid-December to Mid-January may be taken as the interval or transition between the rainy period, and the dry period.

Dry Period:—From the middle of January to the end of March it is very dry, only a few places getting 'significant' rainfall, while the month of February is the driest, no place getting 'significant' rainfall in this month. Judging from the upper limits and the medians, the minimum for the year happens to fall either in the first half or in the second half of February. Hence in this paper the dividing line between the retreating monsoon rains and the hot weather rains is taken to be in the middle of February, the rains of the first half being classed with the retreating and those of the second half with the hot weather.

From a study of the above rainfall rhythm it is evident that the year can be divided into the following rain periods:—

(*i*) The hot dry period—Mid-February to the end of March.

(*ii*) Period of the hot weather showers—Beginning of April to Mid-June.

(*iii*) Transition to southwest monsoon rains—Second half of June.

(*iv*) The period of the southwest monsoon rains—Beginning of July to Mid-October.

(*v*) The rainy period of the retreating monsoon—Mid-October to Mid-December.

(*vi*) The cold transition period between the rainy period and the dry period—Mid-December to Mid-January.

(*vii*) The Cold dry period—Mid-January to Mid-February.

These rain periods naturally group themselves into the following four seasons.

(*i*) The Hot Weather Season—from Mid-February to Mid-June.

(*ii*) The Southwest Monsoon Season—from Mid-June to Mid-October.

(*iii*) The Retreating Monsoon Season—from Mid-October to Mid-December.

(*iv*) The Cold-Weather Season—from Mid-December to Mid-February.

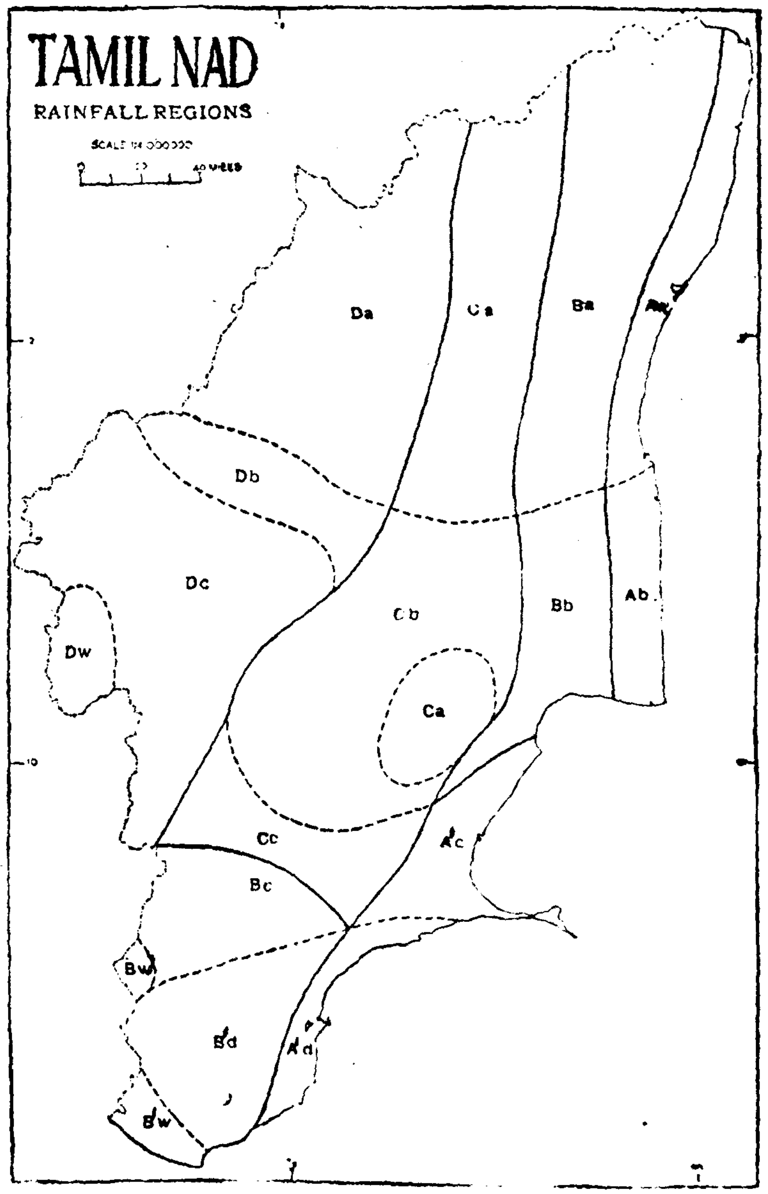
Rainfall Sub-regions.

From the previous section on the rainfall rhythm, it is clear that the rainfall of Tamilnad can be classified under three heads.

(*i*) Retreating Monsoon Rains—from Mid-October to Mid-February.

(*ii*) Hot weather rains—from Mid-February to Mid-June

(*iii*) Southwest monsoon rains—from Mid-June to Mid-October.



