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The Place of Geography in National Planning*

BY

SHIBAPRASAD CHATTERJEE, M.Sc., T.D., Ph.D., D.Litt.; F.G.S.

At the outset I must say how happy I am to preside over the Geography section of the Indian Science Congress, which is holding its twenty-seventh session at Madras, the city which can well claim to be the cradle of the still young school of geography in India. Considering the fact that the aid of geography is often sought in other lands in planning any scheme that affects the whole nation, I decided to address you to-day on 'the place of geography in national planning,' taking my examples from India, and more particularly from Bengal, my home province.

In times like this, when the political map of Europe is again being re-drawn, the importance of the study of geography needs no emphasis. We have got to know the geography of distant lands. It was not until the last world war broke out that the importance of geography could be seen clearly abroad. In the post-war period the science of geography developed considerably, most of the Universities of Europe and America providing facilities for the study of the subject. Let us hope that this time our educational authorities will not fail to give proper attention to the subject, which is long overdue.

* Summary of the Presidential Address of the Geography and Geodesy Section of the 27th Session of the Indian Science Congress, Madras—January, 1940.

It is true that geography takes aid of other branche. ledge, like geology, meteorology and economics with . explaining the causes of certain geographical phenon types of topography or climate or economic activities, but of these on man are never lost sight of. Therein lies its be regarded as indispensable in any scheme of national Prof. Patrick Abercrombie rightly observed that 'geograp the planner aids in three different directions: Natural co Historical growth, Survey of existing state.'

In any scheme of planning, the physiography of the cou to be known first, then its soil conditions and vegetation cov The geographer is competent to furnish ready informat these points. Then, the planner, if he is to plan for buildir cities or for developing industry, must take into account the ent stages in the historic growth of existing cities or indu Geography would also help him in this respect. And fina all the information regarding the existing conditions be not re available, a geographical survey of these needs be conducted

No country in the world needs this kind of survey more India. Take, for instance, Bengal, where lands are deteriora soils fast losing their powers of productivity, rivers failing to f their task of land-building, marshes and lakes increasing in a at the cost of good arable lands, and a large number of populat subsisting on a semi-starved diet in a pitiable environment. Otl provinces are no better, though their problems may be sligh different. For a proper solution of these I maintain that a stoc taking on a provincial basis is needed in the first instance, that to say, a geographical survey is to be conducted with a view t studying the economical and agricultural possibilities of the pro vinces, and furnishing materials on which an edifice of future pros perous India could be built up .

Such a survey, if conducted in India, will have to take into account the major problems affecting one-fifth of the population of the world. A study of the *Oikoumenes* of the world will tell us that out of 209 crores of human beings (1935) more than one-half live in Asia. Of these, India has a population of 37 crores, and China, 45 crores. Africa is about seven times as large as India, but does not have more than two-fifths of the population of India. The New World has about the same size as Asia, but the population is less than that of India. Australasia is twice as large as India but its population amounts to one crore only.

India does not possess any colony, and hence the vast population has to depend entirely on the resources of the country. Unfortunately, the factory industry has not yet been fully developed with the result that the burden of feeding the millions has fallen on the land. The area of British India is about one and a half times greater than that of Indian India. The net area sown in proportion to the total area is far greater in Indian India than in British India, and consequently the area of culturable waste is less in the former than that in the latter. This is all the more striking as we know that the natural conditions, such as, rainfall, temperature, soil, relief—are definitely unfavourable from agricultural point of view in most of the States. None of the important Indian States excepting Travancore receives annual rainfall over 50 inches, and several States, between 20 and 30 inches, leaving aside the question of the Rajputana and Punjab States to the west of the Aravallis where the landscape is dominated by the great Indian desert, the Thar. Most of the important States have a continental type of climate with extremes of temperature, and some have no pronounced winter season. Our information on soil conditions is meagre, but from what we know about the geology of India we find that the residual type of soil predominates in most of the Indian States, which cannot be as fertile as alluvial soil predominating in British India. With regard to relief, practically the whole of the plains watered by the rivers belonging to the Gangetic and Indus systems are situated within British India. The unfavourable climatic, physiographical and pedological conditions are also reflected in the nature of principal crops sown. The principal single crop in British India is rice, whereas in Indian India millets predominate, which are eaten by the poorer people who cannot afford to have more expensive food-grains such as rice or wheat.

This is a point that needs careful investigation, if we are to plan a scheme in the national interest. A geographical survey of the area covered by surface water, buildings, roads and mantles of really unfertile soil is needed before we can say whether the land is better utilized in Indian India than in British India.

Let us now compare the figures based on provincial statistics for the year 1935-36. First as to the area actually sown. In Northern India the proportion of cultivated area to the total is about the same in the Gangetic valley (Bengal, Bihar and U.P.) and in the upper Indus valley (the Punjab) and definitely low in the two Frontier Provinces, Assam in the east and N.W. Frontier Province in the west. Sind, which receives less than 10 inches of annual rainfall has the minimum area under the plough. In the Deccan, Bombay and the two adjoining States, Hyderabad in the east and Baroda in the north, have the maximum area under the plough in the whole of India. This zone of maximum cultivation is surrounded by another zone, where not more than three-eighths of the total area are being actually cultivated. Mysore, Madras, the Central Provinces, Gwalior and the Rajputana States belong to this zone. Travancore and Orissa lie outside this zone, the former having slightly greater and the latter, slightly less percentage of the cultivated area.

As we proceed from Assam to the Punjab through Bengal, Bihar and the United Provinces, we find that the proportion of irrigated area to the total sown area increases steadily following the decrease of rainfall, being maximum in Sind, where artificial irrigation is practised very extensively. This tells us something more, since irrigation means man's effort to get more than what the land readily produces. There is no doubt that the people of the lower Gangetic valley and Brahmaputra valley are not making as much effort in this direction as the people of the Indus valley. It may be argued that irrigation is not the problem with which the agricultural population of the former natural region is faced to-day. But what about solving the drainage problem in Bengal or the problem of bringing more lands under the plough in Assam, which means spending of human energy and getting greater yields from the land?

The proportion of irrigated land also increases as we proceed from Assam to Travancore through Bengal, Orissa and Madras. Travancore is one of the rainiest areas of India, and still the area of irrigated land is about one-half of the total area under the plough. This makes us think whether irrigation can be dispensed with in Bengal. The remaining of the British Indian provinces (Bombay and the Central Provinces) and the Indian States (Hyderabad, Gwalior and Baroda) have low proportions of irrigated land. The proportion of irrigated land in Rajputana though higher than that of its immediate western neighbour, Gwalior, falls far short of the figure that is expected in an arid country like Rajputana.

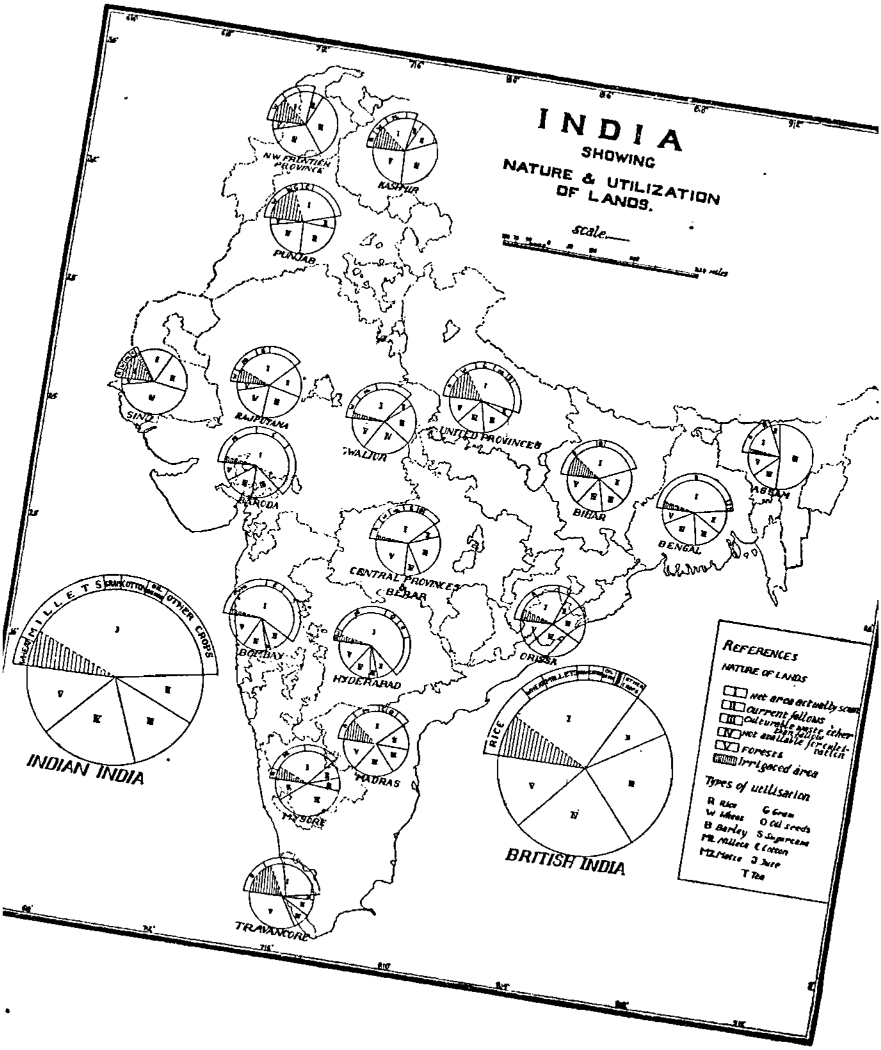
The area of land kept fallow is definitely higher in the lower Gangetic valley (Bengal) than in the upper Gangetic (U.P.) and upper Indus (Punjab) valleys. In the lower Indus valley (Sind) the proportion of fallow land to the total sown area is about the same as in the lower Gangetic valley (Bengal). I am not sure whether it is necessary to leave more land fallow in the lower course than in the upper course of a river, but this point needs investigation, as a large area remains abandoned, at least for sometime. In the northern mountainous region the proportion of fallow land is also low (Kashmir and N.W. Frontier Province).

The upper Brahmaputra valley and the mountainous region of Assam have also a very low proportion of land kept fallow. In the zone of maximum cultivation, Bombay and Hyderabad have fairly large fallow lands, but Baroda has none. The arid lands of India (Sind and Rajputana) have a large proportion of fallow lands. A detailed survey of lands kept fallow in different parts of India and their mapping are necessary before we can say something for or against the practice of keeping a large proportion of valuable agricultural lands fallow.

As to the distribution of lands classified under culturable waste, we find that the proportion of this type of land to the total area, is maximum in Assam, and minimum in Bombay. In the Gangetic valley the proportion is about the same, that is to say, about one-eighth of the total area, in the three provinces, Bengal, Bihar and the United Provinces. In the zone of maximum cultivation, Bombay, as already mentioned, and Hyderabad have very low percentage of culturable waste. There is yet a possibility of bringing under the plough about one-quarter of the total area in the Punjab and little less than a quarter in Sind by developing irrigational schemes.

After successfully tackling the problem of culturable waste land, we should find out the nature of land which is considered as worthless to-day from agricultural point of view. In this connection I would like to refer to what has been achieved by the present Russian Government in the Karakum and Kizilkum deserts of Russian Turkestan. For centuries nothing could be grown in these deserts, but to-day thousands of acres of land are being cultivated with the help of artificial irrigation by hundreds of nomad families who have just been settled on the land. As to the distribution of such type of land, it is natural that we should find the maximum proportion in the region of very scanty rainfall (Sind), and in the mountainous district (Kashmir and N.W. Frontier Province). In Southern India, Mysore has a large percentage of area not available for cultivation.

Forests still occupy a considerable area, though deforestation started from the time the Aryans entered India. The dense forests


INDIA
SHOWING
NATURE & UTILIZATION
OF LANDS.
scale
N.W. FRONTIER PROVINCE
KASHMIR
PUNJAB
SIND
RAJPUTANA
GWALIOR
UNITED PROVINCES
BIHAR
ASSAM
BENGAL
BARODA
CENTRAL PROVINCES & BERAR
BOMBAY
HYDERABAD
ORISSA
MADRAS
MYSORE
TRAVANCORE
MILLETS
OTHER CROPS
INDIAN INDIA
RICE
BRITISH INDIA
REFERENCES
NATURE OF LANDS
I Net area actually sown
II Current fallows
III Culturable waste other than fallow
IV Not available for cultivation
V Forests
Irrigated area
Types of utilisation
R Rice
W Wheat
B Barley
ML Millets
MZ Maize
G Gram
O Oil seeds
S Sugarcane
C Cotton
J Jute
T Tea

of the Gangetic valley had to be cleared off to give place to plants favoured by man—wheat, rice, barley, all members of t grass-family. Forests also indirectly help agriculture by checki the run-off on the surface and thus preventing erosion of t valuable mantle of soil. This is all the more important in hil countries where there is a danger of the surface soil being washe away.

With regard to the distribution of forests in India, we find that the Kashmir valley and the adjoining mountain slopes in the north, and the Vindhya and Satpura ranges in Central India have yet large areas covered with forests. In the south, in Travancore, forests still occupy more than one-quarter of the total area. In the zone of maximum cultivation, the forests still occupy a large area, about one-eighth of the area in Bombay and Hyderabad. In the Gangetic valley, the true forests are found only in the Sundarban region of Bengal. The high proportions shown in Bihar and the United Provinces are really due to the forests growing in a different type of natural region, though included within the political boundaries of the two provinces.

The map also shows the predominating single crops in different provinces and States. As we proceed from Bengal to the Punjab, ice cultivation decreases with the corresponding increase in the ultivation of wheat, following the decrease of oceanic influence nland. In the region of maximum cultivation, millets take the rincipal place, the next important single crop being cotton. Jute principally grown in Bengal, and tea in Assam. Thus each gion has its favourite crop. Bengal and Bihar favour rice, the njab favours wheat, the United Provinces, as it shares the climate of the first two regions favours both rice and wheat, and the can, millets. It is with these crops that the hungry millions being fed daily. A survey of crops, and their distribution and rate mapping on large scale map of India will enable us to he picture of agricultural India in its true perspective.

Let us now have a look at the population map of the Gangetic the most densely populated region of India. It is clear that opulation increases considerably as we proceed towards the either from the northern mountainous region or from the rn plateau region. A part of the former region included the boundary of the United Provinces in the west of Nepal ah, Garhwal and Nainital districts) and a part of the latter ncluded within the Province of Bihar (Singhbhum, Ranchi, and Hazaribagh districts) in the north of the Eastern

States show a clear contrast with the other districts as regards population. Two other regions, one in the north of Rewa and Panna (Mirzapur, Banda, Hamirpur and Jalaun districts) and the other in the north of Rajputana and west of the Jumna are sparsely populated. All these regions do not form part of the Gangetic valley. Coming to the Gangetic valley proper, we also find the population is not evenly distributed. In the Doab of the Hoogly and the Ganges-Meghna, the central part is more sparsely populated than either the western or the eastern, the Sundarbans, and the dead and dying rivers being responsible for the sparse population. A little patch in the lower course of the Hoogly appears to be densely populated. This is the industrial district adjoining Calcutta. If we carefully examine the map, we find that there is some order in the variation of population in the Gangetic valley, that is to say, area of dense population alternates with area of relatively sparse population. This illustrates the theory of Vidal de la Balche that population does not spread out evenly like oil, but spreads out in swarms like bees.

A comparison of the population map with the maps showing the distribution of total earners and workers in trade and industry who do not have to depend on the land for their living, reveals that compared with population the Doab of Bengal has a much smaller number of earners than in the middle or upper Gangetic valley, that is to say in most of the districts of Bihar and the United Provinces, and that the proportion of earners is greater in the upper Gangetic valley (U.P.), than that of the middle Gangetic valley (Bihar). The area in the immediate west of the Jumna (Karnal, Rhotak and Gurgaon) has a smaller percentage of earners, and this probably accounts for the sparse population in the area. The industrial area like the Howrah district in the east or the Delhi province in the west has obviously very thick population.

Since organized industries do not play a large part in the life of the people of the Gangetic valley, and the vast majority have to depend on the land for their sustenance, it will be interesting to see how far the agricultural land is being utilized in this area. Generally speaking, the area of high density of population corresponds to the area where intensive cultivation is practised, e.g., the western part of the Doab of Bengal (Faridpur and Barisal districts) or the Doab of the Ganges and Jumna (Fatehpur, Cawnpore, Etawah and Agra districts). The area of low density of population such as the Khulna district of Bengal or the Santhal Pargana of Bihar or the Chotanagpur Plateau, has not yet utilized the whole of agricultural land available for cultivation. The local causes, if any, of this wastage, are to be determined by the planner.

I shall now take up Bengal with a view to indicating what assistance the geographer can give in solving some of the problems with which we are faced to-day.

Bengal has a more or less triangular shape with its apex in the northern Himalayan mountain and its base washed by the waters of the Bay of Bengal. Three great rivers the Ganges, (also known as Padma) Brahmaputra and Meghna find their way to the Bay through Bengal, and it is common knowledge that the destiny of Bengal lies in the hands of her mighty rivers.

Bengal may be divided into the following regions:—

Uplands

1.	Himalayan region ..	Mountain
2.	Chittagong Hill region ..	Hill.
3.	Rarh region ..	Plateau.

Lowlands

4. Barendra region.
5. Brahmaputra-Meghna region.
6. Bagri region.
7. Hoogly region.
8. Lower Ganges region.
9. Lower Padma-Meghna region.
10. Sundarban region.

For the soil regions I propose the following classification:—

(Plate II)

Residual Soil

Gneissic soil ..	(*a*)
Ferruginous clay ..	(*b*)
Sandy loam ..	(*c*)
Lateritic soil ..	(*d*)

esidual Soil: Gneissic soil (*a*), Ferruginous clay (*b*), Sandy loam (*c*), Lateritic soil (*d*).

ew Alluvium: Doash (loam) 1, Pali (sandy loam) 2, Matial (clayey loam) 3, Entel (hard clayey loam) 4, Khiyar (dark heavy clay) 5, Kalantar (stiff clay) 6, Balia (sandy) 7, Bhasa (soft clay-marshy) 8, Tobe (peaty) 9, Mahina (coastal soil impregnated with salt) 10.

l Alluvium: Sandy loam I, Black clay II, Stiff clay III, Clayey loam IV, Lateritic clay V.

New Alluvium

Doash (loam)	.. 1
Pali (sandy loam)	.. 2
Matial (clayey loam)	.. 3
Entel (hard clayey loam)	.. 4
Khiyar (dark heavy clay)	.. 5
Kalantar (stiff clay)	.. 6
Balia (sandy)	.. 7
Bhasa (soft clay-marshy)	.. 8
Tobe (peaty)	.. 9
Mahina (coastal soil impregnated with salt)	.. 10

Old Alluvium

Sandy loam	
Black clay	.. II
Stiff clay	.. III
Clayey loam	.. IV
Lateritic clay	.. V

Bengal is essentially a land of plains. The upland region is confined in three distinct zones in Bengal—(1) in the extreme north (the Sikkim Himalaya), (2) in the south-east (the Chittagong Hill Tracts), and a narrow stretch of land running along western border from the south of the Ganges to very near the sea board.

The Himalayan region:—

The bracing climate of this region in summer has led to the growth of summer resorts in the mountains. The majestic peaks of the Himalaya rise above the dense forests of the Terai and Western Duars. Cultivation of any kind including tea stops at an altitude of 6,000 ft. above which dense forests clad the mountain slopes. Alpine vegetation is met with at much higher levels. The scarcity of level ground for cultivation is the main problem of the mountaineers. A belt of old alluvium runs along the foot of the Himalaya extending from the Western Duars to the Terai forests and receive a large amount of rainfall, the normal annual rainfall being maximum in Bengal. The soil is in most part sandy loam excepting a patch of black clay in the area between the Tista and Jaldhaka. The latter type of soil is extensively used for pottery. Immediately north of this soil lies a belt of ferruginous clay which is very suitable for tea plants. Further north gneissic soil is met with, which in composition ranges from white sand to red clay. This region has an unlimited water-power resources, especially in the Tista river, which if properly harnessed will cheapen electricity and help in the industrialization of the country. At present, factory industry is confined to tea.

Chittagong Hill region:—

This region consists of long parallel ranges and valleys, the structure being of the Appalachian type. There are four important valleys, which have now been brought under the plough. Like the Himalayan region it is covered with dense jungle. It also receives copious rainfall, the normal annual rainfall being 100 inches. The region has also water-power resources, mainly the river Karnaphuli, which remain to be exploited. Unlike the Himalayan region it has a hot summer and mild winter. The soil is sandy loam in higher levels and clayey loam in the valley bottoms. The yield of sugarcane is definitely higher in this type of soil.

The Rarh region:—

It occupies most of the western districts of Bengal—part of Murshidabad, Bankura, practically the whole of Burdwan and the western half of Midnapore, and presents the appearance of an undulating plateau. It is mainly composed of old alluvium, the residual soil being found in the higher levels along the extreme western border. In the area between the Damodar and Bhagirathi stand several granitic and basaltic hills, with lateritic cappings. To the west of the Dubrajpur granitic hills are found two hot springs which, if properly advertised, may attract a large number of patients from other districts of Bengal, as it is believed that the waters of the springs are very efficacious for certain diseases. The country to the immediate north of the Damodar contains sal forests (shorea robusta). The most characteristic tree in the region being the palmyra palm (borassus flabeiformis), which supplies the villager with trunk and leaves for building his houses, and fruits, in time of famine. It is a region of minimum rainfall, and hence irrigation is the main problem. Since most of the rivers including the Damodar are subject to heavy floods during the rains, it will be necessary to store up the flood waters at certain favourable spots. For this, a geographical survey of the region is needed.

Low Lands

Low lands occupy the rest of Bengal, where the gradient is almost imperceptible.

Barendra region :—

It occupies the Doab of the Ganges and the Brahmaputra roughly corresponding to the Rajshahi division, and may be subdivided into East Barendra, North Barendra and West Barendra. A very extensive capping of old alluvium is met with in this region. This is locally known as 'Barind'. It covers an area of about 3,000 sq. miles, and certainly occupied a much larger space in the past. Fluvial erosion has now left a few low hills with intervening wide depressions. None of the hills rise above 100 ft., and their flat tops at different levels present a terrace-like appearance. The soil is stiff clay in the tops of hills, where nothing but grass and scrub jungle grow. In the depressions, the soil is clayey loam, which is good for winter rice. In the north-western part is found 'Pali' soil which changes to 'Matial' soil further south. The former soil is very fertile and produces two crops in the year (do fasli). The latter cannot retain moisture for long and considering the factor that rainfall is low this soil does not yield two crops. One of the problems of cultivators in the northern part of the West Barendra region is how to irrigate their lands in years of scanty rainfall. Not many tanks exist there, and since most of the streams flow through somewhat deeper valleys water could not be lifted by mud basket to the fields which lie at higher levels. In the central part, however, irrigation from tanks is practised.

In the north of the East Barendra (Rangpur) 'Pali' soil predominates in the north and in the east which receives fresh supply of silt every year, and is very fertile producing two crops. Dark heavy clayey soil predominates in the central and southern Rangpur where marshes and riverbeds once pervailed. Sandy soil prevails along the banks of the Jamuna and in the islands. Artificial irrigation for crops other than tobacco is not practised.

In the south-western half of West Barendra (Malda) 'Khiyar' (heavy clayey soil) predominates in the area between the Mahananda and Kalindi, known as the Tal depression. This area gets submerged as soon as the rains set in; and consequently only the crops that can be harvested before the rains are grown in this region. Further south the country presents a pleasing aspect, no longer marshy tracts covered by reed and tall grass, but open stretches of cultivated fields formed of fertile 'Doash' (loam), and a series of sandy islands in the beds of the Ganges. This is the most densely populated tract in the whole of the Barendra region. The fertile loam extends along the northern bank of the Ganges up to the Barind old alluvium (Rajshahi plain). In the Nator plain the soil is 'Entel' (hard clayey loam). Further west 'Matial' (clayey loam) prevails which is fertile but the area being extremely unhealthy, very few people live there. In the East Barendra region a stretch of fertile sandy loam runs parallel to the Jamuna and form the Bangali and Jamuna plains. The soil in the Bogra plain is 'Entel', and is good only for the cultivation of paddy.

Brahmaputra-Meghna region :—

Three administrative districts—Mymensingh, Dacca and Tippera—are included in this area. A considerable area of the region from Dacca on the south to Jamalpur on the north, consists of alluvial terraces, known locally as the Madhupur jungle and still awaits development. It has been dissected by a number of rivulets. The valleys and depressions have subsequently been filled up by recent alluvium—clayey loam—which yield excellent crops. The uplands have a hard red clay soil, and are taken as 'unculturable waste'. This tract needs a careful survey, and it is likely that with the help of suitable manures, it can be made to yield rich crops. Another small out-crop of old alluvium forms the Lalmai hills, a few miles west of Comilla town.

The area is well watered by the Jamuna, Padma, Meghna, and their many important distributaries like the old Brahmaputra and Dhaleswari. All the rivers carry a large volume of water, which may be utilized in developing the existing fisheries. The Garo hills in the immediate north of the area also provide ample opportunities for a successful hydro-electric scheme. Another problem that needs solution is to remove the surplus water which remains on the surface in several localities in the north mainly between the old Brahmaputra and the foot of the Garo hills and also along a narrow strip of land bordering the Meghna, where nothing but scrub jungle and tall grass can at present be grown. The southern plains, Padma and Meghna plains, are however well drained and every inch of the ground is productive due to the land-building activities of the great rivers. Any interference with the rivers with a view to preventing the flood waters to spread over the plains will cause disaster to one of the most densely populated areas of Bengal.

From agricultural point of view, this is the most important tract being an ideal home of jute and sugarcane. Here are found over two-fifths of the jute lands, and one-quarter of the sugarcane fields. The yield of sugarcane per acre is definitely higher than the average for the province. The yield of jute per acre is not quite satisfactory in the southern part of the region. It is true that the normal annual rainfall in the southern part is 15 inches less than that in the northern area. But this deficiency of rainfall, if it is a cause of lower yield, can be made good either by storing up of flood waters during the rains, or by flushing from rivers.

Oilseeds and rice are also grown extensively. Of the oil-seeds about two-fifths of the til (sesamum) growing areas, and over one-third of the mustard lands occur in this region. Slightly over one-sixth of the paddy lands is also found, though the yield of winter rice is lower than the average yield for the province. The cause of this lower yield may be traced to the unfertile soil of the Madhupur terraces, which, when dry, is as hard as stone. The soil of the Meghna plain retains moisture to a remarkable degree, and is very fertile. The southern part of the Padma plain consists of 'Doash' (loamy soil) and is undoubtedly the most fertile tract in the whole of Bengal, but 'Pali' (sandy loam) prevails in the northern part which cannot retain moisture to the same extent as the former type. In the Mymensingh plain clayey 'Entel' soil (hard clayey loam) prevails, which in places is as hard as the soil of the Madhupur terraces.

The climate of the region is of maritime monsoonal type. The temperature in summer months is considerably lowered by moisture-bearing winds from the Bay of Bengal. The mean temperature in January ranges from 66°F. in the south to 65°F. in the north. The weather is very pleasant in the cold season, from November to February. The normal annual rainfall also increases from the south (74″) to the north (89″).

No organized industry worth the name exists in this region. It is true that the cost of transport of coal from the Raniganj coal fields is enormous, but the proximity of raw materials like jute, oilseeds, sugarcane would have led to development of factory industries, had the cost of electricity been moderate. The water-power resources of the Himalayan region if properly exploited would lead to the development of industries.

The Bagri region:—

This is one of the three famous historical divisions of Bengal, lying in the south of the Barendra tract and in the east of the Rarh area. The Bhagirathi which is known as the Hooghli below its confluence with the Jalangi forms its western boundary, the Ganges —its northern, the Sundarbans—its southern, and the Garai and Bhairab plains—its eastern boundary. The latter boundary was drawn based on the type of fluvial erosion. This flat alluvial plain is watered by a number of moribund sluggish rivers which need resuscitation very badly. Before the construction of the railways, it is the rivers of this region, the Bhagirathi, Jalangi and Matabhanga that afforded the principal means of communication between the lower and upper Gangetic valley but the thalwegs of these rivers have been silted up to such an extent that navigation is not possible except in the rains. This district abounds with marshes because of its defective drainage, and comes in the grip of flood every year. The predominant type of soil is 'Pali' (sandy loam), which is fertile elsewhere. But in this tract the yield of rice and other crops is definitely lower. This shows that the soil is not the only factor that affects the productivity of the land. The normal annual rainfall is 55 inches, about the same as in the Rarh region. The mean temperature in January is 50°F. and in April it rises to 85°F. In the Kalantar tract between the Bhagirathi and Jalangi the soil is hard clay and extremely unfertile. This tract is known locally as the 'region of death,' and its people are the first to feel the pinch of famine when it comes.

The Hooghly region:—

This is the only region in the whole of Bengal that shows some industrial activities. Rainfall is slightly higher in the south of the region (61") whereas in the northern portion the normal annual rainfall is 57". Out of this only about 4 inches of rain fall from January to April. Hard clayey loam (Entel) predominates along the river banks, and sandy or clayey loam, away from the river. In the area between the Hooghly and Damodar the nature of soil was found to change very rapidly. It was surprising to find in a small village, Dafarpur in the Howrah district, a small patch of very fertile soil, which caused the valuation of lands to rise considerably higher than those of the surrounding villages. In the Hijli coastal plain, sand dunes advance inland and sometimes threaten the existence of small villages which are situated in the plain. Some dykes have been built to prevent saltwater destroying the cultivated fields. The yield of jute and rice per acre is higher than in the neighbouring regions. The agricultural population of this region also suffers to some extent due to defective drainage. The main problem is to remove the surplus water. It is true that a number of drainage channels have been built up, but in times of sudden heavy showers some delay in opening the sluices often causes complete destruction of crops.

The lower Ganges region:—

Parts of two administrative districts, Khulna and Faridpur, are included within this region. Unlike the rivers of the Bagri region the rivers of this tract are still engaged in their land-building work. In the south-eastern part of the region the main problem is of drinking water, since most of the rivers are getting more and more saline as their connections with the Ganges are getting silted up. This region abounds with marshes, which are gradually being reclaimed for cultivation, but wherever man has shown undue haste in reclaiming land by preventing the river from completing its task, the reclaimed land started deteriorating very soon, and was once again converted into uncultivable marshy area. The normal annual rainfall (73″) is lower than that of the adjoining lower Padma-Meghna region. Although the banks of the Padma are formed of fertile loamy soil, elsewhere in the region the typical soil is clayey loam. 'Tobe' (peaty soil) is found in the marshes. Since the whole of the region is only slightly raised above the flood level the difficulty about finding a suitable site for building habitations is most acute. In several villages houses are built on artificially raised ground.

The lower Padma-Meghna region:—

This is the rainiest area of Bengal (normal annual rainfall 114″), next to the northern Himalayan region. Along the Chittagong coastal plain is found a heavy clay soil which is impregnated with salt, and is locally known as 'Mahina.' The soil becomes fertile sandy loam as we approach the hill region from the coast. One of the problems is to prevent saline sea water from damaging the crops. The number of dykes is not sufficient along the Chittagong coastal plain. Near the mouths of the Meghna are found several large islands which are still in the process of formation. The islands are being rapidly reclaimed and produce rice, and betel palm. The whole area is well drained and consequently does not have any large marshy tract.

The Sundarban region:—

The Sundarbans occupy a large tract mainly in the administrative district of the 24-Parganas and Khulna, and present the appearance of morasses and swampy islands separated by river estuaries and a network of tidal creeks. The people of this region suffer badly for want of fresh drinking water. 'At times the women folk carry their pitchers by relays to fetch water from a fresh-water tank which often is situated at a distance of 10 or 12 miles.'

The land in the Sundarban area is extremely fertile ; and it may look strange to find that the people of this region want it otherwise. The reason given by Sir James Westland is the following:

'So great is the evil fertility of the soil, that reclaimed land neglected for a single year will present to the next year's cultivator a forest of reeds (nal). He may cut it and burn it down, but it will spring up again almost as thick as ever.'

To sum up, since national planning means a conscious effort of man to change his environment in the best national interest, it is rational to be equipped with a thorough and accurate knowledge of the type, historic growth, and present distribution of the various factors that go to form our cultural landscape, which is the subject-matter of geography. By synthesizing the findings of other branches of knowledge, geography presents a complete picture of the country, which may then pass on to the hands of the planner for retouching. The role of the economist in national planning is not underestimated, but what is claimed by geography is that the geographer can certainly help the economist to keep his feet on the earth. To materialize the scheme of national planning in India, which is the home of one-fifth of the population of the world and where cultivable land per head of population is less than that of other agricultural countries, the starting of an All-India Organization for conducting the Geographical Survey of the country, more or less, on the lines of the existing Geological Survey will be a distinct step forward.

Some Chief Problems of a Suburban Municipality Adjoining the Metropolis with Special Reference to Saidapet*

By

N. Subrahmanyam, M.A., L.T., F.R.G.S.,

The Thesis stated.—The Municipality of Saidapet is a suburb of Madras contiguous with it and is also the headquarters of Chingleput District which surrounds the Metropolis. This peculiar position of the Municipality being also an adjoining part of the capital, *i.e.*, of Greater Madras, has led to the growth of certain interesting and important problems which are examined in this paper and an attempt made to suggest some feasible solutions for them.

The Plan.—The paper is divided into three parts. Part I is descriptive: it gives an account of the main features of the locality. Part II examines the problems; and Part III suggests some solutions.

PART I

Descriptive : Main Features of the Locality

Historical Background.—The exact origin of Saidapet is not definitely known. Puliyur near Kodambakkam is the only part of the present Municipality that can lay any claim to antiquity, being mentioned as a *kottam* or local sub-division in Chola times. Little Mount on the right bank of the Adyar, reputably connected with the martyrdom of St. Thomas, was well-known in the 17th century as a shrine of the Portuguese Church. But Saidapet town itself—the rectangular portion to the north of the railway line—does not appear to be an old village. The place seems to have been called originally *Saidabad* from a certain Saiyad, a member of the Karnatic Nawab's family, and subsequently corrupted into Saida-

* A paper read before the Geography and Geodesy Section of the 27th Session of the Indian Science Congress, Madras—January, 1940.

pet. The main building in the Home's Garden, which formed originally part of the Nawab's property and in which the Collector's Office is now held, the Mosque in front of it and the site known as Saiyad Bagh—all indicate this Moslem connection of the parts along the Mount Road. The weaving industry of Thopet, to the west of the railway line, seems to have been of comparatively recent growth—the stuff made here, the lungis and the kailis, not being connected with the early East India Company days, but being due to the demand of the Indians settled in Burma and the Straits Settlements in the 19th century. The construction of the railway and its recent electrification, the growth of the bus service, the development of the Colleges, the activities of the Turf Club and the creation of the Municipality have all had their influences on the life of this important suburb of the city

Position, Extent and Divisions.—The Municipality of Saidapet forms roughly an arc round Madras on its south-western side and on the southern half of the western side. It is said to cover an area of 8 square miles, though no adequate survey of it has yet been made. It is thus a little more than a quarter of the City of Madras in area. But the residential parts are not contiguous with each other but fall into isolated units, separated by fields and open land, and extending from Little Mount and Guindy in the south on the right bank of the Adyar to Choolaimedu in the North on the right bank of the Cooum. Saidapet town proper falls roughly into three parts:—One part lies along the Mount Road up to the Adyar on the east and the south. It contains the Collector's Office, the Y. M. C. A. College of Physical Education, Fanepet, Todhunternagar, Farm Village, Teachers' College, Richards Park and Panagal Buildings; and it is the part that is best known and gives the best impression to a casual visitor. The other parts are Periapet, which lies between the Mount Road and the Railway-line, and the old town, rectangular in pattern to the west of the Railway-line up to the Perumal temple. The area known as Mettupalayam is contiguous to it in the north-west.

To the north of Saidapet Town lie two other isolated groups of residential areas:—(1) West Mambalam; and (2) Kodambakkam, Saligramam and Puliyur. Thus the Municipality is spread over a large area in distinct residential groups, separated by long stretches of fields and open land.

The population of Saidapet.—The total population of this congeries of residential areas comprising the Municipality of Saidapet is 33,037 according to the census of 1931, and may come to half a lakh by the next census of 1941. The figures of growth since 1881 are given below:—

As per	1881	census,	the population	was	15,345.
,,	1891	,,	,,	,,	17,821.
,,	1901	,,	,,	,,	21,507.
,,	1911	,,	,,	,,	22,043.
,,	1921	,,	,,	,,	27,404.
,,	1931	,,	,,	,,	33,037.

The above figures show that the growth has been steady, though it cannot be said to be rapid; the population has doubled itself in 50 years. While the area of the Municipality is a little over a fourth of Madras, its population is only about a twentieth.

Physical Description.—The surface within the Municipality is fairly level; and most of it drains into the Adyar, which is not at all useful for irrigational purposes. The soil is sandy loam for the most part; but the poor rainfall (less than 40 inches) and absence of good irrigational facilities have prevented the development of agriculture or market gardening except in certain parts where it could be carried on by irrigation from wells.

Industries and Occupations.—Weaving and dyeing, brick and pot making, making and repairing of jutkas, and dhobying are some of the chief occupations of the local people; while several others are employed in the City, residing only in Saidapet area. But nearly all of these industries have of late years suffered decline in one way or other. The weaving and dyeing industry has gone down through competition from more flourishing centres like Chirala. Though the brick trade is itself in a very flourishing condition in general in the neighbourhood of Madras owing to the boom in the building industry, the burning of brick kilns within the Saidapet Municipal area is controlled as a dangerous and offensive trade, as it leaves pits which become after the rains sources of mosquito breeding. They are therefore not permitted near residential areas, but only some distance away from them. Hence, they are more largely to be found in Kodambakkam area. A good number of people depend on this industry for their livelihood. The common use of cheap enamel and aluminium wares has reduced the use of pottery, though the potter still continues to ply his ancient trade.

The bus and electric train have rendered the *jutka* or pony cart almost a superfluity; and hence there is little need for making or repairing of it nowadays. Dhobying for the City of Madras however continues to flourish well, owing to the advantages fresh water in the river above the tidal limit and easy transp from the City.

Communications and Transport.—The electric railway and t Mount Road are the two chief means of communication from Ma ras to Saidapet and beyond. Four stations on the railway line Kodambakkam, Mambalam, Saidapet and Guindy—serve the mun cipal area of Saidapet; while local as well as through buses run i good numbers pretty frequently for going to and returning from th City. The Mount Road, being but the first part of the Great South ern Trunk Road near the City, is metalled and tarred well, being classed as a first class road, and crosses the river Adyar by the narrow Marmalong Bridge. The Bazaar Road, which takes off from the Mount Road near the Teachers' College, continues as the Alandur Road crossing the Adyar by a causeway. This affords an alternative route, especially for heavy carts on race days, when the Mount Road teems with cars and buses. The Arcot Road from Kodambakkam Railway Station westwards is another second class road like the Alandur Road. This road is linked with Saidapet by two connecting third class roads—one through Mambalam, and the other a little more westerly joining it near Saligramam. The last is most cut up by the heavy and frequent brick cart traffic.

The description so far given presents a general idea of Saidapet,—what a straggling place it is, with scattered residential areas. In the next part we shall learn about its insufficient water-supply, poor drainage, poor public health, decadent industries and bad roads, etc. In spite of its contiguity to the City, it has not been a popular part of Greater Madras. Let us examine the reasons therefor a little more closely.

PART II

SOME CHIEF PROBLEMS OF SAIDAPET MUNICIPALITY

Public Health.—The first problem of Saidapet is that of Public Health. From its locational and transport advantages, Saidapet could easily have been a more popular part of Greater Madras but for its reputation for filariasis, brought on by the mosquito. Other common diseases like cholera, small-pox and enteric fever make heir periodical visitations. The municipal authorities are alive to he danger, and are making a vigorous campaign against them every ear; while the Saidapet Health Association has been doing excellent work by way of study, research and propaganda with th hope of realising its high ideal of making Saidapet "the cleanest healthiest town in South India by 1950." This question of the public health of Saidapet is a matter of the utmost concern for the City of Madras. But in spite of the vigorous measures taken to fight against these prevalent diseases, no substantial progress seems to have been achieved as their main causes have not been wholly removed. The provision of an ample supply of safe water for its citizens and a good system of drainage have been the crying needs of the locality for a long time; and these have been the main causes of the state of public health in the town.

Water-supply.—The wells of Saidapet generally contain brackish water, unfit for drinking. A few, however, with somewhat drinkable water in half a dozen places have been meeting the needs of the people till recently. From the time that the Municipality was constituted in 1920, the question of supplying good water was recognised by the authorities; and a scheme was sanctioned and taken on hand as early as 1927 after 4 years of discussion with the Government, though actually the fruition of it took place after nearly 10 years, and good water was made available only in 1937. Street fountains have been set up in over 50 places; and 20 more fountains have been sanctioned. Thus safe water has been provided for from Guindy and Little Mount in the south to Mambalam in the north of the Municipality, though it has not been found possible to give house connections. The northern parts like Kodambakkam, Puliyur, Saligramam and Choolaimedu are too far off to benefit by the scheme and continue to use only the few good wells in their localities as in the past. Thus the problem of water-supply has after all been solved ony in a limited way, which has no doubt contributed to some extent in improving the public health of the town.

Drainage.—But immediately, however, it has only served to ring out more prominently the connected problem of *drainage*, for hich no proper provision has so far been made. Though in the itlying parts there is some kind of natural drainage, Saidapet wn which is the biggest residential area within the Municipality s no system of drainage, open or underground. The waste water m houses is either allowed to run into the gardens or collected cess-pools of masonry work, from which they are baled out ry morning into the municipal carts and taken out and let off ome distance from the habitations. As a matter of fact, these -pools are often seen to overflow into the streets; and waste water let out into the gardens similarly form smaller cess-pools there. These afford fine breeding places for mosquitoes which infest the locality and not only disturb the sleep of its residents, but are also the fertile causes of filariasis and other diseases mentioned above.

It is said that the construction of the Marmalong Bridge (early in the 18th century?) by Peter Uscan, the Armenian merchant-prince resulted in bunding up the river bank and preventing the natural drainage of East Saidapet into the river and created part of the drainage problem. But howsoever caused, the urgent need for a drainage scheme has been generally recognised. In fact, when the water-supply question was first taken up, the necessity for taking up the drainage question at the same time was also urged; but on the score of cost, it was decided to take it after the first scheme was completed. Now that water-supply has come in some measure, the drainage question has become more urgent than ever. The drainage and sewage disposal of the town are anything but satisfactory, and have become a greater menace for public health than ever. It is understood that the Superintending Engineer, Public Health of Madras has arranged to take the levels of Saidapet preliminary to working out a drainage scheme. Till it is carried out the Public Health of Saidapet cannot materially improve. It must be stated in this connection that the Public Health of Madras City stands seriously imperilled by the unsatisfactory conditions in the adjoining area of Saidapet.

Roads.—Another problem which is peculiar to Saidapet is that of roads. Through the Municipality run nearly two miles of the Great Southern Trunk Road, which has very heavy bus, car and lorry traffic always, and much more so during the race season. The infant Municipality in its early enthusiasm involved itself in a heavy debt by incurring capital expenditure on tar macadamising the entire length of this road on its own account, which has resulted in its inability to find the money for other more urgent beneficent schemes.

Another road problem of Saidapet Municipality is the need for linking up its scattered units spread over a long distance by means of good roads. At present a third class road connects Saidapet with Kodambakkam and Saligramam on the Arcot Road, and another similar road runs northwards to Kodambakkam Railway Station through Mambalam. Choolaimedu, the northernmost unit is only accessible from Kodambakkam R. S. by a very poor road, and can be reached more easily from Nungambakkam within the city than directly from Saidapet. Further, all these roads are badly cut up by the heavy traffic of fully laden brick carts going from the kilns to the City. Their maintenance in proper condition would entail a heavy drain on a poor Municipality, which has more urgent calls on its purse. There is also a great need for laying of fresh roads for developing some of the parts of what is really Greater Madras.

Other Amenities.—A park has been laid near the Marmalong Bridge and a radio set installed in it; and electric lighting has been introduced for Saidapet proper. But the residents look for provision of many more such amenities, and in the various parts of the municipal area. West Mambalam stands for example as a glaring contrast to what has been provided for in East Mambalam or Thyagarajanagar by way of amenities, just across the railway-line within the city limits, though even there the development is still incomplete.

Town-Planning Schemes.—While Saidapet is the Headquarters of the Chingleput District, it is at the same time a contiguous and important part of Greater Madras. Four stations of the S. I. R. Electric Railway are in the municipal area; and town-planning schemes well-thought-out and properly carried out will bring in a large residential population, and tend to increase directly and indirectly the income of the Municipality, besides relieving the congestion within the City. These schemes would, however, mean the provision of good water-supply, proper drainage, lighting and other amenities, besides lay-out of good roads linking them with the City. There is no reason, for example, why West Mambalam should not be developed in the same manner as the adjacent part of East Mambalam across the railway-line, though there is no clean slate here to write upon as in the latter case. The parts already built over cannot of course be touched; but farther west is a vast open area which can be indefinitely developed and linked, by means of good roads, with the City. Guindy again with its high ground and easy drainage facilities forms an ideal site for a town-planning scheme of a healthy locality, but water has to be brought to it. All this would involve initial expenditure, which the Municipality in its present encumbered position can ill afford.

Finance.—As a matter of fact all the problems discussed above hinge upon finance, which is the major or key problem of the whole series. Saidapet started as a Municipality with certain initial disadvantages, which had affected its finances adversely. The

Public Health of the locality was none too good; and its reputat for mosquitoes and filariasis had not made it popular as a resid tial area, in spite of its advantages of contiguity to the City a transport facilities in the shape of the electric railway and t regular bus service. The residents of the town have moreov been largely of the poorer sort, eking out a more or less precario existence from industries which are on the decline as pointed o in an earlier section. Hence the revenue to the Municipality fro a potentially richer and larger population has been denied to it.

In the infancy of the Municipality again certain necessary and unnecessary expenditure was incurred by loans from the Government, which have saddled it with a dead weight of a consolidated loan of over two lakhs of rupees, whereas the repaying capacity has been found to be under its present conditions only Rs. 10,000 per annum. A daily market built at a cost of nearly a lakh of rupees might well have been put off, and probably also a local habitation for the Municipality. Water-supply and drainage were prime necessities for the locality more urgently called for; and none can find fault with the expenditure incurred for water-supply, nor the one to be incurred for a drainage scheme. But a loan of over a lakh of rupees was the result of tar macadamising the whole length of the Mount Road. This is a matter of provincial importance the road being part of the Great Southern Trunk Road; and it is a matter of greater and more immediate concern to the Corporation of Madras, whose citizens use it very largely on race days. Naturally, the Race Club should also have been made to bear a good part of the cost of it. But nothing like that happened.

At the same time the Municipality was deprived of its income from tolls, while the bulk of the license fees of lorries and buses went into the coffers of the District Board of Chingleput and of the Corporation of Madras. It was always a standing complaint that its due share was not given to the Saidapet Municipality. Under the circumstances, Government should have written off the loan incurred for tar macadamising the road on the score that it was a matter of provincial importance, thereby relieving the Municipality and allowing it to carry out more pressing and legitimate needs of the locality; but in spite of repeated requests and representations Government has not seen its way to accede to it.

There is another road problem for Saidapet. The scattered parts of the Municipality require to be knit together by a system good roads from north to south—from Choolaimedu, through

Puliyur, Kodambakkam, Saligramam and Mambalam to Saidapet —with cross roads linking to the City, if these areas are to develop rapidly as parts of Greater Madras. But bringing together far-flung places and keeping in good repair the connecting roads, which are subject to the continuous and rapid wear and tear of heavy brick carts mean money again, which is beyond the means of the Municipality whose finances are none too rosy.

Town-planning schemes if successful might ultimately bring in a steady revenue from the new settlements, while relieving at the same time the congestion of the City as stated already. But the launching of them requires money in the first instance.

Thus we see that the major problem of this Municipality, situated in the peculiar position of being suburban to the metropolis without adequate resources is *finance*; and upon it depend all the other problems discussed earlier. The satisfactory solving of all these problems is a matter of concern not only to the Municipality of Saidapet, but also to the Corporation of Madras and to the Provincial Government as well.

PART III

SOME SUGGESTED SOLUTIONS

The first solution that can be suggested for the relief of Saidapet Municipality is an obvious one for the Government to write off its loan at least in part and set it free, in view of its peculiar position as a suburb of the Metropolis with urgent needs to be met in the interests of the town as well as of the City. This the Municipality claims is a piece of justice, and has repeatedly asked for, as some part of it at least, namely, that incurred for tar macadamising the Mount Road was a matter of concern not for itself but for the Madras Corporation and the Provincial Government. If complied with, it will set the administration free to launch on necessary schemes for supplying the urgent needs and amenities of its citizens.

The second solution that may be offered is in connection with *the readjustment of the areas* comprising the Municipality, which has been asking to be relieved of the distant areas in the north such as Kodambakkam, Puliyur, Saligramam and Choolaimedu, all of which bring in little revenue, involve good expenditure and are too far away to receive adequate attention. But these are areas that require to be properly developed as parts of Greater Madras, and contiguous to it; and they cannot therefore be safely taken out of the control of a single authority in the interests of the health of the City as well as for other obvious reasons.

But the other request and complaint of the Saidapet Municipality is just and reasonable and ought to find favour with the Government if no extraneous considerations are allowed to come in. This is the request to extend its limits in the south so as to include in it the Engineering College, the Government Park, the Race Course and Alandur, all of which may be expected to bring in the requisite revenue for discharging duties properly by its residents as the Headquarters of a District and as a suburb of the Metropolis. Government's unwillingness to include the first two places as leading to an increase of its own expenses is natural and can be understood. But there is no reason why the latter two areas should not be included. The turf club is making an enormous profit from the citizens of Madras, for whose benefit the Mount Road is kept in a fine condition, but there is no toll-gate income now. The bringing in of the Race Course within the municipal limits is a piece of justice.

Alandur again is a well-populated area with good trade, healthier than Saidapet, and may be expected to bring in a good revenue by way of property and other taxes. Its inclusion in Saidapet will contribute to augment the revenues of a Municipality which has been saddled with the responsibility for providing the needs of poorer areas lying apart in the north. Incidentally it will bring under the control of a larger central authority, another part of Greater Madras.

But the best solution that can be offered is for the Government to take a more comprehensive and long view of the whole matter and create a suburban ring of municipal areas, as in London, surrounding the City on the south, west and north, from Adyar through Saidapet and Sembium to Tiruvottiyur, dividing the whole area into 2, 3 or 4 administrations with a common advisory board with representatives from these administrations, the Madras Corporation and the Madras Government. Such an advisory body may be expected to take a more just and impartial view of the needs and activities of the several parts far above the narrow parochialism of each of them. If necessary, the limits of the District of Madras may be extended to include the areas of the proposed suburban municipal ring; and to that extent the limits of Chingleput District may be curtailed. But as this district is already recognised to be too big, it can easily admit of such a curtailment. The Headquarters of the District may in that case have to be shifted to Pallavaram, Poonamalle or Sriperumbudur; but that is not an insuperable difficulty, and is a matter of detail which need not be gone into at present.

In conclusion, it may be pointed out that the suburban areas round the Metropolis can be properly developed, and its population can get proper service, only if a comprehensive policy is adopted like the one suggested above. Otherwise the conflicting interests of the Metropolis and the Suburban Areas will lead to insuperable difficulties and incalculable mischiefs, which may be found in the long run to be too costly and irreparable in some cases.

Some Important References

Administration Reports of the Saidapet Municipality from 1921-39.

Census Reports from 1881 to 1931.

Madras Administration Manual.

Chingleput District Manual.

Public Health Reports of the Government of Madras.

Topographical map of the Survey of India (i-inch- per mile).

Development map of the Saidapet Municipality (blue print).

Contour map of Saidapet from the Superintending Engineer, Public Health.

Saidapet Health Project (issued by the Saidapet Health Association).

Some Aspects of the Economic Geography of Guntur*

BY

M. V. KRISHNAMURTHY, B.A., B.ED.,
Asst., Hindu College School, Guntur.

COLONISATION

Guntur is a flourishing town and a trading centre, 200 miles north of Madras and 20 miles south-west of the Anicut across the Kristna. Originally a small agricultural settlement, it has grown to its present size in the course of a few years and bids fair to become a City in the near future.