MAP 7.

The whole region may be divided into the following sub-regions for the purpose of our study, which are styled as Zones A, B, C, D, A' and B' with respect to the retreating monsoon and the hot weather rains and Divisions a, b, c, d and w with respect to the southwest monsoon rains.

A. The North Coastal Zone.

The sum of the medians during the period of the retreating monsoon rains (hereafter this is simply stated as 'retreating monsoon rains') is greater than 20". The Mid-October increase which ushers in this monsoon is of the third degree at all places except at Cuddalore, where the increase, though of the second degree, is very near the third. These rains are at a maximum in Mid-October to Mid-November period at Madras and Merkanam in the north, and in the south it is concentrated in the first half of November. The end of these rains in Mid-January is marked by decreases of at least of the second degree. The dry season (*i.e.* the period in which the lower limits are all zero, when in each half-month of the period no rain has fallen in more than a third of the years) commencing from the middle of January lasts till the month of June. The hot weather rains are very late in occurrence and are less than 1". Hence there is no hot weather maximum in this zone (except at Vedaranyanam in the extreme south in the first half of April, where these showers approach 1").

B. The Sub-Coastal Zone.

In this zone, the retreating monsoon rains vary from 11" to 20". Mid-October increase of the second degree is felt in all stations except Vizhupuram and Vriddachalam facing the concave bend of the coast. The dry season starts by the beginning or middle of January (at Tiruttani on the northern margin by the middle of December) and lasts till the beginning or the middle of May. The retreating monsoon rains attain a maximum in Mid-October to Mid-November period (at Kumbakonam and Pattukottai this is concentrated in the first half of November). The hot weather rains attain a maximum in Mid-May to Mid-June or in the first half of June.

C. The Sub-Montane Zone.

In this zone, the retreating monsoon rains vary from 8" to 11". During the middle of October either there is no increase at all or at best an increase of the first degree. (At Perambalur and Virudunagar near the margins second degree increase is found). The retreating monsoon maximum during Mid-October to Mid-November period becomes much less pronounced than in zones A and B, and is not felt at all at some of the stations. The dry season begins by the middle of December in the northern half of this zone and by the middle of January in the southern half. It ends by the beginning of May in the north, and earlier at some stations in the south, when the hot weather rains commence. These rains vary from 2" to 5", with a maximum generally in the first half of May. In the northerly station of Vellore the maximum occurs in the first half of June and at the southerly station of Madura in the first half of May.

D. The Intermontane Zone.

In this zone the retreating monsoon rains are less than 8". There is no Mid-October increase of the second degree except at Pollachi. The increase of the first degree is found in the stations in the vicinity of the Palghat Gap in the southern part of this zone. There is no Mid-October increase of any degree in the northern part, but on the contrary a decrease of the first degree is to be seen at Ambur, Uttankarai and Erode. The retreating monsoon maximum in the second half of October is to be seen only in the southern part of this zone and not in the northern part.

The dry season commences by the beginning or the middle of December and lasts till the beginning or the middle of April. Only in the northern station of Ambur it is prolonged to the end of April. The hot weather rains appear much earlier than in the previous zones and are generally heavier varying from 3" to 6" with a maximum in the second half of May.

A′ The South Coastal Zone.

In this zone the retreating monsoon rains vary from 10" to 22". The Mid-October increase of the third degree and the maximum of the second half of October is found throughout this coast. The dry period between the retreating monsoon rains and the hot weather rains, lasts generally from Mid-January to the end of March. The hot weather showers are less than 1" as in zone A. The hot weather maximum is noticeable only at three stations (Ramnad, Pamban and Tuticorin) where it occurs in the first half of April.

B′ The Southern Sub-Ghat Zone.

In this zone the retreating monsoon rains vary from 12" to 20". Mid-October increase is of the third degree in all places except at Koilpatti. The retreating monsoon rains attain a maximum in the second half of October (at Koilpatti in Mid-October to Mid-November period). The dry period between the retreating monsoon rains and the hot weather rains is varying, shorter towards the mountainous west and south and longer towards the north and east, but nowhere does it extend beyond the end of March. The hot weather rains excluding Tenkasi and Nagercoil, vary from 2" to 4" with a maximum in the first half of April.

Rainfall Divisions:—Now let us consider the divisions a, b, c, d, w with reference to the southwest monsoon rains.

a. The Northern Division.

The southwest monsoon rains exceed 10.5". There is no dry period during the southwest monsoon season. There is an outlier of this division in division b.

b. The Central Division.