The soils map of Guntur (Figure No. 2) shows a central region of red soil stretching westwards and surrounded by one of rich black. A small patch of *Pati* soil lies near the tank in the eastern half of the town and nowhere else within the revenue village of Guntur. It is well known that this kind of soil can be found only in areas that have long been used as house sites. One has therefore to conclude that this justifies the present name of that part of the town, called Old Guntur (marked O in the sketch map).

Historical references tend to confirm this view. An inscription of 1158 A.D. in the Siva's temple of the place shows that it must have been in existence for over a 1000 years. Reference to the village in the preface to the Andhra Mahabharata by Tikkana (12th Century) establishes that the village must be at least more than 7 centuries old.

Why was this particular site chosen for the first settlement? Food and water supply determine the habitation of man. The rich black soil of the place could be utilised for growing crops. The water-table at moderate depth as can be noticed from the map, induced the people to settle down. Everywhere else in the vicinity, either the soil was poor or the water-table was very low. Naturally the site on which Old Guntur now stands was the only spot that could attract settlers.

* A paper read before the Geography and Geodesy Section of the 27th Session of the Indian Science Congress, Madras—January, 1940.

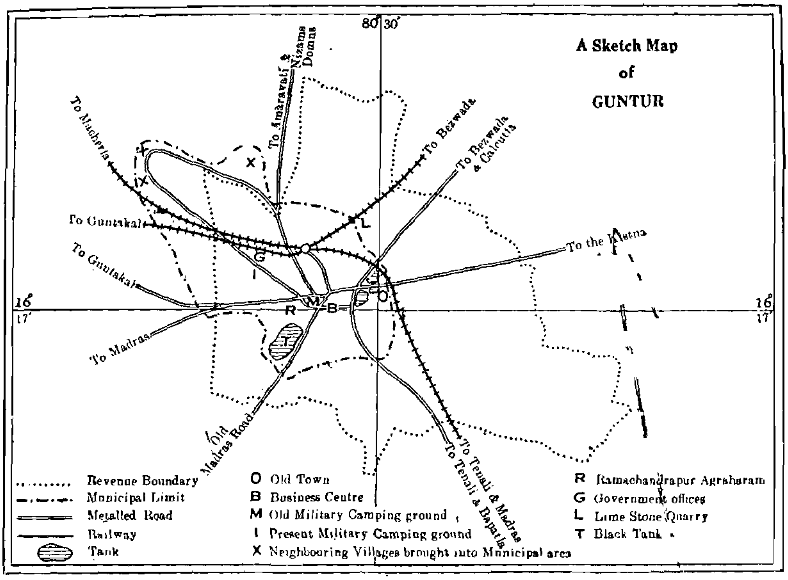


FIG. I

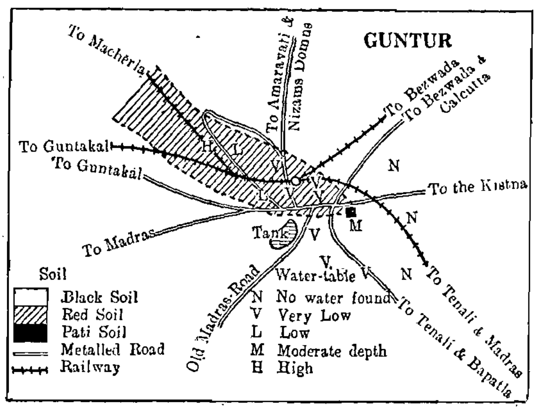


FIG. II

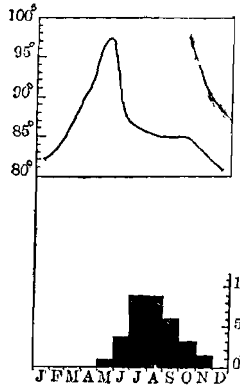


FIG. III

Guntur has been of military importance for several centuries. The celebrated poet of the Andhra Maha Bharata speaks of his father as the *Dandanadha* of Guntur. In 1753, the French established a military camp here in the site at present occupied by the Hindu College and High School Buildings, (M. in the sketch map). It was on account of its central and strategic position that Guntur was selected Head-quarters of the District when the English began direct administration of the region in 1846. Even now a military camping ground is set apart (I in the sketch map).

Therefore when metalled roads were constructed, naturally they passed through Guntur, and it became a focus of several routes. This helped to make the place a trading centre as well. The produce of the neighbouring parts was brought here for sale. Merchants were attracted to the place, opened business houses and gradually settled down. As a matter of course, the junction of the various routes meeting in the town helped to make it a business centre and it continues to be so even to this day.

These settlers had no need to care for the rich black soil like the agriculturists. Their only desire was to secure a cheap site not far away from their business quarters. Even the area of red soil, with its low water-table, was good enough for them.

Increasing business attracted labourers, who, however, did not at first entirely give up agriculture. They chose sites near enough both to the business centres and the fertile black soil, in spite of its low water-table. After the setting up of factories in recent times, these have turned full-time labourers, giving up agriculture unremunerative for people with small holdings.

Two centuries ago (1718), a gift of land, now known as Ramachendrapura Agraharam, (R in the sketch map) was made to some families who were obliged to settle down there, although the water-table was low. The black tank fed by the streams from the neighbouring hills was of some help to them.

In 1788, this region came into the hands of the British, who at first continued the prevailing Zamindary System. In 1846 this was given up and direct British Rule commenced. It is interesting to note that their offices, as well as the French Military Camp of 1753, were all in the red soil area close to the junction of the routes.

The construction of the railway line (1889) from Guntakal to Bezwada brought the town into greater prominence as a commercial centre. Foreign companies too opened business houses. Cotton, grown even in distant Palnad and other regions, was brought here for sale and export. But several of these business houses had to be closed down when cotton presses were set up in the cotton growing areas.

In 1904, Guntur was made the Head-quarters of the newly formed district. Civic amenities, like hospitals and educational institutions have also contributed to the growth of the town.

Since the construction of the railway line, the population of the town has rapidly increased year after year, till it reached the number 65,179 according to the census of 1931.

Census.	*Population.*	*Census.*	*Population.*
1871	18,033	1911	40,529
1881	19,646	1921	48,184
1891	23,359	1931	65,179
1901	30,833		

This rapid increase has been due to the exodus of the rural population into the urban area.

It should be noted that the new settlers were anything but agricultural. The only land available to them was the red soil area, which was not very productive and so could be had at a cheap rate. Even now further extensions of the town are towards the west, and north-west a region of poor red soil. The construction of most of the new government buildings (marked G in the sketch map), in that area has given a further impetus to its colonisation. These extensions have approached three small villages, (marked X in the sketch map, towards the west and northwest), which have therefore become part of the town.

Thus a small agricultural settlement became a focus of routes and developed into a commercial centre. The part played by the soils and water-table of the region in this evolution of the town should not be forgotten. The railway and the factories acted as great forces for the rapid growth of the town.

Climate

The Andhra Calendar is based on Chandramana (Lunar Movments). Still, by tradition the man in the street has got familiar with the weather conditions that may be expected with the Sun in the several constellations, from Ashvani to Revati.

Generally when the Telugu Year commences, the Sun has just crossed the equator in his northward journey. Summer may be said to have set in.

By the 10th of May the Sun, now in Krithika, comes overhead and remains on the horizon for a longer time. The days are unbearably hot and dusty. The maximum temperature in shade shoots up to about 120°F., while the minimum seldom goes below 80°F. Work out of doors after 10 A.M., is well-nigh impossible. The streets, otherwise crowded, present a deserted appearance. The sea breeze blows from about four in the evening and makes the conditions normal. Sometimes the hot west wind, continues far into the night, and the sea breeze is not felt.

On account of its low humidity, the high temperature of Guntur is without doubt more tolerable than the moist heat of the west coast.

But for the break of the monsoon early in June, the temperature should have risen higher still. The showers of rain help to render the weather conditions mild enough. There is a sudden fall in the temperature, although the Sun is not far away from the zenith. The minimum temperature is however almost steady.

The most rainy months are July to September (Fig. 3) and coincide with the Varasharuthuvu of the Hindu Calendar. When the rains are delayed, as may occasionally happen, epidemics break out, perhaps owing to the excessive heat, not so dry as before because of gentle showers.

In October when the general rains have ceased, the fall in temperature is steady. The west wind gives place to the cool north-easterly wind. Cyclones from the Bay sometimes cause destructive rains now. This is the time when the Sun will be in *Libra* (November) and the storms of the season have become proverbial. The Deepavali Day and Karthiga Purnama (Full Moon Day) are notorious for such stormy weather in this part of the country.

The days become shorter and the nights are longer in December, when the Sun is in the southern sky. Except for the cyclones, the accompanying season is generally dry and comparatively cool, favourable for human activities. From the commencement of the English new year, days become longer, and the heat begins to be felt from February. The succeeding months are once more hot and dry ; and with the scorching heat the monsoon is anxiously awaited.

The total rain for the year varies from 25 to 40 inches, resulting in a tropical grass-land vegetation in the region.

Climatic Control

The influence of the weather conditions on the lives of the people is very marked. The ryots depend entirely on rainfall for their crops.

In the dry months of April and May, the fields are manured and kept ready for the monsoon. With the early showers of rain about the 7th of June, when the Sun enters the ORION, is sown the first crop, which hitherto afforded fodder for the cattle, as the ryot found it exceedingly hard to feed them through the summer months when every blade of grass had been dried up in the scorching sun.

But nowadays, after the introduction of the ground-nut into this region about 20 years ago, this has been the commonest first crop. For ground-nut is harvested about the close of October and November, fetching the ryot some income when he is most in need of it. Fodder is grown as a second crop in the same field, after harvesting the ground-nuts.

The principal rainy season is July to September. The black soil when once saturated with water, can retain moisture enough to sustain the crops through the succeeding dry months. Chillies and tobacco need some rain only in the early stages of their growth. The former crop is planted at about the middle of September and the latter, a few weeks after that. Heavy rainfall is injurious, especially to the chillies in the period of growth. The plants are in full bloom in the cool dry months of November and December. They ripen with the increasing heat. Both the crops are harvested before the close of February.

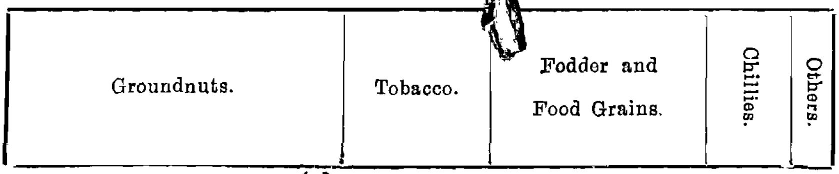
Economic

The ryot may be said to be the very foundation of all society; and as such, the study of his economic condition demands our first attention.

Out of the total revenue area of 8,600 acres, the town site comprises of 1,700 acres. The 5,600 acres of cultivated land are distributed among nearly 1,000 ryots. Not more than a third of them have holdings of over 5 acres; while the rest are owners of only 2 or 3 acres each. So they are obliged to look to other trades as supplementary sources for the maintenance of their families.

For several years, Guntur was noted for the production of tobacco and chillies. The comparative production of the various crops in 1937 (Fig. No. 4) discloses the fact that ground nut and tobacco form the principal crops at present. Chillies have been driven into the background.

FIG. 4. CROPS OF GUNTUR (REVENUE VILLAGE 1937).



The tempting price o[illegible]1-12-0 per maund, coupled with the good yield of 5 candies per acre of ground-nut in the early years of its introduction, has been responsible for this change. But the land frequently used for groundnut and tobacco has been rendered unfit for chillies. The former exhausts the potash content and the latter the nitrates of the soil. The present continuous fall in the price (to As. 10 a maund), as well as the yield (1½ candies per acre) of groundnuts, is driving the ryots into a state of despair.

A species of tobacco, known as the country leaf, was being grown, and purchased by dealers from several parts of the country. This tobacco is cured by being dried in the sun, which costs the grower nothing.

But the advent of the Indian Leaf Tobacco Developing Company encouraged the production of the Virginia species. Guntur district is now considered the best region in India for this crop. The ryot is full of hope, but never sure of his income; for the price of tobacco, a commercial crop, is controlled by the fluctuations in the world market. Competition in this region is either lacking or too weak to last long. A few other companies also have recently opened their offices here, and the effect of this remains to be seen.

The costly process of curing demanded by the purchaser has been another handicap to the grower, without the necessary capital. The parasitic middle man has sprung up to take advantage of the situation.

In 1939 for example, the price of tobacco has gone down so low that the poor ryot has not been able to realise even the bare cost of production.

Thus these two commercial crops, which, the ignorant ryot believed, would improve his poverty-stricken condition, and might be adopted as his main-stay, have not fulfilled his hopes. He is bewildered. Perhaps, one may venture to say that they will prove harmful to him in the long run, if the same state of affairs is allowed to continue.

Food grains cannot be grown as a second crop ; but as the only produce for the year, they do not fetch much income in dry areas. There is also a growing tendency on the part of the ryots to use rice instead of millets for their diet. So, ever since the groundnut displaced millets, the ryot is obliged to depend on others for his food stuffs too—a deplorable condition for an agricultural people. The large number of cattle and horses in the town may be considered to be the chief reason for the utilisation of 1,400 acres of land for growing fodder and food grains. The ryots that use all their land for commercial crops and have consequently neglected to grow fodder, find it necessary to make purchases of straw from the wet lands—miserable indeed.

The soils play an important part in the distribution of the crops. The red soil region can be used for oil-seeds and millets only; while any crop can be grown in the black soil. The statement given as annexure illustrates the annual income per acre of cultivated land for different crops.

In this estimate, it has been assumed that the ryot works in his own land. As already noticed, the ryots of this region have only small holdings. So several of them are obliged to toil hard in rented land. The additional burden of the rent payable to the owner is laid on them. The ryot has therefore almost nothing left to him for his hard labour. No wonder most of them would gladly seek other trades.

In arriving at the cost of production, the actual wages for the number of days the cattle have been employed in the field has been taken into account. As a matter of fact they have to be kept all the year round, which hits the ryot hard.

The cost of manure has also been overlooked, for it is expected that the manure is to be supplied by his cattle. But now-a-days as much of the land is being used for commercial crops, the ryot has not been able to maintain as many cattle as he used to. This has led to deterioration in the fertility of the soil and consequent decrease in the yield.

The agricultural labourer is no better than his master. The daily wages in kind or coin is As. 4 for a man and As. 2½ for a woman. For longer hours of work, as in harvesting, he receives a proportionate sum. He envies his brother, the unskilled labourer, earning a little more in the business centre.

Merely bewailing one's own sad plight can do no good. Self-awakening must be followed by self-improvement. The following suggestions are made as remedial measures for the amelioration of the people depending on agriculture, particularly in the area of our study.

1. The ryot has to be educated about the variety of crops that can be grown in the locality, so that he may not be confined to a limited number in the rotation of the chief dry crops.

2. He needs instruction in the proper manuring of lands on a scientific basis so that the maximum yield may be obtained.

3. Co-operative production societies, with district or provincial head-quarters may be formed in every village, to prevent over production of any particular commodity with the consequent neglect of others.

4. Co-operative marketing societies under State guidance ought to afford relief to the pitiable ryot groaning under the burden of perennial debt. The Debt Relief Act can only save him from past liabilities, but can be no safe-guard against his running into future debts, which is almost certain so long as the present state of affairs continues.

Fruits like mangoes, oranges, and lemons can be grown in this region. Formerly there were some of these gardens, but when the plants gradually died out, they have not been replaced as it was not found to be a paying concern at the time.

A brief account of what has been done in Italy to encourage the fruit industry may not be out of place here. Fruit industry in Italy did not pay a few years back, until the Government came forward with their big schemes to give impetus to fruit industry —such as improving the varieties, raising the quality of fruits through proper standardisation or grading, efficient cold-storage, excellent transport facilities in the form of fast and cheap transportation and organisation of sale known as The Department of Collective Sales of the Products of Earth. The National Institute for Export created in 1925 at Rome has greatly contributed to keep up the price of Italian produce by

(a) Creating standards for various fruits which alone could receive the mark of national guarantee ;

(b) Organising the sale of produce through a great body of direct agents of this institute—the agents being scattered over all the important places in Europe.

The starting point of this system is the local Co-operative Society. All that a producer has to do is to bring his produce every morning to the society. The produce is weighed and thereafter taken care of by the society.

Italians under the lead of Mussolini have imbibed the spirit of co-operation and have realised that in co-operation alone lies their safety. No wonder that the Italians have largely succeeded in capturing foreign markets greatly at the expense of France.

While French exports of horticultural produce in 1928 amounted to 90% against 10% from Italy, in 1930 the French exports went down to 15% against 85% from Italy.

Among the means that the Foreign Governments are adopting to develop the fruit industry of their countries may be mentioned a few such as Laws to regulate the production of nursery plants for sale in Egypt, free supply of nursery plants in Egypt, Palestine, Italy; remission of land revenue in Italy for a number of years to those adopting an approved system of fruit gardening; subsidies to encourage fruit gardening and fruit preservation in Italy and Switzerland; and various others.

—From *Fruit Industry of Italy and Sicily Island* by S. S. Lalsingh, B.Sc., M.Sc., California Fruit Specialist, Lyalpur, Punjab.

The influence of co-operative societies on the dairy-farming of Denmark is too well known to call for a detailed account.

Minor Industries

On account of its focal position the town has been a centre for cottage industries like potteries and basket-making, which do not now-a-days find sufficient market in any single village. Their location only in certain parts of the town is an interesting feature.

Earthenware has always been used by the poorer classes for all their needs, each village having its own potter. When the new settlers came here, they naturally purchased their pots, tiles and such other things from the nearest village, now known as Old Guntur. So even to this day only this part of the town has potteries, although the clay required, is obtained from distant tanks, the black tank (T in the map) included.

The basket weavers have found it more convenient for their business to be as close as possible to the junction of the various roads leading into the town.

Wherever millets are largely grown for food, plenty of fodder is available for cattle. Large numbers of them are reared and they, in return, supply food to the farmer's family and manure to his fields. The womenfolk look after the cows and calves and the she-buffaloes. Dairy-farming has been the occupation of the women-folk. Every year large quantities of ghee, worth several lakhs of rupees are exported from this town, especially to Calcutta.

This has given rise to the tin-making industry.

To meet the demand for flesh in the town, about 100 goats, sheep and cattle are slaughtered each day. This has led to the setting up of a tannery. Lime, the principal tanning material is obtained from the limestone quarries (L in the map) nearby. Most of the tanning barks can be had cheap from the forests of the district.

Ground-nuts have to be husked before being exported. Oil Mills have been set up for pressing the oil out of the seed. There are seven of them in the town this day. The oil is for both local consumption and export. Oil cake, sold at about Rs. 13 per ton of 500 lbs., is used as manure for rice and sugar-cane, and also exported to Europe where it is used for feeding cattle.

Much of the rice from the neighbouring areas under wet cultivation, is milled here chiefly for local use. There are eight rice mills in the town.

Cotton is ginned and pressed into bales for export. This trade as already noticed, is gradually on the decline.

All these mills have been using only steam power. A licensed company for supplying electric power has recently been started. But the high rate charged has been an impediment to the free use of this power by these mills. The proprietor does not readily come forward to replace the steam engine by an electric engine, as it requires fresh investment.

A number of tobacco handling firms have been started. Over 8000 labourers, from the town as well as the neighbouring villages, find employment in them each day.

CONCLUSION

The economic prosperity has brought in its trail some evil effects. The sanitation of Guntur is in peril. The smoke from the factories has contaminated the atmosphere. The labourers' quarters are much overcrowded. Cholera and small-pox levy their annual toll. For want of a proper drainage system, mosquitoes are freely breeding and threaten to become a pest. Malaria is taking firm root in the area.

Along with the supply of cheap electric power, the government should see to it that the factory-owners make free use of it. A well-controlled supply of water, coupled with a proper drainage system, is the most urgent need of the town. Provided these are ensured, Guntur is bound to be a far healthier place and before long a fine city.

A nodal town and consequently a busy trading centre, a railway junction, and the headquarters of the district, Guntur has developed by leaps and bounds. But the ryot, the true foundation of all society, has always remained what he was centuries ago. His condition has not a whit improved, if it has not actually deteriorated. He looks forward anxiously to the national Government for his uplift.

Crop	Cost of production per acre			Yield per acre in candies		Selling price	Value of yield per acre	Net income per acre
		Rs..						
Chillies	Tilling Plantation Total	8 5	 13	Past Present	3 1	Rs. 30 per candy ,, 60 per candy	Rs. 90 ,, 60	Rs. 77 ,, 47
Ground-nut (first years)	Tilling Seed Harvesting Total	3 8 9	 20	4 candies		,, 1/12 per maund	,, 140	,, 120
(present)	Tilling Seed Harvesting Total	3 3 3	 9	1½ candies		,, 10 per maund	,, 19	,, 10
Tobacco (a) Country leaf	Tilling Plantation Harvesting Total	8 5 5	 18	2 candies		,, 40 per candy	,, 80	,, 62
(b) Virginia	Tilling Plantation Total	8 6	 14				,, 30	,, 16
	Leafing & curing 30 (unable to afford this, the ryot sells away the raw leaf)							
Millets	Tilling Seed Harvesting Total	3 2 3	 8				25	[illegible]

Sugar Cane Cultivation in India*

BY

GEORGE KURIYAN, B.Sc. (LOND.),
Department of Geography,
University of Madras.

The name Sugar is applied to more than hundred substances having distinctive properties and scientific names; for example sucrose, glucose, maltose, fructose etc. Of the numerous sugars which occur in plants, sucrose is the most abundant and has been extracted commercially from the sugar cane, sugar beet, maple tree, Indian maize, sorghum grass and several species of palms. As it occurs in solution in the sap or juice, the task is only to extract the juice and convert the dissolved juice into the marketable crystals—the sugar of popular parlance. Therefore, cane-sugar, beet-sugar, maple-sugar etc., consist essentially of sucrose admixed with small percentages of impurities derived from the plant juice. These impurities account for the differences in colour, odour, and flavour of raw cane and beet sugars. When refined, these sugars are odourless and colourless; have equal sweetening power; contain about 99·8% of sucrose and cannot be distinguished from one another by chemical analysis. After further purification in the laboratory, they contain about 100% of sucrose.[1]

Sugar is a necessary food crop and apart from wheat, rice, maize and potato, forms the greatest item of mankind's dietary obtained from the vegetable raw materials. Cane sugar however is not indispensable. By trebling the area in sugar beets, the world demand of sugar, could be met. Moreover, several of the palms could be utilised so that the output of sugar could be enhanced considerably. Maize and Sunroot (Helianthus tuberosus) are rapidly becoming serious competitors thereby gravely threatening the leadership of cane.

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1. Vide *Encyclopædia Brittanica*.

Barrett says that the sugar cane was first domesticated' presumably somewhere in South Eastern Asia or the East Indies.[2] Sugar cane is a perennial grass, the cultivation of which is confined to the warmer regions of the earth. In all probability it is of palaeo-tropical origin and South Eastern Asia is assigned as its home by economic botanists.[3] Etymologically sugar is of Indian origin, the earliest forms of the word being Sharkara[3a] in Sanskrit, Sakkara in Prakrit, thence it can be traced through all the Aryan languages as Schakkar in Persian, Sukkur in Arabic, Suicar in Assyrian and Phoenician, Saccharum in Latin, Azucar in Spanish and Portugese, Zuchero in Italian, Sucre in French, Zucher in German and Sugar in English. It is of interest to note that sugar cane was known to India for the last 2,000 years. The earliest reference to this in western countries dates back to 627 A.D. when sugar figures among the spoils taken by the Byzantines after their conquest of Dastagerd in Persia. Again it is recorded that the Chinese Emperor Tai Tsung sent a batch of Chinese students of agriculture to study the methods of cultivation of sugar cane and the manufacture of sugar. Several Mahomedan writers have stated that sugar is of Indian origin. The sugar cane plant is indigenous to India[4] and it yields a higher proportion of sugar than any other plant,[5] beet coming next to it and the date palm after beet; the maple tree of America may be regarded as the fourth in importance. Sharkara is mentioned in the shastras as one of the five ' Amritas ' or celestial sweets. All this suggests that the cane was indigenous to India and sugar was first manufactured from the cane in India.

2. Barret, *Tropical Crops,* page 112.

3. Proceedings of the 25th Indian Science Congress, 1938, Calcutta, Part 2, page 271. "The fact that such widely varying types (sacharum spontaneum) exist in parts of India even to this day is perhaps indicative of certain of them being the primary centres (or centres of origin) for this species."

3a. It has subsequently been suggested to me that Sarkarai is a Tamil word. In Tamil, Karai means coast and Sarkarai therefore means that which came by the coast.

4. Vide, Proceedings of the Indian Science Congress, 1938, Calcutta, Part 2, page 270. "Members of this group (sacharum spontaneum) occur in the wild state throughout India and are found growing wild in places that are liable to severe drought in summer and flooding during the rains. They are at home on river banks and tank beds which dry up in summer.

5. *Encyclopedia Brittanica.* Record production of beet was 2.19 tons of commercial sugar per acre in Germany in 1910-11, and for cane, 5.5 tons per acre in Java in 1925-26, or about 2½ times that for beet. The corresponding crops were 12 tons of washed beets and 42 tons of cane per acre.

Nevertheless the cane was found growing in Polynesia and the Hawaiian islands by the first European visitors. Ethnologists assert that these islands were settled from the South Pacific at a very early date and probably these early migrators brought the cane with them.[3a] The presence of the plant in the South Pacific at a very remote time is thus indicated, suggesting thereby that the cane is indigenous to both South Eastern Asia and the South Pacific.[6]

A mere enumeration of the principal sugar growing tracts of India would lead one to infer that all kinds of soils answer for the growth of sugar cane, including as they do the archaen soils of Chota Nagpur, the old alluvium of Bihar, the new alluvium of Eastern Bengal etc. "Cane can be grown successfully on a great variety of soils. Typical cane lands have a heavy texture—good clay loams and rather heavy alluvial soils are among the best of course, much depends upon the nature of the sub-soil. A fairly light top soil if underlain by a good clay sub-soil will be very satisfactory for cane. Very heavy top soils on the contrary are better if the sub-soil is somewhat open, since this makes for better drainage which is a matter of first importance. Different kinds of cane have different soil requirements."[7]

Sugar cane has a preference for lowlands and volcanic soils. The character of the soil is indeed of prime importance, the best being loams rich in humus and derived from volcanic, coralline or crystalline rocks. Phosphates are greatly valued as a manure, but where the land is annually renovated by silt, no special manuring is necessary, nor is it of much use. In India it is found that the best canes grow at the junction of old and new alluvia on the sides of streams and rivulets. These are mostly the red clay loams specially rich in mineral matter. For growing the superior varieties of cane, the two principal considerations that should guide one in the selection of a site are:—(1) Is the land close to water from which it can easily be irrigated? and (2) Is the land above inundation level, and easily drained, yet level?

It has been found that lime is an essential constituent of the soils, most appropriate to the cane; in calcareous soils, the most

6. This suggestion is made more probable when the marked difference in habit between the Indian canes and those of the Otaheite and other Polynesian islands is remembered.

7. Earle, *Sugar Cane,* page 193.

robust canes are grown and they afford the sweetest juice. The physical properties of the soil are as important as the chemical constitution; it demands a deep and free soil. Deerr recognises 4 types of soils,[8] the Indo-Gangetic and other alluvial deposits, the Black Cotton or the Regur soils, the red soils of the Madras Presidency overlying the metamorphic rocks, and the laterite soils. Generally all the soils contain large quantities of iron and alumina, with ample supplies of potash and magnesia. Lime, phosphoric acid and nitrogen are usually low.

Sugar cane is a plant that requires a high temperature and large quantities of water. The limits of its cultivation are best defined as lying between the mean annual isotherms of 68°F. In most of the cane growing regions, the temperatures of the coldest months are not much less than 60°F and in the warmest month they may be as much as 83°F approximately. Nevertheless, the cultivation of sugar cane though typically tropical is not confined to the tropics. Louisiana, Argentine, Spain, Southern Japan, New South Wales, the Punjab and upper United Provinces are well outside the tropics, and some of these regions experience freezing weather, sometimes of considerable severity. Since the buds of the growing cane are killed even by a slight frost, the stalks intended for seed have to be protected with cane trash and earth. The standing cane can be utilised for the mill after the buds have been killed by light freezing, but a heavy freeze however, renders it worthless, so that the harvest has to be hastened making the grinding season as short as possible. The worst disadvantage of all these extra-tropical climates is that all the crop has to be made on immature cane. A frost sufficient to kill the standing cane does not usually injure the roots and such fields can be ratooned, although fewer ratoon crops are usually taken in extra-tropical regions.

As the cane is grown in countries widely differentiated both as regards latitude and altitude, there is a wide variation in the conditions under which it is produced. By actual measurements in Hawaii, it has been shown that the rate of growth of the plant during the cold season was decidedly less than during the dry season. The period taken for the cane to ripen is also dependent upon the temperature; with a higher temperature, the period of growth is less.[9] Walter in his book on the Sugar Industry of Mauritius has shown that the product obtained by the multiplication of the

8. See Noel Deerr, *Cane Sugar*, page 71.
9. See Noel Deerr, *Cane Sugar*, page 24

excess of the daily mean temperature over 70°F with the number of days is constant and is equal to 1350. The cane usually takes 12 to 14 months to ripen; the average annual temperature is important, 75°F being desirable with a summer of nine months duration.

Sugar cane can be grown successfully in all parts of the tropics where sufficient moisture is available, either from rainfall or from irrigation. Where the average rainfall reaches 50″ per annum, it can usually be grown without irrigation,[10] but where the rainfall is much under this figure additional water will be required to obtain profitable yields. "With rainfall alone, 100″ a year, if properly distributed will usually give as good or better results than any greater quantity."[11]

The effect of rainfall is more than a matter of total fall, its distribution being of equal importance. The 50″ mentioned above would be entirely inadequate if equally divided among the 12 months of the year. "Climates with a pronounced dry and wet season are much better than those where the rainfall is equally distributed throughout the year, (contrast Java) especially where there is salt in the air or in the soil or in both. While harvest time should be dry, the growing season should receive more than 60″ of rain."[12] It is worth noticing that every part of the cane growing regions of India has a pronounced wet and dry season.

The rainfall of the tropics when averaged over a number of years, may appear to be very even both as regards periodicity and quantity, but nevertheless in several cases, the seasonal rains fail and cause prolonged drought. Likewise, prolonged spells of wet weather are also common, but the damage they occasion is small, compared with what is due to a prolonged drought. Conditions in the cane growing regions of India are no better than elsewhere. In the report of the Agricultural Department of Bihar and Orissa, it is stated that the season under report has been exceptionally dry and most unfavourable.... "although the total amount of rainfall was not very different from what we had in the last two years. Our

10. See Earle, *Sugar Cane*, page 191.

11. Earle, *Sugar Cane*, page 192. The humidity of the atmosphere is also important; as it grows less, the greater becomes the quantity of water that is transpired from the leaves, and the greater becomes the demand on the soil supply.

12. Lyde, *An Atlas of Economic Geography*, page 70. Note that the figure 60″ is higher than that of Earle.

total fall this year was 37·19″ as against 39·59″ and 40·83″ in the preceding years, but only when we look at the actual distribution of the rainfall—the real state of affairs becomes evident. About 50% of this year's rainfall was confined to one month, i.e. August, which was the real wet month of the year causing great havoc in the form of floods etc. Deficient rains in July and September coupled with practically nil in June and October has made the year 1935, one of the worst agriculturally."[13]

The main effect of drought on the crop is reduction in tonnage; what crop is harvested will contain a high percentage of fibre due to the restricted length of the internodes and to the evaporation of water from the cane by increased transpiration.

The temperature change has a very important bearing on the composition of the cane. In those places that have a uniformly high temperature and no cool season, an impure cane low in sugar content and high in reducing sugars, is almost invariably harvested. In such a case there is opportunity for continuous vegetation growth and the crop will consist of ripe and over-ripe canes. The non-sugars present will consist of products in process of metabolic change and of degradation product formed by the breaking down of cane sugar. In extra-tropical climates like Louisiana the limited period of growth affords a cane that does not have an opportunity to reach maturity. A juice low in solids, sugar and purity, and high in reducing sugars results, the latter bodies representing material in process of transformation to cane sugar.

A sweet and pure cane is found in those regions where a longer period is taken for maturity, combined with a season sufficiently cool as to check the vegetative vigour of the plant, whereby, its energy is directed towards the elaboration into cane sugar, of material already in process of transformation. Those localities lying on the confines of the tropics present these conditions and when as in the Punjab and the United Provinces, water can be withheld from the plant, and that in the plant allowed to transpire, the sweetest and purest material results. (The same procedure can be adopted in Madras also although it lies inside the tropics).

It would not be unreasonable to suppose that those areas lying in a zone of nearly constant rainfall would afford a cane of low sugar-content. Such however is not the case. On the other hand,

13. Report of the Agricultural Department, Bihar and Orissa, 1935-36, page 41.

the effect of the heavy rains during the crop season is seen in a diluted juice for several days after the fall.

"The ideal distribution of rainfall and temperature for an annual cane crop in the Northern Hemisphere would be somewhat as follows:—During the crop period (December to April) a cold dry season should prevail with showers of sufficient frequency to maintain the vitality of the cane without interfering with the harvest operations. During the next six months (May to October) there should be a high temperature combined with a heavy and well distributed precipitation. The rains should fall at the rate of about 2" or 3" a week, with absence of excessive falls or prolonged periods of drought. For one month prior to harvest, the rainfall and temperature should both decrease in order to stop the vegetative growth and allow the cane to ripen, but complete absence of water is not desirable. Finally it may be mentioned that early rains after harvest give a cane that itself ripens early."[14]

In a large sub-continent like India, there are wide variations in climate from place to place, but nevertheless there are certain remarkable features of similarity in the whole region. In winter, the North West Frontier Province, the Punjab, and upper United Provinces enjoy cool climates, sometimes even freezing—while the south is distinctly hot, right through the year. In summer however, there is a complete uniformity of temperature, no part of the whole of India having a temperature less than 68°F (excepting some of the hill resorts). Temperature seems to play only a very minor part in delimiting the area under cane cultivation.

The seasonal distribution as well as the total quantity of rainfall varies from place to place; in Assam and the West Coast it is more than 100" while in South West Punjab, Sind and some other tracts it is less than 10". The rainfall statistics of the several parts of India are given in Appendix 1. In general it may be said that everywhere in India, May to October is the season of heaviest rains, July and August being the two months of maximum rainfall (except the Madras coast). December to April is the dry season in India (except the Frontier Province).

The differences of climate met with in India have a direct bearing on the type of crops grown. Sugar cane is moreover grown in a series of separate tracts over the length and breadth of India. As a rule, it is grown as an irrigated crop (about 60% of the total

14. See Noel Deerr, *Cane Sugar*, page 29.

crop in India is grown under irrigation) except where the general flow of water raises the water table.[15] In the North West of India in the semi-arid tract of the Punjab, with occasional frost in winter and intense heat during the summer months, the canes met with are some of the smallest and most fibrous in the world, although such juice as exists, is distinctly good. Proceeding towards the south east along the line of the Himalayas, the climate becomes less and less arid, till in Bengal and Assam it becomes extremely humid. In direct response to the variation of climate a change takes place in the class of canes grown, till in Assam and Bengal thick tropical canes are met with. Similarly towards the south, in Mysore and Madras the canes improve in quality and where sufficient water is available, thick canes almost equal in quality to the best canes found anywhere else in the world are met with.

Roughly then in India there are two main belts of sugar cane to be distinguished differing from one another in as remarkable a manner as possible. The first is a belt in the north, 200 to 300 miles wide running along the line of the Himalayas increasing in density towards the middle (United Provinces) and thinning out at each end. This belt almost entirely consists of thin hardy indigenous canes, differing often greatly from one another but which have been collectively called Saacharum Barbarei. The second belt lies in the Peninsula where in Bombay, Madras, Mysore, and Hyderabad, wherever sufficient water is available, thick tropical canes (Saacharum Officinarum) are the chief forms grown. Here and there under unfavourable conditions, the indigenous types are still met with, but they are merely thicker kinds of the northern types and gradually decrease in number towards the south and finally disappear altogether.

This naturally suggests a great development of the industry in the Peninsula which however is not the case. In India much the larger area under cane lies outside the tropics (vide statistics in Appendix II). More than half the total acreage is in the United Provinces (51·1%), the Punjab accounts for about 14·4% and Bihar and Orissa for 12·3%. Bengal has about 7·67% of the total acreage. All these provinces lying outside the tropics together account for nearly 85·5% of the total. Madras has only 4% of the

15. In Bengal the irrigated crop occupies about one-tenth the total acreage under cane; in Bihar and Orissa the proportion is more than 1/3, the unirrigated crop being confined strictly to the river. valleys. Vide Appendix II for the importance of irrigation for the crop.

total acreage, Bombay less than 2·5% and the other parts of tropical India have still smaller proportions. In India therefore, sugar cane is essentially a crop of extra-tropical regions!

The two main reasons for this apparently anomalous distribution are (1) the presence of rival food crops in the south and (2) the greater cost of growing the tropical canes. In the south, water is comparatively scarce and dear and practically all is used up in growing rice; in the north, wheat is grown as a winter crop, and thus there is no real competition with the sugar cane for water. It is only in Bengal in the north that rice becomes an important crop, but here no scarcity of water is felt, so that both rice and sugar cane can be grown.

As to the cost of growing the two kinds of cane, the thin northern canes thrive under the greatest of neglect and very little money is spent on its cultivation; it is often merely grown as a crop on which the farmer can raise a loan and once the bargain is concluded, it is left to itself. The season for active growth is rather too short, (4 to 5 months) as the temperatures are occasionally too low in winter for even the hardy northern forms to thrive. In the south, on the other hand, sugar cane is one of the most expensive of crops and for a ryot to start growing it is taken as an emblem of success. Much manure in the form of cake is needed; water is costly and attention is required all the year round. Added to this, there is always the danger of water failing during the drier seasons of the year and sometimes disease appears and the whole crop is thus liable to be lost. It is therefore only the better class of agriculturists who attempt a cultivation of the cane in the south. "Sugar cane growing is typical of the most intensive cultivation which the Deccan ryot pursues, and one which causes him great expense in water and manure. In Deccan it is confined to those regions where an assured supply of water is available."[16] Again it has to be remembered that the cane usually takes one year or more to ripen and the South Indian ryot, can in the same period, with the same amount of water, have two or three other crops. The supply of water has to be assured in the case of cane while in the other cases, it is not so imperative. In the south, the difficulties of irrigation are greater, due to the prevalence of the lift system. In addition, sugar cane is a crop which is more or less a gamble from the point of view of the ryot as the price of jaggery or gur is liable to very serious fluc-

16. Simkins, *Agricultural Geography of the Deccan Plateau*, pages 55 and 56.

tuations,—much more than that of any other food crop. The technique in the manufacture of gur is rather specialised; such technical experts are confined to a few families in the South and there is thus a dearth of technicians. Indifferently prepared gur has very poor keeping qualities. It is a result of all these various factors that the south has not become an important area for the cultivation of sugar cane.

Irrigation is general wherever the cane is grown in India.[17] The land is usually watered before planting, after which irrigations follow at first every five days and afterwards every eight days. The water is obtained from wells, tanks or canals as the case may be. The system usually adopted is the furrow irrigation.[18] From the time of planting up to about three months before harvest, it is the object of the plantations to irrigate the area once every week, though frequently the available supply of water is insufficient. During the three months preceding harvest, only enough water is supplied to maintain the vitality of the cane and during this time, it actually evaporates its own water. Irrigation in hot weather has been found to give better yields. "It has also been found that three irrigations, about two acre inches each, given during the period between the third week of April to the beginning of June, provide the plant in advance with an equipment of foliage and surface roots that would be serviceable immediately on the advent of the rains; the possibilities of a quick response and a faster growth during the rains are thus promoted. Where the cane receives no irrigation during the hot season, it reaches the rainy weather poorly provided with the requisite foliage and lateral roots, so that its

17. Vide, Appendices II and III.

18. *Furrow Irrigation.* From the supply ditch water is led to the level ditches laid out at intervals of 150′ to 200′ and with a fall from ½ to ¾% grade. From the level ditches, lead the water courses laid out at distances varying from 30′ to 75′, the distance depending upon the nature of the soil and on the grade. Parallel to the level ditches and at right angles to the water courses are the cane rows from 5′ to 6′ apart down which the water flows. The furrows in which the cane is planted should be with advantage laid out with the level and on their accuracy depends much of the efficiency obtained in the application of water. On very level land it is possible and on porous soils advisable to allow the water derived from the water courses to flow both ways in the furrow, thus halving the length of the travel. "Trench planting of cane does not result either in better cane or sugar yield per acre as compared to planting flat in furrows. On the other hand, it is much costlier." Vide, Report of the Agricultural Department of Bihar and Orissa, 1935 to 36.

phase of quick growth is delayed—a feature of considerable importance in those parts[19] where the main growing season is generally restricted to the rainy weather. It appears that if the hot weather irrigations are properly timed and applied in accordance with the needs of the plant, three irrigations might prove to be the best."[20]

Sugar cane harvesting and planting can proceed for eight months in the year, i.e., September to April but the best time for harvesting is December to February, and the best month for planting the cuttings is February. Harvesting and planting in September and October are advantageous in that high prices are obtained during the Pujah season and sprouting of the cutting also takes place freely during this season as the heat and moisture are both sufficient for the young plant. The cold weather that follows retards the growth and makes the nodes of the cane very short. From November to May as many as twelve irrigations may have to be given to keep the plants in proper condition; from February the growth is again normal and there are no short nodes formed, but as a rule, the time and expense from September to February are wasted, except for the high prices fetched for the chewing cane during the Pujah season. The sprouting is very tardy if planted between November to January and they make no more progress than those planted in February. By planting in March, one irrigation can be saved, but the growth of the cuttings planted in February are better. In Bihar & Chota Nagpur, March planting answers because March is a cool month. The principle of planting in mild temperatures after the cold weather has well passed off, but a good while before the rains set in, can be followed with advantage in every locality. Planting in May or June is very risky except in free and gritty soils as water logging or even heavy rainfall when the plants are still short, is injurious to sugar cane. Sugar cane is benefitted by heavy rainfall if it commences after the plants are about a foot high.

Recent research in Bihar[21] has shown that the soaking of seed selts in ordinary water for 12 to 14 hours before planting ensures full and quick germination and results in better subsequent growth.

19. This statement applies equally well to every other cane growing region in India.

20. Report of the Agricultural Department of Bihar and Orissa 1935-36, page 75.

After January, early planted cane has an advantage over the late planted one, so that where large areas have to be planted, it is best to start early rather than prolong plantings into late March when soil-moisture conditions may not be adequate for good germination."

"The optimum planting distance between rows in the case of early varieties (Co. 299, 313 etc.) is 2½′ while that in the case of mid-season and late varieties (Co. 213, 331 etc.) is 3 feet. Wider spacing does not give higher yields."[21]

The best manures are 40 lbs. of Nitrogen and 50 lbs. of phosphoric acid in addition to a basal dressing of green manure. Where the soils are poorer, the Nitrogen may be increased to 60 lbs. Both Nitrogen and phosphates are best applied in two doses, half at planting time and the other half at earthing up before the rains. When castor cake is to be applied as a manure it is advisable to compost the cake a few days ahead and then thoroughly to incorporate it in the furrows before planting.

Dr. Mirchandani of the Bihar Agricultural Department, suggests that there is no manure as good as farm yard manure, and wherever possible it should be used freely, care being taken that the manure is well rotted before it is put on the land. Organic matter—be it farm yard manure, compost or green manure—in some form is absolutely essential for the soils and the best cane crop can only be grown on land adequately supplied with organic manure. In the Irwin Canal area in Mysore, free use of fertilisers is made and this accounts for the high yield.[22]

(To be continued)

21. Report of the Agricultural Department of Bihar and Orissa, 1935-36, page 76.

22. Department of Agriculture, Mysore, Bulletin, *Development of the Sugar Industry in India.*

APPENDIX I

RAINFALL.

Province.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total for the year.	Total rain-fall in Dec-Apr.	No. of rainy days Dec-Apr.	Total rain-fall in May-Oct.	No. of rainy days May-Oct	Remarks.
Assam ...	0.67	1.53	4.00	9.00	12.08	18.23	18.74	16.83	12.50	5.66	0.90	0.35	100.49	15.55	about 12	84.07	about 80	
Bengal ...	0.34	0.95	1.67	3.25	7.64	14.62	15.14	14.26	10.89	5.08	0.79	0.16	74.79	6.37	9	67.63	75	The rainfall during the growing season is very heavy and there is a danger from over-precipitation. Normally there is no need for irrigation except as a protective measure in partially dry seasons. Even during the harvesting season *the Rainfall* is too heavy.
Orissa ...	0.44	1.17	1.08	1.38	3.31	9.83	13.01	13.00	8.96	4.88	1.52	0.22	58.80	4.29	8	52.99	63	For the 4 months, June to September, the rainfall is both well distributed and adequate. The need for irrigation is less than in the United Provinces. It is only during May and October that irrigation becomes essential during normal years. The region gets drier as the cane ripens.
Chota-Nagpur ...	0.77	1.15	0.93	0.70	2.13	8.97	12.91	13.77	8.10	2.92	0.39	0.14	52.88	3.69	8	45.08	63	
Bihar ...	0.42	0.69	0.47	0.60	2.27	7.78	12.36	12.51	8.80	2.32	0.29	0.09	48.60	2.27	8	46.04	63	
United Provinces East ...	0.63	0.55	0.32	0.19	0.67	4.78	11.55	11.33	6.87	1.87	0.19	0.22	39.17	1.91	4-5	37.07	43	During the growing season, rainfall is adequate and well-distributed. During July, August and September, the total amount of rainfall varies and irrigation is necessary. During the harvesting season, there is a dimunition of both temperature and rainfall.
United Provinces West ...	0.96	0.89	0.61	0.30	0.68	4.06	11.47	11.14	5.96	0.88	0.15	0.36	37.46	3.12	4-5	34.19	43	
Punjab East and North...	1.21	1.02	0.91	0.56	0.62	2.02	6.22	6.37	3.30	0.38	0.13	0.44	23.18	4.14	9	18.61	23	Rainfall is inadequate right through, particulary so during the growing season; *i e.*, May to October. Irrigation therefore, becomes necessary without which, the cultivation of the crop is rendered impossible. It is only N. & E. Punjab and Kashmir which have even a moderate rainfall, S. & W. Punjab being a dry area. Cultivation of the cane is found only in N. & E. Punjab.
Punjab South and West...	0.50	0.53	0.64	0.52	0.42	0.81	2.47	2.56	1.11	0.10	0.08	0.21	9.95	2.40	9	7.47	28	
Kashmir ...	3.71	3.54	4.60	3.45	1.93	2.53	7.26	7.86	3.60	1.05	0.48	1.97	41.98	18.27	8	23.25	23	
North West Frontier Province ...	1.28	1.19	1.89	1.54	0.77	0.86	2.58	3.16	1.18	0.33	0.28	0.54	15.60	6.44	19	8.88	8	The rainfall is completely inadequate and irrigation thus becomes particularly important.
Berar ...	0.39	0.35	0.33	0.24	0.54	6.05	9.12	6.91	5.80	1.57	0.57	0.39	32.26	1.70	about 5	29.99	about 50	In the Central Provinces, rainfall from May to October is just sufficient so that irrigation is more a matter of protection than of dire necessity. In Berar and the Central India States, it is on the contrary, a matter of prime importance as the rainfall is too low.
Central Provinces West...	0.65	0.71	0.59	0.31	0.59	7.39	13.44	12.91	7.60	1.82	0.56	0.30	46.87	2.56	5	43.75	49	
Central Provinces East ...	0.46	1.11	0.60	0.73	0.79	9.32	15.27	14.93	7.60	2.25	0.40	0.29	53.74	3.19	5	50.15	49	
Bombay Deccan ...	0.15	0.08	0.15	0.63	1.35	5.22	7.85	5.44	5.61	3.02	1.01	0.28	30.79	1.29	...	28.49	48	In Bombay, the variations in rainfall are very great. On the Konkan Coast the total full is more than 105". In the Bombay Deccan, it is in the neighbourhood of 30". June, July and August are three months of heavy rainfall. During the remaining 9 months, irrigation is necessary. Rainfall is insufficient and the crop has therefore got to be irrigated. The distribution of rainfall, however, is well suited to the crop. Same as for Hyderabad and the Bombay Deccan
Hyderabad North ...	0.16	0.25	0.37	0.51	0.73	5.51	8.00	7.23	8.10	2.30	0.77	0.36	34.29	1.65	3	31.87	48	
Hyderabad South ...	0.18	0.24	0.42	0.81	1.02	4.33	6.24	6.31	6.82	3.02	1.06	0.22	30.67	1.87	3	27.74	48	
Mysore ...	0.12	0.13	0.31	1.46	3.58	4.80	7.15	5.23	5.18	5.30	2.42	0.45	36.13	2.47	6	31.24	50	
Konkan ...	0.10	0.05	0.06	0.36	1.55	25.31	39.09	23.99	12.53	4.30	1.01	0.13	108.48	0.70	12	106.77	82	Rainfall is ample and irrigation is unnecessary.
Malabar ...	0.92	0.57	1.50	3.84	7.39	23.82	21.50	12.16	7.85	11.33	7.26	1.86	100.10	8.69	12	84.05	82	
Madras South East ...	0.98	0.47	0.51	1.29	2.53	1.56	2.19	3.61	4.48	7.10	7.47	3.38	35.57	6.63	6	24.47	36	Rainfall during the growing season is insufficient (except for the two months September and October). During the hottest parts of the year, there is a scarcity of water and irrigation is a matter of essence.
Madras Deccan ...	0.20	0.14	0.21	0.62	1.67	2.36	3.21	3.91	5.75	4.18	2.18	0.41	24.84	1.58	6	21.08	36	
Madras Coast North ...	0.38	0.39	0.50	0.93	2.10	4.91	6.61	7.07	6.96	6.75	3.69	0.85	41.14	3.05	6	34.40	36	

APPENDIX II

Provinces and states.	Total area under sugar cane.	Irrigated area under sugar cane.	Percentage of irrigated crop to the total crop.	Distribution of the crop in the provinces expressed as a percentage of the total crop.	Distribution of the irrigated crop in the provinces expressed as a percentage of the total irrigated crop.	Total cultivated area excluding current fallows.	Acreage under sugar cane expressed as a percentage of the total cultivated area.	Total irrigated area.	Irrigated area under sugar cane expressed as a percentage of the total irrigated area.
United Provinces and States ...	1,844,580	1,161,745	63.0	51.1	55.9	36,533,209	5.04	10,812,326	10.7
Punjab (states and agency included) ...	520,339	406,680	78.4	14.4	19.6	32,863,925	1.59	17,496,097	2.3
Madras (states included) ...	138,568	121,012	87.4	3.84	5.83	35,731,016	0.39	10,802,918	1.1
Bombay (states included) ...	83,473	82,232	98.5	2.32	3.96	34,543,746	0.24	5,224,661	1.6
Bengal (states included) ...	276,200	31,835	11.5	7.67	1.53	23,357,000	1.19	1,699,448	1.9
North-West Frontier Province.	42,844	42,799	99.9	1.31	2.22	2,199,328	1.24	959,828	2.7
Kashmir ...	8,144	3,157	38.8	0.10	...	1,923,212	...	754,526	...
Bihar and Orissa ...	444,700	152,393	34.2	12.3	7.34	24,131,800	1.84	5,102,453	2.98
Central Provinces and Berar ...	28,890	26,768	92.4	0.80	1.29	24,668,067	0.12	1,045,694	2.8
Central India States ...	22,411	22,297	99.5	0.62	1.07	5,011,721	0.45	375,198	5.95
Rajaputana States ...	12,074	11,452	94.9	0.34	0.55	7,355,834	0.16	1,329,894	0.86
Gwalior ...	7,907	7,740	97.8	0.22	0.37	4,530,561	0.17	228,373	3.4
Hyderabad ...	50,580	50,580	100.0	1.40	2.44	28,370,264	0.18	1,391,300	3.6
Mysore ...	45,525	45,525	100.0	1.26	2.19	6,064,856	0.75	992,268	4.6
Baroda ...	2,278	2,192	96.0	0.06	0.11	3,296,697	0.07	131,361	1.7

APPENDIX III

Provinces and States.	Total area under sugar cane 1930-31	1931-32	1932-33	1933-34	1934-35	Irrigated area under sugar cane 1930-31	1931-32	1932-33	1933-34	1934-35	Remarks.
United Provinces (states included) ...	1,511,347	1,603,320	1,798,504	1,744,432	1,844,580	1,124,720	1,179,643	1,299,706	1,103,835	1,161,745	More than 20 per cent increase in total acreage with a negligible increase in acreage under irrigated crop. The increase in the total acreage is nearly ten times the increase in the acreage under irrigated crop.
Punjab (states and agency states included) ...	436,088	532,442	529,284	521,650	520,339	379,251	430,884	500,563	407,680	416,680	The total acreage has increased by about 20 per cent, while the irrigated acreage has increased by 10 per cent. About half the increase in acreage is due to the improved irrigation facilities.
Madras (states included) ...	126,47	126,515	134,131	134,554	138,568	111,995	113,205	117,978	117,587	121,012	The increase in total as well as irrigated acreage is less than 10 per cent. If the Madras states are eliminated, it will be seen that the whole area under the crop is irrigated.
Bombay (states included) ...	66,697	72,044	78,362	76,832	83,473	65,801	70,743	77,361	75,700	82,232	The total acreage has increased about 25 per cent while the area under irrigation has increased by more than 25 per cent. The increase in acreage is therefore due to better irrigation facilities.
Bengal ...	198,500	233,400	233,200	256,600	276,200	63,171	26,681	26,585	28,200	31,835	Total acreage has increased by 40 per cent while the irrigated acreage has diminished by 50 per cent. Increase in acreage is entirely independent of irrigation.
North-west Frontier Province...	46,877	44,268	53,212	49,391	42,844	46,866	44,263	53,173	49,359	42,799	The total acreage is very variable and has shown an actual dimunition. About 100 per cent of the crop is irrigated.
Kashmir ...	8,924	9,459	9,750	6,596	8,144	3,708	5,972	5,573	2,638	3,157	The irrigated acreage has shown a corresponding dimunition. Same as for the North West Frontier Province.
Bihar and Orissa ...	284,000	302,846	301,700	418,000	444,700	138,099	145,510	150,320	146,028	152,293	The increase in total acreage (57 per cent) is nearly 1 1/2 times the increase in irrigated acreage(37 per cent). The increase in total acreage is therefore independent of irrigation.
Central Provinces and Berar ...	21,354	22,042	27,965	28,806	28,890	19,396	20,044	25,220	26,230	26,768	The increase in total acreage (35 per cent) is almost equal to the increase in irrigated acreage (40 per cent). The increase is therefore due to better irrigation facilities.
Central India States..	9,566	10,779	16,295	9,855	22,411	9,909	10,668	16,238	14,919	22,297	The acreage seems to be extremely variable. The whole area under the crop is irrigated. The Irrigated acreage in 30-31 and 33-34 are greater than the total acreage.
Rajputana States ...	7,010	10,057	11,056	10,250	12,074	4,855	9,933	11,747	9,288	11,452	An increase of more than 70 per cent in total acreage and about 130 per cent in irrigated acreage is seen. The increase in acreage is due to better facilities for irrigation as more of the originally unirrigated area has been brought under irrigation.
Hyderabad ...	34,477	35,393	40,212	46,472	50,580	14,338	15,438	39,322	46,472	50,580	The above remark holds good in this case also Total acreage increased by 50 per cent and irrigated acreage by 250 per cent.
Mysore ...	37,734	36,076	42,093	40,334	45,525	37,734	36,051	40,265	40,616	45,525	The whole area is completely irrigated and shows an increase of more than 20 per cent. Increase in total acreage equal the increase in irrigated acreage.
Assam ...	32,994	31,332	32,007	35,485	35,934	...	...	...	...	...	The crop is totally unirrigated. The increase is less than 10 per cent.
India ...	2,886,215	3,102,899	3,445,870	3,424,072	3,635,518	2,035,257	2,122,638	2,382,905	2,085,633	2,174,635	

Geography of the Casuarina Plant in South India*

By

T. P. Venkatachari, M.A., L.T.,

Introduction.