The southwest monsoon rains vary from 7.5" to 10.5". With the exception of four stations, Namakkal, Nagapattinam, Pattukkottai and Madura, there is a second dry period whose duration varies from a half-month to a month and a half all in the period from Mid-June to the end of July. Another feature of this division is the prevalence of a maximum in the first half of July in many of the stations. (The northerly stations of this division *viz.* Erode, Namakkal, Tiruchirapalli, Kumbakonam and Nagapattinam do not have this maximum).

c. **The Western and South Central Division.**

The southwest monsoon rains range from 3" to 7.5". Excepting at Avanashi and Coimbatore in the extreme north-west of this division there is a second dry period during the southwest monsoon season, whose duration varies from a month at Vattanam to three months at Dharapuram, all in the period from the middle of May to the middle of September.

d. **The Southern Division.**

The southwest monsoon rains are less than 3". The dry period during the southwest monsoon season is most pronounced, the duration varying from a month and a half at Nanguneri to the whole season at Kulasekarapatnam. The rainfall decreases from west to east and the coastal section of this division receives practically no rain during this season (less than 1").

w. **The West Coast Type Division.**

This division w (Pollachi, Tenkasi and Nagercoil) includes stations which are favourably situated with respect to the southwest monsoon winds either in or opposite the gaps in the Western Ghats or on their windward side. Here the June-July rains are a continuation of the hot weather rains and hence there is no second half of June minimum characteristic of Tamilnad.

The Sub-Regions in detail:—By superimposing a, b, c, d, w Divisions according to tho southwest monsoon rains on A, B, C, D, A′ B′ Zones according to the retreating monsoon and the hot weather rains, we have a system of sub-regions Aa, Ab, Ac, etc. Let us now study these sub-regions in detail taking Zone by Zone.

A. **The North Coastal Zone.**

The common features are:—

(*i*) Retreating monsoon rains more than 20".

(*ii*) Mid-October increase of the third degree (except at Cuddalore).

(*iii*) Retreating monsoon maximum in Mid-October to Mid-November period or in the first half of November.

(*iv*) Hot weather rains less than 1".

(*v*) No hot weather maximum (except at Vedaranyam in the extreme south).

(*vi*) Dry season from Mid-January to the beginning, middle or end of June.

(*vii*) Mid-January decrease is at least of the second degree.

There are two sub-regions in this zone, Aa and Ab.

Aa gets better rains during the southwest monsoon period as it directly faces the southwest monsoon winds from the Palghat Gap, but Ab receives less rain being away from that track. Merkanam in the concave bend of the coast has two maxima during this season, one in August and the other in second half of September, and receives the heaviest rainfall among the coastal stations during the southwest monsoon season

Over the whole Zone the retreating monsoon rains decrease southwards from Madras towards Merkanam and Cuddalore and then increases further southwards, reaching their highest at Vedaranyam in the whole of Tamilnad. This is explained by the configuration of the coastline which bends inwards at Merkanam and Cuddalore, but outwards at Madras and the Cauvery delta. As the retreating monsoon is the major contributing factor, the rainfall of the year decreases from Madras to Merkanam and then increases southwards up to Vedaranyam, though the reverse is the case with the southwest monsoon rains.

The sum of the medians for the year is greater at Vedaranyam (42.4") than at Nagapattinam (35.06"). The median of the annual totals also is greater at Vedaranyam (55.24") than at Nagapattinam (50.29"). But the annual average is slightly higher at Nagapattinam (54.98") than at Vedaranyam (54.35"). From a study of the actual rainfall totals for the thirty-five years, it is seen that very high totals are much more frequent at Nagapattinam than at Vedaranyam, and these make the average at Nagapattinam higher than at Vedaranyam though the rainfall of the latter is generally higher than that of the former.

The hot weather rains are very late in occurrence towards the north and are earlier and much more frequent in the south. At Vedaranyam in the extreme south there is even a maximum in the first half of April.

B. The Sub-Coastal Zone.

The common features are:—

(*i*) Retreating monsoon rains - 11" to 20".

(*ii*) Mid-October increase of the second degree (except at Vriddachalam and Vizhupuram).

(*iii*) Retreating monsoon maximum in Mid-October to Mid-November period or in the first half of November.

(*iv*) Hot weather rains - 1" to 2".

(*v*) Hot weather maximum in Mid-May to Mid-June period or in the first half of June.

(*vi*) Dry season from the beginning or the middle of January to the beginning or the middle of May.

There are two sub-regions Ba and Bb. At Kanchepuram, Wandawashi and Tindivanam in Ba there is a Mid-May increase of the second degree, a common dry period from the beginning of January to Mid-May, and annual median sum greater than 30". These stations have two maxima during the southwest monsoon season, once in the second half of August and again in the second half of September.

In Vizhupuram and Vriddachalam in the southern part of sub-region Ba, the Mid-October increase is only of the first degree owing to the inward bend of the coast, which causes the rains of the second half of October owing to the retreating monsoon to be less than in stations north or south in the Zone.

In Bb (Kumbakonam and Pattukottai) the beginning of the dry season is delayed to Mid-January, a half month later than in the northern sub-region Ba. The Mid-August increase of the second degree, the end of December decrease of the second degree, Mid-January decrease of at least of the second degree and a first half of November maximum are the special features of this sub-region in contrast to Ba.