The Royal Commission on Agriculture has struck a note of warning against the colossal waste of farm-yard manure as fuel, and has laid on the Agricultural Department the burden of making the cultivator utilise the farm-yard manure for its proper purpose; and it has further laid stress on the fact that any propaganda can never be effective unless an alternative fuel specially suited to the needs of the Indian house-wife is suggested. Casuarina is a fuel which can best be substituted for the cowdung fuel. In an agricultural country like India the problem of manure is of the greatest importance, and if it could be solved to any considerable extent by solving the problem of fuel, which in itself is not a minor problem, then it is imminent that it is studied soon and a solution got at.

In this paper an humble attempt is made at a study of the geography of the casuarina plant and its possibilities in the solution of the fuel problem of our country.

The Casuarina

An exotic plant, the Casuarina has so well taken to the country, that it has come to be commonly believed to be an indigenous tree. It is a single genus of about twenty or twenty-five varieties occuring in Australia and the neighbouring islands of New Caledonia and East Indies, from where, the species 'the casuarina Equisitefolia' has been brought into India early in the last century, and developed all over the country, especially in South India. And another species, 'the casuarina Muricata' has been introduced by about 1830 from Chittagong and Tenassarim coast where this species thrives best, into the Deccan plateau through Assam and Bengal. This plant has not been developed only in the North-West —the Punjab. There is a belief that the tree was a native of

* A paper contributed to the Geography and Geodesy Section of the 26th Session of the Indian Science Congress, Lahore—January, 1939.

Persia and that it has travelled from there to Australia. But this belief is not so dependable as there is not much of a conclusive evidence. It is, however, a fact that it is wide-spread in the old world tropics.

Migrations of the Casuarina

It is believed that the casuarina has spread northwards from Australia and the neighbouring Islands, through the East Indian Islands, Malaya, Burma and Chittagong into India proper. It was sent to Calcutta in the memorable year 1858, by Dr. Buchanan from Chittagong. From Calcutta it has spread northwest as far as Ambala and south into the Deccan. Simultaneous with the spreading of this plant from Burma and Assam, the Horti-Agricultural society of Madras got down seeds from the Queensland Acclamatization Society in 1875 and developed it north and south of Madras along the coast and in the west coast of Madras. There is another version that the Casuarina came down to us from Japan and this also is plausible as the plant might have taken another route in its northward movement, from whence some seeds might have been brought to India.

It matters little from where it came. It is a proven fact that it is an exotic plant which has taken well to a large variety of otherwise useless soil in India. The object with which Horti-Agricultural Society of Madras brought the plant to India was to improve the sun-beaten, sandy and barren appearance of the shore. This has no doubt been achieved; for the Casuarina is a hardy plant that grows well in the sandy region and stands the saline breeze from the sea. Noticing the bushy growth of the plant, the Military Department of Fort St. George had three parallel plantations formed in the foreshore as a defence and strategic measure, as also to mask the batteries. The childish nature of the scheme was long discussed in the Madras Mail (1890) which pointed out that the plantation only served to prevent the sea breeze and that it served no other purpose. So the plantation was clipped and made to form a beautiful hedge along the foreshore which has harmonised well with the general appearance of the coast.

Description

The branches of the casuarina resemble the feathers of the bird *Cassowary*, and hence the generic name to the plant. But the vernacular names have been derived from its resemblance to the tamarisk (Latin) a feathery-leaved evergreen common at sea side. It is an extratropical hardy plant which grows well on a wide range of soils from pure sand on the edge of the sea to clay soils and sandy loams in the interior. It grows wild even in higher altitudes as in Mysore and Coorg and on the hills of Travancore.

Casuarina is a tall, straight tree growing up to even 100 feet, resembling the coniferous type. The Equisitefolia species resembles the Larch fir, while the Muricata species resembles the pine. It is an evergreen tree. The bark is smooth and brown and the branches are scattered. Its leaves are needle-shaped verticled, slightly furrowed, jointed in 6 to 8 scales and pointed and woolly. Flowers grow on all the verticles and the seeds are small with a wedge-shaped membranaceous wing. The branchlets with the internodal toothed sheaths of connated scales droop and perform the functions of the leaves. It is a distinctive plant, grouped with the walnut, which it resembles only in the nature of the simple flower and peculiar fruits, besides being uni-sexular. A full seasoned tree, say 15 to 20 years old, shows a deep brown colour, and at breast height—5 feet—has a girth ranging between 3½ feet to 4¼ feet. It burns well and quickly with a high caloric value, and the ash further retains the heat for a long time. Though not noted for its timber, it is hard and durable, so long as it is not approached by white-ants.

Generally trees 10 years and below, when cut, appear white or reddish white with a brown streak in the centre. Even these are hard and they only warp, crack and split. But this tendency to split can be overcome if the timber is seasoned slowly. It is difficult to cut through it and compared to many trees Casuarina is strong and tough and at the same time it is also elastic. The timber is hard and not easy to work. It is not durable when exposed to air, though fairly durable under covers. It weighs 50 lbs. per cubic foot and has a transverse strength of 7·4 tons per square inch. It is stronger than even teak.

Distribution

As has already been mentioned, the casuarina plantations have been raised all over India except the N.W.—Punjab. However, the plantations on the plains alone yield good results, 50 tons per annum per acre,—while those in the interior plateau region yield only 28 tons or thereabouts per annum per acre. A fast growing tree, it is found in the natural state on the sandy coast of Chittagong, Arakan especially in the vicinities of Kyanpya, Tenasserim and the Andamans. In South India fine plantations have been raised and are maintained in the Carnatic Districts of Chingleput, South Arcot and Nellore, in the Tanjore District, in the West Coast Districts of Malabar and Kanara, and in the Tinnevelly District. In the other districts of South India casuarina has been grown as way-side avenue. Casuarina has been introduced in Travancore and there it runs wild and grows to over 100 ft. In two administrative divisions there are about 142 acres under casuarina.

The growing need for fuel in the metropolis and the transport facility and cheapness afforded by the Buckingham Canal have increased the acreage under casuarina in the Carnatic Districts mentioned above. In these districts the plantations have extended to inland areas, especially along the banks of the Pennar, and the Palar, where the soil is sandy loam. But the percentage of culturable waste that has been utilised is very low. It is really a woeful state of affairs that such a large area of culturable land should be lying idle. It is the duty of the forest department conjointly with the Agricultural Department to develop the casuarina plantations and help the poor ryot to conserve his useful farm-yard manure.

Life History of the plant

Casuarina is propogated by seeds and cuttings of partly ripened wood. There is a general opinion that the Casuarina Plantation neither coppices nor renews itself freely. But scientific investigation has proved that when the trees are cut, leaving a stump of 2 feet, the tree coppices well. And again if the casuarina is not pruned, it throws decumbent horizontal branches which develop roots and fix in the sand. And these throw up shoots if left undisturbed after the trees are cut. Thus the forest can naturally be renewed. The general opinion has been formed as the planters neither have ever allowed the decumbent branches to lie on the earth and develop, nor cut the trees leaving stumps.

The casuarina produces seeds early and copiously. It is however desirable to collect the seeds just shortly before the nursery operation is started, for it is said that the seeds lose their vitality and do not germinate if kept long; and further they are easily attacked by ants, and to preserve them carefully is a hard task.

Culture, Nursery and Plantations

The casuarina plantations are never raised direct from the seeds by the planter. And for a planter to have his own nursery, the estate has got to be considerably big. So there are nurseries which specialise in raising Casuarina seedlings for sale to planters.

There is an important nursery centre in Cuddalore supplying seedlings for large areas round about. Such nurseries have been started in a number of convenient centres.

For a nursery, a loamy soil free from white ants is chosen, ploughed after the rains have stopped. Seeds collected from 6 to 8 years old trees, and ripening during December to April, are sown generally in January or in February (occasionally in March or April too) and covered by leaves and twigs to avoid direct contact with sun. Till the plant grows to 1" and 1½", hand-watering is advised. The seed germinates in 8 to 10 days and grows to 6" in two months, and at this stage there is trans-plantation to another nursery, in which the plant grows to 2 to 3 feet in 5 to 6 months and the seedlings are now ready for plantation purposes.

The planters purchase these seedlings and plant them at a distance of 4½ to 6 feet on either side, the usual time of planting being during the rains. But in places where the water is likely to stagnate it is better to plant them just after the rains. In lands covered with grass, weeding is essential. In the case of red soil, the land has to be ploughed twice or thrice and thus the earth loosened. The plants are laid in 9" pits, and that better, if laid in baskets. This will facilitate growth of tap-root quickly. The plantation has to be watered in the first one or two seasons. Even in the second season it may not be necessary in regions where there exists better hydro-graphic condition. In any case after the 2nd season, there is no need for watering. About the end of the second or third year the soil between rows of plants is loosened by a country plough.

From the fourth year the lower branches are lopped off. Generally from the fifth year bad trees and diseased ones are weeded off until in the 6th year the plantation is reduced by 25 to 35 per cent and there are only 1500 plants in an acre. This yields good results in wood capacity at the end of 10 years. Generally, in Madras Presidency the trees are never allowed to stand for more than 10 years, the normal period being between 7 and 8 years. But, however, even for fuel purposes 15 years' standing yields very good results.

Conditions requisite for optimum results

It has already been observed that the casuarina thrives best on the foreshore of the sea. The soil being sandy the inference that had been drawn by lay people was that the casuarina can thrive only in sandy regions. However it has been scientifically and practically proved that the casuarina can thrive well in a very wide range of soils. Then the question arises what are the conditions required for optimum results.

An analysis of the conditions of growth of the plant in the fore shore of the sea would enable us to enunciate the conditions for optimum results more easily. The soil being sandy, the tap-root can easily find its way to the water table which is definitely within 4 feet to 6 feet from the surface. And here the supply of water is plentiful. Only the water is brackish. But the casuarina being a hardy plant, it can stand the brackish nature of the water. Now it is evident that the casuarina requires a good supply of water, and a soil which would enable the quick penetration of the root. Then the secret of success of the casuarina in the foreshore is the looseness of the soil, the nearness of the sub-soil water to the surface, and the rich decayed organic matter, in the apparently barren sands of the sea. So it is that casuarina has been found to thrive even in swampy tropical west coast of Africa.

"Casuarina imported from India to west Africa is a complete success. It requires a sandy soil, tropical climate and takes admirably to the borders of west African coastal swamps where the Eucalyptus has failed. And it flourishes also on the embankments at Lagos. In a short time, Africa is expected to be studded with casuarina as the Coramandel Coast." (Indian Agriculturist 1893).

The conditions for optimum results, then, are;

(i) Sandy loam covered over by one or 2 feet of drift sand.

(ii) Water table at a depth of 4 to 6 feet; and if the soil cannot hold sufficient moisture, water table should be at a depth of 3 feet.

(iii) Tap-root must be directed down straight, which is possible by growing it in baskets in 2nd nursery stage and transplanting it in whole, with the basket in plantations. This also saves wastage in plants during the transmission from the nursery to the plantation.

(iv) If planted in June, and in drier regions, the casuarina has to be watered for two seasons.

Plantations raised in sandy regions, where the water table is not near the surface, have been found to suffer from drought, until the tap-root has reached the water table. And in such cases watering is necessary for a longer period.

(v) Fencing is absolutely necessary to prevent the removing of the fallen decumbent branches. For they are of high value, (a) to the plantation itself in that they preserve the humus, (b) to the land in that they fertilise it, and (c) to the planter in that they naturally re-afforest the region.

(vi) The plantation has to be protected from goats whose refuse is very hot and affects the tender plant, and from a number of germs. But the grown up trees are prone to a disastrous fungus disease, and the tree has to be safely protected against this disease.

(vii) Mr. Hutchins of the Forest Department is of the opinion that in the Madras and Mysore Areas 12 feet on either side in smaller estates where profit alone is the consideration is suitable and that in larger estates 15 feet on either side is the best distribution. He says, however, that the popular distance is 6 feet and that some plantations are distanced 4 feet and 3½ feet as well. Casuarina, he says, is such a light loving plant, that it is injurious and uneconomical to plant at short distances.

But, there is a general opinion regarding the interrelation between height of growth, thickness of the plant, weight, and closeness of the plantation. In a close plantation the trees grow tall and the tendency to branch off is lesser. Though, in wider plantations the trees are likely to grow somewhat stouter at first, the increase in girth does not compensate for loss of weight due to short stature and there is wider branching off. Hence the practice seems to be to have a close plantation enabling first the development of height, and in the fifth or sixth year to weed out inferior trees, enabling the lateral development of the trees.

It is for the agricultural botanist to study comparatively and tell us as to the best distance consistent with optimum results.

(viii) Lastly the period of keeping a plantation consistent with optimum economy is again a problem. Whether a long period viz., 15 years and over, the medium period viz., between 10 and 15 years or again a short period below 10 years is profitable has to be studied. In the Madras Presidency, as has already been men-

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(viii) Lastly the period of keeping a plantation consistent with optimum economy is again a problem. Whether a long period viz., 15 years and over, the medium period viz., between 10 and 15 years or again a short period below 10 years is profitable has to be studied. In the Madras Presidency, as has already been mentioned the usual period is 7 to 8 years. It is occassionally that we find plantations standing for over 10 years. If wood capacity alone is the consideration, then 10 to 15 years is considered to give the best results. But if the consideration is the better use of casuarina as timber, then periods over 15 years is most advised. But, however, if mere material profit is the consideration, 10 years period is most normal. But the anxious planter arguing in the economy of reinvestment prefers short periods 7 to 8 years. To make the planter realise the ultimate benefit, he has got to be guided by a marketing information bureau, especially in regard to the prices for various grades of the developed trees.

Adjustability of the plant

It has been clearly shown that the casuarina thrives on a wide range of soils, otherwise useless; and it has also been shown that the casuarina wants a good supply of moisture and loose soil. It has further been shown that it grows well in the sandy regions of the Coramandel Coast as well as the swampy regions of the West Coast of Africa. All these clearly show to us how adaptable the plant is to different environments. It will be interesting to note how the casuarina develops long fine roots to draw moisture from a wide range in the apparently dry land and how it throws out long adventitious roots, in water-logged acres, which float even in 3 to 4 feet of water and obtain the air required. These adventitious roots come down to the surface of the ground and develop as ordinary roots when the water subsides. The casuarina adjusts itself to the various types of soil compositions also, from alkaline to brackish and saline soils, and from clay soil and red soil to pure sand drift soil. The stomata lie in the furrows of the branchlets which serve the function of leaves and thus enable the tree to stand the wild winds of the sea. Again, the casuarina takes in nitrogen from the atmosphere, more than is necessary for it, the excess of which it fixes to the soil as leguminous plants do, by means of clusters of nodules (bacteria) formed at the roots.

Some hold that in water-logged areas, due to excess of water some alkali-toxins are formed which are injurious to plants and that the plants do not thrive in water-logged areas. But experience in Africa seems to be otherwise. So also in the deltaic region of Tanjore. Still this is a problem for the agricultural scientists on which they should divert their research and give us the results.

Uses of the Plant

The main use for which the casuarina is grown is to supply fuel for various purposes—house, railways, sugar and jaggery factories, Brick kilns etc. It has been found to possess high caloric value besides the property of the ash to preserve heat. Capt. Campbell Walker has estimated casuarina to be 4 times as valuable as fuel as any tree in France.

Casuarina, growing tall and straight and possessing strength and elasticity, is highly useful for poles for pandals, sheds and other temporary structures, for scaffolding in the building industry, and as derric poles for boring. For these uses, the trees have to be left for longer period to season and cut when they have grown to greatest thickness and weight. Sold for such purposes, casuarina fetches very good price viz., Rs. 25 per ton, more than double the price for fuel. Yet it is cheaper than the cheapest native timber in South India, viz., the mango timber which sells at Rs. 50 per ton.

Light, thinner trees are seasoned and used for rafters in tiled buildings. They are serviceable only in drier regions, for when exposed to dampness, they are easily attacked by white ants. The poles are also used for masts, spars and felloes of country carts. In the west coast the trees are left longer on the plantation and planks 1 inch thick and 1 foot wide are cut and used for making tile moulds and shelves in the tile factory.

It is the rapid growth of the casuarina, besides its other qualities, which has made it popular in India as an important tree for fuel and for roadside avenue in the plains. Further, when the plants are clipped and left stunted in growth, they form good hedges. It has been considered as good mask for batteries when triple avenue plantations are formed, for they can be kept to any height and made to intertwine and form efficient entanglement.

All casuarina can be pollarded for cattle food. It is much relished by the cattle and it has also been found to possess good value as cattle fodder. Not only the pollarded casuarina, but also the casuarina pods are of high value, for the same purpose. This use has not become popular, in spite of the fact that this was suggested as early as 1866 by the Punjab Horti-Agricultural Society, probably due to the lack of education of the agricultural and pastoral people of our country.

As early as the first quarter of the last century, a Frenchman, M. Jule L'Epine, of Pondicherry extracted a brown dye from the bark and showed that the tannin contained in it was of considerable value. Later it has been found by Mr. Birdwood of Bombay and Mr. Birdie of Madras that this tannin is useful in leather tanning and that it gives a good brown colour to leather. Mr. Wardle has remarked that the shades produced by the bark formed good mordant and as such is widely used in Bombay. It has been considered that the casuarina bark is a very good dye stuff for dyeing fishing nets. The casuarina yields a considerable quantity of gum also.

On the authority of Dr. Gibson, Mr. Kitkar and Mr. Basu have included the casuarina in the "Encyclopaedia of Indian Medical Plants." The bark is slightly astringent and its infusion is useful as a tonic. And, besides, it is a readily available astringent, useful in the treatment of chronic diarrhoea and dysentery. Powdered bark is also useful for dressing wounds. Burnt ash, according to Mr. Smith is a good base for household soaps.

The hardness of the casuarina makes it unfit for use in delicate and fine art work. The cost of working it is enormous. Again its weight is so great that it is not possible to use it as timber. The Javanese use casuarina for beating mulberry bark to soft fibrous material out of which tap cloth is produced. It can be used for a similar purpose to beat cocoanut shells to convert it into fibre. Thus the fact that casuarina could be put to varied uses has made Mr. Drury to include it in his "Encyclopaedia of the useful plants of India".

Land Utilisation.

As the casuarina is found to suit the coastal regions, the entire sandy coast has become culturable land. Further it prevents sand drifts in coastal places; and this fact has been availed of in the Tinnevelly District, where casuarina has been planted to prevent the drifts in the south-west monsoon season. The casuarina plantations have made it possible to bring under culture sandy regions for human benefit. The lands with established casuarina plantations is littered; and this top-dressing left undisturbed fertilises the soil. If the plantation is not very dense, that is not closely laid, many useful dry crops could be raised in the land on the lee-ward side of the plantation. Here ground-nuts and similar crops grow very well. As an after-effect of casuarina plantation much of the land which otherwise would have remained a waste has been brought under cultivation.

Economics of the Plant: Cost and Income

Even as early as 1881 there have been speculations and exaggerated notions regarding the very high profitability of casuarina plantations. Interested parties began to estimate the gross expenditure for a six acre plantation to be Rs. 1,400. And that 18,000 trees on that plantation was the cut-turn in 4 years, yielding a net profit of Rs. 7,600 working at 550%. But this was contradicted by the Secretary, Horti-Agricultural Society who with personal experience showed that casuarina plantation was a profitable concern, no doubt, only if worked on large scale, the period of waiting being about 12 year's and the planter being careful to reduce the costs to the lowest level. According to his estimate the most successful plantation of 6 acres would yield a net profit of Rs. 1,440, the gross expenses of Rs. 1,400 being met from the periodical thinning. A report of the Department of Agriculture, Madras, of about the same time gives an estimate of cost accounting and shows a profit of Rs. 980 in about 8 years from a 6 acre plantation. And another estimate of the 2nd decade of this century shows a profit of Rs. 420 per acre in 10 years. So varied have been the estimates of profitability. But an estimate of the present decade as given in Madras Agricultural Journal 1934 shows a profit of Rs. 560 to Rs. 750 per acre by the sale of 1500 trees, left after the final thinning at the end of the 4th or the 5th year, at as. 6 to as. 8 per tree, the entire cost of seedlings, planting, watering etc., being recovered by the sale of the thinned-out trees, about 25% to 35% in the fourth year, and the periodical sale of the loppings.

Economic Bearing of Casuarina on the Life of the People in the Carnatic Districts

The Carnatic Districts of Nellore, Chingleput and South Arcot alone are responsible for over 40% of the land under casuarina in this province. These Districts supply the growing need of the metropolis, and thus the land utilisation of the culturable waste for casuarina is on the increase. In these districts a sort of distributed periodical felling is followed. The plantation is generally divided into 5 to 7 regions, one region being felled every year, and replanted. This system solves the problem of having to wait long for the return. Only in the first instance there will be some waiting. The Reddis of the Nellore District especially consider casuarina plantations as a definite and safe source of annual income. These districts are served by the Buckingham canal and the cost of transport is considerably low. Thus we find the casuarina affords certainty of income to the cultivator, the serious difficulty of having to wait long being got over as stated above, solves the fuel problem and thus secures and conserves the farm-yard manure for its more proper use as fertiliser, and is of high value in the reclamation of waste sandy tracts. In this Presidency there need be no culturable waste land. Casuarina can be raised in red soil areas which are deficient in nitrogen and thus the soil can be nitrogenated. And when a soil has reached a stage of exhaustion, casuarina serves to re-fertilise the soil.

Conclusion.

In this Presidency of Madras out of about 80 million acres of land 13·5% forms culturable waste of which, again, only about 3% (2·86%) have been utilised and that under casuarina. It is really pitiable to find in most parts of the interior of the Presidency, still much of the farm-yard manure is wasted and the fuel problem is a really serious problem. While this magic solver-casuarina, with its adaptability to all kinds of soils is available, it is really woeful to find only 3% of the culturable waste land under it. "With casuarina and its possibilities there should be no waste lands in this Presidency", said the Madras Horti-Agricultural Society as early as 1883, and it has maintained that "the reclamation of land, properly speaking, belongs to the Forest Department and to them the task should be entrusted". What was said more than 50 years ago holds good to-day. It is a matter of concern for everyone interested in the well-being of the farmer, to see that the Forest and the Agricultural Departments jointly work to bring more and more areas under casuarina and make it possible to bring the cost of transport very low.

The Royal Commission on Agriculture has said that the limiting factor in the solution of the fuel problem through casuarina, is the cost of transport by road or rail and that co-operation with Railway Authorities should be sought and obtained. Thus with transport facilities established, export to the interior districts would be easy and plantations could be developed and practically the whole of the culturable waste lands could be brought under casuarina. Or it would be advisable, as suggested by Mr. E. P. Stebbing, the Forest Officer, that every ryot is given a small area of waste land adjacent to his own field, rent-free and encouraged to grow casuarina for fuel. Or again as the Royal Commission on Agriculture has suggested, the canal and river banks might be widened and casuarina planted for fuel purposes, and managed jointly by the Forest and the Irrigation Departments. This would also enable the rivers to maintain their definite course without changing it now and again, and thus prevent also the deposition of coarse sand and gravel on fertile riverain land. This last method is most suitable for solving the fuel needs of the people in the irrigated areas.

Thus under the able guidance of a rurally minded government many problems could be solved by bringing almost the whole of the culturable waste lands under casuarina. Not only need there be, no waste land in the country, there need be no such heavy unemployment. Only the approach must be sympathetic and on proper lines so that all factors are co-ordinated. And this would enhance greatly the national wealth and dividend of the country.

News and Notes

The XIVth Annual Meeting of the Association was held on Saturday the 24th February 1940 at the Meston Training College, Royapettah. After passing the XIVth Annual Report, the results of the elections of the Office-bearers for 1940 were announced.

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Three ordinary meetings of the Association were held in this quarter. In the first of them, held on 27-1-40, Mr. S. V. Ganapati, M.Sc., Water Analyst in the Health Department of the Madras Corporation, read a paper on "*The Geographical Aspects in relation to the Chemical and the Biological Conditions of the Red Hills Tank.*" A summary of the paper will be published in the next issue of the Journal.

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In the second meeting, which was held on 16-2-40, Mr. M. P. Rajagopal, B.A., L.T., Dip. Geog., opened a discussion on "*Class Tests in A Group Geography.*" A lively and interesting discussion ensued.

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In the third meeting, held on 16-3-40, Mr. T. K. Swaminathan, Editor, Indian Colonial Review, who visited Mauritius as a Representative at the time of the Centenary Celebrations, delivered an interesting lecture on "*The Indians in Mauritius,*" illustrated with views.

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As in previous years, a *Summer School of Geography* will be conducted by the Association in the Geography Department of the Teachers' College, Saidapet for a month from 6th April 1940. The Executive Committee has decided to have another shorter course at Ambasamudram in May next, if there is a demand for it.

* * * * *

For the Tenth Geographical Conference of the Association to be held at Ambasamudram in May next along with the Provincial Educational Conference, Mr. T. S. Sundaram Ayyar of that place has been elected President. He is a veteran geographer that retired after working as an enthusiastic teacher of geography for over a generation in the local Thirthapathi High School.

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At its meeting held on 17-1-40 the Council of the Association decided to have a class of student members of the Association, paying a subscription of 1 Re. per annum and having the same privileges as associate members.

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At the same meeting, Mr. M. Subrahmanya Ayyar, B.A., B.L., one of the founders of the Association who had done so much for it in the first few years, was elected Honorary Life Member.

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Mr. N. Subrahmanyam, M.A., L.T., F.R.G.S., Lecturer in Geography, Teachers' College, Saidapet retired from 14-1-40 after a service of 33 years; and his place was taken by Mr. S. Muthukrishna Ayyar, M.A., L.T., Dip. Geog. It is expected that Mr. Subrahmanyam will now be able to give all his time to the Association and its Journal, for which he has already done so much.

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In the vacancy caused by the retirement last year of Mr. V. Jagannadha Rao, M.A., L.T., Lecturer in Geography, Government Training College, Rajahmundry, Mr. B. M. Thirunaranan, B.A. Hons., of the Department of Geography, University of Madras, has been appointed.

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We have much pleasure in congratulating Prof. M. B. Pithawalla of Karachi, upon whom the University of Bombay has conferred the degree of Doctor of Science for his pioneer geographical research on the Lower Indus Basin (Sind). Prof. Pithawalla is an indefatigable worker, who has produced several monograms on various aspects of the geography of the lower Indus basin, on which he has become a great authority.

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The Indian Science Congress held its 27th session in Madras from January 2 to 8, 1940. The Geography and Geodesy Section of the Congress was presided over by Dr. S. P. Chatterjee of the Calcutta University, whose Presidential Address on "*The Place of Geography in National Planning*" is summarised elsewhere in this issue.

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Several useful papers were read and discussed in this and the Geology Sections; and there was an interesting popular lecture delivered by Swami Pranavananda on "Lake Manasarovar and the sources of the Indus and the Brahmaputra" which was illustrated with views taken by him on his tours.

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As part of the programme of the Congress, some short and three full day alternative excursions were arranged. Of the latter, which were to Madura, Mettur and Mahabalipuram, the last was the most popular among the visitors from Upper India.

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The 28th session of the Congress will be held at Benares early in January 1941; and for the Geography and Geodesy Section of it Prof. Tahir Rizvi, Chairman of the Department of Geography, Aligarh University was elected President and Dr. M. B. Pithawalla of Karachi Recorder.

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The Ceylon Geographical Society, which was started last year, celebrated its first anniversary on the 12th March 1940, after a record of useful work. It is hoped that the Society will in time grow to be sturdy and useful with a Journal of its own as an organ of its activities.

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Reviews

A New Geography of India, Burma and Ceylon. By L. D. Stamp. (Longmans, Green & Co., Ltd.), 1939. Price Re. 1 As. 12.

Longman's Regional Geographies of India, Part IV has been one of the very few satisfactory text-books of Indian Geography for schools; and it is well that Dr. Stamp has brought out a revised edition of it, considerably improved and brought up-to-date, and with some new features, so much so that it is now in its present form practically a new work. Recent political changes such as the creation of the provinces of Sind and Orissa and the separation of Burma from India necessitated no doubt the re-writing of parts of the original book; but, much new information collected on the spot by the author in his recent tour in the country has also been incorporated. While retaining the maps, diagrams, questions and exercises of the older edition, numerous useful pictorial illustrations have been included for the first time, thereby enhancing considerably the value and attractiveness of the volume, which is now increased in size by more than 100 pages. *The useful tables* at the end of the book have been brought up-to-date; Burma should, however, have been shifted to a separate place along with Ceylon in each of tables. We are glad to note that in spite of these improvements and the increased size, the price has been kept very near the old one.

Geography of the World (with a detailed treatment of India). By S. C. Chatterjee. (Longmans, Green & Co., Ltd.), 1939. Price Rs. 2 As. 12.

This is a new text-book of Geography for use in the upper classes of high schools as well as in the Intermediate classes of colleges, written by a qualified and experienced teacher of the subject. One of its chief features is the great emphasis that is laid on the Indian point of view in the presentation of geographical facts and illustrations. The book falls into two parts: Part I dealing with Mathematical and Physical Geography and Part II with Regional Geography of the world. In the treatment of the different aspects a proper balance has been observed; thus, Part I occupies a fourth part of the book, while in Part II India, which has been developed in a fairly detailed manner forms as much. It is pleasing to note that geographical phenomena are explained in a strictly scientific manner; and the bearing of the geographical factor upon human progress has been brought out. The volume has been well illustrated with a large number of useful maps and diagrams.

Food, Clothing and Shelter Geographies: Book V—Asia, Australia and Africa. Book VI—North and South America and Europe. By L. McD. Robison. (Macmillan & Co., Ltd.). 1940. Price Re. 1·25 each.

In reviewing the earlier books in the Primary Series in a recent issue of this Journal, we had pointed out that the central aim of the whole series has been to bring out man's efforts to obtain food, clothing and shelter, as indicated in the general title. "The pupils observe the sparsely settled areas in their own neighbourhood. They apply their growing geographical knowledge to studying where and why man lives in small numbers and in large numbers in different parts of the world." This aim is more fully developed in these two books of the Post-Primary Series under review. They show the relationship between land forms, vegetation, climate and the distribution of population. In the first five chapters there is a broad general treatment, which becomes more detailed under each of the sub-regions in the succeeding chapters. The final chapters gather up the general facts under the heads of *Climates, Food stuffs and other materials, Communications* and *Geographical Regions*. The plan, though novel, is refreshingly original and interesting; and it is hoped that teachers will find it useful in getting away from the rut and infusing the pupils with genuine interest in the subject. The volumes are fully illustrated with maps, diagrams and pictures: and the exercises in Part B of each lesson serve as in the Primary Series both for revision and for further work.

A Map of Asia (for Middle and School Certificate forms). By A. Ferriday. (Macmillan & Co., Ltd.). Price 1sh. 9d.

The teaching of geography in schools has now-a-days ceased to be the dull, mechanical, bookish thing it was; and among the factors that contributed to it have been the books of the type under review.

This *Map of Asia* follows the plan of the previous books of the series, reviewed in earlier numbers of the journal, namely that of presenting the main geographical features in map form with accompanying text on the opposite page. The questions included at the end of each lesson serve to test the pupil's capacity for illustrating his answers with sketch-maps. They include those taken from school certificate papers, being intended for school certificate forms though the more straightforward ones might be attempted by pupils of middle forms.

Elementary Geography—Five books: (in Canarese). By Gregory Menezes, K. Srinivasa Kini, M. N. Kamath and K. Panduranga Pai. (School Book Company, Mangalore). 1939.

This series of five books has been prepared in accordance with the recent syllabus in Geography for Elementary Schools issued by The Madras Educational Department; but, we had occasion to note that this syllabus has not been satisfactory, being far too logical and analytical, instead of having a psychological basis being synthetic and regional. To that extent we have to decry books written in accordance with that syllabus. But in spite of that disadvantage, the authors, who are all qualified and experienced teachers of geography, have succeeded in treating the lessons in an interesting manner in simple language, which is again graded to suit the class. The exercises appended to the lessons are suggestive and stimulating, and serve both for revision and for further individual work. The books are also illustrated with a good number of maps, diagrams and pictures, though some of the blocks could easily have been better.

The Glacial Period in the Territory of U. S. S. R. By I. P. Gerasimov and K. K. Markov. (Akademiya Navk: U. S. S. R.). 1939.

This large volume of over 450 pages in Russian contains, luckily for English readers, an English summary of 20 pages towards the end, which is both interesting and valuable. After a general preliminary discussion at some length, the Quaternary Glaciation of Plains and Mountains and the Quaternary Age in the Non-Glaciated Regions are first considered in some detail. Then follows a short account of the territory of the U. S. S. R. successively (1) in the Post-Glacial Epoch, (2) in the last Glacial Epoch, and (3) in the Inter-Glacial Epoch. The volume closes with the formulation of the following conclusions :—

1. Glaciation of mountains began at the end of the Piocene, glaciation of the plains in the Quaternary age.

2. Intensity of glaciation of plains and mountains diminished eastwards from regions with a marine climate to regions with a more continental climate.

3. Glaciation of the plains developed in various parts of the U. S. S. R. (Europe—East Siberia) and throughout the surface of the earth metachronically.

4. Glaciation was manifold, alternating on the plains with epochs (inter-glacial) of complete thawing of the sheet glaciation.

5. The number of glacial epochs differed in various regions.

6. Physico-geographical conditions (the number of glaciations and changes in the extent of sheet glaciation) were more variable in regions with elements of maritime climate in Europe, whereas in East Siberia they were characterised by a comparative constancy.

7. The immediate cause of Pliocene mountain glaciation was tectonic, the Quaternary glaciation of mountains and plains was due to general climatic causes.

8. The remote non-glacial regions of the U. S. S. R. were distinguished by comparative constancy of climatic conditions. Westwards and southwards in epochs synchronous with glacial and inter-glacial the variability of the climate increased.

9. In the Turan and West Kazakhstan in epochs of glaciation the amount of atmospheric precipitations somewhat increased (on account of intensification of cyclones) as well as the degree of the watering of the surface. This created *pluvial* phases.

10. In West Siberia and in the South of the European territory of the U.S.S.R. the degree of continentality of climate increased in epochs of glaciation. The landscape had the character of forest-tundra and cold forest-steppe, gradually passing into warmer forest steppe and steppe.

11. In inter-glacial epochs the general geographical situation resembles the modern, only differing by a milder (less continental) climate in the north and a more striking and more southern limits of forest-steppe, steppe and desert.

12. For the Post-glacial epochs two warmer phases (climatic optima-Late-glacial and Atlantic) are established in the north, divided by a colder (Boreal) phase. In the south there are traces of a later and dry phase (xerothermic), apparently concurrent with the Atlantic optimum. The general progress of climatic changes in Post-glacial time caused a shifting of the modern soil-vegetation zones.

Select Contents from Recent Periodicals

The Geographical Journal: December 1939.

Settlement and Land Utilization, Malacca—By E. H. J. Dobb

The Geographical Journal: January 1940.

The Search for Oil—By G. M. Lees.
Formal Writing on Maps—By C. B. Fawcett.

The Geographical Journal: February 1940.

Plans for a National Atlas. Discussions opened by Prof. E. G. I Taylor.

The Scottish Geographical Magazine: November 1939.

The Natural Geographical Region. By A. Steevens.
Gibraltar—By P. W. C. Dennis.

The Scottish Geographical Magazine: January 1940.

Agriculture in the Great Clay Belt of Canada—By J. R. Rar dall.

Economic Prospects in the Soviet-Polish Borderlands. B Arthur Geddes.

Geography: December 1939.

Finland and the Winter Freeze. By W. R. Mead.
The "Raw Material" Film. By W. L. Gilbert..

Geographical Review: January 1940.

Canterbury Landscapes—By Kenneth B. Cumberland.
Bolivia's Water-Power Resources—By W. E. Rudolph.
The Function of Meltwater in Cirque Formation—By W. V Lewis.
Singapore—Town and Country—E. H. G. Dobby.

Indian Information: January 15, 1940.

Soil Erosion: Its Dangers, Causes and Cures—By Dr. R. Mac agen Gorrie.

Indian Information: February 1, 1940.

India's Store of Minerals: Resources of Central Provinces an Berar.

Indian Information: February 15, 1940.
Lloyd Barrage Research: How to Predict Soil Behaviour.

Books and Journals Received

Elementary Geography—5 books : (Canarese). By Gregory Menezes, K. Srinivasa Kini, K. Panduranga Pai and M. N. Kamath.

A Map Book of Asia. By A. Ferriday.

Illustrations of Indian Sculpture. By F. H. Gravely & C. Sivaramamurti.

Guide to the Archaeological Galleries. By F. H. Gravely & C. Sivaramamurti.

Asia, Australia & Africa. By L. McD. Robison.

Britain against Hitlerism. H. M. Stationary Office, London.

Aspects of Poland. By M. B. Pithawalla.

Geography of the World (with a detailed treatment of India). By S. C. Chatterjee.

A New Geography of India, Burma & Ceylon. By L. D. Stamp.

N. & S. America and Europe. By L. McD. Robison.

Proceedings of the Royal Geographical Society of Australasia (S. Australia Branch for the session 1938-39).

The Glacial Period in the Territory of U.S.S.R. (Russian). By I. P. Gerasimov and K. M. Markov.

Report of the Operations of the Department of Agriculture, Madras Presidency for the year 1938-39.

Southern India Commerce: December 1939, January and February 1940.

Indian Information: December 1939, January, February and March 1940.

Kalaimagal: December 1939, January, February and March 1940.

Indian Culture: July 1939.

Scottish Geographical Magazine: November 1939 and January 1940.

South Indian Teacher: December 1939, January and February 1940.

The Visvabharathi Quarterly: November 1939, January 1940.

Geography: December 1939.

The Geographical Journal: December 1939, January and February 1940.

Journal of Indian History: December 1939.

Quarterly Journal of the Mythic Society: January 1940.

The Indian Journal of Political Science: January-March 1940.

The Geographical Review: January 1940.

The Adyar Library Bulletin: February 1940.

Report of the XIVth Annual Meeting

THE MADRAS GEOGRAPHICAL ASSOCIATION

The XIVth Annual Meeting of the Association was held at the Meston Training College, Royapettah on Saturday the 24th February 1940, with Mr. M. P. Rajagopal in the Chair. The XIVth Annual Report of the Association (*vide* Annexure) prepared by the Council was adopted (proposed by Mr. K. Sundaresan, and seconded by Mr. A. Tirumalai Ayyangar).

The results of the elections for 1940 (decided by ballot) were then announced as follows :—

President: Miss E. D. Birdseye, B.Sc., Dip. Geog. (Lond.).

Vice-Presidents:

Rao Bahadur C. M. Ramachandra Chettiyar, B.A., B.L., F.R.G.S.

Mrs. P. S. Sundara Raj, M.R.S.T., F.R.G.S.

Secretary: Mr. N. Subrahmanyam, M.A., L.T., F.R.G.S

Asst. Secretary: Mr. K. Ramamurthi, M.A., L.T., Dip. Geog.

Treasurer: Mr. M. P. Rajagopal, B.A., L.T., Dip. Geog.

Ex. Com. Member: Mr. George Kuriyan., B.Sc. (Lond.)

Other members of the Council:

Mr. K. Sundaresa Ayyar, B.A., L.T., Dip. Geog.
Mr. A. Tirumalai Ayyangar, B.A., L.T.
Miss H. T. Scudder, M.A., Dip. Geog.
Miss S. Koman, B.A., L.T., Dip. Geog.
Mr. P. G. Dowie, M.A., L.T., Dip. Geog.
Mr. T. R. Govindarajan, B.A., L.T.

The meeting then came to a close with a vote of thanks to the chair.

The Journal of
The Madras Geographical Association

Vol. XV April—June 1940 No. 2

Proceedings of the Tenth Geographical Conference of the Madras Geographical Association: Ambasamudram: May 1940

The Tenth Geographical Conference of the Madras Geographical Association was held in the Tirthapathi High School, Ambasamudram from 26th to 29th May 1940 under the presidency of Mr. T. S. Sundaram Ayyar, retired teacher of Geography of the same school.

The opening session of the Conference commenced at 3 p.m. on Sunday the 26th May at the spacious Sadasiva Ayyar Hall before a large gathering of members and visitors. Mr. E. H. Parameswaran, M.A., delivered the Welcome Address on behalf of the Reception Committee, after which Mr. T. S. Sundaram Ayyar was formally installed in the presidential chair. He then delivered his Address, after which the meeting ended.

The second session began at 2 p.m. on Monday the 27th May, when the following papers were read and discussed:—

(1) *Climate of Tinnevelly Dt.*, by Mr. K. Ramamurti; (2) *A Plea for the Development of Garden Cultivation in Tinnevelly Dt.* by Mr. V. Srinivasan; and (3) *Cotton Crop of Tinnevelly Dt.* by Mr. B. Natarajan.

The third session met at 3 p.m. on Tuesday the 28th May, when the following papers were read and discussed:—

(1) *Papanasam Project* by Rao Saheb N. Krishnamurthi; (2) *Forests and Forest Products of Tinnevelly Dt.* by Mr. T. D. Ponniah; and (3) *Population of Tinnevelly Dt.*, by Mr. M. P. Rajagopal.

The concluding session of the Conference met at 2 p.m. on Wednesday the 29th May, when the following four *Resolutions* were first passed :—

(1) Resolved to request the Council and the Executive Committee of the Madras Geographical Association to get the Rules of the Association so amended that the non-journal members, paying an annual subscription of Rs. 2 may be treated as full members with voting powers as formerly instead of being mere associate members. (2) Resolved to request the S.S.L.C. Board to arrange to show the marks in History and Geography in the public examination *separately* before adding them up in the S.S.L.C. Certificates of the candidates in order that they may know the results of their relative performances in the two subjects. (3) Resolved that, in view of the great importance of Geography as a school subject in modern times, the S.S.L.C. Board be requested to raise the time for the geography paper to 2 hours and to increase the marks accordingly. And (4) Resolved that it be a recommendation to the S.S.L.C. Board that the question paper in Geography for the Public Examination may contain questions on all the continents instead of on Eurasia and India only; and that if this cannot be done, Part IV of the original syllabus (the World Regions) may be substituted for Revision Work for 24 periods in Form VI.

Then the following papers were read and discussed:—(1) *The Geography of Tuticorin Port* by Mr. V. Thyagarajan; (2) *Paddy Cultivation in Tinnevelly Dt.* by Mr. M. Subbiah Pillai; and (3) *Place-Names of Tinnevelly District* by Mr. T. S. Sundaram Ayyar.

The remaining papers were then taken as read for want of time and owing to the absence of their authors. After the concluding address of the President, the Conference came to a close with a vote of thanks.

On the 30th May, the day after the Conference was over, the Secretary of the Association led a party of teachers on a full day excursion by bus to visit the Banathirtham Falls and the Papanasam Project. Rao Saheb N. Krishnamurthi Ayyar, Executive Engineer in charge of the Project, kindly arranged to show the party round at the Upper and the Lower Dam. On the 31st May, another full day excursion was conducted by bus to Cape Comorin and Nagercoil. Individual members also went on excursion in small parties during and after the Conference to Tuticorin, Tiruchendur and Kuttalam Falls. Altogether the Conference was a great success.

10th Madras Geographical Conference, May '40
Ambasamudram, Tinnevelly District

WELCOME ADDRESS

BY

E. H. PARAMESWARAN, M.A., L.T.,
Headmaster, Tirthapati High School and President, Tirunelveli District Teachers' Guild.

Fellow Delegates,

As Chairman of the Reception Committee, it is my duty and pleasure to offer you a most hearty welcome to this, the Tenth Session of the Geographical Conference. It gives me great personal happiness that this Conference is held in the premises of our school and under the presidency of one who was a teacher of our school for over 30 years and one, who even after his retirement, continues to be a keen student of the Science of Geography.

To-day is May 26, and this day is to be observed as a day of prayer all the world over for the victory of the Allies. It is only right and proper therefore, that I should begin my welcome address to you this afternoon by requesting you all to offer your united prayers for the victory of the Allied arms. That victory is an imperative necessity for the building of a new world order, an order which would ensure peace, justice, freedom and equality.

Within less than 25 years after the last World War, Europe is again having to-day another blood bath, and it looks as though the whole world is going to be involved in mutual man-slaughter on a colossal scale. What is the cause of this madness ? Is it all the making of that one man, Hitler ? The causes, to my mind, lie deeper. The remaking of the political map of Europe after the last war was not based upon equality and justice and the treaty of Versailles only sowed the seeds of fresh war. When this war ends and when the statesmen of the world gather together at a common table for reshaping the world, let us hope and pray that they will not forget the lessons of the last war and that in trying to build for the future peace of the world, they will not do it on the foundations of a mere geographical redistribution of boundaries but that it will be based upon fundamental human needs.

A study of these fundamental needs in their proper environmental conditions becomes therefore a necessity. If education is to be interpreted as an adaptation to our environment it is needless to point out that a careful study of this environment both human and natural is necessary if that adaptation is to be an efficient one. This is what geography attempts to do. It is the hand-maid of all sciences including sociology, economics and politics and it acts as a bridge between the so-called pure sciences and the study of humanities. The cultural and the practical values of the study of such a subject are apparent. If we do not want our children to be mere frogs in the well, if we do not want them to be oblivious of the world around them, we should see that Geography secures its rightful place in our schools and colleges. Yet the introduction of Geography does not mean merely the addition of another subject to an already overloaded curriculam. It means that we should 'Geographise' our educational system and arrange our instructions on 'Geo-centric' basis.

I have often asked myself the question, "What does geography mean to a child who is compelled to learn the location of Timbuctoo and its products while he lives in blissful ignorance of the topography of his own little village? How many of our pupils from Tinnevelly can point to yonder hills and say to which mountain system they belong? How many know that in Tinnevelly more than 2,000 tanks and 36,000 wells are used for irrigation purposes? How many can give a description of the Kannadian Canal?" Yet, it is such geography that adds to the usual knowledge of the pupils. I feel that our syllabus should be so organized that beginning from the immediate environment, we can proceed in ever widening concentric circles. The importance of this aspect of the study would be realised if we remember that the world in which we live to-day, in spite of its vast expanse, is a small shrunken world and modern inventions have brought us so close together that we live on each other's door steps. What is happening on the Western Front to-day is having its instantaneous repercussions in every department of human activity not only in our own country, but the World over. We cannot think in terms of living in isolation.

I do not feel equal to advising you on the correct methods of teaching geography to be adopted in our schools. Very often to satisfy the requirements of external examinations our pupils are compelled to learn by heart isolated, uninteresting and dreary facts, such as heights of mountains, lengths of rivers and capitals of

States. We often forget that Geography, like any other science, can be interesting to our pupils only if it is studied through excursions, field work and laboratories.

The study of Geography should be carried on mainly out of doors. School room geography makes our pupils slaves of books and maps. We should try to create map-makers and not merely map-readers. Who has not heard of the story of G. K. Chesterton who got a shock when he found, on visiting Yorkshire, that it was not yellow as represented on the maps ?

I am aware that a new orientation to the study of Geography is being given largely as a result of the efforts of the Madras Geographical Association and its energetic secretary Prof. N. Subrahmanyam. The Refresher Courses and the Summer Schools in Geography organized by him year after year have given a great impetus to the study of Geography.

I should now conclude. But before I do so I consider it my duty to pay my tribute to Mr. T. S. Sadasiva Iyer who was the Headmaster of this School for about 35 years and who was mainly responsible for making this institution what it is to-day. Many of you may not know that long before Geography was introduced as a subject of study in the S.S.L.C. Curriculam, he was alive to the importance of the study of Geography and equipped the school with up-to-date apparatus and appliances for the teaching of this subject.

I trust your stay in our midst will be made happy and comfortable and when you leave us you will carry with you memories of this beautiful little town of Ambasamudram on the banks of the holy Thambraparni, the cooling and refreshing bath in the pellucid waters of the river, the hills and dales around with the inspiring Agastia Peak and the beautiful cascades of Banatheertham, Kalyanatheertham and Courtallam.

I extend to you a warm welcome once again. I have no doubt that under the wise guidance of Mr. T. S. Sundaram Iyer, we shall have a purposeful session.

10th Madras Geographical Conference, May '40
Ambasamudram, Tinnevelly District

PRESIDENTIAL ADDRESS

BY

T. S. SUNDARAM IYER, B.A.

Ladies and Gentlemen,

Let me first express my sincere thanks to you for the honour you have done me by electing me President of this year's Geographical Conference. I am conscious of my limitations, but I accept it because I feel that this honour done to me is an honour done to the whole class of High-School teachers. I hope that, with your kind co-operation and good-will, this conference will be an unqualified success.

Work of the Conference.

The Geographical conference is one of the laudable activities of the Madras Geographical Association to whose Secretary, Mr. N. Subrahmanyam, we owe not a little of the present position of geography in our Presidency. Its main object is to make a detailed regional study of the district in which the Provincial Educational Conference is held. I feel proud that this year the Conference meets in my native district and in the very High School in which I spent 35 years of my life as a geography assistant. As usual there will be a number of papers dealing with the various aspects of the district, but we cannot be sure of having all the papers read and discussed in the Conference. However they will be published in a special issue of the journal of the Madras Geographical Association. I would earnestly appeal to all the High Schools of the Presidency to go in for the journal, or at least the special numbers in which the proceedings of the various Geographical Conferences and the papers read therein are published. These numbers would form a very valuable collection of reference books which should find a place in the library of every High School in the Presidency.

Importance of Geography.

Geography is a science of all sciences. It is an all inclusive complex science dealing with the facts of astronomy, geology, meteorology, botany, zoology, ethnology and economics, but it is not a patch-work of all these sciences. It is a unity with a well-defined essence of its own. McMurry describes it as "an obtrusively democratic utilitarian sort of study." Geography does not concern itself exclusively with any one of the phenomena that go to make up the earth, but shows the mutual relations of all the phenomena that exist together. It starts from the sciences but leads to the humanities. It is a subject that easily makes our pupils understand the inter-dependence of various nations and thus tends to create in the young minds an idea of internationalism and world citizenship which the present war shows to be essential not only for the onward march of humanity, but also for arresting "the collapse of civilisation."

Its place in the S.S.L.C. Scheme.

The importance of Geography has long been recognised in the western countries, but here its recognition has been very slow. The S.S.L.C. authorities have brought it under the compulsory group only in the 1929 Scheme. It is a well-known fact that unless a subject is intended for the public examination, neither the teacher nor the taught will take a living interest in the subject. Even the present recognition in the S.S.L.C. scheme is meagre and half-hearted. Geography has not yet attained its independence as it is still an appendage to History. Even in the maximum marks allotted it is not an equal partner, so that many of the pupils think that they can afford to neglect the subject and get the necessary marks in History. The authorities would be doing well if they were to enter the geography marks separately in the S.S.L.C. books even though they are not for making the subject independent or giving it a separate minimum. This will enable the geography teacher to gauge the results of his work.

The S.S.L.C. Syllabus.

Geography can no longer be a strain to the S.S.L.C. pupils as a good deal of it has been omitted for the public examination. Since the subject is taught through the medium of the mother tongue and the syllabus covers more or less the same ground which has been covered in the middle school scheme, I cannot see the necessity for this omission. Will this not tell upon the study of geography in the IV Form ? Is it not likely to be treated as a B Group subject there ? You are asked to revise the three southern continents and North America at the end of the VI Form course to give a final link to the study of Geography. Do you honestly believe that this will be done? Now that the IV Form portion is to be excluded from the public examination and questions are to be set only on Eurasia and India, I would suggest to the authorities to consider the advisability of including in the Syllabus Part IV of the 1929 Scheme—especially the portion which deals with the world as a unit. The study of the major natural regions of the world will necessarily give the pupils an opportunity to revise what they have already studied. In fact this is the portion which can place the High School Syllabus on a higher level than the Elementary School or Middle School Syllabus.

Main Stages in the conception of Geography.[1]

When the Renaissance made classical studies important in Schools, Geography, as an independent subject had no place in the curriculum. It was included with historical or other information which the commentator supplied for the explanation of the text. What little Geography was then taught was mainly Ancient Geography. There were detailed maps of Italy, Greece and of the areas of Central and Eastern Europe that formerly formed part of the Roman Empire. No idea of Geography as a Science was possible so long as it was regarded as a collection of miscellaneous topographical information.

In the 15th and 16th centuries when new lands were discovered, a knowledge of Geography acquired a practical value for the explorers. Now began the development of maps which became more and more like those with which we are to-day familiar. But this "sailor-geography" was simply topography—the topography of coastlines. In fact the geography of this period was of "the capes and bays" type.

But when trade was being carried to the new lands beyond the seas, and fresh lands were being opened up, teachers of Geography saw something in the subject "to broaden the mind and fire the imagination." At this stage Geography teaching was regarded as vocational. Boys were being apprenticed in large numbers to sea-captains. Geography was taught to the pupils in the mathematical school at Christ's Hospital. This department of the school was opened in 1673 with a view to preparing boys for service at sea. Another stimulus came from France where "modern subjects" had been introduced to supplement the classical routine. The teaching of such subjects began to spread in England towards the end of the 17th century and during the 18th.

1 Barnard: Principles and Practice of Geography teaching, Ch. 1.

this will be done? Now that the IV Form portion is to be excluded from the public examination and questions are to be set only on Eurasia and India, I would suggest to the authorities to consider the advisability of including in the Syllabus Part IV of the 1929 Scheme—especially the portion which deals with the world as a unit. The study of the major natural regions of the world will necessarily give the pupils an opportunity to revise what they have already studied. In fact this is the portion which can place the High School Syllabus on a higher level than the Elementary School or Middle School Syllabus.

Main Stages in the conception of Geography.[1]

When the Renaissance made classical studies important in Schools, Geography, as an independent subject had no place in the curriculum. It was included with historical or other information which the commentator supplied for the explanation of the text. What little Geography was then taught was mainly Ancient Geography. There were detailed maps of Italy, Greece and of the areas of Central and Eastern Europe that formerly formed part of the Roman Empire. No idea of Geography as a Science was possible so long as it was regarded as a collection of miscellaneous topographical information.

In the 15th and 16th centuries when new lands were discovered, a knowledge of Geography acquired a practical value for the explorers. Now began the development of maps which became more and more like those with which we are to-day familiar. But this "sailor-geography" was simply topography—the topography of coastlines. In fact the geography of this period was of "the capes and bays" type.

But when trade was being carried to the new lands beyond the seas, and fresh lands were being opened up, teachers of Geography saw something in the subject "to broaden the mind and fire the imagination." At this stage Geography teaching was regarded as vocational. Boys were being apprenticed in large numbers to sea-captains. Geography was taught to the pupils in the mathematical school at Christ's Hospital. This department of the school was opened in 1673 with a view to preparing boys for service at sea. Another stimulus came from France where "modern subjects" had been introduced to supplement the classical routine. The teaching of such subjects began to spread in England towards the end of the 17th century and during the 18th.

1. H. C. Barnard: Principles and Practice of Geography teaching, Ch. 1.

In both private and public schools, Geography was still regarded as a mass of topographical details; and it is doubtful whether the average school advanced beyond the " capes and bays " method. Globes were probably used like atlases to indicate the position of places and physical features and not for any scientific demonstration. This state of Geography teaching continued up to the middle of the 19th century in England.

The rapid development of science in the 19th century and the association of this development with the material prosperity of England led to a demand for the teaching of Science in schools and Herbert Spencer put forward a number of arguments in favour of this demand. But the true champion of Science was Huxley. Schools of Science were started, and in them was taught a hotchpotch of geography, geology, physics, chemistry and astronomy which was given the name of physiography. Huxley's physiography which appeared in 1877, has been re-written and enlarged by Professor Gregory. But the emphasis is laid on the scientific side and not on the influence of natural phenomena on human life. Geography could not become an independent subject as it was still " in bondage to Science as it had been to classics."

In 1886 the Royal Geographical Society issued a report on Geography instruction which had been drawn up by Dr. (Sir) J. Scott Keltie and this helped to stimulate interest and to bring about the establishment of a School of Geography at Oxford. The first two Oxford Readers in Geography were Sir Halford J. Mackinder and Dr. A. J. Herbertson. To these pioneers the modern conception of Regional Geography is due. Sir H. J. Mackinder is the author of "Britain and the British Seas," one of the six volumes forming the " Regions of the world " Series of which he is the General Editor. Dr. A. J. Herbertson in his Oxford Geog. Senior has divided the whole world into fourteen natural regions, each representing a distinct type of climate. Though this scheme has often been modified, it remains the basis of the treatment of the subject. Regionalism as applied to Geographical study indicates a method of approach. A whole unit can be handled and treated with comprehensiveness and the causal method can be easily applied.

The aim of teaching Geography.

Geography is no longer a compendium of information to illustrate classical authors or to assist navigators ; it is no longer an account of general Science dealing with natural phenomena. It is now a subject with human interest, " the Science of man on

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earth." The influence of natural phenomena on man's life is studied as well as the reaction of man on Nature. To this study of the interaction of man and nature, the name "Human Geography"[2] is applied. Thus our conception of geography and our methods of teaching it, have been completely altered within a few decades. The new geography is not a list of capes, bays, countries and towns to be committed to memory. It does not rest with the mere statement of facts, but inspired by the Scientific method, it tries to explain why those facts exist. Hence modern Geography is said to answer two questions: 'where ?' and 'why there ?'

Evidently the subject matter of Geography is the earth. But it is not merely the rocks of which its crust is made; nor the oceans and seas that fill the depressions on its surface; nor the atmosphere that encloses it; nor the plants and animals and not even the men themselves, for each of these is the special domain of a separate science. Geography deals with all these facts only in relation to human activities. The natural phenomena are studied not for their own sake, but for the influence which they exert on human life. As Dr. Mill says "Geography is the exact and organised knowledge of the distribution of phenomena on the surface of this earth culminating in the explanation of the interaction of man with his terrestrial environment."

The influence of the natural phenomena on human life should always be kept in the forefront in the teaching of geography in schools. It is this influence that should guide us in determining whether this or that topic should be included in, or excluded from the geography syllabus. Questions of geology should be excluded from the geography lessons if they are studied merely for their own sake. But where they bear upon man's activities, they must find a place in geography teaching. For instance it is geological structure that explains why the Atlas region in north Africa is more intimately connected with south-west Europe than with the rest of Africa itself. The human geography of the northern and south-east England and of the central lowlands of Scotland has been greatly influenced by the structure of those areas *viz.*, the Pennine upfold, the Oolite and chalk escarpments and the rift-valley. In such cases the structural considerations have to be stressed. Sometimes some other aspect will have to be emphasized: the

2. This subject has been dealt with in a paper read by me at the Fourth Geographical Conference held at Trichy and published in the journal of the M.G.A. Vol. 8, No. 2.

minerals such as coal, iron and petroleum, upon which industrial developments are based; or a particular type of soil, such as the black-earth of Russia, the loess of China or the black-cotton soil of the Deccan that gives rise to some important agricultural occupation. Sometimes climatic controls will have to be stressed. They determine the distribution of plants of economic importance, as the tea of Assam, the jute of Bengal, the sugar of U. P. and the wheat of the Punjab and they even have a bearing on the location of industries e.g. the cotton industry of South Lancashire.

Causes other than Environment.

In our enthusiasm to connect cause and effect we are likely to overlook the part played by causes other than environment in human geography. These are political or historical. Madras has no natural harbour, but on account of its political importance as the capital of a great province, it has been made a port by the construction of an artificial harbour. Aden is located in a very inhospitable environment, but it is jealously guarded by England as it occupies a strategic position. Jerusalem has but two insignificant springs—a geographically abnormal environment; but its history has attracted about 40000 inhabitants. Poland decided to make Gdynia her port for political considerations though there was no geographical justification for it.

Again the action of geographical forces is not the same always; it varies with the standard of civilisation of the inhabitants. The original inhabitants of the prairies of North America were the Indians. They were for the most part hunters depending mainly on the herds of bison which roamed over the prairies. Thus they led a nomadic life. But what was the effect of the same environment on the life of Europeans who came there later ? The settlers began to react on the environment and modified the old physical controls to suit their new needs. Cattle from their own countries were introduced, a good portion of the prairies was marked out with ranches and a regular meat export was established. The climate and soil which suited the prairie grass also suited wheat and maize. With the development of railways and water-transport, the whole outlook of North America has been completely changed. Similar changes have been effected on the pampas of South America and the downs of Australia.

The action and reaction of man and his environment is the very essence of the modern conception of Geography, and the subject matter based on this view-point is quite sufficient to make the subject stand by itself. Hence our claim to make Geography an independent subject in the S.S.L.C scheme. Let me now apply the new conception of geography to a study of the Tinnevelly District.

Regional study of the Tinnevelly District.

In studying a country or part of a country, we can divide it into some distinct natural regions based upon differences of soil and climate and therfore of production and occupation. A natural region ignores political boundaries which are artificial and mostly arbitrary. Since it may extend over a large area, it is not suitable for administrative purpose. But from a scientific point of view, a study of the natural regions of a country is better than that of the administrative divisions.

The Tinnevelly District can be divided into two broad regions:— (1) the hills and (2) the plains. The plains fall into four distinct natural regions: (1) the river valleys of the Tambraparni and the Chittar and the areas about the upper reaches of the smaller rivers; (2) the dry red lands; (3) the plains of the black-cotton soil; and (4) the region of sand hills. This fourth region can be subdivided into the *teri* land and the coastal belt. Thus the Tinnevelly District falls into six natural regions. In giving a rapid survey of these regions I shall try to keep the human aspect in the forefront.

(1) *The Hills.*

The Hills on the west of the district are a continuation of the Western Ghats which, except for a recess in the Tenkasi taluk, run in a straight line from the northern limit of the district as far as Papanasam. Thence sweeping for 12 miles in a bold curve towards the south-east they once more run southward towards the sea. The average height of the range is 5000 ft. but some twenty peaks attain more than that height. The frontier between the district and Travancore follows with a few exceptions the watershed of the Western Ghats. To the west of the Tenkasi taluk where the mountains drop to form the Aryankavu pass, the frontier comes east of Shencotta in the low country. Again near Panagudi, the boundary descends from the top of the Mahendragiri, and continues southward along the low country till it meets the sea four miles east of Cape Comorin. South of the border of the Tenkasi and Ambasamudram taluks, the Ghats attain the greatest width. They consist of undulating hills, broad valleys and extensive plateaux. The famous Agastya peak or Eka Pothigai (6,125 feet) the most striking peak in the whole range, is the glory of this part of the mountains: next to it on the south is the Ainthalai Pothigai. The last of the Tinnevelly hills is the Mahendragiri in the Nanguneri taluk.

The hills are covered with forests because of the heavy rainfall there; but the types of vegetation vary with elevation. About the lower slopes grow trees of small dimensions suitable only for fuel. From 1000 ft. to 3000 ft. above sea level are found deciduous trees interspersed with bare grass hills. Above 3000 ft. are to be seen the evergreen forests. The peaks which mark the watershed are nearly bare and rugged. The forests contain but little timber of commercial value. *Kongu* which is found in the evergreen region is perhaps the most valuable among the trees. The deciduous forests contain few species which possess any value except as fuel and small timber. Teak is common, but it seldom grows above pole-size.

The only inhabitants of the Ghats are a few Paliyans and Kanis. The Paliyans are found in the hills of the Sankarankoil taluk and number only about 50 persons. They are an unsightly race with short bodies, square faces and thick lips. They wear scanty clothing and scarcely ever bathe. Their language is a corrupt form of Tamil. They live in groups of one or two families in holes or caves (called *Pudais*) in the lower slopes of the hills. They live upon roots of various kinds, unripe dates and wild mangoes. They generally eat their food raw, but when they receive any grain for service rendered to the renters, they cook it and eat it. After exhausting the resources of a tract, the family moves to another *pudai*. Their stay in a pudai usually lasts a month or two. They are not by nature hunters, but have some primitive devices for catching birds. They keep no cattle and never cultivate. But by their dealings with the contractors, they come more into contact with the people of the plains. Such of these as come under the influence of the missionaries appear somewhat smartly dressed.[3]

The Kanis who number about 200 in this district are in the Kannikatti and Singampatti forests. They are in every respect greatly in advance of the Paliyans. They live in huts made of bamboo and grass, away from the tracks of men and animals. They carry on a kind of primitive cultivation on the patches of land around their dwellings. After a year or two, they move to another spot and cultivate new patches. Cholam, tapioca, sweet potatoes, plantains and chillies are the usual crops and form their staple food. Their language is a mixture of Tamil and Malayalam. Though they have

3. The Gazetteer of the Tinnevelly District, pp. 6-7.

a poor physique, they show "wonderful powers of endurance and make excellent forest guides." In the Kattalamalai estate, the property of the Jesuit Mission, a number of Kanis have become Christians and have settled down as agriculturists.[4] The lives of these two races illustrate the influence of environment on primitive man.

The forests have been more useful to the people of the plains than to the hill tribes. The Government through the Forest Department have arranged to supply the people of the towns and villages with fuel and timber by a systematic scheme of controlled fellings on a regular rotation. Grazing is provided for. Minor products such as honey, cardamoms, grasses of many kinds, leaves for manure, herbs, roots and fibres are collected. There are plantations owned by private agencies in which coffee, tea, spices and fruits are cultivated.

Again the forests serve another very useful purpose. The higher slopes of the range behind Ambasamudram and Tenkasi taluks enjoy the full force of the southwest monsoon, and there are frequent showers in January and February and occasional rains in April and May so that they are wet for the most part of the year. Their inaccessibility has saved the evergreen forests from destruction, and the protection which these afford to the soil is of great value. The forests increase the capacity of the soil to absorb and retain the rain water, letting it out gradually by means of springs. In thickly wooded areas, the springs are perennial and feed the streams and rivers. The dense *sholas* of the Nanguneri hills hold the sources of the Nambiar, the Kila Manimuttar, and the Pachaiyar. The Papanasam hills hold the headwaters of the Tambraparni and the hills between Sivasailam and Shencotta contain the sources of the Jambunadi, the Gatananadi, the Ramanadi and the Chittar, all of which join the Tambraparni in the plains.

The Tambraparni (75 miles), the chief river of the district rises in the Pothigai and enjoys the full benefit of both the monsoons. After receiving the Peyar and the Ullar on the left, it reaches the Banatirtham precipice over which the water falls in a magnificent cascade. At the foot of the falls it is joined by the Pambar on the right, and a mile and a half farther down, by the Kariyar ard left. After receiving the Servaiyar near Mundanthurai, of Cape reaches the Papanasam barrier of rocks over which it plunudram fine cascade of 300 ft. known as the Kalyanatirtham falls of un- Papanasam eastwards to its mouth at Punnaikayal, the rivamous for 60 miles on level country. peak
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4. *Ibid*, pp. 7-8.

The Tinnevelly Mills Company Ltd. (now the Madura Mills Ltd.) taking advantage of the water-power available at Papanasam, built two spinning mills, one in 1885 and another in 1908 at Vikramasingapuram, six miles west of Ambasamudram, at some distance from the right bank of the Tambraparni. The water is carried off above the falls by channels and is stored in a reservoir from which it flows down through cylindrical iron pipes and works the turbines. A new mill worked by steam power has recently been added.

The Government of Madras are now constructing two dams across the Tambraparni between Banathirtham and Papanasam with a view to generate hydro-electric power. Electricity is now being used to light the neighbouring towns, and will shortly be used for the industrial development of the Tinnevelly, Ramnad and Madura Districts. The geographical position of the district makes it easy to start the following industries on modern lines:—rice milling, flour grinding, oil extraction, soap making, sugar refining, cotton ginning and spinning and paper manufacture. The dams may also help irrigation to some extent.

The Chittar which is next in importance to the Tambraparni itself, rises in the hills above Kuttalam. Unlike the Tambraparni, it enjoys the benefit of only the north-east monsoon. It reaches Kuttalam after precipitating over a succession of beautiful water-falls, the principal being the Tenaruvi, the Shenbagadevi fall and the well-known Kuttalam fall, a cascade of nearly 200 ft. The falls are full during the south-west monsoon also when rains are brought in through the Aryankavu pass. The overhanging clouds reduce the temperature of the air to a considerable extent so that Kuttalam enjoys a very delightful climate in this season, and is consequently visited by many people from different parts of the Presidency.

Occasional low hills, called *pothais,* many of which can be found in the Ambasamudram taluk, emerge here and there from the plains. The quartzite ridge extending from Uttumalai (Ten-[illegible]aluk) to Thalaiyuttu (Tinnevelly taluk) form the water-part[illegible]een the Tambraparni and the Chittar. Besides these there [illegible]ated hills amongst which may be mentioned the Kolundu[illegible] near Sermadevi, the Vallanad Hills, 9 miles east of Palam[illegible]nd the Kurumalai ridge near Kumarapuram, (Koilpatti [illegible]). The gneissic rocks near Ambasamudram and elsewhere are [illegible]sed for building purposes.

(2) *The River Valleys.*

The Tambraparni valley is richer and more important than the rest. Many large villages surrounded by green fields and marked by temple towers are to be found at intervals along the bank of the river. The life of the people in these villages is too well-known to need any description. Their occupation is mainly agricultural, but ordinary artisans like the carpenter, the blacksmith, the goldsmith and the potter exist in each village community.

The average mean annual temperature of the District is 85·3°F and the average rainfall for a year is 27·57 inches, of which 3·41 inches fall from January to March, 3·27 inches in April and May, 3·10 inches from June to September and 17·79 inches or nearly two thirds of the total from October to December. Hence the north-east monsoon is the rainy season for the district. In an average year rain falls only on 41 days, and the total rain decreases from west to east, e.g. Ambasamudram 35·05 in; Palamcotta, 27·84 in; Srivaikuntam, 25·19 in. Hence agriculture is not possible without irrigation.

Therefore dams have been built at eight places across the Tambraparni, and water is conveyed to the fields either direct by means of channels or through tanks. The eight anicuts are : Kodaimelalagian, Nadiyurni, Kannadiyan, Ariyanayakipuram, Palavur, Suttamalli, Marudur, and Srivaikuntam. Srivaikuntam anicut differs from the rest in that it bears a bridge over its crest. Above and below most of the anicuts, flood banks of varying length have been thrown up, those near Srivaikuntam anicut being continuous for 16 miles.

In the Tambraparni irrigation system is included the irrigation supplied by its tributaries. The Manimuthar, the first tributary to join the river in the plains, is the chief source of irrigation to the Singampatti Zamindari. The Gadananadi which joins the Tambraparni at Tiruppudaimarudur, is crossed by six anicuts; its tributaries, the Ramanadi, the Jambunadi and their united stream, the Varahanadi are crossed by one, three and two anicuts respectively. The Koraiyar and the Pachaiyar are tributaries on the right bank of the river. The last tributary, the Chittar which is crossed by eighteen anicuts, joins the main river at Sivalapperi.

Though insignificant as regards its length and the area of its catchment basin, the Tambraparni is, for its size, the most important river in the Presidency. Over 94% of the area irrigated, two crops are raised. But a failure of the monsoon or an excessive rainfall involving floods may prove disastrous to the crops. Rice is the chief crop and most of the rice fields yield two good crops every year, other irrigated crops of the wet lands are plantains, betel-vine, turmeric and sugar-cane; but these occupy only a small percentage of the area irrigated. For instance in the Ambasamudram taluk, rice occupies 58% of the total cultivated area, other cereals 24% sugar-cane 1% oil-seeds 12% and other crops 5%. In villages where the class of people known as Saluppans live, some sunn-hemp is cultivated.

In the Chittar valley only a few villages on the upper reaches of the river are able to raise two crops of rice as they enjoy the *saral* from June to August. In the lower reaches of the river, there is a plentiful irrigation supply between October and January when the *pisanam* crop of paddy is raised; but during the *kar* season, one of the millets, ragi or cholam, is raised and wells are largely used to supplement the uncertain supplies of tanks and channels.

Of the total area under river irrigation, the Tambraparni system accounts for 56·75 per cent, the Chittar for 20·63 per cent, the Nanguneri rivers for 16·59 per cent and the Sankaranainar-koil rivers for 6·03 per cent.

Next to agriculture, the industries connected with cotton are the most important. Cotton is grown in the Koilpatti and Sankaranainarkoil taluks where the black-cotton soil exists. Again the weaving of cotton is the hereditary employment of particular castes (the Kaikolars, Pattasalyans and Pattunulkarars) who are found in large numbers in the district and forms the chief occupation of a large number of Muhammadans also. Hand-spinning has fallen into disuse after the starting of the spinning mills at Papanasam and Tuticorin. Handlooms for the production of carpets, blankets and cloths of various kinds exist in hundreds throughout the district. In the river valley region, Ambasamudram, Kallidaikurichi, Viravanallur, Sermadevi, Pattamadai, Tinnevelley, Palamcottah, Melapalayam, Seydunganallur and Tenkasi are some of the most important centres.

Korai is obtained from the beds of the rivers, tanks and channels and mats of korai grass are made mostly by Muhammadans at Pattamadai, Alwarkurichi and Kalakad. The finished articles are sent to Pettai, and thence they are distributed, large numbers being sent to Negapatam and Tuticorin to be exported to Burma and the Straits Settlements. Mats of a very superior quality are made at Pattamadai, and the excellence of these mats is due to the hereditary skill of a few Muhammadan families. Since their production is expensive, there is no real demand for them, in spite of their artistic merits.

The extraction of gingelly oil is the monopoly of the Vaniyan caste, the gingelly obtained locally being pressed in the country mill, called *chekku*. The oil is used for bathing and cooking and the oilcake is an important cattle food. Pettai is a great collecting as well as distributing centre for the article. Other oils are castor, *iluppai* and *pinnai*. Most of the coconut oil used comes from Malabar.

A large portion of the juice of the Palmyra trees which are found in large numbers in the district, is boiled to produce the coarse sugar known as jaggery. Tinnevelly is the chief collecting centre from which nearly half of the product is exported to Nellikuppam, and a portion of the other half is used by the two sugar factories at Tachanallur (Tinnevelly Junction) and Alwarthirunagari.

Another important industry of this region is the making of bell-metal and brass vessels, an industry based on a demand due to the social custom of the people. This industry is the monopoly of the Kannasaries. The brass plates and materials for the alloy are imported. The chief centres of the industry are Vagaikulam and Mannarkoil (Ambasamudram taluk) Narasinganallur and Tinnevelly (Tinnevelly Taluk) and Seydunganallur and Eral (Srivaikuntam taluk). The products of Vagaikulam are the best known and Hindu idols are made there.

This region is the most densely peopled part of this district and most of the Educational institutions are to be found here. The staple food of the people is rice.

(3) *The Red Soil Region.*

Wide areas of dry red sandy lands rise from the river valleys, and include the uplands of Ambasamudram and Tinnevelly taluks, the greater part of Nanguneri and much of Sankaranainarkoil, western Koilpatti and northern Srivaikuntam. The soil is poor and facility for river irrigation is lacking. Hence dry crops are generally raised; but the area is dotted with numerous rain-fed tanks and small patches of rice fields. Palmyras grow everywhere throughout the tract as the loose sandy soil is suitable to them. Except where wells have been sunk, the lands are generally waste. Over large tracts of the Nanguneri, Tiruchendur and Srivaikuntam taluks, acacias are planted along with palmyras.

The Crops usually raised are inferior cereals and pulses, such as *samai, varahu,* horse-gram, black-gram and gingelly. An interesting crop of this region is the Tinnevelly senna (*nilavahai*) which is cultivated on wet lands in some of the villages of the Tinnevelly taluk between the *pisanam* harvest and *kar* sowing. Elsewhere it is raised as a second crop after the main crop on single-crop lands has been harvested.

A saving feature of the dry red land is to be found in the complete change which well-irrigation can produce. An enterprising cultivator can convert his field of useless red soil into a valuable garden by using tank-silt and farm-yard refuse and by sinking a fairly large well. The picotta or double-bullock mhote (*kavalai*) is used to lift water from the wells. Oil engines and pumps have been successfully used at Karumgulam (Nanguneri). Govindapperi (Ambasamudram) and Chintamoni (Sankaranainarkoil).

Cotton cloths are made by Muhammadan weavers at Kadayanallur (Tenkasi) and Eruvadi (Nanguneri) and by Iluvans at Puliyangudi (Sankaranainarkoil).

Villages are scattered and population is less dense than in the river valleys. Though very little rice is grown in this area, it is obtained from the irrigated tracts for consumption by all classes.

The red loamy soil of Kuttalam and a few villages adjacent to it in the Tenkasi taluk is of exceptional fertility and yields two good crops every year. During the south-west monsoon, cholam is cultivated in most of the fields, and in the other season *samai, varahu* or gingelly forms a second crop. In west Tenkasi, cholam forms the food of the poorer classes.

(4) *The Black-cotton Region.*

'The black-cotton' region occupies the greater part of the Koilpatti taluk and a large tract in the north of Srivaikuntam. For nine months in the year, the land is very uninviting and "umbrella trees and dancing heat are the main features of the landscape." The soil is very dark in colour and is lighter than that found in the Ceded districts. Villages occur at wide intervals. The finest farmers of the district are to be found here, and the best of them are the Telugu Kammavans and Reddis who own the greater part of the land. The ryot does his work himself and prefers the assistance of the family members to that of hired labourers. He takes pride in his cattle which are some of the best in the district. They are mostly of the Kangayam breed, Salem and Alambadi being occasionally seen on the plough. They are well looked after, being daily fed on cotton seed and sometimes on horse-gram *Cholanattu* is their fodder.

There are three main crops in this region *cumbu, cholam* and cotton, but cholam is more a cattle fodder than a grain crop. Bengal gram and red gram are grown pure, but other pulses are sown as mixtures with cotton or cumbu, but not with cholam. Castor and coriander are sometimes sown in the cotton areas. To save the land from exhaustion rotation is practised, "Cotton never follows cotton on well-farmed lands." The black-soil peasant has work throughout the year.

The two species of cotton grown in the region are known as *Karunganni* and *uppam.* Besides these two indigenous kinds, "cambodia" is cultivated where regular irrigation is possible, as it cannot stand a prolonged drought.

Prominent among the industries of this region are those connected with cotton. There are many ginning factories here, the chief of which being located at Tuticorin, Kadambur and Nalattinputhur. Tuticorin has steam presses engaged in the pressing of cleaned cotton. The Coral mill at Tuticorin is engaged in spinning and the Koilpatti mill has both spinning and weaving.

At Kayattar mats of korai grass are made. Leather of a good quality is made in a tannery near Pudukkottai, the chief tanning material being the *Avaram* bark. Tinnevelly slippers are noted for their strength and neatness.

Unlike the richer classes of the other regions who generally eat rice, the wealthier agriculturists of this region prefer the 'dry' grains that grow in their fields.

(5) *The 'Teri' Country.*

This peculiar division of the district is a great undulating expanse of red sand which occupies the southern part of the Nanguneri taluk and a great part of the Tiruchendur taluk. The dunes of red sand are composed of grains of quartz with an admixture of fine red clay-dust that has been deposited there by the fierce winds of the south-west monsoon. This tract is characterised by the thousands of palmyras growing both in the level country and on the slopes of the dunes. The sand hills are named after the villages that lie near them. The surface of these masses of sand is often changing under the influence of the south-west winds. The highest of the teris is near Naduvakurichi and Arasur rising to a height of 219 ft. and the largest is the Kuthiraimoli teri covering nearly an area of 21 square miles.

Along the bases of these sand dunes are found some fertile patches of land. All the rain falling on the tops of these dunes is absorbed and flows out continuously into the surrounding level land. In a large number of villages adjoining these dunes (e.g. Kayamoli, Nalumavadi and Arasur) paddy is regularly cultivated. Viramanikkam is famous for its plantains. In other places like Udangudi and Naduvakkurichi, wells are sunk and garden crops like betel, plantains, chillies and vegetables are obtained.

In some of the deep depressions formed amongst these sand dunes are great inland lakes called *taruvais.* The largest of these is the Puttantaruvai, some three square miles in extent. Vairavantaruvai, Sundankottai and Semmarikkulam are other examples. These *taruvais* are filled with water during the north-east monsoon, and as the water subsides, their slopes are ploughed and garden crops are raised. But very heavy rain produces floods which take months to subside as the sand-hill barriers prevent the water from finding an outlet to the sea.

The palmyra grows best in the teri region and in the sandy country behind the east coast as well as in the red soil area already described. There are nearly ten million trees in the district which provide occupation to nearly five per cent of the total population of the district. Every part of the tree can be turned to account and the uses of the various parts are too well-known to be mentioned here. Throughout the palmyra country, baskets are made out of the palmyra leaves. Some are made out of the midribs of the leaves, others of leaves only or a combination of leaves and fibre obtained from the stem. In many villages of Nanguneri and Tiruchendur, young leaves are dyed in a variety of colours, and fancy baskets and articles like models of cars and animals are made. Mature leaves are plaited to form mats which are very useful for packing goods for transport. The fibre obtained from the part of the stem nearest the tree is twisted into yarn and ropes. From Tisayanvilai (Nanguneri taluk) large quantities of fibre are exported to Europe for use in the manufacture of ropes and brushes. The smooth fibre or string from the higher part of the stem is used in the manufacture of chairs, mats and Indian bedsteads.

But it is as a producer of juice that the palmyra is most important. Only a small proportion of the juice produced is used for consumption either as sweet *pathanir* or a fermented toddy; and the rest is boiled to produce jaggery or more rarely, palmcandies. The jaggery is bought up extensively for use in sugar refineries and distilleries. The sugar factories of the district have already been referred to.

Tapping is the monopoly of a particular caste, but it is falling into disfavour in some quarters of the district. "The tea and rubber estates of Ceylon, Malaya and Travancore, the breeding of sheep and fowls for the Colombo market, sheep-keeping and garden cultivation at home offer superior attractions; and the spread of education, chiefly through the agency of Christian missions, has opened up a new field of activity for a most adaptable and enterprising community."[5]

(6) *The Coastal Region.*

Quite distinct from the *teris* are the dunes of white sea-sand thrown up along the coast hy the combined action of the surf and the south-west wind. The sea coast about 85 miles in length extends from Vembar in the north to a point about four miles to the east of Cape Comorin. From Vembar to Tiruchendur, the coast is low and presents the appearance of a continuous forest of palmyras and scrub jungle. At Tiruchendur, the sand has so far hardened that the sea has cut it into a cliff, some 50 ft. high, part of which has been excavated to form the temple of Subramanyaswami. South of Tiruchendur the coast is again low until the high sandy promontary of Manappad is reached. Here the ridge rises to a height of 100 feet or more, and the sand on the seaward slope mixed with shells has become so hard as to serve as a building stone. Towards the south, the rocks of the Nanguneri taluk jut out into the sea as at Kuttanguli.

From Manappad northwards a series of rocky shoals extends as far as Vaippar. A reef fronts Kulasekarapatnam and small vessels can anchor inside it. Off Manappad there is a rock shoal extending for about 10 miles from north to south. The channel between the reef and the coast is navigable, and to guide vessels clear of the reef, the Manappad lighthouse has been built. Small vessels can find safe anchorage off Alantalai, Virapandyanpatnam, Kayalpatnam and Punnaikayal.

The Tuticorin harbour lies within a circular chain of island and reefs formed by the Devil's point on the south, the Punnaiyadi, Cronjee and Pandyan islands on the east and a rocky shoal on the north. The entrance to the harbour is a channel about half-a-mile wide. Ocean going vessels and coasting crafts of large size have to anchor in the roadstead outside Pandyan island, five or six miles away from the town. There is a daily steamer service between Tuticorin and Colombo, and regular lines of steamers trading with

5. The Gazetteer of the Tinnevelly District, pp. 225.

Europe call here. Cotton is sent to Europe and Japan, cattle, gingelly oil, and oil-cakes, palmyra mats and fibre and check cloths to Colombo.

In a number of sea-coast villages, Paravans are found to the practical exclusion of other castes. In Tuticorin, they form one fourth of the population, and the entire community is Roman Catholic. The richer members of the community are traders, brokers, contractors and boat-owners. As a class they are shrewd men of business, intelligent and public-spirited. The poorer classes follow the traditional occupations of fishing and sailing, diving for chanks and pearls and cutting coral stone from the bed of the sea. There are no cultivators among them.

An industry of great commercial and historical importance is the pearl-fishery in the Gulf of Mannar. As compared with the Ceylon banks, the Indian reefs labour under three disadvantages: (1) they are exposed to both monsoons and so enjoy rest only for four months in the year; (2) the large quantity of mud brought down to the sea by the streams mixes itself with the sand and this has a smothering effect on the oysters; (3) the mollusc known locally as *Suran* spreads over the coral rocks crowding out the young of the oyster. Successful fisheries have been conducted between Vaippar and Manappad. The Tinnevelly pearl, though of small size, is unrivalled as regards colour and lustre. Excellent lime is made out of oyster shells.

Another important product of the Gulf of Mannar is the chank or conch. Like the pearl fishery, the chank fishery is a Government monopoly. Not only is the chank valued as a musical instrument in Hindu festivals but it is also cut into bracelets and other ornaments. This industry is now located in Bengal as the demand for chank bracelets come from the women of Tibet, Assam and Bengal; but chank bracelets have been found in this district in prehistoric sites. The chank flourishes in a mixture of sand and mud which smothers the oyster. Therefore Tinnevelly produces poor oyster but good chanks.

Another very important product of this region is the salt obtained from sea water. The salt factories of the district are located at Tuticorin, Kayalpatnam, Kulasekarapatnam and Kuttankuli. The first two groups contain four factories each and the last is small and unimportant.

Thus we see that man's life in the various natural regions is governed by his environment: primitive life in the hills, 'wet' cultivation in the river valleys, 'dry' cultivation in the red soil area, cotton cultivation in the black-soil region, palmyra industry and garden cultivation of the teri land, fishing and manufacture of salt in the coastal belt. The construction of dams across the rivers for irrigation, the use of water-power to drive machinery in the Papanasam mills, the establishment of factories driven by steam for the ginning, spinning and weaving of cotton and for the refining of sugar, the plantations on the hills, the present attempt to harness water to generate hydro-electric power, and the construction of railways and roads connecting important towns and trade centres are all examples of the reaction of modern civilised man on his environment.

Let me conclude with a word about the qualifications of a Geography teacher. Within the last few years our University has awakened to the importance of Geography, but there has been no response from the colleges. But for the Diploma course and the L. T. degree in Geography, we would not have had even the few qualified teachers which we now have.

Geography is a rapidly growing science and its subject matter is from day to day changing, so that the books we use in class often get out of date. So it is imperative that Geography teachers should keep abreast of their subject by reading up-to-date books and journals.

Finally it is desirable that a Geography teacher should from time to time travel. The Government and school authorities should encourage teachers to organise holiday tours by giving them grants. The excursions which the Secretary of the Madras Geographical Association is now and then arranging, either during the Christmas holidays or along with the Annual Conference are very good opportunities which no Geography teacher should miss. These long excursions enable the Geography teacher to widen his knowledge of subject matter and to vivify his teaching.

"Forests and Forest Produce of Tinnevelly"

By

T. D. Ponniah, M.R. (Hons.)

Forest Ranger, Ambasamudram.

Forests in this district are mostly found in the mountains of the Western ghats, extending from practically near the sea at Cape Comorin, to the northern boundary of the district and occupying in the west about one-seventh of the extent of the district. There are also some small isolated forests in Vallanad hills, Thalaiyuthu hills etc. The total Forest area is some 330 square miles of Government Forests and about 100 square miles of Zamindari or private forests made up chiefly of the Zamindari forests of Singampatti and Sivagiri. The forests are of tropical type, being situated as you all know, between 8°21′ and 9°38′ North latitude. In the broadest parts, the ghat forests are about 15 miles wide and these parts are near Papanasam. The highest peak in the Western Ghats of the District is Agastiamalai 6125′. This peak is almost a perfect cone and towering as it does above other peaks in the sky line, can easily be spotted from many parts of the district, even from places as far as Palamcottah or Tinnevelly Town. It is not generally known that this peak ceased to be in Tinnevelly District from 1928, as it was then handed over by the Madras Government to Travancore. Along the skyline, the average height of the Western Ghats of the District is 5000′; and many of you may not have realised that Papanasam at the foot of the mountains is only about 100′ in elevation, above the sea level. So the Western Ghats are pretty steep and it is a pity there is no motorable road leading to the Travancore frontier, though one exists up to Kariar from Papanasam which is about halfway to the frontier.

Having given a general idea, I shall now mention some details about Tinnevelly Forests.

GEOLOGICAL FORMATION AND SOIL

The principal underlying rock throughout the ghat forests is of granitoid gneissic formation, containing narrow veins of black mica. The soil is generally red being ferruginous in origin. It is quite deep, being 15′ to 20′ in places and mostly well drained. The popular notion about mountains is that they are mostly of rocks, but that is not really so, as will be seen by a visit to these ghats.

There are trees in these forests 150 to 200′ high, i.e., taller than the Church Tower at Palamcottah and such tall trees cannot grow, if the soil is not deep enough to support them. In many parts of the District, rock stratum is nearer the surface, in the plains than in the ghats.

CLIMATE

The climate is hot and dry up to an elevation of 1500′ but equable, bracing and even chill, as we get higher and higher. There are places in the ghats which can vie successfully, from a climatic point of view, with Kodaikanal or Coonoor and if only these ghats are made accessible by the construction of motorable roads leading to various points in the Travancore frontier, I am sure the District can easily have the benefit of several hill stations with bracing climate and people will then find it cheaper and easier to go to a hill station for spending their summer vacation. In other countries, so much is done and so much money spent, to attract tourists and the indifference of our public men in this District in this matter, is I think, chiefly due to their not knowing or not realizing that within a dozen or 15 miles of Ambasamudram, which is a notoriously dusty and hot place, where people are sweltering in the summer heat, there are places on the hills, where during the same period they may need a fire to prevent their hands and legs being benumbed by cold. I hope this learned body will do something to stir up enthusiasm in this direction. The highest temperature recorded in the District is 107·1° in May 1906 and the lowest 64·9°. These figures relate to the years between 1893 and 1911 and at Palamcottah. In the ghats, of course these must be very much lower.

RAINFALL

The ghat forests are benefitted more or less equally by both the monsoon rains and statistics gathered from rain-gauge stations on the hills during the past about 50 years show that there is hardly a month of the year in which there is not some good rain on the ghats. Thus, the rainfall is well distributed on the ghats. As against the average annual rainfall of about 20″ to 30″ in the plains of the district, in the hills it varies from 45″ to 165″. During recent years the rainfall in the district has been capricious, not that it is very much less than usual, but generally speaking it rains when it ought not to, as was especially the case this year during April and May, and does not rain when it ought to. Local people have a notion that this irregularity is due to destruction of Forests, due to the Hydro-Electric scheme in Papanasam forest introduced recently. But, only some one thousand acres are affected so far by the H. E. Dam works; and that is but a drop in the ocean of some 400 square miles or 2½ lakhs of acres of Forests i.e., less than ½ a per cent of the total area of forests. Again some say that the failure of rains is due to the departmental felling of coupes for fuel and timber. These again are not only about a thousand acres in extent in the whole district each year and are less than ½ per cent of the total forest area. So it cannot be due to any forest fellings that rains have been erratic in the district of late. I have an idea that the cause is to be sought elsewhere. I am a native of the District and have been in it for about half a century now, besides spending about quarter of a century in observing forests and studying them. It has struck me that there were many more wooded spots in the plains and many more trees in villages and village lands, a quarter of a century ago than now. The disappearance of these woods have I think affected the climate of the District. There were once upon a time not long ago valuable and cool poromboke forests. These have all practically disappeared. I think their restoration will correct the erratic nature of the rainfall of the district. In other countries especially in the west big villages and towns have their community forests, maintained by village and town authorities. Why we who have a traditional love for *vanams* inherited from our *rishis* and sages should not have village forests with deer and pea-fowls inhabiting them, is a matter for consideration by our public men.

RIVERS

The Thambraparni and all the other chief rivers of the district have their sources in the ghat forests. So the district owes its prosperity very much to the forests, as forests have no doubt a great deal to do with the retention of moisture in the soil and prevention of floods, even if they do not influence the actual rainfall appreciably, which is a controversial point. With regard to floods, again, people finding floods rather frequent of late, are attributing their frequency to destruction of ghat forests. But a study of the rainfall statistics referred to already by me shows that rainfall on the hills is more or less equal in both the monsoons, while it is not so in the plains. Another fact is floods happen mostly, if not exclusively during the North-East monsoon. The inference is then obvious that the ghat forests have no bearing on floods, but that the destruction of trees and woods in the plains coupled with bringing extensive areas under the plough, has resulted in there being nothing in the plains of the district to check the rush of rainwater during the N. E. monsoon, which rush results in floods and consequent destruction of valuable property. Thus again we are brought face to face with the problem of the re-creation of village forests and preservation of trees in porombokes and tank-beds, etc.

PREVALENCE OF MALARIA AND OTHER HILL DISEASES

The Tinnevelly forests are comparatively free from malaria, guinea worm and such allied hill diseases. Generally speaking there is very little cause for the dread in which the hills are held from this point of view, but of late due to people from Coimbatore, Salem and other such malarial districts having come for work in the hills in connection with the H.E.D. works, malaria and allied diseases have taken a hold in the lower regions. But malaria is an easily preventable and curable disease, if you do not make yourself a prey to it by sheer fear. So, when you go to the forests I shall advise you in the words of the Bible " fear not but be of good cheer."

FLORA.

Botanically speaking the Tinnevelly forests are very rich. We have teak, the tree that ought to be made our national tree, as the oak is the national tree of the British. Teak as you know is a tree in a class by itself among the trees of the world. It is not found in North India. It has unbeatable good qualities. In the forests of this district, there are about 1000 acres of plantations of this species, made by the Forest Department. We have besides several specimens of natural teak areas, also rosewood, vengai, vagai, kongu, senkurichi (gluta travancoria) and we have also hundreds of rare herbs and medicinal plants in these forests. Mr. Natesa Naicker the Treasury Deputy Collector of the District who is a keen collector of Indian medicinal plants told me recently that he got from Tinnevelly Forests, some very rare herbs such as Blue nelli—(Phyllanthus) etc. They say there are jothi grass and jothi trees i.e., grass and tree which emit light in the night, though I have not seen these myself. Bamboos are rare, but Itta reed is plentiful.

FAUNA.

The forests have an abundance of sambur, spotted deer, jungle sheep, wild pigs, Ibex-black buck, panthers, cheetahs, tigers, bears, wild-fowl (but pea-fowl rare) and all kinds of snakes, including hamadryads. I shot a Hamadryad sometime ago in Srivilliputhur hills, and it was 12' 6" long which is only a few inches shorter than the longest hamadryad, on record; while on this point, I would like to say again that though the forests have wild animals and snakes, ordinarly there is nothing to fear from them. They are cautious, so that you rarely meet them. All animals have a natural respect and fear of man and man has ordinarily no cause for fear. Shooting innocent, beautiful and pleasure-giving animals such as sambur and deer, before they are fully mature is surely a sin, and civilisation and science have given us recently the hobby of photographing animals in their wild stage. I wish all of you try photography of animals in the forest and I am sure you will find it a hundred times more pleasant than to shoot down animals which do no harm.

HILL TRIBES

These forests have a few hundred kanies and palias. They are given land for cultivation by the Forest Department in return for their raising forest plants at stated intervals in those areas. Of course, they are given change of areas, when the trees grow big enough to cast too much shade for cultivation of agricultural crops. These hill people are Tamilians by origin but intermingle with the hill people of Travancore. They talk Tamil and Malayalam in a corrupt form. They chiefly work for forest contractors gathering honey etc. They are a dwindling race, their dwindling being chiefly caused by loss of vitality due to excessive addiction to Ganja which Government have allowed them to grow for their use. Their chief agricultural produce is Tapioca and Thinai.

FOREST PRODUCE: MAJOR PRODUCES

These forests are the chief source of fuel supply to the district, also small and big timber. Kongu is the chief big timber and it is extensively used. Pali (Palaquiem eliptica) is the next in demand. Teak of course is plentiful but not in such big sizes or in such straight beams as in Travancore or Coimbatore. Sandalwood is an introduced species and is not either plentiful or big enough for exploitation.

MINOR PRODUCES.

They are honey, dammar, Peenaripattai (an ingredient used in making scents and till recently, very much in demand in Germany, now going to America) Pulukkapattai etc., and the variety of the last found here is known as the Mysore variety. Recently there has been a proposal to lease out lands for cardamom cultivation. We have some 10000 acres of land fit for this and if proper motorable roads are made and good use made of these areas, I am sure it will lead to the greater prosperity of the district. There is a popular idea that cardamom cultivation leads to forest destruction and soil deterioration in forests. It is surely not true; since, for cardamom cultivation somewhat dense shading trees are a necessity and so, no trees are interfered with ordinarily. This is not so, for tea or coffee, which require much clearing. For cardamom cultivation to be successful in the district, good roads leading to these plantations are absolutely necessary.

INDUSTRIAL POSSIBILITIES OF TINNEVELLY FORESTS

We all know that probably the only water-power driven cotton yarn mill in India is in Papanasam. The enterprise is by Britishers but in the Western Ghats there are many more spots with big and small water-falls which can be utilised for similar enterprises. In the Western countries, I understand even small cascades are made use of, for driving machinery for industrial purposes.

We have of course the recently started Hydro-Electric scheme under way in Papanasam Hills and we are likely to have an abundant and cheap supply of electricity in the district shortly which is sure to lead to industrialization of this district. Things move very slowly in Tinnevelly District and as you all may know this scheme had been incubating for the last about three-fourth of a century. In the Western Ghats above about 4000′ height up to the skyline there is a thick mass of itta bamboos (Ochlandra radii) which has been proved to be very good for paper making material. Extensive surveys and studies of these areas have been made as early as 1926 and proposals made to start a Paper Mill. I undertand the Madura Mills authorities are keen about this. If this scheme comes through it will be a very good thing for Tinnevelly. In countries like the United States of America, Norway, etc., unlike in Tropical countries like ours, paper making has great handicaps in the matter of basic materials. You all may know in these countries paper is made from trees felled and ground into paste. In those countries due to the temperate nature of the climate, trees like pine, fir, etc., take not less than 80 to 100 years to mature and get fit for felling. So if one acre of forest is needed to keep a mill going for one year they should have something like a 100 acres more of forest-trees in reserve. You can imagine what that means by way of capital investment, etc. But in India, we have bamboos, which are equally good if not better for paper making and which grow like weeds.

Further, bamboos mature in 2 to 3 years. So our reserve of forests need be only 2 to 3 times the yearly consumption. With such obvious advantages, India must be able to compete in paper-making with any Western country. But we have yet to learn enterprise and it is time we stir ourselves in this direction.

Recently in Papanasam Hills Government have assigned on lease to an influential, rich and highly educated gentleman of the district something like 300 acres of forest area near Mundanthorai for a Dairy Farm. Our country is getting part of its milk and butter brought from countries 4000 to 5000 miles away. This gentleman appears to be a man with a vision and he wants to make butter, can milk etc., and compete with foreign butter, milk etc., I hope and wish he will succeed. If he does, that will be a very useful industry in these hills.

In the Western Ghats of the district there are thousands of acres fit for tea, thousands of acres fit for coffee, oranges, nutmegs, cloves, and cardamoms. If only our big men know how to utilize those areas there need be no unemployment anywhere in these parts. I therefore request you all to interest yourselves more in forests, and forest matters and not to think of tigers, when you think of forests.

Papanasam Hydro-Electric Project

BY

RAO SAHEB N. KRISHNAMURTI,

Executive Engineer, Construction Division, Papanasam

1. "Hydro-Electricity," it is needless for me to say, is closely allied to the geographical features of the country. If 'Geography' is the science of the earth's surface, form, physical features, etc. Hydro-Electricity is the science of utilising the natural configurations of the country and the resultant rainfall to serve the needs of mankind. To explain these more fully, the chief factors that decide the possibilities of Hydro-Electric Development are, among others, the head of water that can be stored and the quantity of water that can be obtained. Both of these factors are most pronounced only in the hilly tracts of a country. In the absence of hills, valleys, rivers and rainfall, about which Geography deals in full, there can be no thought of Hydro-Electric Development and this association between the Geography of the country and Hydro-Electricity is probably the justification for your President calling upon me to give you an account of the "Papanasam Projects."

2. A look at the map of South India clearly brings to our mind how the Western Ghats are situated in an one-sided manner in relation to the width of the Peninsula and how largely it is a deciding factor in causing variations in the precipitation of rainfall over these hills; and it is here that all the Hydro-Electric Schemes of South India (except perhaps a single exception) are located—to name only a few, the Andhra Valley Power Scheme in Bombay, the Jog Falls Scheme contemplated in Mysore, the Pykara Scheme in the Madras Presidency, the Pallivasal Scheme in Travancore and the Papanasam Scheme, now under construction. The Sivasamudram Scheme in Mysore and the Mettur Scheme in Madras Presidency, though not situated exactly on the Western Ghats, depend only on the Western Ghats for their water.

3. It should, by no means, be assumed that the power resources of the Western Ghats have been fully tapped by the development of the Schemes referred to above. Hundreds of other similar schemes might be possible in these hills, but the economics of the

schemes will pale into insignificance when considered in the light of Schemes already developed.

4. Just as the Hydro-Electric Schemes of South India are situated predominantly in the Western Ghats, those of North India are at the foot of the Himalayas.