Taking the whole Zone, the retreating monsoon rains increase from Tiruttani in the north up to Vizhupuram, and after a decrease at Vriddachalam (west of the inward bend of the coast) again increase towards the south. The 5% interval of the median is larger in the first half of November than in the second half of October, indicating greater variability of rains in the first half of November.

C. The Sub-Montane Zone.

The common features are:—

(*i*) Retreating monsoon rains - 8" to 11".

(*ii*) Mid-October increase is at best of the first degree excluding the border stations of Perambalur, Tanjore and Virudunagar.

(*iii*) Retreating monsoon maximum becomes much less pronounced than in Zones A and B and is not found at all in some of the stations.

(*iv*) Hot weather rains - 2" to 5".

(*v*) Hot weather maximum generally in the second half of May.

(*vi*) Dry season from Mid-December to the end of March at the southern stations.

There are three sub-regions Ca, Cb and Cc.

At Vellore, Polur and Tiruvannamalai in the northern part of the sub-region Ca there is a Mid-May increase of the third degree and a common dry period from Mid-December to the end of April. The southern part of the sub-region Ca (Kallakurichi and Perambalur) tends to possess some of the characteristics of Zone B, its retreating monsoon rains (9.5" to 11") approaching those of Zone B. There is a maximum in Mid-October to Mid-November and there is even an increase of the second degree in the middle of October at Perambalur. In the outlying portion of this sub-region Ca (Pudukkottai. Tiruppattur, and Ramnad) the retreating monsoon maximum falls in the first half of November.

In Cb (Tiruchirapalli, Tanjore, Dindigal and Madura) the dry season begins by the middle of January with a decrease of at least of the second degree (except at Tanjore). The hot weather rains cease with a decrease of at least of the second degree in Mid-June.

Tanjore near the border of Zone B has its hot weather maximum in Mid-May to Mid-June and its retreating monsoon maximum in Mid-October to Mid-November period as in Zone B.

The sum of the medians for the year in Cb is between 22" and 24" whereas in Ca it is from 25" to 29".

The sub-division Cc (Virudunagar) is really a transitional type. (Periyakulam but for its retreating monsoon rains being more than 8" which would include it in Zone C really belongs to sub-region Dc possessing as it does the features of Dc.) Virudunagar has the retreating monsoon rains 8.68" of Zone C, but has the Mid-October increase of the second degree of Zone B and the maximum in the second half of October of Zones A' and B'. It has, in addition to these transitional features, a maximum in the the second half of September, which is peculiar in the southern part of Tamilnad.

D. The Intermontane Zone

The common features are:—

(*i*) Retreating monsoon rains—less than 8" (except at Periyakulam).

(*ii*) No Mid—October increase of the second degree (except at Pollachi).

(*iii*) Retreating monsoon maximum only in the southern part of this Zone in the second half of October.

(*iv*) Dry season from the beginning or the middle of December to the beginning or the middle of April (only at Ambur on the northern margin to the end of April).

(*v*) Hot weather rains appear earlier than in the previous Zones and are generally heavier varying from 3" to 6" on the plains.

(*vi*) Hot weather maximum in the second half of May (at Periyakulam in the first half of May).

There are three sub-regions Da, Db and Dc in this Zone.

The sub-region Da receives the highest amount of rain in the whole of Tamilnad during the hot weather (except for Tenkasi and Nagercoil). In the hot weather period there is a Mid-May increase of at least of the second degree.

The sub-region Db (Namakkal and Erode) is transitional between Da and Dc. Namakkal has a second half of August maximum as in the southerly stations of Da and the decrease of the third degree at the end of May as in Dc. Erode has the increase of the second degree at the beginning of October as in Dc.

In Da the main maximum of the year occurs in the second half of August or in the second half of September in the southwest monsoon period, but in Dc the main maximum occurs in the second half of October during the retreating monsoon period and in the transitional Db the maximum occurs in the first half of October or spread out during the whole month of October, both the monsoons contributing to the result.

In Dc (Coimbatore, Avanashi, Dharapuram, Karur and Periyakulam) except at Coimbatore there is everywhere a decrease of the third degree at the end of May. The maximum rainfall of the year occurs during the period from Mid-October to Mid-November (except at Karur) preceded and succeeded by decreases of at least of the second degree. The dry season sets in by the middle of December and lasts till the beginning or the middle of April.

The sub-region Dw (Pollachi) in the windward side of the water divide in the Palghat Gap, does not show any feature of the minimum in the second half of June, but there is a general increase of rains from the beginning of April to a maximum in the second half of July and thence a decrease to a minimum in the second half of September followed by a secondary rise to a maximum in the second half of October.

A′. The South Coastal Zone.

The common features are :—

(*i*) Retreating monsoon rains - 10″ to 20″.

(*ii*) Mid-October increase of the third degree.

(*iii*) Retreating monsoon maximum in the second half of October.