5. The Papanasam Hydro-Electric Scheme has for its purpose the utilisation of the waters of the Tambraparni river, the only chief river of the Southern District of this Presidency, for development of Electricity. The power resources of this river have been known for a very long time, at least for 60 years when the Harvey Mills constructed their small hydraulic plant for the purpose of their textile factory, but intensive studies for the full utilisation of the power resources of what is now known as the Papanasam Project was taken up by the Department in the year 1928 and a report on the same was also produced about the same time. It was then considered that the success of the Scheme depended largely on additional industries that should be started in the Tinnevelly District. Besides negotiations had to be carried on with the Harveys Mills Ltd., for converting them to Electric drive. Consequently other schemes that could be justified from an economical point of view were concentrated upon.

6. In this connection, I would like to refer to a recent statement of Sachivothama Sir C. P. Ramaswamy Iyer, present Dewan of Travancore (and ex-Member of this Government in charge of Electricity during the years 1923-28) but for whose foresight and drive the development of Electricity in this Province would not have been what we see it to-day. He observed: —

"In the years 1923 and 1924 the question of introducing Electricity as a means of adding to the amenities of town-life had been in the thoughts of many and a great and notable example was before us on account of the work initiated in Mysore by the genius of Sir K. Seshadri Ayyar, helped as he was by a great Engineer Lobiniere. It was the desire of the Madras Government at that time that a similar attempt should be made here in the Madras Presidency......... The question was where a beginning was to be made. One idea was to begin somewhere in the Agency Tracts in Vizag. This was the Kolab Scheme and the thought underlying it was to utilise the great head of water there and tap the forest and other resources in the Agency Tracts and, if possible, to electrify the Railway. There were many difficulties attendant upon that Scheme and it was given up. The next in order of date was the Papanasam

Scheme which has just now been taken up. There the proximity of industrial enterprise and the possibility of utilising the abundant 'eta' fibre for the manufacture of rayon and paper were the attractions."

Though eventually the Pykara Scheme was taken up as the first Government venture in this Province, Papanasam was always in the thoughts of the Government and was given a prominent place also in what is known as the 'Madras Grid', which, in common language, means the formation of a National Scheme with a network of transmission lines connecting the several electrical schemes of the Presidency. The unexpectedly rapid growth of power demand on the Pykara Generating Station, which to-day is serving the Madura, Ramnad and the portion of the Tinnevelly District down to Koilpatti, and the repeated representations of the landholders of the Tinnevelly District, forced the attention of the Government for a re-examination of the Papanasam Project as a combined Irrigation and Power Scheme in the year 1935. The Irrigation services in the Tinnevelly District were also intended to be improved by storing 2,000 million c.ft. of water in the Tambaraparni river. The subject was studied in the light of how the cost of storage Dams is to be shared by the two Departments viz. P. W. D. and Electricity Department, in proportion to the benefit received and, in case of a reasonable understanding between the 2 Departments, it was thought that a remunerative power scheme could be designed. The fact that Messrs. Harveys water licence would expire in the year 1941 made it still more necessary for the Government to start the Scheme in sufficient time to be able to supply themselves the power required for the Harveys Mills from the time the licence would expire.

7. Though it was recognised on all hands that a reservoir at Papanasam was absolutely necessary for overcoming the vagaries of the Monsoon and rectify the deficiency of irrigation water supply at Marudur and Sri Vaikuntam Anicuts—the 2 lowest anicuts of the Tambraparni System—the Government after careful examination came to the conclusion that the Scheme could not be sanctioned as a part of Irrigation Project but considered that the investigation of the Project as a purely Hydro-Electric concern should be carried out to completion. It should be remembered here that the proposal to construct the Dam in the Tambraparni River above Papanasam had been discussed by several Engineers and Revenue Officers for the last 100 years and more. The incessant representations of the Tinnevelly landholders, especially in the year 1935,

for adequately safeguarding the irrigation interests of the 2 lower anicuts which were suffering from drought too often, had also to be satisfied. The Government, therefore, ordered that in making the investigation, the requirements for Irrigation purposes should also be taken into account and if it was found that there was an assured supply of water from that reservoir for Irrigation, resulting in additional irrigational revenue, the question of affording credit to the Hydro-Electric Project from Irrigation Funds would be considered. So much about the origin of the Scheme. The present development is the result of subsequent studies of the Project, as a purely electrical scheme.

8. The Tambraparni River which rises in the Western Ghats has a drainage area of 127 square miles above Papanasam of which 57 square miles are in the high ranges with an average rainfall of 121″, while the balance of 70 square miles lie in the low ranges with an average rainfall of 52·6″. The length of the river to its mouth is about 75 miles. It is joined by the Kariar and the Servair above Papanasam which also carry a large quantity of water during the rains.

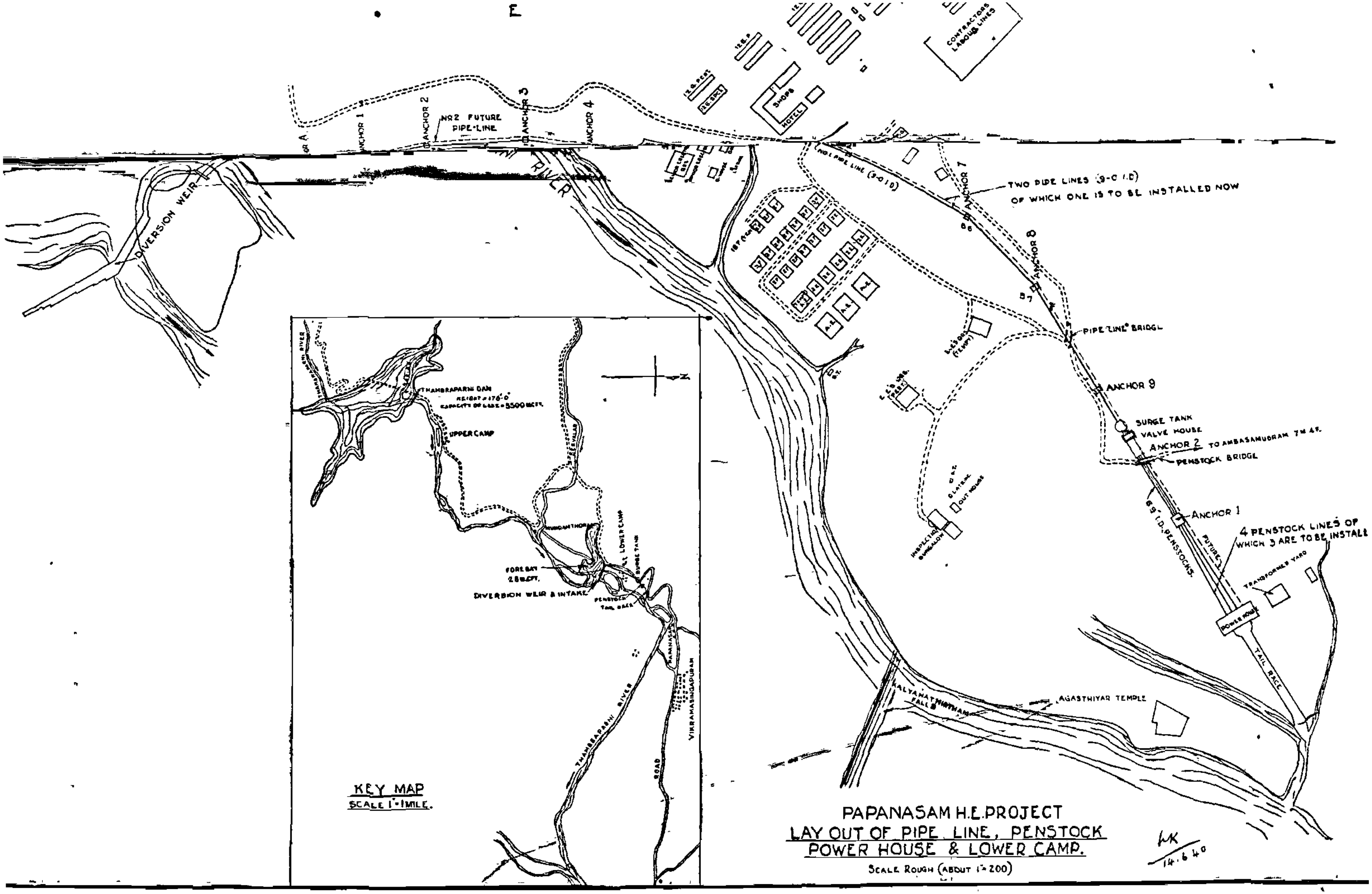
9. Briefly speaking, the present development will have the following features:—

(1) Building a masonary dam 176′ high to impound 5,590 million c.ft. of water in the Basin of the river just below the point where the Kariar tributary joins the Main River Tambraparni.

Note.—The water so stored will be drawn as and when required by means of two 8½′ dia. pipes imbeded in the Dam.

(2) Building a Diversion Weir, or an Anicut 35′ high across the same river about 5 miles below the Main Dam. This Diversion Weir will provide a further storage of 28 million c.ft. of water for daily regulation and will force down the water into two 9′ dia. steel pipes that will be built in the same. This Diversion Weir is so located that advantage could be taken also of the waters brought down by the Servair which joins the Tambraparni river about a mile above.

(3) Erecting two 9′ dia. steel pipes to convey the water from the Diversion Weir to the top of the bluff—a distance of 3,500 ft. with a gradient of 1 in 300 and providing necessary control valves at the lower end. In the first stage the proposal is to erect only one pipe; the second will come in at a later date when the demand increases.



PAPANASAM H.E. PROJECT
LAY OUT OF PIPE LINE, PENSTOCK
POWER HOUSE & LOWER CAMP.
SCALE ROUGH (ABOUT 1" = 200)

(4) Branching the above pipes into four 69″ dia. pipes and leading the water down the hill-slope from the top of the bluff to the Power Station below a distance of 650 ft. Of the 4 pipes intended as the final development, only 3 will be installed at present.

(5) Construction of a Power House near the Agastiyar Temple situated at the foot of the Kalyanathirtham Falls at about M. S. L. +320. The gross head available at this site is 330 ft. The Power Station will be built for accommodating 4 Units of 9,000 H.P. capacity each, of which only 3 will be installed at present. Each Unit will consist of a vertical Francis Turbine of 9,000 H.P. maximum rating connected to a 6,250 KVA, 50 Cycles, 11,000 Volts, Alternator.

(6) Erection of suitable Transformers to step up the Voltage from 11,000 to 66,000 for transmission purposes.

(7) Connecting the transmission System which has at present been built up to Koilpatti to the Power Station. A branch of this transmission line will be taken to Tuticorin from a place called Kayattar or Pudukudi.

A 11/12 K. V. transmission line connecting the Power House to Tenkasi in the first stage and to Rajapalayam eventually *via* Sivagiri is also provided for.

The existing transmission lines to Ambasamudram, Kallidaikurichi and Sermadevi will be merged into the future Transmission System.

10. The construction of the Scheme as a purely electric project necessarily imposes a restriction on the ultimate development, since only the water that is in excess of the Irrigation requirements can be impounded for power generation. It has also been established by a careful study of comparative costs of steam and Hydro-Electric power in this area that, owing to the storage beyond 5,500 million c.ft. being not economical, any additional demand beyond the capacity of the present power station will have to be met by a steam plant which will, probably, be located at Madura on some future date. Generation of additional power from the stored head of the Tambraparni Reservoir (like Mettur) by building a Power House just at the foot of the Tambraparni Dam and utilising the issuing water to do double work is also visualised. There are possibilities of obtaining further power by utilising the Banathirtham Falls higher up the Reservoir.

11. The total anticipated expenditure of the Scheme is Rs. 1,79,00,000 initially rising to Rs. 2,58,75,000 within 10 years from

the commencement of operation of the station. The financial fore cast worked conservatively shows a net return of 6·55% on th Capital outlay.

Owing to the present international situation, a temporary res triction of expenditure has been imposed on this Scheme totalling u to Rs. 1,39,00,000 in the intial stages but this, however, is not likel to affect the time of bringing the power station to commercial us at the earliest possible time, consistent with delivery of machiner ordered on English firms. The restriction of expenditure referre to above will have, however, the effect of limiting the height c construction of the Main Dam for some years.

12. Now as to the possibilities of the Scheme: let us conside the same from the standpoint of the success that has attended th 2 previous Hydro-Electric Schemes (Viz. The Pykara and th Mettur) and the Thermal Stations started recently in the North ern Districts by our Government. In the administration Repo of the Electricity Department for 1938-'39 there is a very interes ing Chart attached from which the following figures of growt are abstracted.

The installed generating capacity has increased from 19,650 KW in 1934 to 54,900 KW in 1939.

The arithmetical sum of System peaks rose from 3,150 KW i 1934 to 26,950 KW in 1939.

The total units generated rose from 10·9 Million KWH in 19 to 131·1 Million KWH in 1939.

The total length of Transmission Lines Single Circuit is show in the following table in both 1934 and 1939:—

Description of Trans. Line (1)		In 1934 (Miles) (2)	In 1939 (Miles) (3)
66 K. V. Line	..	212	1,094
33 do.	..	18*	292 *In 19
22 do.	..	166	615
11 do.	..	115	788

Other interesting features relating to electrical development are comparatively as follows:—

Description (1)	In 1934 K. W. (2)	In 1939 K. W. (3)	
1. Industrial connected load ..	4,400	20,030	
2. Cement connected load ..	*1,000	3,350	* (In 1935)
3. Licensee's connected load ..	†1,680	30,860	† (In 1935)
4. Tea Factories connected load ..	710	3,560	
5. Agricultural connected load ..	190	6,710	
6. Miscellaneous load ..	150	6,960	

Financial Aspects

	In 1934	In 1939
Capital expenditure ..	Rs. 123.4 lakhs	475.5 lakhs
Gross Revenue ..	Rs. 4.4 lakhs	42.4 lakhs

i.e., nearly 10 times what it was in 1934. This is in 5 years of Operation.

The figures quoted above are self-speaking. If the electrical enterprise has been found successful in the other parts of the Presidency, there is no reason to believe that the same success would not attend also the "Papanasam Project" now under construction.

13. 'Electricity' is often said to be the servant of man in several ways. The uses to which it can be put are so many that it is well-nigh impossible to do justice to the subject in this short account, but a brief reference to the more important ones will be made.

'Electricity' as a form of energy has an unique advantage over other forms in that it could easily be converted to either heat or light. It may also be used for motive power direct. No wonder, therefore, that the various ways by which it is made to serve mankind is multiplied.

14. The Madras Government Electricity Department have, from time to time, published some propaganda pamphlets entitled.

'Electricity in Industry'
'Electricity in Agriculture'
'Electricity in the Village.'

These phamplets describe in simple language as to how electricity can be harnessed for our domestic and industrial purposes, how it is economical to take to electricity in place of coal or oil for motive power and how the man-in-the-street can obtain electricity. I shall refer here to some of the uses.

15. It is common knowledge now that, after the advent of electricity in the Coimbatore Mill areas, there has been a marked increase in the number of textile mills in the area. The number of mills supplied with electricity in 1933-34 by the Department was only 7 whereas by the end of the year 1938-39, it is 31 under the Pykara System. Such being the case, there is every hope of a similar development in the cotton growing areas of this District.

16. Among other notable uses of electric power in industries may be mentioned the following:—

Electrochemical industries such as the manufacture of Sodium Carbonate, Caustic Soda, Chlorine, Bleaching Powder, etc., for which large quantities of common salt are available at Tuticorin.

If we remember that India has been importing about 60 lakhs of rupees worth of Sodium Carbonate every year in the last 15 years and in the case of Caustic Soda the imports into India have increased from 18 lakhs in 1926-27 to 45 lakhs in 1938-39, the necessity for developing Electro-Chemical Industries will be apparent.

Fixation of nitrogen in the atmosphere and manufature of manures largely used in Tea Plantations are also to be considered in this connection.

It is important to note that the imports into India of Ammonium Sulphate used for manurial purposes has increased from 4·75 lakhs in the year 1926-27 to 83 lakhs in the year 1938-39. The corresponding figures of imports for the Madras Presidency alone are 17,000/- in 1926-27 and 39 lakhs in 1938-39. The enormous increase in the demand for such manures suggests a fruitful field for exploration of local manufacture of such materials.

A paper and pulp industry is also feasible owing to the availability of large quantities of 'eta' grass and bamboos in the adjoining forests.

17. Electricity in the hands of the agricultural workers is a "source of unlimited power, flexibility, cleanliness and variety unknown in other methods of power supply." It can be used for well-irrigation, thrashing and such other farm operations including farmstead lighting, dairying and poultry farming. The following table gives an idea of what can be done by an expenditure of one unit of electricity (price ·9 anna) in the household:—

Raise 2,500 gallons of water over 50 feet.
Light one 40-Watt lamp for 25 hours.
Toast 60 pieces of toast.
Make 60 cups of coffee or tea.
Make light breakfast for four people.
Heat 6 gallons of water to bath temperature.
Heat 2 gallons of water to boiling temperature.
Run a sewing machine for 20 hours.
Run a 10-inch fan for 50 hours.
Run a Ceiling fan for 10 hours.
Milk 52 cows.
Separate 300 gallons of milk.
Churn and work 180 lbs. of butter.
Wash 2,500 milk bottles.
Make 10 lbs. of ice.

This catalogue gives you roughly an idea of how electricity can be turned to our advantage.

18. Besides the above, it will be possible to develop industries such as rice-milling, ginning, oil pressing, sugar-cane industries, ground-nut decorticating, flour-milling, etc., which are closely associated with the agriculturists.

19. But for the advent of electricity, would it have been possible for the increase of the number of radio sets all over India from about 11,000 in 1935 to 100,000 in April 1940?

20. But in considering the usefulness of electricity for local application we have to pay special regard to availability of raw materials, tendencies and habits of the people and demand.

The conversion from hand-loom to power looms seems to be within practical politics.

The following comparative data between hand-loom and power-loom collected from experience in other districts are of interest:—

	Hand Loom	Power Loom
Cost of Loom 36" to 54" reed space	Rs. 30 to Rs. 40	R. 450 to 600
Approximate cost of motor and switches		Rs. 200
Output (in 9 hours)	6 to 8 yards.	40 to 45 yards.
H.P. required	Man-power.	½ to ¾ H.P.
Cost of power per yard		1 pie.
Earning per working day	Re. 0-10-0.	Rs. 3-12-0.

Power looms are reported to be in use in the Erode and Salem areas after the advent of Electricity.

The Rotary oil mill should also prove successful in the oil seed crushing industry, which by careful planning of other dependent industries can be made to supply all local demand in respect of cheap oil cake for manures, artificial ghee, lubricants, candles, etc.

21. In 1881 Mr. J. V. Pennington, who was then the Collector of this District observed as follows in regard to the Irrigation development in this District:—

"It is not the direct pecuniary gain to Government by such improved irrigation that is a measure of its value. It should be considered that Government cannot fail to benefit also by the increased prosperity of the people, though it is impossible to estimate such direct returns in figures. There is one satisfactory feature about all Irrigation schemes in this District and that is the extraordinary enterprise of the people. Only provide water and the people will do the rest."

22. The same remarks, with slight modifications, will apply to electrical developments also. I do not believe that the extraordinary enterprising spirit referred to in the above quotation is any the less to-day among our people. With judicious planning, co-operative effort and proper marketing we should be able to utilise electricity for Cottage Industries of various kinds such as fabrication of tooth brushes and hair brushes, combs, toys, buttons, umbrellas, bolts, locks, brass work, metal polishing, electro-plating, etc., etc., Our own efforts should therefore be directed towards popularising the application of electricity to agricultural and cottage industries and thus increasing the prosperity of the people and their standard of living.

23. Pandit Jawaharlal Nehru is reported to have observed as follows: —

"There are not only economic but also psychological reasons why we should pay special attention to the development of cottage industries. Every one should not only be a consumer but also be a producer. He should be able to take part in increasing the wealth of the country, whether artistic or material. The development of cottage industries will not only bring about the economic uplift of the villager but also a psychological change in him in as much as it will satisfy his creative instinct."

24. It is to be hoped, therefore, that when the basic system of education which has been discussed threadbare in the last few years is introduced special arrangements will be made to spread the method of application of electricity to cottage industries with due regard to local conditions and talents.

25. Here again, you, Teachers, who have been entrusted with the sacred task of training young minds and fashioning their future, have a great part to take and do!

A Plea for the Development of Garden Cultivation in Tinnevelly District

By

V. Srinivasan, B.Sc. (Ag),

Research Student in Economics, University of Madras.

Introduction.

The role of water in plant nutrition is of paramount importance in so far as it enables the intake of food materials from the soil. The primary sources of this important factor are the rainfall of the locality, rivers, storage tanks, and last but not least wells, especially in dry areas. Much reliance cannot be placed on rainfall, because it is unequal and irregular in distribution and is restricted only to a few rainy days in the year. Moreover, the geographical position of the mountain ranges influences the intensity and periodicity of the rainfall; and hence the recourse to irrigation will assure definite supply whenever required. But looking to the future, the question of developing canal irrigation seems rather limited under the present financial stringency. The day of great irrigation schemes is now over and in many districts the limits of canal irrigation have already been reached, wherein there is no possibility of further expansion. Moreover irrigation projects of great magnitude, like river or storage works require heavy capital outlay and are beyond the means of individuals or groups of individuals. Also, such irrigation schemes favour only certain localities, where the local topographical conditions are suitable; and are not within the reach of the other parts of the country. Tank irrigation is rather insecure. So the only other source left is to tap the subterranean or under-ground water supply and to develop garden cultivation by digging more and more wells.

Existing sources of irrigation in Tinnevelly District.

The figures[1] on page 126 show the area irrigated by different systems in the several taluks of Tinnevelly district:—

1. The Gazetteer of the Tinnevelly District, Volume II.

Taluk.	*By Govt. canals.*	*By Private canals.*	*By Tanks.*	*By Wells.*	*By other sources.*	*Total.*
Koilpatti	23	5,331	5,331	9,961		15,315
Sankarankoil	1,456		30,717	17,830		60,00
Ambasamudram	20,326		19,558	2,898	496	43,278
Nanguneri	3,479	10	36,512	8,632	327	48,960
Tenkasi	5,282	3,016	30,787	17,271		456,360
Tinnevelly	8,598		27,117	728	27	36,470
Srivaikuntam	7,308		18,813	958	161	27,240
Tiruchendur	2,055		18,930	4,520	1,870	26,835
Total	48,527	3,026	187,225	72,798	2,885	314,461

Thus, there are nearly 3 lakhs of acres under irrigation, of which the areas irrigated by Government Canals tanks and wells work out to 15·7%, 60·7% and 23·6% respectively. The only important river of the district is the Tambraparani with its affluents, irrigating one of the most fertile parts of the Presidency. But this area, which can be pronounced safe, occupies only about 3% of the total occupied area or 6·5% of the net area sown and about 30% of the total irrigated area of the district. The rest of the irrigated as well as the rainfed area, mostly in the taluks of Koilpatti, Nanguneri, Sankarankoil and Tenkasi, is at the mercy of the jungle streams and rainfed tanks.

The district of Coimbatore, taking it for comparison, stands first in the Presidency with regard to both the extent and the intensity of garden cultivation. The percentage of the area irrigated by wells to the total area irrigated is 74, which is the highest proportion in the Presidency. Such a high development of well irrigation is an index of the great capacity for hard and intelligent work of the cultivators of that tract. In fact, they are much better off than their slovenly neighbours in wet-land areas. This is more aptly so, in Tinnevelly district, where the burden of wet assessment is in some cases Rs. 22/8 per acre, which is about the maximum the Government has thought of in this presidency.

There are about 36089 wells[2] in this district, and wells are more concentrated in the red soil areas of Sankarankoil, Tenkasi and Koilpatti taluks. In addition to these independent or 'ayakat' wells, wells are also met with in Naguneri and Tenkasi taluks, which serve as supplemental sources to the existing canals and tanks. Sankarankoil taluk would have proved to be a desert but

2. Statistical Atlas of the Madras Presidency revised upto Fasli 1340.

for the large number of wells and fair development of garden cultivation.

Till now, due to the geographical position of the district, the labour population found an easy outlet to the planting districts of Ceylon, Travancore, and the Straits settlements, especially after the development of tea and rubber plantations and consequently the district suffered but little in an unfavourable year. But this exodus of labour is coming to a stop, and the pressure of population is already keenly felt in the villages. The requirements of labour for wet-lands areas during transplantation of Paddy or its harvest get concentrated and the operations have to be rushed through within 3 or 4 weeks in the year. Practically for the rest of the year, it has become a serious problem for the labourers to sustain themselves during the off-season. This deplorable state of unemployment can only be averted if garden cultivation can be increased side by side with wet and dry cultivation.

Suitability of the district for garden cultivation.

Underground water supply:—

It is desirable as an essential pre-requisite for any proper development in this direction, that an exhaustive survey should be undertaken to gauge the availability of the subterranean springs, sufficient to cope with the proposed extension of well irrigation. This survey, unfortunately does not appear to have been even attempted in this district. " The theory of underground storage of water is a very complicated one, since many factors that go into the problem are unknown."[3] Such being the existing state of affairs, experiments in this direction by conducting trial borings and by deepening of some of the ryots' wells have to be made to collect data for reliable guidance. The available information may be placed to ryots through the propaganda machinery of the Agricultural department. But from the geographical position and from the fact that the whole district is studded with innumerable number of tanks, it is presumed that there is likely to be a good and adequate underground supply of water for utilisation of garden cultivation.

In this connection what Alfred Chatterton wrote in 1906[4] holds good, now, too : " . . . . nothing has been done to help the agriculturist in selecting the site for a well, nothing

3. The underground water sources of the Madras Presidency by N. M. Adyanthaya.

4. Lift irrigation by Alfred Chatterton.

to show him how best to tap such water-supply as may exist, and very little, and that of no practical utility, to indicate the best means by which the water may be raised above the surface of the ground. What has been done in the past has been done by the ryot himself, what yet remains to be done must necessarily be on much the same lines."

The economics of digging a well.

With almost similar conditions prevalent in Coimbatore, the wells in this district are neither as deep nor sunk in such rocky beds as in Coimbatore district, and as such the cost of sinking a well is bound to be less than 50% of the average cost in the latter district. The loans issued under the Land Improvements Loans Act of 1883 during the decennium ending in 1930-31 amount to Rs. 1,46,995 for sinking 445 new wells.[5] The cost of sinking a well according to this works out to only Rs. 330. Allowing a fair margin, the average cost of digging a well under the conditions obtained in Tinnevelly district is about Rs. 400. This is a figure which varies within wide limits and is usually bound up with the economic condition of the ryot, the nature of the geological strata, the surface dimensions of the well and the depth at which water is struck. There is a considerable scope for expansion of well irrigation in this district especially in the taluks of Koilpatti, Sankarankoil, Nanguneri and Tenkasi. In this connection it cannot however be over-emphasized, that a portion at least of the idle and shy capital from within the villages should be diverted into permanent improvements as digging a well and reclamation of land. Very rarely in this district does a capitalist spend for agricultural improvements of a permanent nature, while in Coimbatore, profits earned in trade and commerce are diverted to agriculture. Also the Government agencies, while making the loans more popular with the ryots, could well afford to be quicker in the disbursement.

The garden land ryots of Coimbatore district are more energetic, hard-working and are enterprising and they dwell in the farm itself. Some of their wells are as deep as 100 or even 120 feet, sunk in all its entirety in rocky strata. They consider digging a well as an ambition in life and strive hard for its achievement. While here, if we meet with rocky strata or if we do not strike water at a shallow depth, we drop the idea of digging a well as hopeless. It is here in this great task of developing our national industry, that we have to learn a lesson from the Coimbatore agriculturist and provide for more intensive garden cultivation.

5. Statistical Atlas of the Madras Presidency revised upto Fasli 1340.

The problem of lifting water

The water-lifts generally in use are the hand picottah and the familiar mhote commonly known as the "Kavalai." Human labour can be utilised profitably only when the area is small and the lift is a few feet high. Bullock labour is much the more common, but often the cost of maintaining large-sized bullocks is very high. Mechanical appliances like oil-engines, electric motors and pumps are rapidly gaining favour, the former giving place to the electric drive. During the year 1933-34 there were only 8 consumers with a connected agricultural load of 61 H.P. in the Pykara hydro-electric distribution in Coimbatore district. It rose up to 97 consumers and a connected load of 811 H.P. in the next year, and the steady increase was kept up; so that, in 1938, there were 970 consumers with an agricultural load of 5927 H.P.[6] At present, more than 2000 pumps are installed in this system, and some of the pumps irrigate even 100 acres in a block. Tinnevelly District has equal chances, if not more, to provide immense potentialities for the development of the electric drive for lift irrigation. This has turned out to be a veritable boom for the agriculturists after the development of the Papanasam Hydro-Electric Scheme. There is ample evidence for this statement, for, already an agricultural load of 200 H.P. has been guaranteed in the villages of Kadayam, Shermadevi and Mukkudal. I have visited a few villages in Koilpatti, and Tenkasi taluks and the ryots are quite prepared for installing electric motors. Only there must be more of propaganda and the Government must come forward and provide power by extension of the lines upto the well.

From a study of Coimbatore Garden cultivation and the more common lifts employed, an idea could be had from the following average figures collected there.

Lift used.	Mhote.	Oil Engine & Pump.	Electric Motor & Pump
Capital Investment and cost of installation.	Rs. 40 for 2 Mhotes. Rs. 360 for 2 pairs of cattle. Total Rs. 400	Six H.P. Rs. 1,500	Six H.P. Rs. 550
Cost of irrigating an acre–Lift 40′.	Rs. 3-8-0 to Rs. 3-12-0.	Rs. 1-12-0 to Rs. 2-4-0.	Rs. 1-8-0 to Rs. 1-12-0.

6. The Administration Report of the Electricity Department, 1937-38.

The above statement by itself will not give an idea, for, though electric motors and pumps are comparatively cheaper than mhotes, a fair margin has to be allowed for the maintenance of cattle pairs, for other farm operations than irrigation. Also, oil engines cannot claim universal approbation, since the initial investment is very high, and is within the reach of only a few rich enthusiasts. And many of the wells do not justify heavy pumping; and the maintenance of a driver involves high overhead charges.

It was only the other day that I read in the columns of *The Hindu* that the National Planning Committee strongly pleaded that the high tariff of Electricity for industrial purposes stands in the way of their development. They have recommended a sharp reduction in the tariff to give a fillip to the industrial progress of our country. Unfortunately there are very few to plead the cause of these labouring agriculturists. The local economic councils and agricultural associations must organise and agitate on behalf of the ryots for the reduction of electricity tariffs given for agricultural pumping. This is sure to give an impetus for the installation of centrifugal pumps and development of hydro-electric drive.

Superiority of garden cultivation.

In order that the cultivation carried on purely from lifting water from wells materialises to a paying proposition, the general cropping here is of a high order and every gallon of water lifted is utilised more economically. Money crops find a prominent place in the general rotation. Cambodia cotton, tobacco (especially of the chewing variety), chillies and onions are some of the crops which find favour in the cropping scheme. Nutritive millets as Ragi, Cholam, Cumbu, Samai, Tenai and Panivaragu are grown in garden lands, and incorporation of this in the daily menu makes the cultivators hardy agriculturists.

Again, it is only well irrigation that should build up the Live-stock Industry of our District. All the cattle requirements of our district, both of the black soils and of the red soils are met by other districts. These are amply provided for by large fairs, notably those at Kazhugumalai, Trichendur and Sivalapperi, to which are brought thousands of cattle from Mysore, Salem and Coimbatore. Every Coimbatore Gounder especially of the Kangayam tract keeps one or two cows and reserves a portion of his garden for providing pasture and cultivates fodder crops. Thus the Garden cultivator looks to the nutrition of the man, the animals and the soils (by returning to the soil the dung of the large stock of cattle) and thus solves what is known as "the triangular problem of nutrition."

Turning next to the question of consumption of vegetables and fruits in this district, I think we are nowhere near the ideal. From the nutritional stand-point, and from the requirements of the modern dietetic standards these must find a prominent place to supplement the daily menu. It is the non-availability of vegetables and fruits in this district at a fair price that accounts for the very low consumption. We are now entirely depending on other districts for good quality fruits, paying an unduly higher price; and this stands in the way of higher consumption of fruits. Rich loamy and drainable lands especially along bus routes can be tried for fruits like mangoes, and oranges, vegetables and flowers, after their conversion into garden lands. I dare say there is a bright future for fruit ad market gardening.

The immediate necessity for the district is the role which supplemental wells can play in insuring the tank fed wet lands of this district against any failure of water supply. What Tinnevellians consume as the best Jaggery in the market comes up all the way from Udamalpet Taluk of Coimbatore district and are cultivated in thousands of acres in the tank-fed wet lands. There is a chain of tanks wherein the water supply is insecure even for three or four months of the year ; and a few hundreds of rupees spent in digging up a well has facilitated marked development of sugarcane cultivation. Thanks to the Imperial Sugarcane Station at Coimbatore many high yielding varieties have been evolved and has made sugarcane cultivation more profitable. The District of Tinnevelly is not lacking potentialities for sugarcane and turmeric cultivation; and it is the want of enterprise and enthusiasm that stands in the way of more profitable utilization of the thousands of rich tank-fed wetlands in the various taluks of this district.

Conclusion

The first concern of Agriculture should of course be to produce a sufficiency of food crops to support the huge population. But this is not the only concern of agriculture for the value of irrigation must be considered under three heads—Local needs, Commercial Crops for Export, and the maintenance of Live-stock Industry. Reduction of the cost of production, increased yield and proper marketing are the cry of the cultivator and the needs for successful farming. Our ambitions and aspirations must be to achieve this goal.

Cultivation of Cotton in the Tirunelveli District

By

B. Natarajan,

Lecturer in Economics, M.D.T. Hindu College, Tirunelveli.

Types of Cotton.

Until late in the 19th century the "Tinnevellies" or the "Tinnies" were famous in the Liverpool and London markets as India's best cotton staple.[1] Locally this staple falls under two main classes, karunganni or munjikai (a form of Gossipium indicum) and uppam or mandaikai (a small bolled variety of Gossipium herbaceum). Some are of opinion that uppam is an exotic to the district, as it is know in some places as Udamalpet cotton.[2] Others are of opinion that uppam rather than karunganni is the pure black cotton soil variety, as the latter would thrive even on red soil.[3] A third view is that both these varieties must have been yielded by the exotic Bourbon which got acclimatized since the beginning of the last century.[4] Karunganni is superior in economic properties such as staple length of linting percentage. For a long time this was not realized and the two were grown invariably mixed together except in a few villages in the extreme south. Since 1907 not only has the cultivation of karunganni spread, but better types of the same have also been evolved. Besides these two, there is the Cambodia cotton, which is a garden crop and Nadam which is a variety of country mixed cotton. But the last two are of less significance in this district.

Geographical Distribution of the Cotton Area.

Cotton plays an important part in the economy of the Tinnevelly district. Of the total cultivated area of the district nearly one-fourth is devoted to it. In recent times there has been a steady

1. Memorandum of the Madras Chamber of Commerce (1889) quoted in Indian Cotton Committee Report (1919), p. 118*ff*.

2. G. A. Gammie: The Present Position and Prospects of Cotton Cultivation in India (Brussel Conference Papers, 1910).

3. Reports of the Work of the Agricultural Statistics for 1925-26.

4. Sampson: Cambodia Cotton in Madras in Agricultural Journal of India, Vol VI (1911).

increase in the acreage. In the decennium 1921-31, the area under the crop increased by 146,438 acres. The depression that followed did not have a visible effect on the extent of cultivation. The following table shows the extent of cultivation of the crop in the various taluks.

Cropping in Representative Years (F. 1335-39)

Taluks.	Acreage under cotton.	Net cultivated area (acres).
Ambasamudram	406	55,218
Koilpatti	213,902	537,172
Nanguneri	10,919	111,565
Sankarankoil	34,564	167,456
Srivaikuntam	31,104	102,801
Tenkasi	1,868	110,517
Tinnevelly	5,389	62,744
Tiruchendur	2,098	82,739
Angengo	—	257
Tangasseri	—	336
Total	300,250	1,230,805

Thus in all the taluks of the district except Angengo and Tangesseri the crop is grown to a more or less extent. Angengo and Tangesseri do not really belong to the Tinnevelly district geographically. They form a part of the Malabar coastal strip and are included in the Tinnevelly district only for administrative purposes since 1927. Of the rest, Koilpatti taluk leads in cotton production. Nearly half the area of the taluk is dominated by the cotton crop; and 2/3 of the total quantity of cotton raised in the district comes from this area. The taluks of Sankarankoil and Srivaikuntam together produce about a fifth and the other taluks contribute the rest.

Soil.

The black clay soil of the district also called *regur* is eminently suited to the culture of cotton. Hence the soil has got the name cotton soil. There are nearly 3 million acres of this land in this Presidency of which the Tinnevelly district has a tenth. The soil consists of black clay which is friable when dry, sticky and adhesive when wet and cracking in hot weather. Because of this tendency to crack, it does not support a tree flora whose root system it injures. Hence it supports herbs and shrubs rather than trees. But the black soil in this district being rather shallow cannot crack to such an extent as deep black soil would. Still throughout the tract in this district we miss a luxuriant vegetation of inviting trees and the thorny "umbrella trees" (flat topped acacias) only serve to make barrenness more barren.

Karisal, veppal, and pottal are the different varieties of the Tinnevelly dry soil. They differ considerably both in colour and depth. Karisal or the black-coloured is of the best quality ranging from 5 to 7 feet in depth. "It rests on a bed of canker and nodular limestone which in its turn rests on a rotten garnetiferous gneiss. Small nodules of canker and some garnetiferous sand are found in the soil itself." Veppal or the grey coloured is shallower and contains much more canker. Pottal or white coloured soil is shallow and slightly alkaline and as such the soil gets dried up quickly. Hence cotton thrives here only if there are frequent rains, but the bursting of bolls takes place earlier on this land. The red soil known as seval is loamy in character and is found suitable to the growth of Cambodia plant. Cambodia thrives on low-lying lands when rainfall is more than ordinary.

The black soil, even of the best karisal, although found highly suited to cotton is deficient in organic matter and other important constituents such as humus, phosphoric acid and nitrogen; and the red soil on which Cambodia thrives is deficient in limes. This is not peculiar to the Tinnevelly district. It is so throughout the cotton land in the Madras Presidency and it is one of the main reasons for the comparatively low outturn per acre in Madras. The further effects of the soil on the mode of cultivation and the human ecology of the district will be subsequently dealt with.

Effect of Climate and Rainfall.

Cotton is an unirrigated crop from time immemorial in this district. பாயாத காட்டுக்குப் பருத்தி விதை *'cotton-seed for unirrigable wild'* is an ancient proverb. It is at the entire mercy of the monsoons. It thrives best in black soil, if the rainfall is below the average, and also well distributed. Under these conditions, growth in the early stages is rapid, the size of the mature plant is well above the normal and the bolls mature early. Disease and boll-shedding do not appear. Heavy rainfall is very harmful to the crop. Growth becomes slow, plants get stunted, bolls open late, pests take their toll and yield becomes low. This is because heavy rainfall on black soil produces soil colloids which interfere with aeration and percolation and profoundly influence the flora and chemistry of the soil as well as the root development of the cotton plant.[5]

The district as a whole is one of the driest in the Presidency. Four districts only have a lighter rainfall; and these are Coimbatore, Kurnool, Anantapur and Bellary. The total rainfall received by the district viz., about 29″ is fairly typical of the cotton growing tracts in South India. But there is one important peculiarity. Tinnevelly gets only 3·10″ of rain in the S.W. monsoon months against 17·79″ from N.E. monsoon, whereas the other cotton tracts of South India receive the bulk from S.W. monsoon. Three-fourths of the rainfall is received in the three months from October to December. This geographical peculiarity of the district has important bearings on the cotton culture. It means that sowings commence with the setting in of N.E. monsoon, *i.e.* in September and October. Thus cotton is a much later crop here than in other parts of India. In the parts of the district further south the crop is still later by a month. The sowing usually lasts for about six weeks.

The geographical factors, climate and monsoons, it is believed, have determined the distribution of karunganni and uppam to the habitats best suited to each. The south is nearer the sea; the sea breeze blows more frequently and strongly than in the north and the rainfall in the south is generally low and precarious. It is therefore congenial to the growth of long duration varieties, like karunganni.[6] The lack of uniformity in the beginning of the monsoon in the southern and northern parts of the same district has been attended with certain disadvantages. It has made the experimental work of the Agricultural Department difficult. Two separate strains, one for the north and another for the south, have to be evolved as had been done for a long time at the Koilpatti Farm, and this work has to be done carefully. Further this lack of uniformity in the plant variety brings about differences in the kapas which introduce further problems of marketing, like grading, sampling, standardizing, etc.

But this feature of the rainfall has been beneficial to the southern parts. In the north of the district, cotton picking commences in January and February and lasts for about one month.

5. A. Howard and H. A. Hyde: The Cotton Growing Problems of the Black Soils in India (Indian Science Congress Paper, Bombay, 1926).

6. Captain Roger Thomas: The Improvement of Tinnevelly Cotton (Indian Science Congress Paper, Lahore, 1918).

In the south, as sowing had been later and duration of the crop longer, picking commences only in March. It lasts for about two months. But then summer rains set in. They are heavy showers, the average being 3·58″. But they have their vagaries. Occasionally they fail totally while at other times they have recorded a fall of 6″. These summer showers are a blessing to the cotton growers of the southern part of the district denied to their compeers of the north. They give the cotton a second flush and a summer picking ensues and thus the picking season is prolonged from two to five months. However this is not without its dangers. If instead of heavy summer rains, there happen to be light showers or heavy mist at this time the buds and young bolls begin to shed. Further, the long-spread harvest tells upon the bolls also. Bolls of high locular composition are produced only at a certain period, generally early in the season. The harvest period spreads and so a wide range of variation ensues in the quality of raw cotton, its weight per seed, weight of lint, etc. The lint length is found to decrease with the advance of season, as also its strength and spinning quality. However, it provides the cotton grower with work for several months together.

After the sowing, rain continues and the average fall from October to December for the whole district is 16·34″. This gradually diminishes in December. January to March are usually dry with occasionally a heavy rain, the average for these three months being 3·55″, and in cotton tracts it is much less. From the close of January the S.E. breezes begin to blow in. This is locally known as "uppam" or sea breeze and is generally found to be highly beneficial to all standing crops. It assists in the ripening of cotton and bursting of bolls. The dry weather in February and March are very helpful in the proper boll formation and bursting. Then fall the summer showers mentioned above. From June to September occasional light showers occur averaging 3·53″ which are usually only utilized for ploughing the land in preparation for the sowing season.

The effect of the rains on the karunganni cotton crop had been studied over a long period of twenty-one years at the Koilpatti Farm by Mr. (now Rao Bahadur) V. Ramanatha Iyer, the cotton Specialist, and he has come to the conclusion that the following weather conditions must prevail for a maximum yield:[7]

1. There must be heavy rainfall in the two fortnights preceding the sowing followed by a light shower of one or two inches in the first night after sowing.

7. *Madras Agricultural Journal*, July 1929, p. 267.

2. A dry spell must be experienced during the second and third fortnights followed by good showers in the 4th, after sowing.

3. Another dry spell in the 5th, 6th and 7th fortnights, especially that during the 7th fortnight is highly up, is extremely beneficial.

4. The 8th, 9th and 10th fortnights after sowing should have fairly good showers.

These investigations were further carried to find the effect of excessive rains on the cotton crop of the district, especially the valuable karungannies.[8] It has been found that extra rain has a negative influence on the yield almost throughout the year. The greater effect is seen in the dry months of July and August before sowing and the least in the months of January and February when the crop is on. Further, its effect is significant in the case of cotton after cumbu than of cotton after cholam. These conclusions it will be agreed, are substantiated by the experience of the ryots themselves. The cotton growers of this district are alive to the importance of seasonal rains and timely agricultural operations. "Make your cultivation in the proper season and the golden age of Lakshmi will return" is a proverb current among the Kammavar cotton growers of this district.

No other crop is so susceptible to shedding as cotton. Delayed crop often results in kapas of poor quality, insect attack, etc. The improved varieties in this respect are not better resisting. "An improved strain under bad weather conditions generally fares worse than the ordinary crop grown from bazaar seed under favourable weather conditions." Attempts are therefore being made to evolve strains which would be least affected by untimely rains.

The economic characteristics of the plant are further affected by the weather conditions, if the sowings are not in the normal season. It has been found that lint length, kapas, seed weights and ginning percentage seem to be affected by sowing made prior to the normal season, the late sown lots being more or less alike.[9]

What is the effect of temperature on the culture of cotton? Of the cotton growing tracts, Tinnevelly has the highest annual mean temperature, which is due less to great heat in the summer than to absence of moderate coolness in the cold season. Is this equable climate in any degree responsible for the high quality of the Tinnies?

8. S. N. Venkataraman: *Madras Agricultural Journal*, August 1930, p. 404.

9. *Madras Agricultural Journal*, April 1932, p. 125.

Methods of Cultivation: Rotation

The karisal is seldom more than six feet deep and often is not even half this depth; further it is deficient in organic matter. Hence it gets exhausted very soon. To replenish the soil, therefore, a universal system of rotation of crops has been practised by the agriculturists of this tract from time immemorial. On well-farmed land "cotton never follows cotton." Hence three main crops are grown on this black soil, viz. cumbu, cholam and cotton. Of the two cereals that are rotated with cotton, cumbu takes the main place. This is a peculiarity of this district. In other districts cholam is more usual. Even of the cholam, it is the fodder cholam or chola nattu that is more generally grown here than the cereal variety. "The reason for this local difference is probably that the temperature of the district is high throughout the year and cumbu is a better food for such a climate than cholam." If this were so, the knowledge of the ancient agriculturists of this tract not only about valuable agricultural practices like rotation but also about dietics is marvellous.

This three course rotation is not uniform. It varies with the economic condition and needs of the ryot. Some of the poorer ryots are forced to repeat cotton on the same land, while some of the rich grow cumbu successively in their "cumbu Adi" of which plot they are proud as being the most heavily manured. With some ryots Bengal gram takes the place of cholam. The rotation followed at the Koilpatti Agricultural Station is cotton, cumbu, cotton and fodder cholam.

It is generally known that cotton after cumbu yields a richer crop than after cholam; one reason for this is cumbu is a crop that is richly manured and assiduously cultivated unlike cholam. In the Koilpatti Farm it has been found that "cotton after cumbu gives on an average 50 lbs. of kapas more than that after cholam."[10] This is true only if the rains are well distributed. But if they are badly distributed, cotton after cumbu suffers more than cotton after fodder cholam. It is gratifying to note that one of the problems under investigation at the Koilpatti Farm is to devise remedial measures for the depressing effects of fodder cholam on the succeeding cotton.

Cotton is often grown mixed with certain pulses and cereals. Indeed there is no pulse crop that thrives on the black soil. Yet, horsegram, green gram, black gram, cow gram, Bengal gram, and

10. V. Ramanatha Aiyar: *op cit.*

occasionally cluster beans are sown in furrows about 8 feet or so apart in the cotton crop. Pulichi, which yields a fibre and serves also as a vegetable, is also occasionally sown in rows in the cotton crop. Castor and coriander are sometimes broadcast in the cotton crop, especially in the south of the district. Latterly, coriander is fetching remunerative prices and is becoming cotton's closer companion. But experienced ryots point out the dangers of a rapid exhaustion of soil fertility by such an alliance. Many cotton growers are aware of this, but the temptation of immediate gains dims the distant dangers.

This time-honoured system fulfils many of the requirements of a good *system of rotation*. The light rooted fodder cholam takes up the fertility of the top layer of the soil and the deeper rooted cotton eats up that of the second layer. The fertility thus exhausted is restored by the heavily manured cumbu. The leguminous cover crops also help in this process of restoration. The cumbu solves the food problem of the ryot and the fodder cholam that of his cattle. And the rotation leaves very little interval as off-season and idle time for the ryot. There is little necessity for the devising of a second string to the bow.

Ploughing

Ploughing in this tract commences immediately after the first rain that follows the harvest. In this respect also this tract differs from the rest of the cotton soil tracts in the Presidency. As has been pointed out elsewhere the black soil here being shallow cannot crack to such an extent as deep black soil would. Its moisture retaining capacity also is less. Hence it is wiser to plough up immediately after the first rains. This is another of those instances where the accumulated experience of our ryots has crystallised into healthy agricultural practices. The importance of a thorough ploughing at the proper season is adequately realised by the cotton growers. " Turn a pound of earth to a pound of dust and you will want no manure ; " "Ploughing is poor man's manure " are proverbs familiar in these parts. Ploughing is of deep character and heavy bulls are used for this purpose. A pair of bulls covers 5 to 8 acres per day. The system of passing the Guntakas every year with deep ploughing on co-operative basis once in five years which enables the ryot of the Ceded Districts to cover 40 acres with a pair is not adopted in this District. Perhaps the soil, with tendency to less cracking, would not admit of such a devise.

Manuring.

Of the three crops in the rotation, cotton is the least manured, except for penning sheep; cumbu is the most favoured in this respect and "cumbu Adi" receives all the cowdung. The manuring of black soil as a whole is elaborately done. A judicious process of mixing soils is handed down from ancient times. The red soil is mixed with black and the black with red until to a superficial observer red appears black and vice versa. A large part of the summer months is employed in improving the land in numerous ways, carting soil, tank silt and manure and rooting out hariali grass which is the enemy of the black soil. Great importance is attached to sweepings and cowdung. The practice of burning brattie or cow-chips for fuel is seldom restorted to. This is rendered possible, thanks to the cotton stalks which are carefully pulled up and neatly stacked in the village yard. "Each man has his own pit, into which all his cattle manure, house refuse and threshing floor sweepings are dumped. This mixture is periodically covered with black cotton soil or silt and the whole forms a more or less homogeneous mass of well-rotted manure."[11]

Seeds.

Attempts to improve the quality of seeds have been carried on in this district ever since the 18th century when the East India Company sent Dr. Anderson for the distribution of exotic cotton seeds. He introduced the Bourbon cotton. The work was taken up by Mr. G. A. Huges, a private merchant who was successful in producing the best cotton in India which went after his name. After his death in 1835, under the guidance of Dr. Wright, the Madras Government sent three American planters to popularize American seed and American method of cultivation. The attempts ended in fiasco. However the experiments continued till the fifties under Mr. Finnie when it was abandoned for good.[12]

These early attempts to introduce cotton exotics and improved methods of cultivation and ginning proved to be failures because they "inevitably led the natives to imagine that Government alone have the means and facility of raising American cotton."

For another half century nothing was done. With the dawn of the 20th century fresh attempts were made to improve the cotton seeds. The Koilpatti Agricultural Station was founded in 1901 which ever since has proved the nucleus for cotton improvement in

11. *Tinnevelly District Gazetteer,* Vol. I, p. 158.
12. T. Wheeler: Handbook of Cotton in the Madras Presidency.

the Tinnevelly District. The work commenced in 1905 on the lines laid down by the Government of India in the letter No. 23-9-36 of 16th September 1904.[13] The following are the main lines on which work had been carried on.[14]

1. Selling seed from bulk selection and thus improving the purity of crops.

2. Testing, development and distribution of unit strains.

3. Fostering of co-operative marketing of pure crops direct to the large firms.

4. Spread of the use of seed drills and harrows.

5. In addition to these, the practice of certifying the purity of cotton by competent Government staff and the formation of co-operative village seed unions.[15] Another measure taken in this direction was the passing of the Cotton Control Bill to preserve the purity of Karunganni from vicious associations with pulichai or mallam, the Jari of the United Provinces. This northerner that came into this district in 1907 was helpful in adulteration and at one stage was responsible for bringing down the reputation of karunganni to its lowest depths. The Act has resulted in the extermination of the exotic.

Ever since the superiority of Karunganni over uppam was recognised (1907), the work of the Agricultural Department was mainly directed to the evolution of better strains out of it. The credit of evolving two very good strains goes to Mr. Sampson, late Deputy Director of Agriculture. But due praise must also be given to Messrs. A. & F. Harvey for the encouragement they were steadily giving to the improvement of cotton in this district by offering premiums for better varieties. The latest strain of karunganni evolved is Kovilpatti No. I and further work is in progress to evolve still better types.

Cambodia.