(*iv*) Hot weather rains less than 1″ (At Paramagudi on the border 2.29″).

(*v*) Hot weather maximum only in the three stations of Ramnad, Pamban and Tuticorin in the first half of April.

(*vi*) Dry season from Mid-January to the end of March generally.

There is a pronounced dry period during the southwest monsoon season and its duration increases from north to south along this coast. It we exclude the peninsular portion of Ramnad, the retreating monsoon rains amount to less than 15″. The north coast of this peninsula protruding eastwards into the sea is at right angles to the retreating monsoon winds blowing between Ceylon and Vedaranyam coasts, and hence this part receives a higher rainfall during this period. Hence the stations of Ramnad and Pamban are not so typical of this coast as the stations of Vattanam in the northern part of this Zone and Kulasekarapatnam in the southern part.

There are two sub-regions A′c and A′d. Paramagudi though a little to the interior is included in A′c as it experiences the Mid-October increase of the third degree. On account of its interior location the hot weather rains exceed 2″.

It is worthy of note that there is an increase of the third degree in the beginning of August at Paramagudi and in the middle of August at Ramnad. These features are unique at these stations in the whole of Tamilnad.

In sub-region A′d (Tuticorin and Kulasekarapatnam) the southwest monsoon rains are least in the whole of the region (sum of medians is less than 1″). The whole period from Mid-January to Mid-October is dry but for a few interruptions of the hot weather showers. The suddenness of 'burst' of rains in the middle of October is highly remarkable as the change then is from rainfall which is not 'significant' in the first half of October to a maximum for the year in the second half of October.

The Tirunelveli coast is the driest in the whole of Tamilnad (Sum of the medians for the year at Tuticorin is 11.7″ and at Kulasekarapatnam 13.43″) and most of the rain falls during the period of the retreating monsoon. Even in this season the rainfall is much less on this coast than in the interior (sum of the medians of the retreating monsoon rains is is 10.57″ at Tuticorin and 13.77″ at Palamcottah. Also it is

12.84″ at Kulasekarapatnam on the coast and 14.25″ at Nanguneri in the interior about the same latitudes.) Mr. H. F. Blanford observes, "Lying under the lee of the lofty hills of Travancore, it is completely cut off from the rainfall of the westerly monsoon; while on the east, it is separated only by the Gulf of Manaar from the northern part of Ceylon, which takes off much of the rain that would otherwise be brought by the easterly winds". (Ind. Met. Mem. III, p. 38).

B′. The Southern Sub-Ghat Zone.

The common features are:—

(*i*) Retreating monsoon rains - 12″ to 20″.

(*ii*) Mid-October increase of the third degree (second degree only at Koilpatti).

(*iii*) Beginning of October increase of at least of the second degree.

(*iv*) Retreating monsoon maximum in the second half of October (Mid-October to Mid-November at Koilpatti).

(*v*) Hot weather rains 2″ to 4″.

(*vi*) Hot weather maximum in the first half of April.

(*vii*) There are two dry periods, duration varying with stations.

There are three sub-regions B′c, B′d and B′w.

In the sub-region B′c, the increase at the beginning of October is of the second degree and there is a decrease of at least of the second degree in Mid-November. In these two respects it resembles Dc, but the Mid-October increase is at least of the second degree in B′c whereas it is only of the first degree in Dc. In B′d and B′w the increase both at the beginning and the middle of October are of the third degree, but the Mid-November decrease is of the first degree only.

The beginning-of-October increase in all these three sub-regions Dc, B′c and B′d has been explained before as being due to the increase of rainfall towards the Ghats just before the 'burst' of the retreating monsoon and the low rainfall at the tail end of the southwest monsoon. As both these tendencies increase towards the south, the Ghats being nearer to the sea, this increase at the beginning of October is of the third degree in the south. The same feature of greater accessibility to moisture bearing winds during the retreating monsoon season towards the south and greater nearness to the sea and the persistence of these winds to a later period in the year explains the variations in the gradients of changes in Mid-October and Mid-November from north to south in these three sub-regions.

In B′w (Tenkasi and Nagercoil) as the southwest monsoon rains commence much earlier than in other sections of B′, the minimum between the hot weather rains and the southwest monsoon rains occurs in the second half of May at Tenkasi in the north and in the second half of April at Nagercoil in the south, southwest monsoon rains attaining a maximum in the second half of June at Tenkasi and in the whole of June at Nagercoil.

General Summary of the distribution of rainfall.

The retreating monsoon rains begin by increase of the third degree in all the coastal stations (with the exception of Cuddalore) and in the southern stations near the ghats by the middle of October. They are heaviest on the northern part of the coast and decrease steadily towards the interior and are least in the Intermontane Zone, surrounded on all sides by high hills. In Tirunelveli district, on the contrary, the rainfall of this season is least on the coast and increases towards the ghats. The maximum rainfall of the year generally occurs in this season in Mid-October to Mid November period, excepting the western sections in the northern half of the region.

The rainfall decreases very rapidly in the second half of November, and the dry season begins in about half the stations by Mid-December and is established throughout by Mid-January. The period Mid-January to the end of March is a pronounced dry period all over the region.

The hot weather showers in March, April and May though small in amount are of great importance to agriculture, being the first showers after a long dry season, and is also useful in mitigating the summer heat of the day. They are least on the coast and increase steadily towards the mountainous west. They generally attain a maximum in the second half of May. In the eastern sections of the northern and central parts of the region the maximum is somewhat delayed and in the southern parts of Tamilnad it occurs earlier.

A minimum of rains in the second half of June is a feature of the whole region except at some of the coastal and sub-coastal stations, and the stations of Pollachi, Tenkasi, Nagercoil, Ambasamudram and Nanguneri. The southwest monsoon rains which commence by the middle of June and last till the middle of October are heaviest in the north of the region and generally decrease towards the south, and are least on the Tirunelveli coast. It is interesting to note that they are poor close to the Palghat Gap but increase towards the east on account of expansion of air with increasing distance from the Gap. The rains of this season are very low in Dharapuram (3.23") close to the Gap and increase towards the east (Karur 6.29" and Tiruchirapalli 10.19") and then again decrease towards the east from Tiruchirapalli (Tanjore 9.45", Nagapattinam 7.58"). Rainfall at the close of this season is heavy in the northern mountainous areas, where convectional thunderstorms are greatest.

APPENDIX I

A note on the time of occurrence of rainfall at Madras and Bangalore.

(Hourly rainfall records are available only for one station Madras, which can represent only the coast. They are published in an article entitled, 'An analysis of the Madras Hourly Rainfall Records from 1865 to 1875 and 1901 to 1907' by Mr.

V. Doraiswamy Iyer in Ind. Met. Dept. Scientific Notes Vol. I, pp. 13-24. The author has chosen seasonal grouping of the figures for his discussion, but many interesting features are revealed by the monthly data as they are when represented by graphs.

Bulletin No. 4 of the Colombo Observatory is 'On the General Circulation of Air over Ceylon with special reference to the time of day of rainfall by Mr. Bamford. Miss E. K. Cook in her Geography of Ceylon has reproduced a series of useful diagrams from it (pages 121 to 125) and a study of these throw much light on the similar phenomena at Madras.

As there is no interior station in the region, for which hourly records have been published, the station Bangalore lying outside the region is taken to represent the conditions of the interior. These are available in the Mysore Meteorological Memoirs No. 1. (1901) page 78 and charts based on the same on page 79).

1. *The Hot Weather Season.*

At Madras, the prevailing winds are southeasterlies and there is a maximum as in the previous season in the morning hours of land breeze. At Bangalore, the maximum fall occurs between 3 P.M. and 11 P.M. owing to the hot weather thunderstorms of the afternoons.

2. The Southwest Monsoon Season.

At Madras, in the month of June, the transition month from the hot weather to the southwest monsoon, there is a maximum in the morning hours as in the previous seasons. But the main maximum occurs in the evenings due to the struggle between the west winds and the sea breeze. In July the period of heavy rainfall is between 3 P.M. and 5 A.M. with a maximum between 9 and 10 P.M. The evening rains are due to the interaction of the monsoon and the sea breeze and the rains of the night are due to nocturnal cooling. This latter feature is characteristic of the southwest monsoon months of July, August and September and to some extent October too.

In these months, the prevailing winds have travelled over a vast stretch of heated land and though they contain much water vapour they are drying winds somewhat like the trades. During nights, nocturnal cooling causes condensation of this vapour in the air and brings about precipitation. It has been remarked by Mr. V. Doraiswamy Iyer that in this season 74% of rainfall occur in the period 6 P.M. to 6 A.M.

In August the evening rains are not so great as in July as the southwest monsoon has asserted itself over the sea breeze, the same is true of September. The transition month of October partakes the features of both the advancing and the retreating monsoons. Though the nights are more rainy than days, the day hours have greater rainfall than in September.

At Bangalore, the southwest monsoon rainfall is greatest in the evenings owing to the afternoon thunderstorms and there is another maximum in the early morning hours between 1 and 3 A.M. In July and August the afternoon maximum is more important than the early morning maximum but in September the latter becomes more important. Here also as in Madras, the nights are more rainy than days in this season.

3. Retreating Monsoon Season.

In this period the diurnal variation of rains is not well-marked as rains may occur at any hour of the day; caused by depressions from the Bay of Bengal. However there is a slight maximum in the early hours of the morning between 1 A.M. and 5 A.M. due to the nocturnal cooling. In November, at Madras there is a secondary maximum just before noon (10 A.M. to 12 A.M.) due to reinforcement of the retreating monsoon winds after the land breeze has subsided. At Bangalore in this month, the second maximum occurs between 4 P.M. and 8 P.M. probably due to afternoon convectional thunderstorms.