Another noteworthy attempt made in this direction in recent times is the introduction of Cambodia cotton. The root structure of this exotic is such that it cannot withstand prolonged drought. Hence it thrives only as an irrigated crop. Although the credit of introducing it into the District is generally attributed to Mr. A. Steel

13. H. C. Sampson: *Agricultural Journal of India*, Vol. X (1915), p. 137.

14. J. M. Mackenna: *Agricultural Journal of India*, Vol. XII, (1917), p. 311.

15. Captain Roger Thomas: *op. cit.*

of Messrs. A. & F. Harvey & Co., the credit of establishing its possibilities as an irrigated crop goes to the ryots themselves. Irrigated Cambodia is a better yielder compared with karunganni, the proportion being 250: 103 lbs per acre. But it has its limitations in this district. Irrigation is little developed in this tract. Although there is a rich deltaic area in this district with a marvellous network of Tambaraparni anicut system, the extent actually irrigated is only 21% of the total cultivated area. Even of this irrigated tract only about 1/5 is watered by wells. In other words, the area under wells in this district is only about 4% of the total under cultivation. As such, Cambodia which thrives on lowlying lands where rainfall is more than ordinary and promises to do well as a garden crop only has not much scope at present. The very natural forces that aid the growth of Tinnevellies act as a check on the spread of Cambodia. The out-turn of Cambodia cotton may be looked upon, at best, as an addition to the ordinary Tinnevelly crop. So far it has not succeeded in replacing any of the indigenous varieties. Indeed, the area of irrigated cotton in this district is put down as 8470 acres. But it is well known that the area under well is usually exaggerated in official records. Further the statistics include cotton which is raised as an irrigated crop on the beds of single crop paddy lands, when water is not abundant enough to support paddy cultivation, but is enough to support cotton. Of the irrigated cotton area, Cambodia has the larger share, for the practice of cultivating irrigated karunganni has not come into vogue in this district as for example in Coimbatore. In the matter of intensive garden cultivation, the Nadar peasant beats everybody else hollow in this district. There must no doubt be subterranean supplies of water existing in this dry tract, whose utilization will become a possibility if the Papanasam Hydro-Electric Scheme brings with it an extensive use of electrically driven water lifts. When that happens, Cambodia cotton and with it the cultivating Nadars have a bright future in the district.

Implements.

It is much easier to evolve improved strains at the Farm than to induce the ryots to grow them. However even the latter task has been accomplished to a commendable degree in the Tinnevelly district. To-day a large part of the cotton tract is sown with improved types of seeds. But the same cannot be said of the efforts of the Agricultural Department to popularise improved agricultural implements. For example, it is not yet adequately realized that intercultivation and efficient tillage are as important in the raising of good crops as is good seed and the sowing of seeds in lines with bullock-hoes later between them makes for good cultivation. The attempt had commenced as early as 1907 when the Government of Madras allotted a sum of Rs. 5,000 for the improvement of cotton cultivation, a part of which was devoted to drill cultivation in Tinnevelly. The instrument which is so familiar in cotton tracts of Ceded Districts found very little welcome among the agriculturists of Tinnevelly. Conservatism stands as a dead wall to all progress. Drill cultivation requires thinning and this goes against the grain of the ryot. He says, "It is like taking the life of my children to pull these plants which have grown." Again, the use of the seed drill to be effective, rendered the sowing of cotton alone without mixtures like pulses, coriander, etc. The women to whom the yields of these went, objected to sowing cotton alone. This objection, however, is said to have vanished when they found that the seed-drill lightened their labour in hoeing which was formerly entirely relegated to them. Superstition and fear of offending the deities when any innovation is practised have also played their part in checking the rapid spread of the seed drill. Mr. H. C. Sampson records an interesting instance of this. "In November 1907 a very heavy rain of more than 7 inches fell on one day and breached several tanks, doing considerable damage to the standing crops on the black soil; As a result, some ryots refused to work the bullock hoes in their drill sown crops, as they said that this rain was a signal of divine wrath. One man actually ploughed up his crop."[16] Over two decades of propaganda have not resulted in any conspicuous improvement. Seed-drill requires more 'idea-drill.' Iron ploughs are still rare. The usual excuse that they are too heavy to be dragged by our bulls does not apply to this tract where the cattle is of a sturdy type. Further, there are light iron ploughs also. Extreme conservatism, inertia and apathy together with low economic conditions alone explain the dogged adherence to old-world ways.

Human Factor

Cotton crop had had profound effects on the human geography in the southern states of America. It has resulted in what is known as the "cotton system."[17] On the ryots of this southernmost district of India, its effects, even if not so very conspicuous, are not less important. It has produced the finest farmers of the district. The most enterprising peasant is found mainly in the black cotton

16. *Agricultural Journal of India,* Vol. IV (1809), pp. 188-97.

17. R. B. Vance: Human Factors in Cotton Culture (University of N. Carolina Press).

tracts of Koilpatti and in the north of Srivaikuntam. The bald environments and the necessity for grappling with a dry black soil had moulded him into a real farmer.

The farmers are mainly Telugus, who it is said came to this part of India during the days of Vijayanagar and Naik rulers. These Telugus, so to say, are sons of the black soil. Kammavas, Reddis and Kambalattans are the three main castes among them, inhabiting the black cotton soil. Between them they own the greater part of this class of land. The Kammavas, who are chiefly found in the predominantly cotton taluks of Koilpatti and Sankarankoil, are a fine sturdy hardworking race of agriculturists. In the cultivation of the black cotton land the only rival they meet with are their own Telugu brethren, the Reddis.

The cotton grower is invariably a peasant proprietor. "He does his work himself and prefers the assistance of his family—men, women and boys—to that of hired labourers. His pride is in his cattle, cumbu Adi and the cleanness of his land and he is ever on the look-out for the time when his less industrious neighbour may fail in the great competition. Hariali grass அறுகம்புல் is the enemy of the black soil, and the ryot who neglects it is the man to whom money should be advanced on the security of his field; soon the mortgage will be fore-closed upon and the land will change hands. So the industrious farmer reaps his reward and the fittest survives."[18] His surplus is usually invested in land or cattle; a few however used to take to moneylending. Some had dabbled in cotton dealing and families have risen and fallen on that account. Disputes over land are frequent. Being a hot blooded people, riots ending in bloodshed and murder are not rare.

Livestock.

The cotton grower of this tract is a great lover of his cattle. The rotation system he adopts enables him to provide them with adequate fodder. The cotton seeds are also given as food to them. Bulls are solely used for purposes of draught. "The cattle owned by ryots of the black cotton country are amongst some of the best in the Presidency. They are all imported from outside the district and are mostly of the kangayam breed......In the cotton country cattle are well looked after; except during the season which follows

18. *Tinnevelly District Gazetteer, op. cit.*

sowing when pasture is plentiful and work is scarce, they are fed daily with cotton seed and sometimes with horsegram as well. Their fodder is cholanattu or a mixture of this and cumbu straw."[19] Of the ten centres of cattle dealing where fairs are held twice a year, nearly eight are situated in the cotton tract, indicating the demand for draught bulls in this tract. Although much attention is paid to feeding, breeding is practically neglected. Perhaps the tract is little suited to it.

Consumption.

This district produces about 78,690 bales of cotton every year, which is about 15% of the total production in the Madras Presidency. Of this about 5,000 bales are irrigated cotton. A good part of this cotton is consumed locally. It is ginned mainly in the factories in Srivaikuntam (Tuticorin), Ambasamudram and Koilpatti taluks. There are spinning mills also in these places. The mill at Koilpatti spins as well as weaves. At Thalaioothu, a new spinning and weaving mill is started. There are more than 250 gins employing 1500 workers daily. The mills employ about 10,000 workers daily, a number equal to that of the textile workers in the city of Madras. Handloom weaving is an important occupation and the most important centres are located in the river valley region, close to the consuming markets. About 4 per cent of the population is engaged in these industries and there is every possibility that the number would increase in the near future with the increase in the number of mills.

Future

The district will soon have the blessings of electrical energy from the Papanasam Hydro-Electric Scheme. This would bring with it great possibilities for the development of the cotton cultivation in this district. Irrigated cotton may be more extensively cultivated; more mills would be started affording scope for consumption of raw cotton as well as employment for workers. The possibilities of utilizing the cotton stalks for the preparation of articles like paper on a commercial scale may also become accomplished. The manufacture of rayon from short staple cotton may also be taken up, especially with the starting of alkali production in South India. These together with improved marketing facilities will undoubtedly better the position of the cotton grower in the Tinnevelly District.

19. *ibid.*

Cotton and Cotton Markets in the Tinnevelly District

(A STUDY OF THE INTERACTIONS BETWEEN GEOGRAPHICAL AND HUMAN FACTORS)

By

J. S. Ponniah, M.A.,
American College, Madura.

Tinnevelly takes the first (288,333 acres), Ramnad the third (233,158 acres) and Madura the fourth places (209,059 acres) in cotton cultivation in the Madras Presidency, and no other three contiguous districts put together record so much acreage under cotton as these three—their share being 19% or very nearly one-fifth of the total Presidency acreage.

Concentration of Cotton Cultivation.

More significant than the large acreage under cotton in the Tinnevelly District is its heavy concentration in particular tracts. Koilpatti Taluq has 72·30% of its cultivated area under cotton; Sankarancoil comes next with 13·07% and Srivaikuntam ranks third with 11·07%, and these three taluqs account for 96·44% of the total cotton acreage in the district. The explanation is simple: "the greater part of the Koilpatti Taluq forms with the north-west region of Srivaikuntam an almost unbroken stretch of black soil".[1]

Specialisation of Particular Varieties of Particular Tracts.

Even more significant than the concentration of cotton acreage is the cultivation of a single variety in a particular tract. An analysis of acreage under cotton in the different Taluqs shows that Koilpatti has 83·6% under Karunganni, Srivaikuntam 82·8% under Tinni and Sankarankoil 72·15% under Cambodia.

The principal factors determining the specialisation of a single variety in particular tracts are soil and climate. The black soil of Koilpatti Taluq, to quote from the Handbook of Cotton Cultivation in the Madras Presidency, "is very dark in colour" (kari-

1. *Tinnevelly District Gazetteer*, Vol. I, p. 23.

sal) varying in depth from two to five or six feet; the lower portion to a depth of four or five feet will retain moisture for four or five weeks . . . . . . The soil is considered extremely fertile . . . . . . Moreover, in these tracts, kunkur or decomposed gneiss is met with, and in some spots, occasional strata of crystalline limestone crop up through the gneiss. . . . . . Further, the northern part of the district is intersected by numerous small streams and the cotton fields are consequently well drained." (pp. 8 and 229). It is on account of these factors that Karunganni thrives best in the Koilpatti tract.

The black soil of the eastern part of the district is of an inferior ('Vepal') type, where rainfall also is slightly lower and is received four or five weeks later than in the northern part. These factors explain why the ryots are compelled to raise the hardier but inferior variety of cotton known as Tinni.

The cultivation of Cambodia in the Sankarancoil Taluk is explained by the fact that it is a red soil area, where that exotic variety flourishes best.

The Human Factors in Cotton Cultivation.

If the student of physical geography of the Tinnevelly District is surprised at the peculiarities in soil formation which explains to a large extent concentration of cotton acreage and the specialisation of particular varieties in particular tracts, the student of human geography is no less surprised at the peculiarities of caste groups engaged in this business of cotton culture. For, cotton cultivation in the black soil tract is practically the monopoly of the Naidus and Reddis. The *Tinnevelly District Gazetteer* notices that "the black cotton industry is their 'close preserve' and that they live almost entirely in villages, often to the entire exclusion of other castes".[2] The same authority observes further "that farming in the black cotton country demands patience and close attention. . . . . and it is therefore not surprising that Brahmins, whose experience of agriculture is limited to giving lands on lease, are very few in the Koilpatti Taluq."

The author of the *Tinnevelly District Gazetteer* says that "the Naidus are a fine, sturdy and hard-working race of agriculturists, and in the cultivation of the black cotton land which they inherit, they have only one rival—the Reddis."

2. Vol. I, p. 193.

A simple, but conclusive proof of the efficiency of the Tinnevelly cotton farmer is the very high normal average out-turn of lint per acre, which is 180 lbs. This record is the highest for the Presidency and for the whole of India. It may be added that this output is equal to the average lint production per acre in the United States of America.

The high yield is certainly all the more remarkable, because of all the cotton tracts of India, Tinnevelly has the "highest annual mean temperature"[3] and also because "the soil is not as rich as in Berar...... and generally speaking, deficient in organic matter and other constituents of vital importance such as humus, phosphoric acid and nitrogen."

Numerous Markets in Close Proximity to Each Other.

While the student of geography is struck by the concentration of cotton acreage, the specialisation of particular varieties in particular tracts and the coincidence between caste grouping and cotton cultivation, the student of economics is struck no less by certain unique features in the structure of market organisation in the district.

The first important feature is the existence of a very large number of markets in close proximity to each other. To mention only the important ones:—Nalli, Koilpatti, Nallattinputur, and Kadambur in the Karunganni tract; Vilathikulam, Nagalapuram, Ettayapuram, Tuticorin and Maniyachi in the Tinni tract and Sankarancoil, Kalugumalai and Karivalamvandanallur in the Cambodia tract. Primary markets are too numerous to mention; for, in almost every cotton-growing village are to be found active local buyers of cotton.

The advantage to the cultivator of a large number of markets within easy reach will be readily admitted, since, under such circumstances, price information would reach quickly and marketing costs would be lower. This may be explained further by an illustration from Berar—the paradise of some of our marketing reformers—where unfortunately, the markets are only few and far between.

> "There are no markets in small places. Only where there is a big quantity of cotton to be dealt with, is there

3. Report of the Indian Cotton Committee, p. 88. For the effect of drought on yield of cotton see International Cotton Bulletin, Vol. XIII, July 1935, p. 592.

a market. The distance from which this market (Akola) draws kapas is about 50 miles. The nearest markets to Akola are Balapur (12 miles), Akote (28 miles) and Bassin (40 miles).

—*Indian Cotton Committee,* Vol. IV, p. 42.

" Some villagers have to take their cotton to a market as far distant as 40, 50 or even 60 miles."

—Royal Commission on Agriculture, C. P. Evidence, Vol. I, p. 326.

A Large Number of Small Ginneries.

Not only are the markets numerous and in close proximity to each other, but also are ginneries, where the first important process of separating the seed from the lint is to be gone through. The total number of ginneries in the district is 49 and the average number of gins in each factory is about 15. The significance of a large number of small ginneries as opposed to a few large ones is the absence of monopolistic control over ginning by a few firms, or what is known as 'ginning pools' as in Burma. The evils of ginning pools are eloquently set forth in the following passage:—

> " In Burma, a Combine owns 123 gins and only 20 gins are outside ...... The farmers complain bitterly of this Combine, which is managed by three European firms of the highest reputation ...... Prior to the emergence of this Combine, the ginneries paid much higher prices owing to keen competition ".[4]

A student of economics meeting with such striking features in market organisation would indeed like to dwell further on the personnel or agencies of marketing, market conditions, prices and allied problems, but as the scope of this study is limited to the geographical aspect of marketing, suffice it to explain only a few relevant points.

Geographical factors governing market structure

What is the reason for the existence of a large number of ginneries and markets in the district ?

Firstly: The most important reason is, of course, high concentration of cotton acreage. The particular variety of cotton

4. Report of the Indian Cotton Committee, Vol. V, p. 69.

cultivated has also a bearing on it. For example, Karunganni, the prince of indigenous cotton, on account of its superior spinning value, is in great demand and consequently promotes keen competition among buyers, necessitating the use of markets at every concentration point.

Secondly: Tuticorin, being the only port of export for this district, the foreign firms were obliged to have their ginneries and buying offices in different cotton-growing areas, for the sake of controlling the purity of lint. When ginning profits were high and cotton prices shot up during the last Great War, a number of Indian merchants set up small ginneries in the villages with the result that some of these new centres of ginning also developed into important markets.

Thirdly: The Spinning Mills of the Harveys consume about 70,000 candies of cotton, and nearly three-fourths of this quantity are purchased in the three districts of Madura, Ramnad and Tinnevelly. That two of these Mills are located in the Tinnevelly District—one in this very place where we have met in Conference and the other in Tuticorin—is sufficient explanation for purchase of cotton locally. Such active local purchasers through Indian merchants tend to keep up all these small local markets.

The Human Factor in Marketing.

There is a fourth factor, the human factor, in determining market structure, which should not be ignored. A careful study of the merchants engaged in cotton trade, whether in the Ramnad or the Tinnevelly district would show that this business is largely in the hands of a single community—the Nadars. Three or four Nadar firms at Tuticorin control practically the entire trade of the Tinni area—owning also a number of ginneries at Etaiyapuram, Nagalapuram and Vilathikulam. In the Karunganni tract, their share is less, but important nevertheless. Needless to add that in all the primary markets, retail buyers and travelling buyers are drawn very largely from this community.

The dominant position held by this community, in the cotton trade is a highly significant sociological problem, which may be left to the more curious-minded to investigate further. Suffice it to note here that it is the communal solidarity of this group which has been responsible for the establishments of 'open markets' by the wise use of their charity collections known as 'mahimai.' It is some of the enterprising individuals of the community who have been responsible first for obtaining by wire price information from

Bombay and establishing also village ginneries and 'interior markets.' In short, many of the excellent features in market structure for cotton in these three districts are due to the business talents of this community just as the commendable features in cotton production are due to the skill and enterprise of the Reddis and Naidus.

Geographical and Human factors in co-operative Marketing of Cotton.

The study may well close with a reference to co-operative marketing of cotton in the District. On the production side, everything is favourable—high concentration of cotton acreage, and, especially the raising of a single variety in particular tracts —for the development of what the American economists call 'community production of cotton.' The social solidarity of the Naidus and the Reddis is also an invaluable asset in this respect. How else could there exist two of the most successful co-operative cotton sale societies in the district, one at Koilpatti and another at Tuticorin.[5] That such success has been achieved in competition against the highly organised business of the Nadars is sufficient proof of the stability of co-operative marketing. Under these circumstances, every advance in co-operative marketing is a direct challenge to improve the efficiency of private marketing and vice versa. That the co-operatives continue to progress is an indication that the future is with them and not with the private marketing agency.

To what extent geographical factors have contributed to this hopeful development could be easily inferred from the foregoing analysis. More than that is the part played by the human factor. In fact, the success of cotton marketing organisation in the area is due to the favourable combination of both these factors and the beneficial interactions of the one upon another. A study of cotton marketing in certain parts of the Madura District shows that where cotton cultivation is dispersed, where the cultivating classes are backward and where the trading community has not developed sound trade practices, the market structure is weak. The geographical and the human factors may be compared to the right eye and the left eye of a person. In an area where both these factors interact beneficially progress is bound to be even, and this truth is illustrated abundantly in the marketing of cotton in the Tinnevelly District.

5. This claim is made on the basis of the proportion of business handled by the Society to the total volume of business in the whole market. See *Indian Co-operative Review*, Vol. I, No. 4, pp. 455-57.

The Geographical Aspects in Relation to the Physical, Chemical and Biological Conditions of the Red Hills Lake*

By

S. V. Ganapati, M.Sc., A.I.C.,
Water Analyst, The Corporation of Madras.

Lakes vary widely in character according as they are located in eroded rocks of the lake district of England, or in partially filled, soda-covered rift valleys of Africa, or in the old volcanic craters and depressions of lava-covered areas of Sumatra, Java and Bali, or are formed by damming rivers as in Mettur, Mysore and Madras. The morphological, geological, and meteorological aspects—included here broadly under the term " Geographical"—of the lakes mentioned above, appear to have influenced profoundly the important physical, chemical and biological characteristics of their waters. An attempt has been made in this paper to correlate the various morphological, geological and meteorological factors of the Red Hills reservoir—the source of water supply to the city of Madras—with its salient physical, chemical and biological conditions of 1933-35.† Such a study, besides being of enormous practical value for water works authorities, as for example in forecasting the possibilities of algal development in water and therefore in predicting possible filtration troubles in the form of tastes and odours etc., which constitute a serious problem in the tropics, has also a great scientific interest inasmuch as similar studies of Indian lakes and reservoirs do not appear to have been made so far—(Bharadwaj, 1940). The subject is discussed below under the following heads: —

A. Geographical Factors.

1. *Morphology.* Location, shape, depth, area, size, nature of the bottom and catchment area.
2. Geological character of the catchment area.
3. Meteorology.

* A paper read before the Madras Geographical Association on 27-1-1940.

† For fuller data please refer to my Annual Reports for 1933, 1934, 1935 and 1938.

B. Important physical, chemical and biological conditions of the lake water.

C. Inter-relationship between geographical factors and the physical, chemical and biological conditions of the lake water.

A. GEOGRAPHICAL ASPECTS

1. Morphology

The Red Hills Lake is situated in the district of Chingleput, about eight miles north-west of Madras and is in the tropics, latitude 13° 4′ north and longitude 80° 15′ east. The lake bottom is about twenty feet above the mean sea level.

The so-called Red Hills surrounding the lake are merely undulating arid lands of a very low elevation, the highest portions of which hardly reaching fifty or sixty feet above mean sea level. The colour of soil is generally red being part of a laterite formation which occupies a triangular area of about fifty square miles.

The lake is not a natural, but an artificial one formed by damming. It was constructed about sixty-five years ago for supplying water to the city of Madras. A small river by name Kortalayar river was diverted by means of a masonry weir built across it at a place called Tamarapakkam about seventeen miles north-west of Madras. The weir diverts the river, excluding the greater flood discharges, from the main river into a channel which leads to a small lake known as the Sholavaram Lake, wherefrom the water is sent lower down again by another channel into the Red Hills Lake.

The lake is 3.5 miles long with a maximum breadth of 2.5 miles and a mean breadth of 2·0 miles and covers an area of 7 sq. miles at its maximum level. Its maximum depth is about 25 feet. Its capacity has been estimated at 2162·05 million cubic feet.

From the elevated grounds on the south-west, the land slopes towards the lake, which is bounded on three sides by the eminences described above and water in the lake is confined on the greater portion of the eastern side by an artificial embankment of laterite blocks. On the north-eastern side of the lake, a sluice is put up to allow for the overflow. On the eastern side of the lake undulating masses of laterite jut forth from the soil; and on the south-eastern corner, there are numerous pits where the rock has been quarried to furnish material for the repair of the adjoining trunk road to Nellore. In the north of the lake also one can see extensive tracts of laterite masses. Further, about fifty miles to the north-west of the lake, a picturesque hilly outline is visible.

In the middle of the lake, there are three islands, in one of which the remains of a ruined building is still visible. The islands contain a wild growth of luxuriant vegetation. When the lake level is very low, a stretch of land is visible which extends from the bungalow right up to the farthest island; which is located almost opposite to the Jones Tower, wherefrom water is drawn off for the city's water supply.

The bed of the lake shows numerous depressions and elevations which are well seen when the lake level goes down considerably low during certain years due to the failure of the north-east monsoon rains.

There are five outlets for the lake. One is an overflow weir for the discharge of the excess water during the rainy season, which cannot be stored safely in the lake. It works automatically so that when the water reaches a limit above a certain level, the sluice-gate opens and allows the excess water to flow out. The other three sluices are smaller ones. Water is allowed to pass through them for irrigating the paddy fields situated on the eastern side.

2. The Geological Character of the catchment area

The lake has an extensive catchment area of 14 square miles of grazing, agricultural and waste lands and together with the Sholavaram lake and Kortalayar river and its tributaries has a combined catchment area of 977 sq. miles. The percentage of cultivable lands in the catchment area of the lake is about one, and is considerably low.

The soil of the catchment area of the lake is composed of brown and red ochre earth, which consists essentially of iron, silica and alumina. Lime and magnesia are absent or present in very small quantities only.

Further, it is a bad type of catchment area from the point of view of yield. The soil is so porous and the ground is so flat that rain falling upon it is readily absorbed. Even when the ground is saturated, it is not until the 141 tanks in the surrounding area have been filled that any water becomes available for the two lakes.

3. Meteorology

Under this heading it is proposed to discuss briefly the seasonal changes in temperature, hours of bright sunshine, rainfall, and wind velocity, for a normal year (being the average for the 94 year period from 1796 to 1890) and for the years 1933-35. The data are those for the city and have been obtained from the local observatory, which is located about ten miles from the lake, as similar data for all the items except for rainfall and temperature do not appear to have been recorded for the lake region. It is also believed that there may not be great variations in the records of the two places so closely located and for the purpose of this paper, the data for the city appear to be sufficient. The data for a normal year are given in the author's annual report for 1938 and those for 1933-35 are shown in the author's annual reports for 1933, 1934 and 1935.

(a) *Temperature*

It may be seen from table II (Ganapati 1938) that for a normal year (i) there was a gradual rise from January to May, and from May to December a fall; (ii) from February (the end of the cold weather period) to March (the beginning of the hot weather period), there was a sudden and big rise in temperature but from May (the end of hot weather period) to June (the beginning of the south-west monsoon season) there was a very slight rise; and from September (the end of the south-west monsoon season) to October (the beginning of the north-east monsoon season) there was a big drop in temperature; (iii) maximum temperature was reached in the hot weather period and the minimum in the north-east monsoon season.

Reviewing the seasonal changes in atmospheric temperature during the three years 1933-1935 (Ganapati, 1933, 1934, 1935) the following conclusions may be arrived at.

(*i*) During the cold weather period the temperature ranged between 75-77°F; and there was usually an increase of about 1° from January to February.

(*ii*) From the end of the cold weather period (February) to the beginning of the hot weather period (March) there was a rapid rise of about 2°-4°F, as in a normal year. During the hot weather period the temperature ranged between 78°-89°F; and the maximum temperature of a year was reached in May. (In 1933 this was reached in June). Further there was a rise of about 2°-5°F from one month to the succeeding month.

(*iii*) From the end of the hot weather period (May) to the beginning of the south-west monsoon (June) there was a slight fall of about 0.8°F., as in normal year. (In 1933, there was a rise of 1.8). During the south-west monsoon season, the temperature ranged from 83°-88°; and there was a gradual fall of about 1° from one month to the next (but a slight increase was noticed from August to September only).

(*iv*) From the end of the south-west monsoon season (September) to the beginning of the north-east monsoon season (October) there was a big drop in temperature of 2°-4° as in a norma year. During the north-east monsoon season, the temperature ranged from 75°-80°F; there was a fall about 2°-3°F from one month to the next; and the minimum temperature of the year wa reached in December as in a normal year.

(*v*) There was not considerable seasonal variation in temperature during the three year period of investigation.

(*b*) *Hours of Bright Sunshine*

Maximum and Minimum Values:

The range of variation is from 4.1 to 9.9 hours for normal yea in Madras. The maximum number of hours (9.9) was recorded in February and the minimum (4.1) in July during a normal year.

During the three years' investigation period, the number varied from 4.8 to 10.2 in 1933; from 5.6 to 10.8 in 1934 and from 5.4 to 10.4 in 1935. The maximum number of hours recorded during the three year period was 10·8 in February and May 1934; and the minimum (4.8) in July 1933.

Taking the three years separately, it is seen that the maximun hours of bright sunshine was reached in February in 1933; in February and May in 1934; and in May 1935. The minimum was reached in July for 1933 (4.1 hours); in July for 1934 (5.6) and in July for 1935 (5.4 hours).

It may be seen that for a normal year (i) from January to February there was an increase of about one hour and from February onwards there was a gradual decrease till the minimum wa reached in July; and again from July onwards there was a gradua increase in the number of hours of bright sunshine till December (ii) maximum number of hours is recorded in the cold weathe period and the minimum during the south-west monsoon season.

Reviewing the results of the three years, the following conclusions may be arrived at as regards the seasonal changes in the hour of bright sunshine in the Madras City.

(*i*) During the cold weather period (January and February the number varied between 6.7—10.8; and there was an increas of about 1.8—4.7 hours from January to February when the maximum in all the years was reached.

(*ii*) From the end of the cold weather period (February) t the beginning of the hot weather period (March) there was a de crease of about 0·3 to 1·1 hours. During the hot weather period the number of hours ranged from 8.3 to 10.8 hours; and there was an increase from March to April and a decrease from April to May in 1933 but steady increase in the other two years. But in the case of a normal year, there was a gradual decrease from March to May.

(*iii*) From the end of the hot weather period (May) to the beginning of the south-west monsoon season (June) there was a decrease of 2.0 hours in a normal year. During the South-west monsoon season the number of hours ranged from 4.8 to 8.0 hours; the minimum was reached in July in all the years ; and there was a fall from June to July and from July onwards till September there was a gradual increase in the number of hours.

(*iv*) From the end of the south-west monsoon season (September) to the beginning of the north-east monsoon season, there was a fall of 0.5 to 1.6 hours, while in a normal year there was an increase of 1.1 hours. During the north-east monsoon season, the number varied from 4.7 to 8.4 hours; and there was an increase generally from month to month.

(*v*) The annual monthly average was 7.3 hours in a normal year; while it was 7.3 in 1933, 8.0 in 1934 and 8.3 in 1935.

(c) *Rainfall.*

Maximum and Minimum Values:

The range of variation in the amount of monthly rainfall for a normal year in Madras is from 0.28 to 13.21 inches, the minimum being in February and the maximum in November.

During the three year period of the present investigation, the amount varied from nil to 15.0 inches in 1933; from nil to 15.58 in 1935 and from nil to 16.82 inches in 1934. The maximum amount recorded during the three year period was 16.82 inches in October 1934; and the minimum (nil) in January and February of 1935; February and March of 1934 and February to May of 1935.

Taking the three years separately it is seen that the maximum amount of rainfall was recorded in December 1933 (15.0) in October 1934 (16·82 inches) and in October 1935 (15·58 inches). The minimum (nil) was recorded in January and February 1933, in February and March of 1934; and in February to May of 1935.

Seasonal changes in the amount of rainfall in a normal year.

So, it may be seen from the above that (i) there is a gradual increase in the amount of rainfall from January to November, when the maximum for the year is recorded and thereafter a decrease (ii) there was less than 1 inch of rainfall in the cold weather period; 0·39″—2·12″ in the hot weather period; 2·11″—4·69″ in the south-west monsoon season; and 5·28″—13·21″ in the north-east monsoon season.

Reviewing the records of the three years the following conclusions may be arrived at as regards the seasonal variations in the amount of rainfall.

(*a*) *Cold weather period.*—In a normal year there will be less than 1″ of rainfall. In 1933, the two months were dry; in 1934, January experienced an unusual rainfall 2·5″ while February had none; and in 1935 nearly half the normal average was recorded in January while there was none in the following month.

(*b*) *Hot weather period.*—March 1933 had the greatest rainfall (3·4″) which was nearly nine times the normal while for the same month in the two succeeding years there was no rainfall.

As for April 1934 it had 0·74″ which was in excess of the normal by 0·12″; while the other two years were nearly dry.

In May, in a normal year one should expect 2·12″ of rainfall, but during the three years there was practically no rainfall.

(*c*) *South-west monsoon Season:*—In June, nearly half the quantity recorded for a normal year was recorded in 1933 and 1935, 1934 nearly approaching the normal.

3·87″ have been recorded in July for a normal year. But in 1933, there was only about one inch of rain, and in the other two years 2·0″ and 2·2″ respectively. Thus in none of the three years the normal average was reached.

As for August, in 1935 nearly double the normal amount was recorded and in 1934 the rainfall was above the average by 2·61″, while in 1933 it was less than the normal by 1·56″.

In September the rainfall was much lower than the normal in all the three years, sometimes being only half the normal.

(*d*) *North-east monsoon season.*—Of the three years 1934 had the greatest rainfall in October *viz.*, 16·82″ while the normal average for that month is 11·0″. October 1935 had nearly the same amount as 1934 but in 1933 it was less than the normal by 1·15″.

November has normally about 13″ of rainfall. But during the period under study the rainfall was much less during all the three years. 1934 recorded the minimum of 1·86″ while 1933 and 1935 had only half the normal average.

December is normally a rainy month showing about 6″ of rainfall. In 1933, the rainfall was quite unusual being as much as three times the normal. But in the following two years the record was only half the normal.

Considering the total rainfall recorded during the three years, 1933 had the largest rainfall, while 1935 the least. But compared with the 94 year average (normal year), the rainfall in these three years was considerably less, the deficiency varying between 9-12 inches.

October is normally the wettest month, but in 1933 the wettest month was December. In the other two years, October was the wettest month as per normal.

February is normally the driest month. The three years agreed with this normal.

A reference to Tables containing the rainfall data in the lake region proper for 1933-35 (*Ganapati: 1933, 34, 35*) would show that there was no great variation between the city and the lake region.

(*d*) *Wind Velocity.*

Maximum and Minimum Values:

The range of variation in the velocity of wind in the city for a normal year is 122-227 miles per day. The minimum is recorded in February and the maximum in May.

During the three year period (1933-35) the velocity varied between 141-245 miles per day in 1933; between 148-235 miles per day in 1934; and between 185-311 miles per day in 1935. The maximum velocity recorded during the three year period was 311 miles in December 1935; and the minimum velocity was 141 miles in October 1933.

Taking the three years separately, it is seen that the maximum velocity of 245 miles per day was reached in December 1933; of 235 miles per day in December 1934 and of 311 miles per day in December 1935. The minimum velocity of 141 miles per day was recorded in October 1933; of 152 miles in February 1934 and of 185 miles in October 1935.

So, it may be seen from the above that in a normal year (*i*) there is a decrease from January to February and there is a gradual increase in the wind velocity from February to May when the maximum for the year is recorded; and thereafter there is a gradual reduction till October when the minimum is reached and after October there is an increase again; (*ii*) the velocity i lowest in February and highest in May.

Reviewing the results of the three years the following cor clusions may be reached regarding the seasonal variations in th velocity of wind in Madras.

(*a*) *Cold Weather Period (January and February)*.—I both the months, the wind velocity was nearly one and a half time the velocity recorded for the normal. Of the three years, th velocity was greatest in January 1933 and 1935.

(*b*) *Hot Weather Period (March and May)*.—In Marc and April the velocities were greater than the normal in all th three years. The maximum for these months for the three year being recorded in 1935. In May it was nearly the same as th normal in 1933 and 1934 but was considerably greater than th normal in 1935.

(*c*) *South-West Monsoon Season (June, September)*.—I June, July and August, the velocity was slightly less than the nor mal in 1933 and 1934 but was much higher than the normal i 1935. In September, it was only slightly higher than normal i 1933 and 1934 but in 1935 it was much higher than normal.

(*d*) *North-East Monsoon Season (October—December)*.- The averages were greater than the normal in all the 3 years bu the maximum was recorded in 1935.

Taking the annual averages into account, the wind velocity i all the three years was greater than the normal. Of the thre years it was greatest in 1935 and least in 1933.

Taking the different months of the year, the wind velocity wa greatest in December 1933, 1934 and 1935 and least in Octobe 1933, August 1934 and October 1935, while in a normal year th maximum is recorded in May and the Minimum in February.

(*e*) *Summary of the Meteorological Conditions During* 1933-193

(*a*) *Cold Weather Period:*—The mean temperature varie between 75°-77°F., rainfall practically nil; hours of bright sun shine ranged between 6-10; and the wind velocity between 150-22 miles per day.

(*b*) *Hot Weather Period*.—The mean temperature varie between 78°—89°F., rainfall between 0-3″; hours of bright sunshin between 8-10; and the velocity of wind between 150-300 miles pe day.

(*c*) *South-West Monsoon Season*.—The mean temperatur varied between 83°-88°F., rainfall between 0·8″—9·0″; hours bright sunshine between 4-8; and the velocity of wind between 148-228 miles per day.

(*d*) *North-East Monsoon Season.*—The mean temperature varied between 75° and 81°F., rainfall between 2″-17″; hours of bright sunshine between 4-8; and velocity of wind between 140-310 miles per day.

B. IMPORTANT PHYSICAL, CHEMICAL AND BIOLOGICAL CONDITIONS OF THE LAKE WATER

1. Physical Conditions

The important physical conditions considered below are:—(*a*) water level,. (*b*) colour and transparency of water, and (*c*) vertical and seasonal distribution of temperature of water.

(*a*) *Maximum and Minimum Levels during* 1933-1935.

The range of variation was from 14·80 ft. to 22·60 ft in 1933; 16·05 ft. to 23·12 ft. in 1934; and from 13·42 ft. to 23·11 ft. in 1935. The maximum depth (23·12 ft.) during the three year period was reached in November 1934 and the lowest (13·42 ft.) in August 1935.

Taking the three years separately, it is seen that the highest level for 1933 (22·6 ft.) was reached in December; for 1934 (23·12 ft.) in November; for 1935 (23·11 ft.) in October. The lowest was reached in October 1933 (14·80 ft.); in September 1934 (16·05 ft.) and in August 1935 (13·42 ft.).

Reviewing the results of the three years together the following general conclusions may be arrived at, regarding the seasonal variations in level in the Red Hills Lake: (*i*) There was a gradual decrease in level from January to August or September, i.e., till the end of the south-west monsoon season, (*ii*) a sudden big rise in level took place from September to October, and thereafter the rise was not great; (*iii*) maximum level was reached towards the end of the north-east monsoon season and the minimum level towards the end of the south-west monsoon season; (*iv*) the fall from month to month was greater in 1935 than in the other two years, and the rise also was greater in 1935. The maximum difference in level was about 10 feet.

(*b*) (*i*) *Colour.*

Various methods are in vogue to estimate the colour of natural waters. The colour of water as it appears to the naked eye at the time of sample collection is noted, The colour of the lake water varied between green and yellow, the percentage of each varying during differnt seasons. Green colour was dominant in the cold weather period and yellow in the south-west monsoon seasons. For some time in the beginning of November after a heavy rainfall, the water was whitish in colour, and this was probably due to surface washings from the catchment area. The same changes were noticed in all the three years under examination.

(ii) *Transparency.*

Regarding transparency, various methods are also known (Whipple et al 1927). In this paper, Secchi's method has been employed. Secchi's disc made of aluminium and painted white was 20cm. in diameter and the values are expressed in centimetres. This is not a very accurate method, but yet interesting results can be obtained.

Maximum and Minimum Values.

The extreme values of transparency was 79 to 112 in 1933; 76 to 120 in 1934; and 50 cm. to 100 cm. in 1935. The highest value for transparency during the three year period was reached in April 1934 and the lowest in August 1935.

Taking the three years separately it is seen that the highest value for 1933 (112 cm.) was reached in January for 1934 (120 cm.) in March and for 1935 (100 cm.) in April. The minimum value was reached in November 1933 (79 cm.); in August 1934 (76 cm.); and in August 1935 (50 cm.).

Reviewing the results of the three years, it may be concluded that the water was most transparent in the hot weather periods and least in the south-west monsoon season and rose again in the north-east monsoon season and cold weather periods; that the monthly variations were not very great and that the Red Hills Lake cannot be considered as having a clear water like those of temperate lakes. In some of the Alpine lakes for example a similar disc can be seen at 10 or more metres. Ekman reports 18m as the limit of vision in Lake Vatteru (Muttkowski, 1918).

(c) TEMPERATURE T°C.

Method.

The temperature of the surface water was measured by means of an accurate thermometer graduated from 0°C. to 50°C., each degree being subdivided into a fifth of a degree. The temperature of the water at different depths was measured by means of a deep sea reversible thermometer.

(i) The temperature of the Surface Layer and its Seasonal Variations.

(a) *Maximum and Minimum Values*:—The extreme ranges of temperature observed by me in the surface layer was 25·6°C.-31.5°C. in 1933; 26.4C.-32.6°C. in 1934, and 25.2 C.-31.4°C. in 1935. The highest temperature recorded during the three years period was 32·6°C. in April 1935 and the lowest 25·2°C. in December 1935, while for the atmosphere the highest temperature 31·7°C. (89·1 F.) was reached in May and the lowest 23·9°C. or (74·9°F.) in December 1934.

Taking the three years, the maximum for 1933 (31·5°C.) was reached in August; for 1934 (32·6°C.) in April, and for 1935 (31·4° C.) in April. The maximum temperature for the atmosphere was reached in June in 1933 (31·1°C. or 87·9°F.), in May in 1934 (30·9°C. or 87·5°F.) and in May in 1935 (31·7°C. or 89·1°F.).

The minimum temperature of the surface water was reached in January in 1933 (26·6°C.), in December in 1934 and in 1934 (26·4°C.) and in December in 1935 (25·2°C.). The lowest temperature for the atmosphere was reached in December (24·2°C. or 75·4°F.) in 1933, and in December (23·9°C. or 74·9°F.) in 1934 and in January (24·0°C. or 75·3°F.) in 1935. Summing up, the amplitude of variation during the three years was as follows:—

1933 = 26·6°C.-31·5° i.e. 4·9°C.
1934 = 26·4°C.-32·6° i.e. 6·2°C.
1935 = 25·2°C.-31·4° i.e. 6·2°C.

It may be seen from the above that the annual temperature cycle of the surface water followed closely that of the atmosphere during the three year period. Similar changes were observed by Apstein (1907) in a lake in Ceylon. Summing up briefly, the temperature of the surface water of the Red Hills Lake is lowest in December or January. From January onwards, it gradually rises till it reaches the maximum for the year in April or May and then decreases slightly in June and July and then increases again from July to September when a second maximum is reached. But the second maximum is always lower than the first. From September onwards the temperature begins to go down steadily till the minimum is reached in December or January.

(ii) *The Temperature of the Middle Layer and its Seasonal Variations.*

(a) *Maximum and Minimum Values.*—As the samples for the bottom layer were taken at a depth of 6·0m., the maximum depth of the lake being 6·5 m., samples for the middle layer were taken at a depth of 3·0m. The temperature of the 3·0m. layer was taken only for two years, 1934 and 1935, as the necessary apparatus for recording the temperature of the deeper layers was received only towards the close of. 1933.

The maximum temperature for 1934 (30·4°C.) was recorded in April and May; and for 1935 (30·4°C.) in April. The minimum for 1934 (25·4°C.) was reached in December and for 1935 (25·6°C.) in January. In 1934, the difference between the maximum and the minimum was 5·0°C. (30·4°C.-25·4°C.); and in 1935 was 4·8°C. (30·4°C.-25·6°C.). Thus the difference in the range of temperature in both the years was nearly the same.

(b) *Seasonal Variations.*—The annual temperature cycle of the middle layer followed closely that of the atmosphere during 1934 and 1935. Summing up briefly, the temperature of the middle layer in the Red Hills Lake is lowest in December. From January onwards it rises gradually till it reaches the maximum for the year in May and then decreases slightly in June and July and then rises again from July to September when a second maximum is reached. But the second maximum is always lower than the first. From September onwards the temperature begins to go down steadily till the minimum is reached in December.

(iii) *The Temperature of the Bottom Layer and its Seasonal Variations.*

The bottom temperature was recorded only for two years 1934 and 1935.

(a) *Maximum and Minimum Values.*—The maximum temperature for 1934 (30·0°C.) was recorded in May and for 1935 (29·9°C.) in April. The minimum for 1934 (25·2°C.) was recorded in December and for 1935 (25·4°C.) in January. In 1934 the difference between the extremes of temperature (25·2°C.-30·0°C.) was 4·8C., and in 1935 was 4·5°C. (25·4°C.-29·4°C.). Thus the difference in the range of temperature was nearly the same in both years.

(b) *Seasonal Variations.*—The annual temperature cycle of the bottom layer followed closely that of the middle and surface layers, which (surface) in turn followed closely that of the atmosphere in 1934 and 1935. Summing up briefly the temperature of the bottom layer in the Red Hills Lake is lowest in December. From January onwards it rises gradually till it reaches the maximum for the year in May and then decreases slightly in June and July and then rises again from July to September, when a second maximum is reached. But the second maximum is always lower than the first. From September onwards, the temperature begins to go down steadily till the minimum is reached in December.

So, in the lake the temperature of the surface, middle and bottom layers followed more or less a similar cycle throughout the year. The mean temperature cycle of the atmosphere also is very similar. Griffiths (1936) has made a similar observation in the case of the Long Pool, Butterby Marsh.

Briefly stated, the thermal conditions in the Red Hills Lake were:—

1. In the Red Hills Lake, no permanent stratification is seen. A temporary stratification is gradually formed daily towards the middle of the day. In the early morning, no stratification is seen but as the day progresses, the surface layers get heated and a stratification is gradually formed but is destroyed daily in the night.

2. In the middle of the day when this temporary stratification is seen, the temperature of the surface water varies between 25°C and 32°C; that of the middle layer between 25° and 30°C, and that of the bottom also between 25° and 30°C.

3. The temporary thermal stratification observed daily in the middle of the day is fairly well expressed, and may in a way be compared to the permanent stratification seen in the lakes of the East Indies. The differences in temperature between the surface and bottom layers in both is very small. And in the Red Hills Lake a sort of an epilimnin thermocline and a hypolimnin can be distinguished during the brief period of this temporary stratification daily.

4. The temporary thermal stratification of the Red Hills Lake can be compared to the minor stratification seen within the few metres (epilimnion ?) from the surface in the East African or even temperate lakes (in summer) and also some Javanese lakes during midday.

5. The Red Hills Lake can be classified under the third subgroup of Whipple's modification of Forel's classification of lakes.

2. Important Chemical Conditions

The chief sources of food for both microscopic and microscopid plants in water are present in the form of dissolved gases and inorganic substances. They are oxygen, free carbonic acid, hydrogen ion concentration (pH), carbonates, bicarbonates, calcium, phosphates, silicates, nitrogenous substances and organic matter. They are utilised by plants and any deficiency in the amount of one of them may act as a limiting factor for certain groups of plant organisms such as diatoms and desmids (Pearsall, 1922, 1924), or any excess of one of these may have a deleterious effect generally on algal denizens, as for example in the case of the highly alkaline lakes of Africa (Genkins 1932, Beadle 1932-34) or of the acid waters of Japan (Neno 1934). So a knowledge of the paucity or plentitude of the nutrient substances of biological importance in lake waters is essential from an ecological stand-point inasmuch as they give a clue to the fertility of the aquatic soil, and this information can be obtained only by a chemical analysis of the water during different seasons of the year. These data are furnished in detail in the annual reports of the author for 1933, 1934 and 1935, to which references are made in this paper.

I. Dissolved Oxygen.

The seasonal and vertical distribution of dissolved oxygen is discussed below:—

1. *The oxygen content in the surface layers and its seasonal variations.*

(*a*) *Absolute Values.*—The absolute value of dissolved oxygen varied from a minimum of 4·90 cc/l to a maximum of 5·41 cc/l in 1933; from 4·03 cc/l to 5·82 cc/l in 1934; and from 4·77 cc/l to 5·97/l in 1935. The maximum amount estimated during the three year period was 5·97 cc/l (in January 1935) and the lowest 4·03 cc per litre (in August 1934).

Taking each of the three years separately, the maximum for 1933 was 5·41 cc/l in December; for 1934, 5·82 cc/l in January. The minimum for 1933 was 4·90 cc/l (in August); for 1934, 4·03 cc/l (in August) and for 1935, 4.77 cc/l (in August).

(*b*) *Percentage saturation.*—The maximum recorded during the three year period was 104·9% (in February 1935); and the minimum was 72·8% (in August).

Taking each of the three years separately, the maximum for 1933 was 98·9% (in May); for 1934, 98·6% (in January and February) and for 1935, 104·9% (in February). The minimum for 1933 was 83·6% (in March); for 1934, 72·8% (in August); for 1935, 84·3% (in August).

(c) *Seasonal variations.*—A comparison of the absolute oxygen values of the three years shows that (i) the oxygen content is greatest in December or January when the temperature is lowest; (ii) the 0 content decreases gradually from January to March or April (when the first minimum is reached) and increases again in May. From May there is a gradual fall till the second minimum is reached in August and the second minimum is always lower than the first and (iii) from August they steadily increase till the maximum is reached in December or January.

Comparing the saturation values for the three years, it is seen that (i) the maximum value for saturation is reached in January. After January there is a gradual fall till the first minimum is reached in March. From March, there is a gradual rise again till a second maximum is reached in May, and then there is a gradual decline till a second minimum is reached in August; (ii) the minimum value in August is much lower than the first minimum in March. A comparison of the absolute values and of the values for saturation shows that there is a great similarity between them.

2. *The oxygen content in the middle layers (3 metres) and its seasonal variations during* 1934 *and* 1935. (*Maxima and Minima.*)

(*a*) *Absolute values.*—The absolute value varied from a minimum of 3·96 cc/l to a maximum of 5·80 cc/l in 1934; and from 4·77 cc/l to 5·99 cc/l in 1935. The maximum amount recorded during the two years was 5·99 cc/l (in January); for 1935, 5·99 cc·l (in January). The minimum for 1934 was 3·96 cc/l (in August); and for 1935 was 4·77 cc/l (in August).

(*b*) *Percentage of Saturation.*—The maximum recorded during the period was 100·1% (in January 1935) and the minimum was 75·1% (in August 1934).

Taking each of the two years separately, the maximum for 1934 was 97·3% (in January); and for 1935 was 100·1% (in January). The minimum for 1934 was 71·5% (in August), and for 1935 was 83·8% (in August).

(c) It will be seen from the few observations that (i) the oxygen values were comparatively higher (5·37 cc/1—5·99 cc) in October, January and February than during the remaining months (4·99—4·77 cc/l); and (ii) they decreased gradually from January to August and increased thereafter till the end of the year.

Briefly summarising the results of the two years, it is seen that (i) the oxygen content is greatest in January; (ii) it decreases gradually from January to August and rises again gradually till December. In this respect, the values follow more or less those of the surface values.

It will be seen from the above that the saturation values were comparatively higher in October, January and February than in the other months; and (ii) they decreased gradually from January to August and increased thereafter till the end of the year.

Briefly summarising the results of the two years, it will be seen that (*i*) the saturation is highest in January; (*ii*) that the saturation values decreased gradually from January to August and rose again till December. Thus these values followed closely those of the corresponding surface values, and those of absolute values of the middle layers.

3. *The oxygen content in the bottom layers and its seasonal variations in* 1934 and 1935. (*Maximum and Minimum Values.*)

(*a*) *Absolute values.*—The absolute value varied from a minimum of 3·37 cc/l to a maximum of 5·69 cc/l in 1934; from 4·56 cc/l to 5·87 cc/l in 1935. The maximum amount estimated during the two year period was 5·87 cc/l (in January 1935) and the minimum 3·37 cc/l (in August 1934).

(b) Taking each of the two years separately, the maximum for 1934 was 94·5% (in December 1934) and for 1935, 98·1% (in January 1935). The minimum for 1934 was 72·8% (in July) and for 1935 79·9% (in October).

(c) Comparing the two years, it will be seen that (i) the oxygen content of the bottom layers generally followed those of the middle and surface layers; (ii) the oxygen content is greatest in December or January; (iii) the oxygen content decreases gradually from January onwards till it reaches the minimum for the year in August and then rises gradually till the maximum is reached in December or January.

From the above it will be seen that (i) the saturation values decrease gradually from January to August and thereafter increases till it reaches the maximum in December. They follow closely the corresponding saturation and absolute for the middle and the surface layers.

From the above, it will be evident also that the saturation values gradually decline from January to October, Summing up briefly the vertical changes in the oxygen content during 1934 and 1935, we find that the maximum difference between the surface and bottom layers noticed in 1934 was 0·66 cc/1 or 13·3% sat. (August) and in 1935 1·22 cc/1 24·2% sat. (October). In both the years, in February, the difference was fairly high (0·44 cc/1, 8·6% in 1934 ; 0·48 cc/1, 11·6% in 1935). During the other months, the differences ranged between 0·0 cc/l and 0·39 cc/l. These data show that in most of the months a very weakly expressed O_2 stratification was present.

From the data on vertical and seasonal distribution of dissolved oxygen for 1933, 1934 and 1935 (Ganapati 1933, 1934, 1935), the following conclusions may be drawn :—

1. In the Red Hills Lake, no permanent oxygen stratification is seen. In the early morning, the oxygen conditions are uniform throughout and an oxygen stratification is gradually formed by the middle of the day and reaches its maximum towards the afternoon. This stratification is daily destroyed during the night and by the early morning the oxygen content becomes uniform again.

2. This temporary oxygen stratification observed daily in the afternoon is fairly expressed, though the difference between the surface and bottom is very small.

3. When this temporary oxygen stratification is formed in the afternoon, the oxygen content of the surface water varies between 5·97 cc/l and 4·03 cc/l, that of the middle layer between 5·87 cc/l and 3·37 cc/l.

4. The temporary oxygen stratification of the Red Hills Lake can be compared to the minor stratification seen within the few metres from the surface in some lakes of East Indies and even in some of the temperate lakes.

II. Free Carbonic Acid.

"Free CO_2" was not found at any time except on one occasion in the surface samples of 1933, 1934 and 1935. Samples collected from different depths in 1934 and 1935 also did not contain "free CO_2."

III. 1. The pH value of the surface layers and its Seasonal Variations.

(*a*) *Maximum and Minimum Values.*—The pH value varied from a minimum of 7·7 to a maximum of 8·9 in 1933; from 8·3 to 8·9 in 1934 ; and from 8·5 to 8·9 in 1935. The maximum value recorded during the three years period was 8·9 (April 1933;

August, September and October of 1934, and May, June and July of 1935), and the lowest 7·7 (in December 1933).

Taking each of the three years separately, the maximum for 1933 was 8·9 (April); for 1934, 8·9 (August, September, and October) and for 1935 8·9 (May, June and July). The minimum for 1933 was 7·7 (in December) for 1934, 8·3 (in April); and for 1935, 8·5 (in January, February and December).

(b) *Seasonal Variations.*—A comparison of the pH values of the three years shows that (i) the pH value is highest in April, May, June, July, August, September or October; (ii) it increases gradually from January to April, May or June, then there is a slight fall and then an increase, till October and then a fall in the last two months. Hem Singh Pruthi (1932) found the pH value of surface water of the Calcutta Museum pond water to be lowest in January (7·65) and reaching the first maximum in April (8·25), then a fall (7·85) in May or June, steady for 3 months and fall in August. From August it increases and attains the second maximum in October; and finally fell again to the lowest in January.

2. *The pH Value of the Middle Layer* (3m.) *and its Seasonal Variations during* 1934 *and* 1935.

(a) *Maximum and Minimum Values.*—The pH value varied from a minimum of 8·4 units to a maximum of 8·9 units in 1934; and from 8·5 to 8·9 units in 1935. The maximum value recorded was 8·9 units in April, June (1935) and in August, September and October (1934) and the lowest 8·4 (in November 1934).

Considering the two years individually, the maximum for 1934 was 8·9 units (in August, September and October); for 1935 was also 8·9 units (in April and June). The minimum for 1934 was 8·4 (in November) and for 1935 was 8·5 (in January and February).

(b) *Seasonal variations.*—A comparison of the pH values of the middle layers during 1934 and 1935 shows that (i) it is highest in April, June, August, September or October, (ii) it increases gradually from January to April, May or June, then there is a slight fall and then an increase till October and finally a fall in the last two months. Thus the changes in the middle layer follow the same course as that for the surface layer in both the years.

3. *The pH value of the bottom layers and its seasonal variations in 1934 and 1935.*

(a) *Maximum and Minimum values.*—The pH value varied from a minimum of 8·4 to a maximum of 8·9 in 1934; and from

8·4 to 8·9 in 1935. The maximum value recorded was 8·9 in both the years (April and June of 1934 and August of 1935); and the minimum was also the same i.e. 8·4 in both the years. (in November and October 1935).

Taking each of the two years separately, the maximum for 1934 was 8·9 (in August) ; for 1935, also 8·9 (in April and June). The minimum for 1934 was 8·4 (in November) and for 1935 was also 8·4 (in October).

(*b*) *Seasonal Variations.*—A comparison of the pH values of the bottom layers in 1934 and 1935 shows that (i) it is highest in April, June or August; and lowest in October or November; (ii) it increases gradually from January to April, May or June, then there is a slight fall and then a rise till August and finally a fall in the last few months. Thus the changes in pH values of the bottom layers follow those of the middle and surface layers in both the years.

4. *Nature of the vertical changes in pH values in the different seasons.*

Reviewing the four weather periods during 1934 and 1935, it may be stated that there was no stratification at any time in pH values.

(1) The pH values of the surface layer varied from a minimum of 7·7 to a maximum of 8·9 during the three year period.

(2) The pH values of the middle layer and bottom layers varied from a minimum of 8·4 to a maximum of 8·9 during 1934 and 1935.

(3) The seasonal variations in the surface layer are seen. The pH value increases from January to April, May or June, then there is a slight fall and then an increase till October and finally a fall and then an increase till October and finally a fall in the last two months. The middle and bottom layers follow similar fluctuations.

(4) The pH values showed no stratification at any time during 1934 and 1935.

(5) On the basis of the pH values, the Red Hills Lake can be classified under the "drainage" type of Birge and Juday.

IV. *Carbonates and Bicarbonates.*

1. *The carbonate and bicarbonate content in the surface layers and its seasonal variations.*

June). The minimum amount for 1934 was 9·0 mg/l in March and December and for 1935 6·0 mg/l (in October).

(b) *Bicarbonate ion:*—The bicarbonates varied from minimum of 79·3 mg/l to a maximum of 108·3 mg/l in 1934; from 97·6 mg/l to a maximum of 132·7 mg/l in 1935. The maximum amount recorded during the two year period was 132·7 mg/1 (in July 1935) and the minimum amount recorded was 79·3 mg/1 (in January 1934).

Taking each of the two years separately, the maximum for 1934 was 108·3 mg/l (in July) and for 1935, 132·7 mg/l (in July). The minimum for 1934 was 79·3 mg/l (in January) for 1935 it was 97·6 mg/l (in February).

B. Seasonal Variations:—Comparing the bicarbonate values of the bottom layers for 1934 and 1935, it may be seen that they are higher in 1935 than in 1934; the maximum figure is generally reached in the hot weather period (in July) and the minimum in the cold weather period (in January or February). Broadly speaking, there is a gradual rise from January to July and then a decline till December. The bicarbonate curves take the opposite course to those of the carbonates.

So, the carbonates were found to increase from the surface to the bottom in May 1934; and in February, June and August 1935. They were found to decrease from the surface to the bottom in April, July, September and October of 1934, and in July and October of 1935. They were nearly homogeneously distributed in January, March, April, June, August, November and December of 1934; and in January, April, and August of 1935. The carbonate content of the intermediate layers were higher than the surface or the bottom in March, May, June, July, August, and December of 1934; and in February, April, August, and in October of 1935.

The bicarbonates, on the other hand, were found to decrease from the surface to the bottom in March, April, May, June and December of 1934; and in February, June and August of 1935. They were found to increase from the surface to the bottom in April, July, August, September and October of 1934 and in January, April and October of 1935. They were almost the same from the surface to the bottom in January, and November of 1934; and in April and July of 1935. The bicarbonate content of some of the intermediate layers was found to be less than the surface or the bottom in March, May, June, July, August, September and December of 1934; and in January, April, August, and October of 1935.

Summing up briefly the vertical distribution of carbonates and bicarbonates during 1934 and 1935, it will be seen that (i) as regards the carbonates the maximum difference of 3·0 mg/l was found in May and the maximum difference of + 3·0 mg/l in October in the year 1934; and in 1935, the maximum difference of 1·5 mg/l was found in February and June and of + 3·6 mg/l in October. (ii) As regards the bicarbonates, the maximum difference of 9·1 mg/l was found in October and + 7·6 mg/l in June in the year 1934; and in 1935, the maximum difference of 4·2 mg/l was found in October and of + 11·1 mg/l in August. (iii) Broadly speaking, the carbonate curves took almost the opposite course to those of the bicarbonates.

V. *The lime content (CaO) in the surface layers, during 1933, 1934 and 1935.*

(*a*) *Minimum and maximum values.*—The lime content varied from a minimum of 39·9 mg/l to a maximum of 62·3 mg/l in 1933; from 35·7 mg/l to 53·2 mg/l in 1934; and from 50·4 mg/l to 69·3 mg/l in 1935. The maximum amount estimated during the three year period was 69·3 mg/l (in August 1935) and the minimum was 35·7 mg/l (in January 1934).

Taking each of the three years separately the maximum for 1933 was 62·3 mg/l (in June); for 1934 was 53·2 mg/l (in June and July) ; and for 1935 was 69·3 mg/l, (in August). The minimum for 1933 was 39·9 mg/l (in December); for 1934 was 35·7 mg/l (in January); and for 1935 was 50·4 mg/l (in January).

(*b*) *Seasonal variations.*—From the above it may be seen that (i) the lime content increases gradually from January to August and then decreases till the end of the year ; (ii) greatest rise was recorded from April to May and the greatest fall from August to September.

Comparing the three years it may be seen that (i) the lime content gradually increased from January to June, July or August when the maximum for the year is reached and then decreased till the end of the year. Sudden rises and falls have also been noted from one month to the succeeding month.

VI. *Phosphates.*

Phosphates were not detected at any time in the samples drawn from the surface and at different depths in the Red Hills Lake, at any time during 1934 and 1935.

VII. 1. *The silicate content in the surface layers and its seasonal variations during 1934 and 1935.*

(a) Maximum and minimum values.—The silicate content varied from a minimum of 11·2 mg/l to a maximum of 24·0 mg/l in 1934; and from a minimum of 13·0 mg/l to a maximum of 18·0 mg/l in 1935. The maximum value recorded during 1934 and 1935 was 24·0 mg/l (June 1934) and the minimum was 11·2 mg/l (March 1934).

Taking each of the two years separately, the maximum for 1934 was 24·0 mg/l (June), for 1935 was 18·0 mg/l (April). The minimum for 1934 was 11·2 mg/l (March) and for 1935 was 13·0 mg/l (March) and for 1935 was 13·0 mg/l (October).

(b) Seasonal variations.—Comparing the two years 1934 and 1935 it may be seen that (i) in 1934 the variations from month to month are greater than in 1935 and (ii) there was a sudden drop from September to October in both the years.

2. *The silicate content in the middle layer and its seasonal variations during 1934 and 1935.*

(a) The maximum and minimum values and the seasonal variations for 1934 and 1935 were almost the same as those for the surface layer the only three variations being on 11-3-34, 29-4-34 and 27-10-35.

(b) So, the seasonal variations follow those of the surface layer; and the values are also the same for each month.

3. *The silicate content in the bottom layer and its seasonal variations during 1934 and 1935.*

(a) Just as in the case of the middle layer, the maximum and minimum values and the seasonal variations for 1934 and 1935 were almost the same as those for the middle and surface layers. Minor variations were noted on 11-3-34 (14·0 mg/l), 29-4-34 (16 0 mg/l), 20-5-34 (13·8 mg/l) and 30-9-34 (18·0 mg/l) only.

(b) But for these minor variations, the seasonal variations were found to be the same as those for the surface and middle layers in 1934 and 1935.

4. *The vertical distribution of silicates in the different seasons of 1934 and 1935.*

Briefly reviewing the results of the two years, it may be stated that (i) the silicates were uniformly distributed from the surface to the bottom in January, February, July, August, October; November and December of 1934, and January, February, April, June, July, August and September of 1935; (ii) they were found to increase with depth in March, April, and September of 1934 and October of 1935; and to decrease with depth in May and June of 1934 only.

VIII. The total iron content in the surface layers and its seasonal variations during 1934 and 1935.

(*a*) *Maximum and Minimum values.*—The total iron content varied from a minimum of trace to a maximum of 0·028 part per 100 in 1934 and from a trace to 0·03 part per 100,000 in 1935. The maximum amount estimated during the three year period was 0·03 part per 100,000 (in February 1935) and the minimum was "trace" (in November 1934 and January 1935).

Taking each of the two years separately, the maximum for 1934 was 0·028 part (in June); and for 1935, 0·03 part (in February). The minimum for 1934 was "trace" (in November and December) and for 1935 was also "trace" (in January).

IX. Nitrogenous substance.

Four forms of nitrogenous compounds were estimated of which ammoniacal nitrogen was found in traces, nitrites and nitrates absent, and albuminoid nitrogen to vary from *0·022* to *0·067* parts per 100,000.

These two are uniformly distributed in all the layers. The amount of ammoniacal nitrogen was nearly the same throughout the year. But the albuminoid ammonia showed some amount of seasonal variation. It was generally at its maximum at the end of the south-west monsoon season and at its minimum in the north-east monsoon season or in the cold season.

1. *Vertical and seasonal changes in Ammoniacal nitrogen during 1933, 1934 and 1935. (Maximum and Minimum values).*

Ammoniacal nitrogen varied from a mere trace to a maximum of 0·003 part in 1933; from a trace to 0·004 part in 1934; and from a trace to 0·003 part in 1935. The maximum amount estimated during the three year period was 0·004 part (December 1934) and the minimum was trace (January, February, April, July, August, October, November 1934; and January to August and December 1935).

Taking each of the three years separately, the maximum for 1933 was *0·003 (in March); for 1934 was 0·004 (in December);* and for 1935 was 0·003 (in September). The minimum for 1933 was trace (in January, February, April and June to November);

for 1934 was also trace (in February, April, July, August, October and November); and for 1935 was also trace (from January to August and December).

Seasonal variations.—So, during the three years, the figure for ammoniacal nitrogen did not show any wide variations from season to season but was almost the same (traces) for the major portion of the year. The figures were found to be the same at all depths.

2. Albuminoid nitrogen in the surface layers during 1933, 1934 and 1935. (Maximum and minimum values).

The figure for albuminoid nitrogen was found to vary from a minimum of 0·022 part to a maximum of 0·060 part in 1933; from 0·028 to 0·061 in 1934; and from 0·027 to 0·067 in 1935. The maximum figure reached during the three year period was 0·067 (in July 1935).

Taking each of the three years separately, it may be seen that the maximum for 1933 was 0·060 (in August); for 1934 was 0·061 (in July and September) and for 1935 was 0·067 (in July). The minimum for 1933 was 0·022 (in December) for 1934 was 0·028 (in January) and for 1935 was 0·027 (in December).

Seasonal Variations.—Comparing the three years the following conclusions may be drawn:—

(*i*) The albuminoid nitrogen increases gradually from January to March, April or May when the first maximum for the year is reached, from March to April or April to May or May to June, there is a reduction; from April, May or June again there is a gradual rise till September when the second maximum is reached; and from September there is a gradual reduction till December when the minimum for the year is reached.

(*ii*) The two maxima are reached in the hot weather and south-west monsoon periods respectively.

(*iii*) The second maximum is generally higher than the first (they were equal in 1935).

(*iv*) The minimum was reached generally in the north-east monsoon season or occasionally a little later in the cold season.

X. Oxidisable organic matter (Tidy's) during 1933, 1934 *and* 1935 *(Maximum and Minimum values)*

The organic matter content varied from a minimum of 0.096 part to maximum of 0.216 part in 1933; from 0.091 to 0.174 part in

1934 ; and from 0·123 part to 0·207 part per 100,000 in 1935. The maximum amount estimated during the three year period was 0.216 part (in October 1933) and the minimum was 0.091 part (in December 1934).

Taking each of the three years separately, the maximum for 1933 was 0·216 part (in October) for 1934 0·174 part (in September) and for 1935 0.207 part (in August). The minimum for 1933 was 0.096 part (in December) for 1934 0.091 part (in December) and for 1935 0.123 part (in December).

Seasonal Variations.—A general survey of the changes in the oxidisable organic matter during the year shows that there is a gradual rise from January to April or May, a slight fall in May or June and then a rise till August or September; from August to September or from September to October there is a sudden fall and the fall thereafter continues to be gradual till the end of December when the minimum is reached. It may be seen that there are two maxima during the year ; the first during the hot weather and the second towards the end of the south-west monsoon season, the second maximum being greater than the first. The minimum is reached towards the end of the north-east monsoon season.

3. BIOLOGICAL CONDITIONS

A detailed study of the biological conditions was made during the three years 1933-35 and the data gathered during this period will be published separately. For the purpose of this paper, it is proposed to discuss very briefly the results of the bacteriological examination of the surface water and of the seasonal variations of the phytoplankton (*i.e.*, the free floating, microscopic, vegetable organisms).

(*i*) *Total colonies count*

Maximum and Minimum values.

The total colonies count varied from a minimum of 540 to a maximum of 1790 organisms per c.c. in 1933; from 390 to 1000 per c.c. in 1934; and from 400 to 1000 organisms per c.c. in 1935. The maximum count recorded during the three year period was 1790 organisms per c.c. (in December 1933) and the lowest 390 organisms per c.c. (in April 1934).

A comparison of the total colonies count in the Red Hills Lake for 1933-35 shows that (1) they decrease generally from January to April, May or June, when the minimum for the year is reached and later increase moderately during the south-west monsoon season, and finally attain the maximum in the north-east monsoon season ;

(ii) Minimum is reached in the hot weather and the maximum during the north-east monsoon season.

(ii) B. Coli Test

Maximum and minimum values.

Lactose fermenters were present in as small a quantity of 1 c.c. and upwards, to as large a quantity of 60 c.c. and upwards during 1933; from 1 c.c. to being absent in volume of 60 c.c. in 1934; and from 1 c.c. to being present in volumes of 60 c.c. in 1935. The lake water was of maximum purity during the three year period in January and March of 1934 and of least purity during November and December of 1933 in June and November of 1934 and in August of 1935.

Considering each of the three years separately, the lake water was of maximum purity (L.F. in 60 c.c.) in June 1933 in January and March of 1934 (L.F. absent in 60 c.c.) and in June (present in 60 c.c.) of 1935. It was of least purity (1 c.c. and upwards) in November and December of 1933; in June and November of 1934 and in August of 1935.

A comparison of the results of the three years shows that the lake water was of highest purity (lactose fermenters being present in 20 c.c. and upwards to their being absent in 60 c.c. and upwards) during the cold weather, hot weather and the beginning of the south-west monsoon periods, of moderate purity (10 c.c. and upwards) during the south-west monsoon period and of least purity during the north-east monsoon period.

As for the phytoplankton content of the lake water, the following brief observations are made.

69 species were recorded from the lake. They belong to the following groups:

Volvocales were	..	2
Chlorococcales were	..	22
Desmids	..	8
Zanthophyceae	..	2
Bacillariophyceae	..	5
Dinphyceae	..	2
Euglenineae	..	4
Cyanophyceae	..	24

Of these, the following were the most dominant (ccc) at one time or other during the period of investigation.

1. Aphanocapsa elachista var novo.
2. Oscillatoria limnetica Lemm.

Periodicity of the dominant forms.

1. *Aphanocapsa elachista var novo.*—This algae was one of the few that developed into an abundant form in the lake. Its development was particularly noteworthy in 1934 and 1935. In 1933, however, from a stray form in January, it became common (c) in February and decreased to a very rare (rr) form in March. From April to August 1933, it became stray (rrr) and developed into a very rare (rrr) form in September and thereafter it was a rare (r) form till January 1934. In February 1934, it showed a sudden rise to a very common (cc) form and in the beginning of March, it became abundant (ccc). Towards the end of March, it decreased to a common (c) form, but in May and June it was very common (cc.). In July 1934, it dropped down to a rare (r) form but developing suddenly once again to a maximum (ccc) in August and September. In October it decreased to a very rare (rr) form and then began to increase gradually till January 1935, when it was cc. But in February 1935, no specimen of this species was noticed, while in March it was very rare (rr) and in April and May common (c). In June, it was rare (r) and in July stray (rrr). In August and September, it was a very common specimen (cc) in the collection and in October it became abundant (ccc) dropping to a very rare (rr) form thereafter.

2. Of the other cyanophyceae, *Oscillatoria limnetica* was an important form and like *Aphanocapsa elachista var novo* showed a splendid growth in 1934 and 1935. In 1933, it was a stray (rrr) form from January to March, and absent in April. It was stray (rrr) in July, and absent in August and September and very rare (rr) in October. In November, no specimens were noticed in the collection but in December there was such a prolific growth of this species as to make it suddenly increase into an abundant (ccc) form. Then from January to March 1934, it was very common (cc) and attained a maximum (ccc) once again about the end of March. In April it was very common (cc) and common (c) in May. In June, there was total absence of this species, but it was very common (cc) in July and August and abundant (ccc) in September and October. In November there was a sudden fall (r) and in December 1934, there was an equally sudden rise to abundance (ccc) which continued during January 1935 also. It was common (c) in February, absent in March, common (c) in April, very common (cc) in May, common (c) in June, very rare (r) in July and August, common (c) in September, very rare (rr) in October, rare (r) in November, and stray (rrr) in December 1935.

(To be concluded)

A Scale of Units

BY

KAZI S. AHMAD,

Department of Geography,
Muslim University, Aligarh.

In the Cartographical representation of economic data, frequent use is made of circles. Where these circles are to be constructed to show proportionate areas, as in maps of land use, or of cultivated or irrigated areas, the determination of the radii of such circles involves a lot of cumbersome mathematical processes. Calculations are very tiresome and so, when many such circles are to be drawn, one often refrains from making these circles proportionate to the area represented by the map. Equal circles are drawn and subdivided to indicate various matters. But, to give a correct idea of comparative values, these circles should not only be proportionate in themselves according to respective areas but should also be adjusted to the scale of the map on which they are drawn. Such circles can be constructed with the help of a scale of units giving lengths of radii. The method of constructing such a scale is explained below by a concrete example.

Example :—It is required to construct a scale of units for determining the radii of circles, proportionate to the areas which are given in millions of acres, for a map the scale of which is 1 inch = 64 miles.

As the figures are in millions of acres, let us assume 1,000,000 acres as one of the areas to be represented.

$$1{,}000{,}000 \text{ acres} = 1562 \cdot 5 \text{ sq. miles}$$

$$\pi R^2 = 1562 \cdot 5 \text{ sq. miles}$$

$$\text{or} \quad R = \sqrt{\frac{1562 \cdot 5}{3 \cdot 14}}$$

$$= 22 \cdot 3$$

On a scale of 1 inch = 64 miles, a length of 22·3 miles will be represented by 22·3/64 = ·35 inch, or in other words a line of 3·5 inch will represent ten such lengths.

Take a line 3·5 inch in length and divide it into ten equal parts. Each part now represents 1000 (the square root of 1,000,000) units. Number these parts as below. The first one may be further subdivided into ten equal parts each of which will represent 100 units.

Scale of Units

This is the required scale of units. To find out the radius of each circle for any given figure we may read the square root of that figure from it. For example, if we want to find out the length of the radius of the circle for 3,240,000 acres, we may read the length of its square root "1800" from the scale and so on. The circles drawn in this way will all be proportionate in area and as according to construction the circle for 1,000,000 acres correctly represents the area on the scale of the map, all other circles will also represent correct areas. Such a scale of units will be of great use, for example, in showing the correct extent of cultivated land in various districts on any given map which could be sub-divided to indicate the area occupied by various crops or irrigated by different methods.

The construction of such a scale of units in cases where areas are not involved is still simpler. For example it is intended to show the export trade of different ports which is given in millions of Rupees. We may take any line of suitable length,* considering the size of the map on which the circles are to be drawn. It may be divided into ten or fewer equal parts, to be numbered 1000 to 10,000 or less. The square root of the figure of the export trade of each port may be read from this scale for the radius required.

* This line should be carefully chosen, as the longer the line that we choose the greater will be the size of the circle and vice versa.

Travel and Education

By

N. Subrahmanyam

(Summary of a lecture delivered on the 28th of May 1940 at the 31st Provincial Educational Conference at Ambasamudram.)

The words " travel " and " travail " are derived from the same root. The reason why travel was associated with travail was that in the old days travel was done with a great deal of difficulty. In talking of Travel and Education we must derive and relate the two words.

* * * * * *

Having spoken something of travel I wish to remind you what education connotes. Education, as we all know, consists in " drawing out " the best qualities of the person.

Advantages of Travel. The chief value of travel lies in the opportunities which it affords for the attainment of real knowledge and understanding of things. It supplements book knowledge. Through it we understand things clearly and in their natural setting. Further, travel benefits students in their study of particular subjects such as history, geography and geology.

On the emotional side, we find that the appetite for travel " grows with the eating thereof "; for, the joy of travel is great indeed. But more important than this is the human sympathy we learn to have for those in whose land we travel. There grows along with it a feeling of tolerance towards the customs and habits of people which are different from our own. "Ours are not the only ways of doing things" is what we realize. Mental liberation which is one of the right aims of education is achieved by travel.

On the conative side also, travel is highly beneficial. Learning is best done by doing. It is not by mere study but by experience that we have real education. In travel, there are challenging situations which call forth the best efforts of the individual. Travel makes a person self-reliant and resourceful.

Travel should be a concomittant of education if not also a completion of it. In western countries boys and girls go on tours and excursions during weekends and vacations, from which they return transformed into new beings. People sometimes talk of risks and dangers in travel; but are we free from them nearer home in this age of automobiles? Such mistaken notions should not stand in the way of travel becoming more common in these days of cheap and quick transport. Finally, travel is often a solace to bereaved persons.

Opportunities for Travel. There are many opportunities for travel open to us in the educational world. There are inter-school debates and matches and inter-University tournaments, and these are excellent opportunities for travel, though in the nature of things they are confined to a few of the prize boys. For all pupils to benefit by travel, there must be a system of conducted tours. As for us teachers, we have our educational conferences—District, Provincial and All-India, with their annual shifting venues. We should realise the value of the personal and social contacts brought about during these conferences and the advantage to us individually as well as to the profession as a whole.

Some fifteen years ago excursions were almost unknown in South Indian schools, but now they have become popular, though they require to be properly planned and conducted in order that the best educational values may accrue from them. Teachers of all subjects should take active part in the conduct of such tours.

Modes of travel. Man is a highly locomotive animal. Half his height is due to the legs, and he should make a good use of them. Hiking or walking is a form of travel which makes detailed study of localities possible. This intensive study offers a corrective to the general impressions formed by modern modes of quick travel. Next comes cycling. It is a quicker method by which a larger distance can be covered for local study. Then there is the bus, which has brought the road back into common use, making the most distant corners of the country easily accessible. The railway has its undoubted advantages for travel, far and near, and with its varieties of concessions for educational institutions and educational purposes, it offers an unlimited scope for travel which teachers and students should not fail to take advantage of.

Technique of travel. In order to get the best out of travel, it must be planned with care and forethought. The leader of the party must plan several days ahead; the time of arrival, the programme and the time of departure must all be settled in their details. The places of lodging, the kind of food, the places to visit must all be thought out previously. In fact the skill and responsibility demanded of the leader is very great. He will find it advantageous to consult the District Gazetteers and guide books as well as the quarter inch map and the one inch map. The latter must be taken for reference during the journey.

Abroad, the tourist industry is a major industry, which has developed considerably even in small places. With its wide ramifications it supports a large number of educated people in western countries. Its organisation is a nation-wide one in which are linked up several parties such as photographers, bus companies, railway companies, tourist agencies, hotel-keepers and industrial concerns, besides governmental authorities—national and local. A similar development in our country with its wonderful beauty-spots, holy shrines and historic monuments is sure to absorb a considerable proportion of the educated unemployed.

Prof. Maneck B. Pithawalla, upon whom the University of Bombay has conferred the degree of Doctor of Science for his pioneer geographical research on the Lower Indus Basin (Sind). He is the first D.Sc. from Sind and the first Indian to secure this highest distinction in the science of Geography in India.

Report of the Summer School of Geography

(Held at Saidapet, April 1940)

The Secretary of the Association has the honour to present the following Report of the Summer School of Geography, held at the Teachers' College, Saidapet from 6th April to 4th May 1940:—

At its meeting held on 24th February 1940 the Executive Committee of the Association decided to hold a Summer School of Geography for a month from the 6th April, and authorised the Secretary to organise and conduct the course as in the previous years. 28 teachers joined the course (Appendix A.), some of them coming from distant places such as Sargoda in the Punjab, Phaltan in Bombay Presidency, Secunderabad and Mangalore.

The classes were formally opened by Mr. D. Samuel, M.A., Retired District Educational Officer, when Mr. M. Subramania Ayyar delivered the Inaugural Address. (Appendix B.).

The work of the Summer School went on steadily for over four weeks at 5 to 6 hours a day; and the following scheme of work was gone through:—

(*a*) *Pedagogy of Geography* by Mr. N. Subrahmanyam;
(*b*) *Elementary Surveying* by Mr. K. Srinivasaraghavan;
(*c*) *Map Work* by Mr. N. Subrahmanyam;
(*d*) *Mathematical Geography* by Mr. S. Muthukrishna Ayyar;
(*e*) *Diagrammatic Methods* by Mr. S. Balakrishna Ayyar;
(*f*) *Land Forms* by Mr. V. D. Krishnaswami;
(*g*) *Climate and Weather* by Miss E. D. Birdseye;
(*h*) *Oceanography* by Mr. K. Ramamurti;
(*i*) *Economic Geography* by Mr. V. Thyagarajan; and
(*j*) *Plant Geography* by Mr. M. S. Sabhesan.

The following general lectures were also delivered to the teachers attending the course:—

(1) *Pre-History & Geography* by Mr. V. D. Krishnaswami;
(2) *Defence of India: A Study in Historical Geography* by Mr. M. Subramania Ayyar; and
(3) *The Growth of Modern Japan: A Study in Dynamic Geography* by Mr. M. Subramania Ayyar.
(4) *How Survey Maps are prepared* by Rao Bahadur K. N. Narasimhacharya.

Miss H. T. Scudder gave a show of *geographical films.*

Besides short excursions to St. Thomas Mount, the Pencil Factory, Adyar mouth and Ennore backwaters, two full day excursions were conducted—the first to Mahabalipuram and the second a circular tour to Poonamalle, Sriperumbudur, Trivellore, Tripasore, Pundi, Uttukottai, Tamarapakkam anicut, Cholavaram tank and Red Hills.

On the afternoon of Saturday the 4th May—the last day of the course, a tea party was held. Prof. S. K. Yegnanarayana Ayyar then presented the certificates to the teachers who attended the Summer School, and delivered the Valedictory Address. The course then came to a close with vote of thanks.

The total collection of fees amounted to Rs. 390, out of which a sum of Rs. 160 was expended on conveyance allowance of lecturers, clerical and other services and miscellaneous expenses, leaving a net balance of Rs. 230.

The thanks of the Association are due to the Lecturers for their honorary work in the Summer School as well as to the Director of Public Instruction, Madras and the Principal, Teachers' College, Saidapet, for allowing the classes to be held in the Geography Department of the Teachers' College.

APPENDIX A

List of Teachers who attended the Summer School of Geography in April-May 1940.

1. *Mr. P. Balasundaram;* A. R. C. Higher Elementary School, Madras.
2. *Mr. Som Nath Bhatia,* B.A.; Teacher, Shahpur City, The Punjab.
3. *Mr. J. B. Chandra Babu,* B.A., Hindu High School, Madurantakam.
4. *Mr. V. Doraiswami,* B.A.; Triplicane, Madras.
5. *Mr. A. N. Gundu Rao;* Saivite Higher Elementary School, Kondithope, Madras.
6. *Miss Agnes I. Joseph,* B.A., L.T.; Methodist Girls' High School, Royapettah, Madras.
7. *Mr. P. Kalyanasundaram,* B.A., The Social Service League Free Higher Elementary School, Tanjore.
8. *Mr. C. K. Kissan Rao,* M.A., L.T.; Mahbub College, Secunderabad.
9. *Mr. V. M. Kolekar,* B.Sc., B.T., Mudhoji High School, Phaltan.

10. *Mr. P. Kothandaswamy Naidu,* Theogaroya Chetti Hindu Secondary School, Washermanpet, Madras.
11. *Mr. P. S. Krishnamachari,* B.A.; Madhavaram Road, Perambur.
12. *Mr. B. S. Muthukrishnan,* B.A., L.T., G.D.A.; Muthialpet High School, Madras.
13. *Mr. M. Narasimhayya,* B.A.; Nandyal, Kurnool District.
14. *Mr. A. Natesan*; Teacher, Velappadi, Vellore.
15. *Mr. T. R. Padmanabhachari,* M.A.; 29, Car Street, Triplicane, Madras.
16. *Mr. V. Ramanathan;* 20|21, Ramaswami St., George Town, Madras.
17. *Miss Guernsey Rangaswamy,* B.A.; Methodist Girls' High School, Royapettah, Madras.
18. *Mr. D. D. Sathia Das,* B.A., L.T., C.M.S. School, Nallur.
19. *Mr. R. Subba Rao,* B.A.; New High School, Visweswarapuram, Bangalore.
20. *Mr. K. Subrahmanyam,* B.A. (Hons.); M. D. T. Hindu College, Tinnevelly.
21. *Mr. V. Subrahmanyam,* B.A.; Teacher, A. R. High School, Madura.
22. *Mr. V. Subramanian,* 31, Venkier St., Mint Building P.O., Madras.
23. *Mr. S. Thangiah,* B.A.; Department of Fisheries, Madras.
24. *Mr. N. Thiagaraja Chettiar,* Teacher, Muthialpet High School, Madras.
25. *Mr. V. N. Venkat Rao,* B.A.; No. 6 Vythiraman Street, Thyagarayanagar.
26. *Mr. P. Venkatachalam,* M.A., Teacher, T. T. V. High School, Madras.
27. *Mr. H. Venkatroya Shenoi,* B.A.; Naravi, Karkala, South Kanara District.
28. *Mr. T. K. Sambasivan;* 20|21, Ramaswamy St., George Town, Madras.

APPENDIX B

The Summer School of Geography
Inaugural Meeting

Miss E. D. Birdseye, President of the Association, described the good work done by it in promoting geographical studies in South India; and proposed Mr. D. Samuel, I.E.S., (Retd.) to the Chair.

Mr. Samuel paid a tribute to the services rendered by the Association and its Secretary, Mr. N. Subrahmanyam, in the diffusion of Geographical knowledge, raising it to higher levels, from the elementary stages up. He referred also to the basic school scheme of Wardha; and while approving its practical turn, he missed in it the synthesis of Geography and the larger synthesis of Religion which that scheme apparently fought shy of, for toleration's sake.

Mr. N. Subrahmanyam next gave a brief account of the nature of studies and the aims and objects of the course.

Mr. M. Subrahmania Aiyar then delivered the inaugural address. He showed how the course made up for shortness of time by the length of hours, by intensive effort and by its severely practical character. He described with appropriate examples the relation and importance of geography to other studies of school and college and how it was a preparation for them and their fulfilment; and finally, he stressed its place in culture and life.

With the usual vote of thanks the school was inaugurated.

Report of the Refresher Course in Geography

(Held at Ambasamudram in May 1940)

The Secretary of the Association has the honour to present the following Report of the Refresher Course in Geography, held at Ambasamudram in May 1940:—

At its meeting held on 24-2-1940, the Executive Committee of the Association, decided in response to the request of the Reception Committee of the 31st Provincial Educational Conference, to hold a Refresher Course in Geography at the Tirthapathi High School, Ambasamudram for a fortnight commencing from the 13th May 1940, under the joint auspices of the Provincial Educational Conference and the 10th Geographical Conference. The Secretary was authorised to organise and conduct the course, which was joined by 13 teachers (Appendix), who were mostly from within the Tinnevelly district.

Mr. E. H. Parameswaran, M.A., Headmaster, Tirthapathi High School, formally opened the course at 10 a.m. on Monday the 13th May; and the work of the course went on steadily for two weeks at 5 to 6 hours a day, and the following scheme of work was gone through: —

(*a*) *Pedagogy of Geography* by Mr. N. Subrahmanyam.
(*b*) *Climatology* by Mr. T. S. Sundaram Ayyar.
(*c*) *Oceanography* by Mr. K. Ramamurti.
(*d*) *Land Forms* by Mr. T. S. Sundaram Ayyar.
(*e*) *Mathematical Geography* by Mr. K. Ramamurti.
(*f*) *Diagrammatic Methods* by Mr. S. Krishnamurthi.
(*g*) *Map Work* by Mr. N. Subrahmanyam.
(*h*) *Elementary Surveying* by Mr. S. Krishnamurti.
(*i*) *Economic Geography* by Mr. V. Thyagarajan.
(*j*) *Plant Geography* by Mr. M. S. Sabhesan.

Two excursions were conducted to two neighbouring hills for illustrating field study and geographic methods of observation in the home region.

On the afternoon of Saturday the 25th May, the course was brought to a formal close by Mr. E. N. Subrahmanyam, M.A., of Madanapalle, who distributed the certificates and delivered the Valedictory Address.

The total collection from fees was Rs. 65 at Rs. 5 from each teacher; and this amount was expended partly towards the payment to the staff and partly for the printing of the Presidential Address of the Geographical Conference.

APPENDIX

List of Teachers who attended The Refresher Course of Geography at Ambasamudram in May 1940

(1) *Mr. P. N. Ananthanarayana Ayyar*: Chatram Committee School, Kadayam.

(2) *Mr. P. Anavartham,* B.A.: Teacher, Kallidaikurichy.

(3) *Mr. V. R. Boominathan*: Tirthapathi High School, Ambasamudram.

(4) *Miss Flora Devadasen*: St. John's Girls' High School, Nazareth.

(5) *Mr. G. G. Joshua*: St. John's College, Palamcottah.

(6) *Miss Mercy Muthiah*: Board Girls' School, Ambasamudram.

(7) *Mr. S. Minakshisundaram*: Hindu Elementary School, Ambasamudram.

(8) *Mr. R. Narayanan*: Hindu Elementary School, Ambasamudram.

(9) *Mr. R. Padmanabhair*: Board Higher Elementary School, Chatrapatty.

(10) *Mr. R. Totadri*: Committee Higher Elementary School, Sermadevi.

(11) *Mr. H. Venkatasubbaiyyar*: Sri Sailapathy Higher Elementary School, Alwarkurichy.

(12) *Mr. V. Vijiaraghavelu,* B.A., L.T.: S. A. V. High School, Tuticorin.

(13) *Mr. K. V. Viswanatha Iyer*: Committee Higher Elementary School, Sermadevi.

Select Contents

News and Notes

Though no meeting of the Association was held at the headquarters during the summer vacation, the period was one of intense activity for it in the shape of the conduct of the Summer School of Geography at Saidapet, the Refresher Course of Geography and the Geographical Conference at Ambasamudram.

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The Summer School of Geography was conducted at the Geography Department of the Teachers' College, Saidapet from 6th April to 4th May 1940, which was attended by 28 teachers, some of them coming from such distant places as Sargodah in the Punjab and Phaltan in the Bombay Presidency. A Report of the Working of the School is published elsewhere.

* * * * *

At the request of the Reception Committee of the 31st Provincial Educational Conference, and under the joint auspices of that Conference and of the 10th Geographical Conference at Ambasamudram a Refresher Course in Geography was conducted for a fortnight there, a Report of which is also published elsewhere.

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The 10th Geographical Conference of the Association was held at Ambasamudram from the 26th to the 29th May 1940, under the presidency of Mr. T. S. Sundaram Ayyar, when papers on various aspects of the Geography of Tinnevelly District were read and discussed. The Presidential Address and some of the papers are included in this number. The remaining papers, which have been held over for want of space, will be published in the next issue.

* * * * *

As part of the programme of the Conference, excursions were conducted to Banathirtham and Papanasam Project, Cape Comorin, Courtallam, Tuticorin and Tiruchendur. Four important resolutions were passed at the Conference; and these are given elsewhere under the Proceedings of the Conference.

* * * * *

Among the general lectures delivered at the Provincial Educational Conference was one by Mr. N. Subrahmanyam on *Travel and Education*, a summary of which is published elsewhere. After talking of the advantages, opportunities and technique of travel, he put in a strong plea for the proper organisation in this country of the

Tourist Industry, which will provide useful occupation for a large number of the educated unemployed.

* * * * *

The next Conferences—Educational and Geographical—have been invited to Chittoor District; and the venue will probably be either Madanapalle or Rishi Valley. It has been suggested that the next Summer School of Geography may be conducted at the place where the Conference will take place.

* * * * *

Dr. Tahir Rizvi, the President of the Geography and Geodesy Section of the next session of the Indian Science Congress to be held at Benares in January 1941 has sent a circular letter which is published elsewhere. It is hoped there will be a good response to it by our members in South India and elsewhere in the shape of contribution of papers, membership and attendance.

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The Advisory Board of the Imperial Council of Agricultural Research has approved the scheme for an All-India Soil Survey for a period of five years. The scheme provides for the collection of available data in the Provinces and States for the first two years by 12 to 15 officers working under the supervision and guidance of a central officer in close co-operation with local departments of Agriculture, the actual survey being undertaken thereafter to fill up the disclosed gaps.

* * * * *

The Great European War now going on may be called a Geography War. Geography underlies the causes, directs its course and ultimately has to settle the peace in terms of dynamicism of lands and peoples. Never before has the value of the Geographer been realised as now. Half the Geography Department of the University of London, for example, is with the colours doing geographical work for the operations. A New Era of Geography is bound to spring up with the New Order of the World heralded by the British Empire.

Reviews

Food, Clothing and Shelter Geographies: Book 7—The World for Junior Students. By McD. Robinson. (Macmillan & Co., Ltd.), 1940. Price Re. 1-6-6.

In reviewing the earlier books in the Primary Series in a recent issue of this Journal, we had pointed out that the central aim of the whole series has been to bring out man's efforts to obtain food, clothing and shelter, as indicated in the general title. "The pupils observe sparsely settled areas in their own neighbourhood. They apply their growing geographical knowledge to studying where and why man lives in small numbers and in large numbers in different parts of the world." This aim is more fully developed in the books of the Post-Primary Series of which the volume under review is one. These show the relationship between land forms, vegetation, climate and distribution of population.

In this 7th book of the series there is a posting up of the ledger, and the general geography of the world is revised in it as follows:— The first five chapters deal in order with the Earth, Water bodies, the Air, the Land Bodies and Natural vegetation. The next three chapters deal with human geography under the heads of Cultivated Vegetation, Man's Occupations and Man's Settlements. In the last chapter the different natural and geographical regions of the world are treated under 12 sub-heads, with the usual correlations which form the peculiar feature of the series. The volume is well got up and finely illustrated with numerous choice pictures, sketch-maps and diagrams; and as in the Primary Books of the series the exercises in Part B of each lesson serve both for revision and further work.

New Method Atlas Geography: The Southern Continents & North America. By T. P. Venkatachari. (The Educational Publishing Co., Madras). Price Re. 1.

This is a combined text-book and atlas, prepared in Tamil by a well-known author, who is a specialist in the subject, based on the latest S.S.L.C. Syllabus of the Madras Educational Department, and suitable for use in Form IV. We commend the plan of treatment followed in the book as one calculated to fix the facts well in the minds of the pupils, while giving them the requisite training in the right methods of study. Throughout, the map is made the basis of study; and each lesson starts with preliminary map work in the shape of map-reading and map-correlation, which is followed by a descriptive presentation of the facts of the lesson thus elicited and correlated. Finally, each lesson closes with suggestive questions and exercises. The technical terms have been well chosen; and the language is easy and the treatment simple.

The Archaean Complex of Mysore. By B. Rama Rao. (Government Press, Bangalore). 1940. Price Rs. 1-8-0.

This is bulletin No. 17 of the Mysore Geological Department. Dr. W. F. Smeeth, the then Director of Geological Survey in Mysore had given a succinct account of the State's rock formations, in his " Outline of the Geological History of Mysore," published in 1916. Summarising the results of subsequent investigations, Mr. B. Rama Rao in his Presidential Address to the Geological Section of the 23rd session of the Indian Science Congress held at Indore in 1936, had given a revised account on the nature and constitution of the Mysore Archaean Complex, indicating at the same time the several problems that still needed solution. As this Address is not easily available Mr. Rama Rao has published in the form of this bulletin a brief revised account of the Mysore Archaean Complex, which gives a somewhat more detailed account of it than that contained in his Presidential Address, including also the results of further investigations conducted since then. After giving a preliminary account of the physical features of the State and reviewing the previous researches, the Archaean Complex is treated in detail under the heads of the Dharwar System, Granites and Gneisses, and Dyke Rocks. Tables of chemical composition of the Mysore rock formations and a list of selected references are appended; and the volume is illustrated with a dozen fine plates and four good geological maps (one of them being the geological map of Mysore folded in the cover packet). The student of the Geology of Mysore State will find this bulletin a highly helpful volume.

List of References on Geology, Geography & Meteorology of the Madras Presidency. Compiled by S. R. Srinivasa Iyengar. (Agricultural College and Research Institute: Coimbatore). 1940.

The Librarian of the Coimbatore Agricultural College has done a piece of useful service to students of Geography in South India by preparing this bibliography on Geology, Geography and Meteorology of the Madras Presidency, containing references not only to books but also to Geological Survey Memoirs, Indian Science Congress Proceedings and papers published in magazines. It is gratifying to find a good number of the list from the back issues of this Journal. A similar bibliography for the Geography of India is a desideratum.

Books and Journals Received

The World for Junior Students: (Food, Clothing & Shelter Geographies Book 7). By L. McD. Robinson.

N. & S. America and Europe: (Food, Clothing & Shelter Geographies Book 6). By L. McD. Robinson.

New Method Atlas Geography: The Southern Continents & North America. By T. P. Venkatachari.

The Archaean Complex of Mysore. By B. Rama Rao.

List of References on Geology, Geography and Meteorology of the Madras Presidency. Compiled by S. R. Srinivasa Iyengar.

South Indian Commerce: March, April & May 1940.

South Indian Teacher: March, April & May 1940.

Indian Information: March 15, April 1, April 15; May 1 and 15; June 1; and June 15.

War Aims: Indian Information Series.

The Educational Review: March, April & May 1940.

The Visvabharathi Quarterly: February-April & May-July 1940,

The Hungarian Geographical Review: Vol. LXVII, No. 4 (1939).

International Review of the Hungarian Geographical Society: Vol. LXVII, No. 2 (1939).

The Karnatic Historical Review: January 1938.

Geography: March 1940.

The Geographical Journal: March, April and May 1940.

Problems of Physical Geography: VII—(Akademia Navk-II, U.S.S.R.), 1939.

Kalaimagal: April, May and June 1940.

Quarterly Journal of the Mythic Society: April 1940.

Annals of the Sri Venkateswara Oriental Institute, Tirupati: March 1940.

The Indian Journal of Political Science: Conference Number: April-June 1940.

The Indian Educator: March and April 1940.

The Geographical Review: April 1940.

Journal of the Andhra Historical Research Society: April 1939.

The Adyar Library Bulletin: *Brahma Vidya*: May 1940.

The Ramakrishna Home and Schools' Magazine: April 1940.

The Scottish Geographical Magazine: May 1940.

Renascent India: Vol. I, No. 1.

The Indian Co-operative Review: January-March 1940,

Indian Science Congress Association
28th Congress

DEAR SIR,

The 28th Session of the Indian Science Congress will be held at Benares from the 2nd to the 8th January, 1941. I have been nominated to be President of the Section of Geography & Geodesy.

On behalf of the Sectional Committee I request you to become a Member of the Congress, join its deliberations and contribute a suitable paper for reading at the meetings of the Section. The subscription should be sent to the Treasurer, Indian Science Congress Association, 92, Upper Circular Road; Calcutta.

Papers should be sent to the General Secretary, Indian Science Congress Association, 92, Upper Circular Road; Calcutta; so as to reach him *by the 15th of September, 1940, at the latest.* They should be accompanied by three typed copies of an abstract which shall not exceed 200 words, and shall not contain any diagrams and formulæ. *The name of the Section, which a paper is meant for, should be mentioned in each paper and in the abstract.* Copies of papers and abstracts should be retained as it may not be possible to return them.

Papers published or submitted for publication elsewhere will not be accepted. *Abstracts of papers, the full text of which is not sent to the General Secretary will not be accepted.* Under Rule 33 (III) the abstracts will be printed in final bound form before the meeting.

In accordance with Rule 32 (*a*) and (*e*) abstracts of papers which do not reach the General Secretary, Indian Science Congress Association, 92; Upper Circular Road; Calcutta; by the 15th of September, shall on no account be included in the printed abstracts which are issued before the Congress. Contributors from the Punjab are allowed extra time but if their papers and abstracts are not received by the General Secretary before the 1st October it will not be possible to include the abstracts in the printed volume circulated before the meeting.

In accordance with the rules of the Congress only Ordinary and Full Session Members have the right to contribute papers for reading at the Session of the Congress. Associate and Student Members must have their papers communicated by an Ordinary

Member. In the case of joint papers *each author must be a Member of some category* and this should be ensured at the time of communicating the paper to the General Secretary.

The rules will be strictly enforced, and I invite your co-operation in this matter.

In addition to the reading of papers, discussions held within a Section or jointly by two or more Sections form an important part of the activities of the Congress. Suggestions regarding suitable subjects for discussion will be welcome, and should be sent to me *at a very early date.* Abstracts of what members intend to say at such discussions should be marked as "Discussion" and should reach the General Secretary on or before the 15th September, 1940.

Every effort is made to provide projection lanterns at the meetings. The use of suitable diagrams and illustrations often heightens the interest of a paper.

It will be helpful if authors would hand over to me and to the Recorder at the time of reading their papers two copies of fuller summaries of their papers. Extra copies might be made available to those who intend to take part in the ensuing discussion.

I shall be much obliged if you could see your way to join the Congress and contribute to its deliberation and success.

Dated, 7—5—1940.

S. M. TAHIR RIZVI,
PRESIDENT,
Section of Geography & Geodesy.

The Journal of
The Madras Geographical Association

Vol. XV July—September, 1940 No. 3

Sugar Cane Cultivation in India

By

George Kuriyan, B.Sc. (Lond.),
Department of Geography,
University of Madras.

(Continued from Vol. 15, No. 1, page 54).

The total area under sugar cane in India has been varying very considerably and the following tables (include Burma also) give the total acreage under sugar cane in millions of acres:—

					Average for the quinquennium
1915-16	1916-17	1917-18	1918-19	1919-20	
2·669	2·730	3·153	3·179	3·008	2·948
1920-21	1921-22	1922-23	1923-24	1924-25	
2·887	2·699	3·044	3·232	2·837	2·940
1925-26	1926-27	1927-28	1928-29	1929-30	
2·993	3·245	3·227	2·836	2·751	3·010
1930-31	1931-32	1932-33	1933-34	1934-35	
3·061	3·267	3·617	3·600	3·783	3·466

Average rate of increase per year for the period 1915 to 30=0·14%
Average rate of increase per year for the period 1930 to 35=3·03%

From the above statistics, it is clear that the acreage under sugar cane has been fairly constant—about 3 million acres—during the period 1915 to 30. Since then there has been a remarkable increase. No correct statistics of cultivation are available since

1935, but it has been estimated by Mr. Gandhi in his *Sugar Annual* of 1937 that this increase has been continuing even since 1935 and his estimate of the area under cane sugar in 36-37 is 4·431 million acres. (Vide Appendix IV). The distribution of the crop in the various provinces of India are also shown in Appendix IV and it is obvious that by far the largest portion of the crop is grown in the United Provinces, the Punjab, Bihar & Orissa and Bengal. They have really been the most important regions for sugar cane from the earliest times of which we have definite statistics. The two maps of sugar cane cultivation appended herewith also bring out this fact very clearly.

It is found that the total cultivated area in India (excluding Burma) in 1934-35 was 277,270,610 acres of which sugar accounted for 3,635,518 acres forming nearly 1·3% of the total cultivated area. It might therefore appear to be an unimportant crop, but it should be remembered that the sugar industry is the third largest industry in India.[23] It has been estimated that there are nearly 20 million agriculturists who are sugar cane cultivators and their interests have to be zealously protected.[24]

23. Cotton comes first with 470 mills, a subscribed capital of 40 crores of rupees and about 400,000 workers. There are about 150 sugar mills working (178 registered) with a subscribed capital of about 7 crores of rupees and nearly 100,000 workers. In the Jute industry there are nearly 109 mills and a subscribed capital of nearly 20 Crores of rupees. Nevertheless, it should be borne in mind that neither the number of workers nor the amount of capital invested in any industry could be taken as absolute criteria regarding the importance of the industry. The shift system and the average output per employee have also got to be considered. Again, at best the sugar mills work only for about 150 days in the year. The number of agriculturists involved is perhaps a fairer factor to determine the relative importance of any industry.

24. The cane crop is the most important cash crop for the agriculturists of Bihar and the United Provinces and nothing has yet been devised to replace it. On the fortunes of this industry depend a very large number of ryots in both Bihar and the United Provinces. In a statement made by the Government of India (*vide* reply to a question in the Council of State dated 16th February 1937) it was stated that during 1935-36 the amount of 833 lacs of rupees was paid to cane agriculturists by the mill owners! From the available statistics of production, it is found that nearly 11,315,000 tons of cane were crushed and based on an average yield of 15 tons per acre, this shows that nearly 758,000 acres were under cultivation which supplied the factories. On an average in the United Provinces and Bihar the two predominant cane areas—one acre represents the average holding for a family of five persons (this is true of almost every other part of India) and hence the factories alone maintained nearly 3,800,000 agriculturists!

For India as a whole, the crop occupies only 1·3% of the total cultivated area; in some parts the proportion is much greater while in others it is much less. It is only in the United Provinces that this proportion is as high as 5·04%; i.e. nearly 4 times the All-India ratio. In Bihar and Orissa and the Punjab, it is slightly greater than 1·3%, in Bengal and in the North West Frontier Province, it is slightly less than 1·3%. In the other sugar-growing tracts of India, the proportion is much less than this (Vide Appendix II.)

It is not merely the total area under a crop which determines the importance of that crop, but in any region the actual proportion of the area under a crop to the total cultivated area is a much better index of the relative importance of that crop. This is well brought out by the map showing the 'Distribution of Sugar Cane Area in India.' Thus Mysore has nearly 90% of the sugar cane acreage of Hyderabad, but in Mysore the crop occupies 0·75% of the total cultivated area while in Hyderabad it is as low as 0·18%; i.e. to Mysore the cane crop is nearly 4 times as important as it is to Hyderabad although the total area under the crop in Mysore is less than that in Hyderabad. Many other similar examples can be cited and column 7 of Appendix II, brings it out clearly.