4. The cold weather period of the northeast monsoon.

In the months of January and February at Madras a maximum is to be seen in the morning hours when the land breeze prevails. This is due to the ascent of the northeast monsoon air from the sea over the land breeze. In Bangalore the rainfall is too poor to show any marked feature in these months.

APPENDIX II.

Outline Statement of Methods employed in Analysis of Rainfall Data.

Historical:—Rainfall Data have been recorded for very long periods of years and are made available for India, in Indian Meteorological Memoirs Vols. III and XVII, and for the World in Smithsonian Institute's Miscellaneous Collections, Vol. 79 (1927) and Vol. 90 (1934), Washington.

Until recently, the only use made in Climatology of the accumulated material has been as a side support to results founded on qualitative, personal, and so subjective, observations. The method employed has been to take the Arithmetic Mean and find Monthly and Annual Average Rainfall to point a statement or embellish an inference. Such has been the case with the great works of Blanford (1886), Elliot (1907) or Hann (1908-11). Koppen, introduced quantitative considerations to support his conclusions (Handbuch der Klimatologie 1927-36).

Mr. P. R. Crowe of Glasgow University has evolved more recently (1933) a Graphical Method for the treatment of Rainfall data based on Theoretical Statistics so as to rest Rainfall Results in Climatology upon quantitative foundations. He has applied his method with remarkable success to the Rainfall Data of Europe (Scottish Geographical Magazine Vol. 49, (1933) pp. 73-91) and to the Rainfall Data of Western Plains of North America (Geographical Review, New York, Vol. 26 (1936) pp. 463-484).

Indian Rainfall Data have been subjected to modern analysis by Clark, (Geography, London, Vol. 17 (1932) p. 290); and by

Willimason and Clark (" The variability of the Annual Rainfall of India ", Quarterly Journal of the Royal Meterological Society, Vol. 57, (1931) pp. 43-56; " The Rainfall Regions of India ", Geography, Vol. 16 (1931) pp. 103-104). A map has been prepared in the last quoted article giving Zonal distribution of rainfall. In this map, it may be remarked here, Tamilnad comes under three Zones 9b, 9c and 9d.

Dr. H. A. Matthews has applied Mr. Crowe's method to the Indian Rainfall data and has obtained interesting results thereby. (Scott. Geog. Mag. Vol. 52 (1936) pp. 84-97).

Dr. S. R. Savur has elaborated another technique by means of Theoretical Statistics (Current Science, Bangalore, Vol. 5, 1936-37, pp. 419-421; Proceedings of the Indian Academy of Sciences, Vol. 5, 1937, pp. 564-576), and following him Mr. L. S. Mahalingam has issued, 'An Analysis of Indian Rainfall using the Median as a Statistic.' (India Meterological Dept. Scientific Notes, Vol. 7, pp. 243-254).

Yet another approach to Statistical treatment has been suggested by Mr. W. R. Thomson in Ann. Math. Stat., Vol. 7, 1936. While there is little substantial difference between the two, Thomson's method is somewhat complex and not so easy of manipulation as that of Savur (L. S. Mahalingam, op. cit.)

The Technique:—Let the unit interval of time be a month (as in Crowe and the others). Take the rainfall in inches for a particular unit, say the month of January for every January of every year in the period of years (n). These form a series. Arrange these numbers of inches in a sequence of ascending or descending order.

(*i*) In this sequence of ascending or descending order, take the mid-most term; there will be as many terms before it as after. This is the '*median*'.

(*ii*) There may be repetition of several Januaries clustering round certain particular number of rainfall inches. That number of rainfall inches which has the maximum repetition of Januaries will be the '*mode*'

(*iii*) Take the sum of all the rainfall inches and divide by the number of years. The quotient is the '*Arithmetic mean*'.

For the graphical representation, along the abscissa (or the horizontal line) twelve equipaced intervals are taken to represent the successive intervals of unit time, the twelve months of the year. As an illustration, the first month of January may be taken. It is the first division on the horizontal line. The 'n' records for the 'n' Januaries are plotted each by means of a dot above this interval at a height representing the amount of rainfall in each year. Draw a horizontal line at the highest and the lowest of the 'n' dots to complete the rectangle of frequency for the month of January. This rectangle encloses all the dots standing at their several heights. Mark a horizontal line across the median or the middle-most dot. There are as many dots below the median as there are above it. Next, to cut off the extremes in this rectangle of frequency to get the picture of the normal rainfall, we have to insert a line L_u below the upper end and a line L_l above the lower end. The position of these limit lines has been determined differently by different writers.

Crowe suggests that from the upper end and the lower end a quarter of the dots should be cut off—the Quartiles Q_u and Q_l — and the limit lines inserted there. In case where extreme values are important, the eighth, the Octiles (O_u and O_l) may be cut off instead. The Rectangle thus bounded by the limit lines forms the basis of study. Messrs. Williamson and Clark take two records above and two below the median and define by them deviation from mean probability. (Op. Cit.)

Dr. Savur (op. cit.) works out a formula for an years, for locating the limits. Here L_u and L_l have definite statistical meaning. It is obvious that the median will vary with the sample of the years chosen for study. The limits L_u and L_l of the interval within which the median may range, allowing an error of 5%, are given by the relation u is the integral part of $\frac{1}{2}$ (n - 1 - 1. 6449 $\sqrt{n}$) and l is n + 1 - u

Mr. Thomson has done likewise with his own formula.

If such rectangles of frequency are erected for every interval, we have a graph for the whole year, the rectangle of each month may now be compared with that of the adjacent and light thrown on their relative heights; their maxima and minima; their gradient of change from one to another; what month wet and what dry; and so on.

The method of Analysis adopted in this thesis:—Fifty-four stations are taken up and the unit of interval chosen is the half-month. The rainfall data for each one of the stations and for each half-month have been collected and graphed after the manner of Crowe.

The median is the 18th term of the descending series of the 35 records of rain inches. The lengths cut off for Error are however based upon Savur. Putting n = 35 in the above formula, u = 12 and l = 24. That is the 12th and the 24th terms from the top give respectively the upper limit L_u and the lower limit L_l of the interval, and the cutting off lines are inserted there, thus providing for the 5% error as found by Savur.

Advantages of the Method:—The arithmetic Mean is easy and simple but is overweighted by sporadic phenomena; it slurs over small occurrences; does not disengage the incidental from the accidental; and does not show the nature of change from one interval to another.

The Arithmetic Mean being thus vitiated, the Mode and the Median are better; but the Median is the best of them all, being the more informative (Matthews, op. cit. p. 85). Rainfall Analysis by all the later writers is made dependent on the Median.

The Median is the best representative of the frequency. It has as many occurrences above it as below it; the deviations from it are bounded by the Error limit lines and these warn against false accuracy. Other advantages are apparent in the text.

THE INDIAN GEOGRAPHICAL SOCIETY.

1948

President.

Dr. M. S. KRISHNAN, M.A., Ph.D., etc.,
Superintending Geologist, Geological Survey of India, Madras Circle,
Bheemasena Gardens, Mylapore, Madras.

Vice-Presidents.

Sri Rao Bahadur
C. M. RAMACHANDRA CHETTIAR,
B.A., B.L., Advocate, Coimbatore.

Sri G. NARAYANASWAMY AIY
M.A., L.T., Lecturer in Geography,
Teachers' College, Saidapet, Madra

Miss A. R. IRAWATHY, B.A. (Hons.,)
B. Ed., Lecturer in Geography,
Queen Mary's College, Mylapore, Madras.

Sri KEDARNATH SRIVASTAVA,
M.A., B.T., Lecturer in Education, Vidya
Bhavan, Teachers' Training College, Udaipu

Sri V. S. MATHUR, M.A. (Lond.,)
Government College, Rohtak, E. Punjab.

Secretary and Editor.

Dr. GEORGE KURIYAN, B.A., B.Sc., Ph.D., (London),
Head of the Department of Geography, University of Madras.

Treasurer.

Sri M. P. RAJAGOPALAN, B.A., L.T.,
Dip. in Geography, Sir M. C. T. M. Chettiar
High School, Vepery, Madras.

Assistant Secretary.

Prof. R. S. MANI, B.A. (Hons.) T.D. (Bom),
Professor of Geography,
Vivekananda College, Mylapore, Madras.

Executive Committee.

Mrs. R. RADHA, M.A., L.T.,
Assistant Lecturer in Geography,
Queen Mary's College, Mylapore, Madras.
(Elected by the General Body).

Sri V. KALYANASUNDARAM,
M.A., L.T., Dip. in Geography, Junior
Lecturer, Dept. of Geography, University
of Madras (Elected by the Council).

Members of the Council.

Sri K. RAMAMURTI, M. A., M. Litt.,
L.T., Dip. in Geog., Lecturer in Geography,
Vivekananda College, Mylapore, Madras.

Sri V. KALYANASUNDARAM, M.A., L.T.,
Dip. in Geography, Department of Geography,
University of Madras.

Prof. T. N. MUTHUSWAMY AIYAR,
M.A., L.T., Professor of Geology,
Presidency College, Madras.

Sri P. KOCHUNNI PANICKER, M.A., L.T.,
Dip. in Geography, Government
College, Coimbatore.

Mr. A. M. SATYA, M.A., L.T.,
Dip. in Geography, Assistant,
Wesley High School, Royapettah, Madras.

Mrs. H. NEWMAN, B.A.,
Demonstrator in Geography,
Queen Mary's College, Mylapore, Madras.

Printed by Mr. R. Ravaimanickam, at Ravai & Sons, (Ravai Press), 148, Big St., Triplicane, Madras
and published by Dr. G. Kuriyan, Wellclose, Cathedral Post, Madras.