Table I

India (excluding Burma)	1921-22	1925-26	1931-32	1934-35
Total cultivated area in acres	269,781,428	272,563,199	281,172,401	280,271,501
Total irrigated area in acres	54,760,870	54,299,873	56,986,382	59,183,304
Percentage of total irrigated area to total cultivated area	20·3	19·9	20·3	21·1
Total area under sugar	2,503,807	2,801,230	3,102,899	3,635,518
Percentage of total area under sugar to total cultivated area	0·9	1·0	1·1	1·3
Total irrigated area under sugar	1,711,807	1,824,373	2,122,638	2,174,635
Percentage of total irrigated area under sugar to total area under irrigation	3·1	3·4	3·7	3·7
Percentage of total irrigated area under sugar to total area under sugar	68·4	65·1	69·3	60·8

Table II

Period	Increase in total cultivated area	Increase in total irrigated area	Increase in irrigated area under sugar cane	Increase in area under sugar cane	Ratio of 3 to 4 percentage	Ratio of 3 to 2 percentage
	1	2	3	4	5	6
1921-22 to 1925-26	2,781,771	—460,997	112,566	298,023	37·8	—
1921-22 to 1931-32	11,390,973	2,225,512	409,245	556,980	73·5	18·4
1921-22 to 1934-35	10,490,073	4,422,434	459,514	1,068,502	43·0	10·4

Note the reduction of percentage in columns 5 and 6 of Table II above since protection, 1932.

The above statistics in Table I prove the importance of irrigation to this crop. More than 60% of the total area under sugar is irrigated. It is noteworthy that there has been a diminution in the proportion of irrigated to total acreage. In 1921-22 it was as high as 68·4%, it came down to 65·1% in 1925-26 while in 1931-32 it reached the peak position of 69·3%. Since 1932 the proportion has been diminishing steadily and in 1934-35 it was only 60·8%. The percentage of total irrigated to total cultivated area in India has been fairly constant about 20% for the whole period 1921-31. In 1934-35 it was nearly the same, 21·1%; even if it is construed as a variation it is only an improvement in the conditions of irrigation. For India as a whole therefore, the increase in sugar cane acreage has very little to do with the improved facilities for irrigation. This conclusion is more amply brought out by a study of Table II above. 1921-22 has been chosen as a base year for comparison and these ratios bring out clearly the role of irrigation in the increased cultivation of the crop for the whole of India. Based on these statistics, the following conclusions can be arrived at :—

1. The increase in irrigated area under sugar cane, when expressed as a percentage of the increase in area under sugar cane has been diminishing since 1931-32. (i.e. since protection was given to the industry).

2. Equally well, the ratio of the increase in irrigated area under sugar cane to total irrigated area has also diminished since 1932.

3. Increase in sugar cane acreage has very little to do with the increase in facilities for irrigation. The last column 6 of Table II shows that the increase in irrigated area has been at a faster rate than increase in irrigated sugar cane acreage, (nearly twice as much).

4. Column 5 of Table II shows the influence of irrigation on increase of acreage under sugar cane. The last two ratios show that during the period 1932-35, the proportion of the rate of increase of irrigated area under sugar cane to total increase in area under sugar cane was much less than during the period 1921-31.

It is therefore clear that for India as a whole, the increase of acreage under sugar cane has not been due to the better facilities for irrigation. Probably therefore it has increased since 1932 due to other economic factors. This however does not mean that there are no regions in India where increase in acreage is not due to the improved conditions in irrigation. There are large tracts like the Central India States, Hyderabad, Rajaputana states etc., where the increase in acreage under sugar cane can only be attributed to the improvements in irrigation.

It has already been shown that sugar cane occupies slightly more than 1% of the total cultivated area in India. It was 0·9% in 1921-22, 1·1% in 1931-32, and 1·3% in 1934-35. India is a country where irrigation plays an exceedingly important role in agriculture and it is found that the proportion of irrigated area under sugar cane to total irrigated area is nearly 3 times as great (3·7 : 1·3) as the proportion of total area under sugar to total cultivated area in India. It is the more important crop that is grown under irrigation and hence the importance of this crop becomes obvious.

Much of the increase in acreage under sugar cane has been since 1930. Appendix III shows the total and irrigated acreage under sugar cane since 1930 till 1935, the last year for which official statistics are available. The heaviest increases are in Bihar and Orissa and in the Rajaputana states. The climatic requirements of Bihar and Orissa (vide appendix I) are such that irrigation is not essential and this fact is reflected in the percentage increase in total acreage being slightly greater than that of irrigated acreage. The total area under sugar cane in the Rajaputana States is small and the percentages worked out are likely to be misleading. Hyderabad has also shown an enormous increase, both in the total as well as in the irrigated acreage. Climatically in both these regions the rainfall is inadequate and unless amply supplemented with irrigation the crop cannot be grown successfully. Hyderabad and the Rajaputana States are perhaps the best examples which show that with increased facilities for irrigation even previously unirrigated crop becomes an irrigated one; in other words, the crop is a serious competitor for irrigation water, the ryot using the irrigation water in increasing quantities for the cane crop. The increased acreage in both these areas is due to better facilities for irrigation. In Hyderabad it is mostly in the area irrigated by the Nizamsagar that the increase is seen.

Central Provinces and Berar are regions where the increase in total acreage is great—nearly 30 to 40%—but this increase is proportional to the increase in irrigated acreage. The rate of increase in C. P. & Berar has been very slow since 1923, indicating probably that maximum has nearly been reached.

United Provinces, Mysore and Bombay have all shown a steady growth, though a smaller one—about 20 to 25%—the average increase per year being fairly constant. Both in Mysore and in Bombay the increase in acreage is due to the better facilities for irrigation. In the United Provinces irrigation is necessary to supplement the rainfall, but the increase in acreage far exceeds the increase in irrigated acreage. It indicates that most of the area that could be irrigated has already been irrigated and the ryot has extended the area of cultivation without a proportionate increase in irrigation, thus gambling with the monsoons. In the Punjab also the needs for irrigation are similar, but the increase in total acreage is nearly double the increase in irrigated acreage. The Punjab ryot also gambles with the monsoon like his U. P. neighbour.[25]

It is however noteworthy that in Madras, in tropical India where irrigation is essential for the cultivation of the crop and where it is cultivated by a better class of agriculturists,[26] the increase in irrigated acreage equals the increase in total acreage!

Again, where due to climatic reasons, irrigation is unnecessary as in Bengal, a diminution in the total irrigated acreage is seen. It is only in Assam that the whole crop is unirrigated.

25. As in C. P. so also in the Punjab, 1931 seems to be the boom year since then there has been a decline in acreage, probably due to the unsuccessful gamble which the ryots had with the monsoons. In Punjab in 1934, the insect pest was very serious.

26. Page 51, *J.M.G.A.*, Vol. 15, No. 1.

Province	Total area under sugar cane 33-34	Area under improved cane 33-34	Total area under sugar cane 34-35	Area under improved cane 34-35	Increase in area in improved cane in 34-35 compared to 33-34	Percentage of improved crop to total crop in 34-35	Percentage of increase in improved crop to total area under improved crop in 33-34
United Provinces.	1,744,432	1,445,000	1,844,580	1,671,000	226,000	90·5	15
Punjab ..	521,650	187,300	520,339	200,600	13,300	38·5	7
Madras ..	134,554	42,095	138,568	57,943	15,848	41·9	38
Bombay ..	76,832	5,528	83,473	11,070	5,542	13·3	100
Bengal ..	256,600	113,304	276,200	170,762	57,458	61·8	51
North west Frontier Province ..	49,391	201	42,844	45	156	—	—
Bihar & Orissa ..	418,000	297,351	444,700	358,363	61,012	80·6	20
Central Provinces & Berar ..	28,806	?	28,890	?	—	—	—
Assam	35,485	10,027	35,934	7,836	—2,191	21·8	—
Mysore	40,334	10,583	45,525	20,498	9,915	45·0	94
Hyderabad ..	46,472	6,567	50,580	14,359	7,792	28·4	118
Total for India ..	3,424,072	2,295,257	3,635,518	2,512,476	217,219	69·1	9·4

Note that the increase in acreage under improved cane is more than the increase in total acreage under cane.

In the United Provinces, Bihar & Orissa, the indigenous canes are now almost extinct, occasional small patches being met with only in the interior. In Bengal and the Punjab the new and better varieties of the Coimbatore canes grow in popularity.

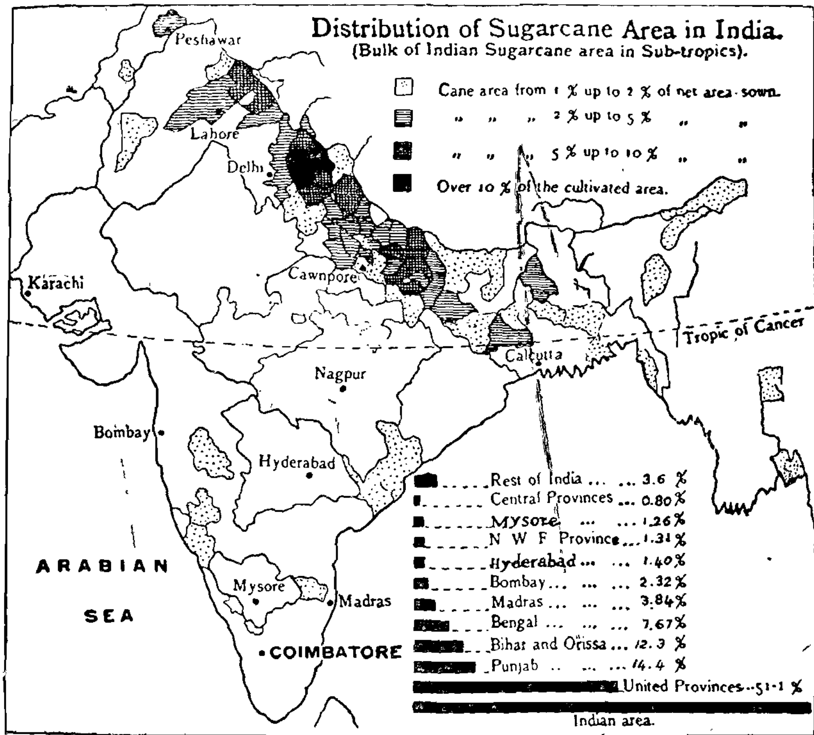
Acreage under Sugar Cane

Year		Total acreage	Acreage under improved varieties	Average Cane production in tons per acre
1931-32	..	3,102,899	1,170,478	14·1
1932-33	..	3,445,870	1,845,788	14·9
1933-34	..	3,424,072	2,295,257	15·3
1934-35	..	3,635,518	2,512,476	15·3
1935-36	.. (Estimate)	4,020,000	3,071,153	15·3
1936-37	.. (do.)	4,431,000	3,500,000	15·3

These statistics clearly show that in 1931-32 slightly more than 1/3 the total area under cane was under improved crops, but by 1934-35 the area under improved crops was more than 2/3 the total area under the cane showing thereby a phenomenal increase in the acreage of better varieties. If the increase goes on steadily, it is sure that in a few years, the cane cultivation of India will be of the superior quality of the canes. It is however surprising that in spite of this, the average cane production in tons per acre has not proportionately increased.

The yield per acre is highest in the tropical parts of the peninsula; in Madras it is 6,224 lbs while in Bombay it is 5,422 lbs. The Punjab has the lowest yield,—1764 lbs,—Delhi is slightly better (1,792 lbs). The yield in the United Provinces is poor (3,463 lbs) as is that of Bihar (3,287℔) and Orissa (3,659℔) or the Central Provinces (3,584℔). The yield of Bengal is decidedly better (4,127 lbs). In respect of the yield of cane per acre, its sucrose content or average percentage of recovery from cane, India is still far behind Java, Cuba, Hawaiian Isles, Philippines etc. The cane crop is poor both in yield and quality (approximately the Hawaiian yield is 4 tons per acre, Javan and Cuban yields are 2 tons per acre while the Indian yield is less than 1 ton per acre of refined sugar). This is due to:—(1) plantation of cane without a scientific system of rotation; (2) extended ratooning; (3) the absence of manures and fertilisers, (4) the lack of suitable seeds; (5) the lack of water; (6) the disease in the cane crop and (7) insect damage as in the Punjab and the United Provinces.

It is true that the acreage under improved varieties has increased phenomenally in the near past, but it is often forgotten that these



improved varieties often demand more manure. Unless artificial manuring is done, the soil will diminish in quality very rapidly.[27]

27. The Director of Agriculture, Bihar states that "the development and growth of the Coimbatore canes have conferred a substantial benefit on the cultivators and it is essential that this should be maintained. The Coimbatores have a much better yield than the old idigenous varieties, but they also remove larger quantities of plant food from the soil and unless this is replaced by fertilisers of organic manures, the soils would get exhausted and the deterioration of the cane would be inevitable." *Vide, Gandhi Sugar Annual for* 1937, page 90. The Director of Agriculture, Bihar in his annual report for 1935-36 says "the yield of the new cane varieties is extremely poor, the crop is badly farmed and badly manured. The ratoon is a neglected one. New crop varieties which are capable of high yields coupled with

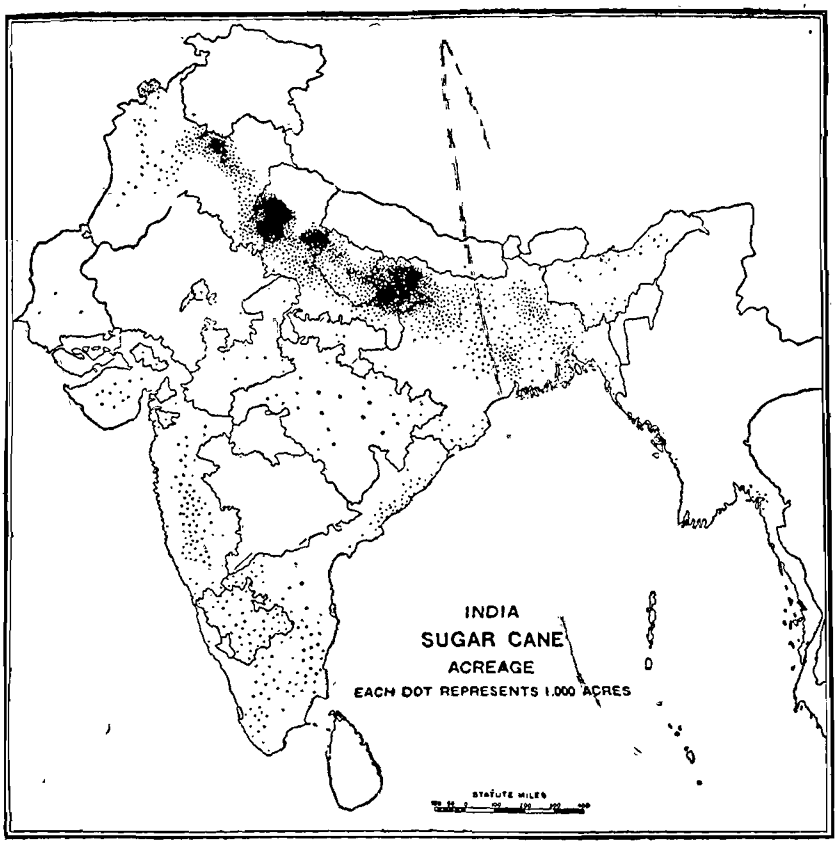
The sugar factories in India do nothing to foster the cultivation of the cane although the cost of the cane is nearly 2/3 the cost of the final product. It is only in Bombay that the cane grower is the capitalist so that the holdings are large. In his annual report on the Department of Agriculture, Bombay for 1935-36, the Director says that the factories have their own cultivation for about 11,566 acres (more than 1/8 the total area under cultivation in the Presidency) and the yield in this tract is nearly 3½ tons of refined sugar per acre. (Total yield is about 39,115 tons). In the United Provinces which is the largest sugar-growing tract of India, the conditions are the exact counterpart of this. If the factories in the United Provinces foster the growth of the early and late ripening varieties, the yield would be much better and the factories would have a much longer working season. If the industrialist and the agriculturist were to work in co-operation, the yield can be increased so that the miller gets his crop at a reduced price without reducing the income of the cultivator. A part of the profits in the industry must be ear-marked for investments in the fields,—irrigation projects if necessary—and this should be considered as part of the capital expenditure.

In Mysore, in the Irwin Canal area the yield of the cane is about 40 tons of cane per acre; the average for the United Provinces and Bihar is only 15 tons per acre and even in the other parts of Mysore it is only 20 tons per acre. The Mysore Sugars Ltd. have instituted prizes for the best cane yields in one acre blocks and five acre blocks. The Mysore ryot co-operates with the plans and programmes adopted by the factory. The time of planting is adjusted to the requirements of the factory so as to obtain as long a crushing season as possible. The mills advance up to Rs. 500,000 for the cultivators and also employ a good trained staff to instruct them about pests, manuring, proper methods of cultivation etc. It is only in the Irwin Canal area that the factories work for 9 months; and it is well worthy of emulation by the other sugar manufacturers.

The average cultivator of India is hardly aware of the latest improved methods of farming or manuring or crop rotation or selection of varieties suitable to the soil; he simply carries on the traditio-

better quality make a much bigger demand on the resources of the soil and it must therefore be borne in mind that the introduction of such crops into the agricultural system of a country demands a fairly high standard of cultivation and manuring. Unless this is done, the soil will rapidly deteriorate and yields will fall off very rapidly."

nal methods from year to year without effecting any improvements in the quality of the cane grown in his fields. Sugar cane crop is one of the most important cash crops of the country, the annual value of which is approximately Rs. 60 crores, (vide reply to the Council of State, February 1937) and the prosperity of the third largest industry in the country is closely linked with it. Demonstration farms and nurseries should be established to improve the conditions of the crop throughout the country.



The crop planning conference of 1934 held that the area under sugar cane in India was not of a magnitude to affect the general question of crop planning. The Imperial Council of Agricultural Research in 1935 stated that in the absence of reliable data regarding the yield of cane per acre, it was not possible to lay down any general direction regarding the optimum area under cane cultivation in the country. In July 1936, the sugar expert to the Government of India urged that the local governments should not actively assist in further increasing the area under cane cultivation except in localities adjoining existing sugar factories. The sugar committee did not take any action in this matter as several relevant statistics (e.g. the consumption of sugar) were not available. In May 1937 the sugar committee expressed its opinion in favour of improving the quality of the cane crop by arranging zones, research etc. and against any further extension of the acreage. It is certainly true that the present area under cultivation meets the demands of the country and more attention should be devoted to improving the quality and lowering the cost of cultivation of the crop rather than increase the area. With the best qualities of cane being cultivated in increasing quantities, it is clear that within a few years, India without increasing the acreage under the crop, can, not merely be self sufficing as in the past as regards her needs of refined sugar, but could also hope to play a very important role in the world market in spite of the severe competition with Cuba, Java etc. Indian export of refined sugar has not met with considerable approval even from the Empire marketing board and perhaps that may to a certain extent—and only to a very limited extent account for the failure of the export trade in sugar. This however is not our main theme at present.

Province.	Acreage under Sugarcane in 1921-22	1925-26	1931-32	1934-35	Increase Percentage during 1921-35	Annual Percentage increase	Estimate of cane acreage in 1935-36	Estimate of acreage in 1936-37	Increase of Percentage for the period 1921-1937		Increase of percentage for the period 1931-37	
United Provinces (states included)	1,169,199	1,440,408	1,603,320	1,844,580	57·8	4·1	2,249,000	2,519,000	115·5	7·2	57·1	9·5
Punjab including the Punjab States and Agency States	414,625	392,027	532,442	520,339	25·5	1·8	474,000	551,000	32·9	2·1	3·2	0·5
Bihar & Orissa	305,900	290,200	302,846	444,700	45·4	3·2	478,000	490,000	60·2	3·8	74·0	12·3
Bengal	220,900	215,000	233,400	276,200	25·0	1·8	325,000	355,000	60·7	3·8	52·1	8·7
Madras (States included)	138,663	121,304	126,515	138,568	0·1	0·0	119,000	122,000	12·0	0·75	3·6	0·6
Bombay (States included)	58,703	69,790	72,044	83,473	42·2	3·0	122,000	126,000	114·7	7·2	75·5	12·6
North-West Frontier Province	34,439	48,124	44,268	42,844	24·4	1·7	59,000	72,000	109·1	6·8	62·6	10·4
Assam	40,972	40,636	31,332	35,934	12·3	0·9	37,000	38,000	7·2	0·5	21·3	3·6
Central Provinces (including Berar)	17,252	22,942	22,042	28,890	50·1	3·6	30,000	30,000	73·9	4·6	36·1	6·0
Hydrabad	31,623	54,624	35,393	50,580	60·0	4·3	59,000	58,000	83·4	5·2	63·9	10·7
Mysore	32,345	32,999	36,076	45,525	40·7	2·9	51,000	52,000	60·7	3·8	44·1	7·4
Central India States	6,634	6,344	10,779	22,411	237·8	17·0	?	?	?	?	?	?
Delhi	6,510	7,766	3,225	7,621	17·1	1·2	3,000	5,000	23·2	1·7	55·0	9·1
India—Total	2,503,807	2,801,830	3,102,899	3,635,518	42·7	3·1	4,020,000	4,431,000	77·0	4·8	44·8	7·5
Total cultivated area in India	269,781,428	272,563,199	281,172,401	280,271,501								
Total irrigated area in India (excluding Burma)	54,760,870	54,299,873	56,986,382	59,183,304								
Total irrigated area under sugar in India (excluding Burma)	1,711,807	1,824,373	2,121,052	2,171,321								

The Geographical Aspects in Relation to the Physical, Chemical and Biological Conditions of the Red Hills Lake

By

S. V. Ganapati, M.Sc., A.I.C.,

Water Analyst, The Corporation of Madras.

(Continued from page 181 of Vol. XV, No. 2.)

C. DISCUSSION OF INTER-RELATIONSHIP

In the previous section a brief account of the seasonal changes in the physical, chemical and biological conditions of the lake water during the three years of 1933-35 has been given. It is now proposed to discuss the inter-relationship that exists between geographical factors on the one hand and some of the important physical, chemical and biological conditions on the other.

(i) Rainfall, Temperature and Lake Level.

The level of water in lakes depends upon climatic conditions, especially rainfall and temperature of the region in which they are located.

In the case of the lake under study, the maximum level is reached in December (north-east monsoon season) on in January (cold weather period) and the minimum in August or September (south-west monsoon season).

It is a shallow lake and is subjected to nearly uniformly high temperature for nearly nine months in the year. Besides the fall in level resulting from evaporation, water is daily drawn for the city's water supply throughout the year and for irrigation purposes periodically so that there is a gradual fall in level from January to September.

With the decrease in level, the shore all round is gradually increased and large tract of meadow land is seen towards the end of the south-west monsoon season. This land gets completely covered again with water during the next north-east monsoon season.

(ii) Rainfall, Wind, and Colour and Transparency

The lake water varies from yellowish green to whitish in colour. It is yellowish green from January to September and whitish during the remaining months. The yellowish tinge is most probably due to fine slime disturbed from the bottom and shore by wind action during the period referred to above. The greenish tinge is due to phyto-plankton, chiefly *oscillatoria limnetica* and *Aphanocapsa elachista var novo,* the two most dominant algae in the lake water. The whitish colour is due to clayey turbidity brought into the lake from its own catchment area, to water from Sholavaram lake, which gets it from the Kortalayar river during the north-east monsoon season.

(iii) Temperature of Air, Bright Sunshine, Wind, Surface Area, Depth and Temperature of Water

The chief source of heat for lake waters is the sun. The surface layers are heated to a depth to which the sun's rays can penetrate and this depth is dependent upon their colour and transparency. The heat thus received in the surface layers is distributed to the deeper strata to a certain extent by wind among other causes. This temperature is also influenced to a certain extent by other causes such as rain and feeder streams or rivers, but these causes are only of minor importance. Lake waters lose their heat by radiation, by conduction to air and by evaporation.

A general account of stratification so far recorded in temperate and tropical lakes.

Thermal stratification in temperate lakes:

Studies of the seasonal changes in the thermal conditions of lake waters of the temperate region have shown that the entire depth of any deep lake is divided into three well defined strata in summer. First, there is a top layer of about 8-12 metres in thickness which is more or less of a uniform temperature. Its surface is the warmest part of the stratum and is subject to diurnal variation. This layer is known as "epilimnion." The thickness of the epilimnion in temperate regions varies according to the amount of solar heat available, but the maximum depth of this layer is about twelve to fifteen metres.

Immediately below this layer is the stratum of rapid cooling known variously as "thermocline", "sprungsicht," "metalimnion," "transition zone," "discontinuity layer" etc. In this layer which may vary in thickness from one metre or less up to three metres, the fall of temperature per metre is greater than 1°C and may be as much as 9°C per metre. About 60 to 70 per cent of the decline in temperature is found in this stratum (Birge and Juday 1912). The change in temperature from the epilimnion to the thermocline is fairly marked, whereas the change from the thermocline to the hypolimnion is not at all sharp, but very gradual, so that it is not easy to fix up the exact lower limit of the thermocline.

The entire body of water below the thermocline is known as "hypolimnion." In this hypolimnion, immediately below the thermocline, the temperature decreases towards the bottom at first more rapidly and then somewhat more slowly till the bottom of the lake is reached. The rate of decline rarely exceeds one degree per metre and the temperature curve in this region is almost a straight line. The amount of fall varies from 11 to 40 per cent of the total fall in the temperature of the whole lake (Birge and Juday l.c.)

Thermal stratification in tropical lakes:—

Practically very little work has been done in equatorial lakes where there is not such a pronounced seasonal difference in temperature as in temperate lakes. According to Ruttner (1931) the most important problem of tropical limnology particularly with reference to the equatorial zone, is to find out whether a stable stratification as is seen in all temperate lakes ever occurs in these tropical waters with their high bottom temperature. Cunnington (1905), Marquardsen (1916), Nevu Le Maire (1904)—(all cited by Ruttner l.c.)—have made temperature measurements of some of the big African lakes but none of them has stated anything about the presence or absence of a stable stratification. Juday (1915), Downes (1911), Graham (1929), Ruttner (l.c.), Jenkins (1929, 1932), Worthington and Beadle (1932) and Beadle (1932-34) are perhaps the only investigators who have contributed to this aspect of tropical limnology. Juday (l.c.) who examined the four tropical lakes situated near the middle of the north tropical zone in central America referred to the existence of a stable stratification even though the temperature difference was very small in the several layers. Downes (l.c.) found definite thermal stratification taking place in some reservoirs of the Panama canal region (cocoli, carabali and comatic) even though they were very shallow, their depth ranging from 9-26 feet only. Graham (l.c.) found a similar stratification in the lake Victoria in East Africa, even though the temperature difference between the surface and bottom layers was extremely small (i.e., 1·6°C for a mass of water 65 m thick). Ruttner (l.c.) in his investigations of the lakes of East Indies found similar small differences varying from 0·25°C in D. Batur to a maximum of 5·5°C in R. Klindungen. Most of those lakes are considerably bigger and deeper than the Red Hills lake. He states that even when there is a difference of only 0·9°C between the surface and bottom layers as in Stausee

Sindanglaja (Ruttner l.c. p. 315) it must be considered as a case of stratification, only the stratification will be a weakly expressed one. Jenkins (1929, 1932), Worthington and Beadle (1932), Beadle (1932-34) and Worthington and Riccardo (1936) found small differences in the temperature of the several layers in some East African lakes investigated by them. But they did not consider these small differences in the temperature as amounting to a thermal stratification. And Welch (1935) also does not agree with Ruttner. He states that "during the period over which these lakes were studied by Ruttner, the contrast between the bottom and surface temperatures was only about 4·5°C., sometimes less, even in lakes of considerable depths. The thermal resistence is, therefore, small, and this so-called thermal stratification is easily eliminated by wind action. If Ruttner's curves had been so drawn that the space units on both ordinates and abscissas were of equal dimension, as is commonly done, the curves would have little resemblance to those representing a typical thermal stratification." From this it will be seen, that Welch measures "thermal resistance" from the difference in number of degrees. The greater the difference the greater the thermal resistance according to Welch. He would therefore, probably consider that the thermal resistance would be greater in temperate lakes than in tropical lakes. But Ruttner (l.c. p. 404) has pointed out that the change in density for a temperature difference of 10°C.

between 4°— 5°C	.... is	0·000008
between 9°—10°C	.... is	0·000081
between 14°—15°C	.... is	0·000145
between 24°—25°C	.... is	0·000252
between 29°—30°C	.... is	0·000298

Therefore the density of waters with an increase of temperature of the same amount in a higher range of temperature decreases more suddenly than in the neighbourhood of maximum density. He cities Birge (1916), Juday (1915) and Schmidt (1915) in support of this view as they have already shown the significance of density at different temperatures for the stability of thermal stratification of lakes with high temperatures. He also states that the thermocline in temperate lakes is to be found in many cases in a temperature range of 10° — 15°C while in tropical lakes between 25° — 30°C. He argues therefore that the same difference in temperature in the latter will be conditioned by a stability two to three times as great as that found in the former. So, the stability of the thermal stratification is according to him really very great in the lakes of Java, Sumatra and Bali, even though the differences in temperature are very small.

Red Hills Lake

The lake investigated by the author is a tropical one and situated at nearly sea-level. It is very shallow, its maximum depth being about 25 ft. (7 m). A definite stratification is observed in the lake, but this stratification does not remain undisturbed for a long period like that of the lakes of the temperate region or like that of the Javanese etc. lakes investigated by Ruttner. In fact, the stratification does not last continuously even for a single day. In the early morning there is no stratification, but as the day progresses, the surface layers get heated and a fairly well expressed stratification is formed in the hot part of the day, and it is destroyed in the night. So, this is a very peculiar type of stratification in that it is formed easily during the day time and destroyed every day during the night so that in the mornings no stratification is seen. The term "Diurnal temporary stratification" may be used to distinguish this type of stratification from that found undisturbed over long periods, say, for a whole season as seen in temperate lakes and in the larger lakes of the tropics such as those of Java, Sumatra and Bali investigated by Ruttner. It also closely resembles what takes place in the surface layers of some temperate lakes (Birge and Juday 1912) on a bright, sunny, summer day and also to the phenomenon recorded by Jenkins (1929, 1932), Beadle (1932-34, p. 174) Worthington and Beadle (1932) and Worthington and Ricardo (1936 p. 58) in the surface layers of some East African lakes. They state with reference to one of the lakes "Both graphs indicate some mixing of the water near the surface down to a depth of about 5 metres during the night but there were no signs of a turnover." (Worthington and Ricardo l.c.). Worthington and Beadle (1932, p. 55) make a general statement from their observations of a number of East African lakes. "As a general rule, the water from the surface to a depth of two or three metres heats up several degrees during the day, and complete mixing takes place at night, so that from midnight onwards the temperature curve is vertical or even reversed in the upper few metres as illustrated in Fig. I for lake Naivasha." Jenkins (1932, p. 550) has stated as follows: "Even at mid-day only slight temperature gradients were developed, and there is evidence that, after the night cooling, the top few metres of water may be distinctly cooler than those below (Jenkins 1929, p. 574). This in itself leads to mixing of the layers affected, and may even extend to the bottom of the shallower lakes; in any case during these daily inversions of temperature there will be isothermal stages when the water, being of the same density throughout, will be readily mixed by the wind. This mixing, for which there is considerable evidence, is aided in the alkaline lakes by their extreme shallowness and by the regularity of the wind." What takes place daily in the surface layers of deep lakes like Naivasha, takes place in the entire body of the water in the Red Hills lake daily, since the maximum depth of the lake is only 5-6 metres. In fact the stratification of the Red Hills lake would be considered by Worthington and Beadle as merely a case of daily heating and cooling of the whole body of the water, since the lake is shallow; and that is really taking place in the Red Hills lake.

The temporary stratification formed in the Red Hills lake is shown in Tables IX *(Ganapati 1934, 1935) and graph I (Ganapati 1934).*

It is interesting to note that within this stratification, there is a region of nearly uniform high temperature near the surface and a region of greatest fall immediately below it and finally a region of more or less uniform temperature which however may gradually decrease towards the bottom. These three regions may be compared to the epilimnion, thermocline and hypolimnion of the temperate lakes during summer and to the larger lakes of the East Indies investigated by Ruttner. It is again interesting to note that the amount of the greatest fall is seen generally in March and April. It is just possible therefore to differenciate a temporary epilimnion, a temporary thermocline and a temporary hypolimnion within this temporary stratification, during the short period of its occurrence daily. The author believes that a similar temporary stratification with the three thermal strata would be found in the surface layers of the East African lakes, which get heated up during day time.

Detailed observations on shallow lakes of the type of the Red Hills lake over a long period have not been made so far in the tropics. The interesting point about such lakes is that a temporary stratification is fairly well developed by the middle of the day, and is destroyed at night. But in the case of a small pond in Calcutta Museum, Hem Sing Pruthi (1933) found the least difference (0·5°-1·0°C) between the surface and bottom in December and January and greatest (2·3°C) in summer *(April to June); that there was* complete stratification during the latter period; that in November and December there was a decrease in temperature difference so that the stratification of the water was disturbed; and that finally in January when the difference was least, a complete mixing of the waters took place. That our experience with the Red Hills Lake is extremely different has been sufficiently explained above.

Classification of the Red Hills Lake based upon its thermal conditions.

Forell (1895, cited by Whipple, 1927) was the first person to study the thermal relations in the various strata of lake waters. He classified the lakes of the temperate region into three types from their thermal conditions—polar, tropical and temperate. " Polar " lakes are those in which the entire mass of the water has always a temperature lower than 4°C. The surface layers are colder than the bottom layers exhibiting what is known as an " inverse " stratification. In " tropical " lakes, on the other hand, the temperature always remains above 4°C in all the layers. The stratification that is seen here is " direct " stratification. Their waters show highest temperature near the surface in summer and the temperatures decrease with the depth. " Temperate " lakes show the conditions of " polar " lakes during winter and of " tropical " lakes in summer. The temperature of the surface water in winter is lower than 4°C but during the rest of the year is always higher than 4°C.

Whipple's (1927) modification of Forel's classification is as follows: He classifies each of the above three types into three sub-groups: (i) lakes whose bottom temperature is near 4°C throughout the year and having only one circulation period possibly in winter; (ii) lakes whose bottom temperature varies but not far from 4°C and having one circulation period in winter and (iii) lakes whose bottom temperature is very similar to that of the surface and having practically a continuous circulation throughout the year.

None of the truly tropical lakes so far e.g. the lakes of Java, etc., investigated by Worthington etc., and the South Indian lakes investigated by the author, can come under the first two groups of tropical lakes according to Whipple's classification, since the bottom temperatures of these lakes are far above 4°C and often come very close to that of the surface (within about 5°C). The lakes that can come under these two groups of Whipple are those of Italy, which in a way belong to the warmer parts of the temperate region and can be considered tropical only from a North European or North American point of view, who will consider the climate of Italy as really tropical. Thienemann (1931, p. 213) for instance calls them " Warm " lakes.

The tropical lakes of Java, Sumatra and Bali, East Africa and South India referred to above may come under Whipple's third group of tropical lakes, since as already pointed out, the bottom temperature differs from the top only by a few degrees.

In this third group, according to Whipple's definition circulation of water takes place continuously throughout the year from top to bottom. Worthington and Riccardo (1936, p. 64) mention that in the East African lakes complete mixing takes place during windy months. They state " the mixing of the water is probably helped by strong winds which are prevalent at certain seasons on most of the lakes." The depth to which wind could be effective in mixing up the waters depends, according to Ruttner (1931, p. 407) on the surface area of the lake. Since the East African lakes have a large surface area (more than 10 sq. Km.) and are comparatively shallow, the waters of these lakes can be completely mixed up when a strong wind prevails. Worthington and Beadle (1932, p. 55) state in another place "These results confirm Ruttner's conclusion with regard to area and wind mixing, since all of those lakes mentioned are of the larger type, with areas more than 10 sq. Km. and range up to the enormous area of Lake Victoria; but the wind effect, if responsible, produces even greater mixing in that no thermoclines were detected at any depth." From this statement it is clear that mixing is possible only during periods of strong wind and cannot be continuous and as such cannot conform completely to Whipple's definition, where he states that mixing is continuous throughout the year. Though this complete mixing is seasonal and not continuous, a partial mixing confined to the surface layers up to a depth of about 5 metres is seen continuously throughout the year. This mixing of the surface layers goes on daily. Worthington and Beadle (1932, p. 55) state " As a general rule, the water from the surface to a depth of two or three metres heats up several degrees during the day and complete mixing takes place at night, so that from midnight onwards the temperature curve is vertical or even reversed in the upper few metres as illustrated in Fig. I for Lake Naivasha." In another place, Worthington and Riccardo (1936, p. 58) state with regard to Lake Bunyoni "Both graphs indicate some mixing of the water near the surface down to a depth of about 5 metres during the night, but there were no signs of turnover." So, these East African lakes fulfil the definition of Whipple only partially as regards the question of continuous mixing throughout the year. Continuous mixing throughout the year is seen but is confined only to the upper layers. And complete mixing occurs when the wind is strong but is not present throughout the year.

Regarding the South Indian lake, it conforms completely to Whipple's definition. The bottom temperature is very similar to that of the surface and there is continuous mixing throughout the year. Since the lake is very shallow (about 25 feet) the entire body of the water gets heated up during the day and cooled during the night and behaves like the surface portion (upto 5 m.) of the East African lakes referred to above. The mixing is diurnal and continuous throughout the year. Owing to its wide area and shallow depth, a thorough mixing can also take place whenever the wind is very strong.

Coming to the lakes of the East Indies investigated by Ruttner, the bottom temperature recorded is very much above 4°C., the lowest bottom temperature recorded being 20·1°C (Ruttner 1931, p. 403). The bottom temperature is very near the surface temperatures, the difference being only 0·25°C to 5·5°C (Ruttner l.c.). So from the standpoint of temperature, these lakes can come under Whipple's third group. But as regards the question of circulation, complete mixing takes place owing to wind and cooling in the case of certain lakes like D. Bratan (Ruttner l.c. p. 392) and partial circulation only in others like D. Batur (Ruttner l.c. p. 397). But in lakes with less than 2 sq. Km. of surface area the wind cannot bring about the complete mixing of the waters below a certain depth from the surface. The mixing would be confined only to the upper portion of the lake. The diurnal heating and cooling also, as in the case of the East African lakes brings about a mixing of the surface layers upto a depth of few metres (about 5 metres) (Ruttner 1931, p. 221 and Table I). But a complete mixing from top to bottom will not be possible in a lake of this type at any time during the year. In these lakes a complete turn over is possible only if there is a possibility of the surface waters becoming cooler than the bottom layers at some time during the year. From the data given by Ruttner for his several lakes, it looks as though such an occasion never arises at any time during the year. If such should prove to be the case, a complete turn-over can never take place at any time in these deep lakes. Ruttner (p. 446) states "Es ist leicht moglich, daß sehr tiefe Seen nur selten bis zum Grunde durchmischt werden." This point has to be verified by further work viz. whether the surface layers in these East Indian lakes at any time during the year become cooled down to a temperature lower than that of the bottom.

So we can provisionally subdivide the third group of tropical lakes of Whipple as follows, basing, our classification upon the nature of their mixing:

(i) Lakes in which complete mixing takes place throughout the year. This is brought about by the daily heating and night cooling and may also be brought about by strong winds occasionally e.g., South Indian lakes.

(ii) Lakes in which complete mixing is seen only periodically i.e. during very windy seasons. In addition to this a partial mixing confined to the upper layers upto 5-7 m. brought about by the sun's heat during the day and cooling at night may be seen continously throughout the year, e.g. East African lakes and some lakes of Java (less than 5 sq. Km. in area) and D. Braten.

(iii) Lakes in which complete mixing never takes place at any time during the year. Mixing in these lakes is only possible and confined to the upper region and brought about (a) periodically by wind whenever it is strong and (b) continuously by the sun's heat and night cooling and confined to the surface layers upto about five metres depth as in (ii).

(iv) TEMPERATURE OF AIR, BRIGHT SUNSHINE, WIND, SURFACE AREA, DEPTH AND DISSOLVED OXYGEN.

Lakes receive their supplies of oxygen from (i) the atmosphere (ii) from the photosynthetic activities of chlorophyll bearing plants in the water; and (iii) from bacteriological denitrification. From the atmosphere the surface layers of water get oxygen by mechanical admixture of air through the action of waves, so that when the lake water is in complete circulation, the entire lake is saturated with oxygen in the above manner. During the process of photosynthesis, the chlorophyll-bearing organisms "diminish or deplete the supply of CO_2 and increase the oxygen content beyond saturation." A very small amount of oxygen which is practically negligible is added through bacterial denitrification.

The quantity of oxygen present at any time in the day is the resultant of several factors such as diffusion, photosynthesis, respiration, the chemical processes of decay and of reducing substances. (Carter 1936, p. 177). Now if the consumption of oxygen by various organisms present in water and by decomposition of organic matter exceeds the supply of oxygen derived from the photosynthetic activity of chlorophyll bearing organisms, then the amount is below the saturation point. But if the latter process exceeds that of the former than the water is saturated or supersaturated. (Brige and Juday 1912).

A general account of Oxygen distribution so far recorded in temperate and tropical lakes.

(a) Distribution in temperate lakes.—A brief review of the important literature on O_2 distribution of temperate lakes is given

below: Birge and Juday (1912), Juday and Birge (1932) found definite O_2 stratification in the summer months in the lakes of Wisconsin and New York. They found that the oxygen distribution at different layers i.e. (1) above the thermocline, (2) in the thermocline and (3) below the thermocline differed considerably. Above the thermocline i.e. in the epilimnion, the O_2 content was near the saturation point or sometime even super saturated; in the thermocline, there was a rapid decrease of O_2 or sometimes was higher than that found in the epilimnion; and below the thermocline i.e. in the hypolimnion, it was practically absent, or present in very small amount or fairly high but less than that found in the epilimnion. Bronstead and Wesenburg-Lund (1912, cited by Minder 1924) concluded from their study of Furesee that (i) the oxygen distribution was homogeneous at the time of complete circulation, and this condition was attributed to convection currents bringing about a mixture of all the different layers; (ii) that during stagnation in summer months, the O_2 content decreased towards the depth; and (iii) that the most important source of O_2 for a lake was what it got from the surface layers.

Thienemann (1918) found from his investigations of the O_2 conditions of the different north-German lakes in summer that a definite relation existed between the bottom fauna and the O_2 content of the bottom layer. He also found that in lakes with a bottom fauna containing predominantly chironomid Tanytarsus, a relatively greater amount of oxygen down to the bottom; and in the lakes with a bottom fauna consisting chiefly of chironomus larvae, the bottom layers were very poor in oxygen.

Thienemann (1914) has considered the relation of the total quantity of O_2 found in a lake to the amount required to saturate the water at all depths, and the difference between the two amounts is a measure of the deficiency or excess of O_2 in the different strata of a lake. The vertical distribution of oxygen and the deficits and excesses at the various depth are given by him. (l.c. Table III). It will be seen therefrom that the quantity of O_2 actually found at the different depths in the various series was below the theoritical point of saturation except in a few cases where the O_2 liberated in the process of photosynthesis in the region of the thermocline brought up the amount to the saturation point or higher. The deficiency in the several layers was due to the demand for O_2 in the respiratory processes of aquatic organisms and in the decomposition of organic matter.

(b) *Tropical lakes* have been studied by a few investigators—Fritsch (1907), Downes (1911, cited by Whipple et al, 1927), Ruttner (1931), Jenkins (1932), Worthington (1903), Hem Singh Pruthi (1933), Beadle (1932-34), Worthington and Ricardo (1936). Fritsch (l.c.) stated that the O_2 content of tropical lakes would be low considering their high temperature. Downes (l.c.) examined three reservoirs—Cocoli (9 ft.), Carabali (12 ft.), and Comache (26 ft.)—in the Panama canal region. He found 8.66 cc/l in the surface, 6·2 cc/l at 5 feet below, 0·8 cc/l at 7 feet below, and nil at 9 feet below the surface in Cocoli reservoir; in Carabali reservoir, O_2 was absent at a depth of 8 feet; and in Comache reservoir, it was absent at a depth of 14 feet.

Thienemann (1930) has stated that the deep tropical lakes are devoid of O_2 in their *hypolimnion.* Ruttner (1931) who actually investigated the lakes of East Indies has made a very valuable contribution to this *important problem of tropical limnology. His important* conclusions are detailed below.

(i) The oxygen curves of most of these tropical lakes resembled those of the eutrophic type of temperate lakes. Ruttner has given the following reasons for the presence of the eutrophic type and for the absence of the oligotrophic type of O_2 curves in them.

(a) Oxidation of organic and inorganic matter, respiration of animals—these processes by which O_2 was consumed took place in the entire depth of the water while the process of photosynthesis by which oxygen is supplied was confined only to the upper illuminated water mass.

(b) The vertical distribution of oxygen will therefore be dependent upon the quantity of oxidisable substances present in the lake water and on the rapidity of the oxidation process. The latter in turn was dependent upon temperature, and according to Vant Hoff's R.G.T. Rule the quickness of a reaction will be doubled or trebled with a temperature increase of 10°C. The bottom temperatures of tropical lakes is about 20°C higher than those of temperate lakes. This means therefore, that at the bottom of tropical lakes, oxidation process will be hastened at least four to nine times. If the oxidation process is hastened, then the concomitant oxygen consumption must be very great and result is the eutrophic type of O_2 curve. The O_2 stratification in the lakes of East Indies, therefore, is due to the great difference in the temperature in the tropholytic zone.

(ii) Ruttner found that a few days were sufficient to effect a sharply expressed O_2 stratification with the complete disappearance of oxygen at the bottom.

(iii) The lowest value observed by him was 61% saturation in the surface water of Ngebel-see. This figure did not represent the minimum occasionally reached in these tropical lakes, since he thinks that in some lakes much lower figures may be expected.

(iv) Supersaturation was generally very high and usually reached in the afternoons an extremely high figure. In one single instance, the value came up to the extremely high figure as 347%.

(v) During night time, a large portion of the O_2 was consumed by the respiratory process and very little was lost to the air.

(vi) Maximum amount of oxygen was not found at the surface but was a little below the surface as in lakes of the temperate region.

Jenkins (l.c.) found the surface water of lake Nakuru saturated to the extent of 113%, and the water at a depth of 1·75 m, only 18·2%. In the lake Elmenteita the percentage of saturation varied from 44·4% to 104·8%; and in Naivasha, from 40·7% to 86·9%. She concluded that "the comparative abundance of oxygen (see Table III) at all depths in these lakes may well be contrasted with the conditions in tropical swamps, since it cannot here, as there, be one of the limiting factors in distribution (Carter and Beadle, 1930, p. 249)".

Beadle (l.c.) obtained at station 30 in the Lake Naivasha at midday on 23-11-30, 5·46 cc/l; and at 18 m. depth, 3·54 cc/l; and on 26-2-31, 5·50 cc/l and 3·70 cc/l for the above. He has also remarked that the oxygen content from the surface to bottom was uniform at dawn and that at midday there was a considerable rise in that of the surface water to a depth of (probably) about 5 metres and that the surface water at midday was saturated to 94%.

The nature of the Oxygen distribution in the Red Hills Lake

From a study of the dissolved oxygen content in the several layers of the Red Hills Lake the following facts are noticed. In the early morning the entire vertical layer is homogeneous i.e. contains nearly the same amount of dissolved oxygen from the surface to the bottom; but as the day advances the surface layers contain slightly though definitely more oxygen than the bottom layers. This is illustrated by the data for January, February, March, April, July and August for 1934; and for January, February, April, June, August and October for 1935 (Table No. X Ganapati 1934, 1935), indicating the formation of a weak stratification. This is not permanent but is destroyed at night so that in the morning the values are the same from the surface to the bottom.

In the afternoons when a weakly expressed O_2 stratification is formed, the differences between the surface and bottom layers do not exceed 1 cc/l (vide Table No. X l.c.). These small differences may be due to two causes: (i) photosynthetic processes of the chlorophyll-bearing organisms resulting in increased oxygen content in the upper layers, and (ii) mixing taking place daily in the night effecting a uniform distribution of O_2 from the surface to the bottom. If daily mixing did not take place, and a stratification of long duration resulted in the Red Hills lake, one should expect a considerably greater depletion of O_2 in the bottom layers, so that the differences also will be considerably greater. Thus, the small differences between the surface and bottom layers in the Red Hills Lake and the relatively high O_2 content of the bottom layers are indirect proofs of the diurnal mixing which takes place at night (Beadle 1932-34), Worthington (1930), Worthington and Ricardo (1936) and Jenkins (1934).

Diurnal variations.—The maximum amount of oxygen in the surface layers is shown between 4 and 5 p.m., and the minimum at about 7 a.m., as will be evident from the data for diurnal variations on 31-3-34 and 2-4-34 (vide Table X l.c.) Similar results have been obtained by Hem Singh Pruthi (1933), and by M. O. T. Iyengar (1926 p. 1180). The former found the Calcutta Museum pond water to be below saturation in the morning, almost saturated at 10 a.m., and supersaturated at 12 noon and 4-30 p.m. and decreasing after 5 p.m. and reaching the minimum at 10 p.m. M. O. T. Iyengar found the O_2 content was lowest at 6 a.m., and that it reached its highest level between 3 and 4 p.m., in the afternoon and thereafter declined gradually till the lowest level was reached at 6 a.m., on the following day. So, the fact that maximum content of oxygen is being reached at about 4 p.m., in the afternoon and the lowest value being recorded at 6 a.m., are also shown by the Red Hills Lake.

The amplitude of diurnal variations in the O_2 content of the Red Hills Lake was small, i.e., 0·61 cc/l on 31-3-34. M. O. T. Iyengar also found similar small ranges (1·65—1·78 mg/l). It must however be pointed out that Pruthi found in the case of the Calcutta Museum pond water a greater difference between the minimum and the maximum amount of O_2 produced in the course of a day.

These diurnal fluctuations are due to a large extent to the photosynthetic action of the algal flora present in a piece of water. The greater the algal content, the greater the diurnal fluctuations, Butcher et al (1930). So, in the case of the Red Hills Lake, the small difference in the diurnal fluctuation only shows that the plankton algal population is comparatively very small.

Supersaturation in the lake water.

The quantity of oxygen found at different depths in the Red Hills Lake was also below the theoritical point of saturation except in a few cases where the O_2 liberated in the process of photosynthesis brought up the amount to the saturation point or slightly higher as in the case of the temperate lakes. A small or only slight supersaturation (109%) was noticed in January, February, and October 1935. This slight supersaturation indicates again that the lake does not support a vast growth of algae. The quantity of oxygen in the several layers on other occasions was less than the theoritical point of saturation; and this deficiency is to be ascribed to "the demand for O_2 in the respiratory process of aquatic organism and in the decomposition of organic matter" (Juday and Birge 1932).

Another interesting feature noticed in the Red Hills Lake is that the O_2 content was always lowest in the second half of the south-west monsoon season i.e. in August or September. At this part of the year the velocity of wind was low and the organic content of the lake water has been found to be at its maximum and the duration of bright sunshine was less. This is most probably due to the using up of the oxygen by the fairly large quantity of organic matter present in the water at this part of the year for oxidation purposes (Pearsall, 1923, p. 53 Juday and Birge l.c.). The oxygen content was highest in May, when the duration of bright sunshine was longer, velocity of wind higher and temperature also higher. It was also high during the last quarter of each of the 3 years. This was due to fall in temperature of air and water which increases the solubility of oxygen, brought in from the atmosphere.

Relation between the vertical distribution of oxygen and the vertical changes in temperature of the Red Hills Lake.

A definite relationship has been established between the vertical distribution of O_2 and the vertical changes in temperate lakes during summer months. Thermal stratification was almost always accompanied by oxygen stratification (Thienemann 1925). Ruttner (1931) has also made a similar statement in the case of the tropical East Indian lakes. In the case of the Red Hills Lake also we find a definite relationship between the two. A temporary thermal stratification is noticed bv the afternoon and this is accompanied by a temporary stratification of O_2 also, as in the case of the East African lakes (Beadle l.c.)

Classification of the Red Hills Lake based upon its oxygen Conditions.

Thienemann (1914) classified the lakes of the Eifel district, Germany, on the basis of their thermal and oxygen relations in summer. He differentiated the following three groups. In the first group of lakes the three strata of varying temperatures e.g. the epilimnion, thermocline and the hypolimnion are present but the oxygen curve does not correspond with that of the temperature. In the second group, the three thermal strata are present but here the oxygen curve follows generally that of the temperature.

In the third group, no definite stratification is seen, the temperature being more or less uniform throughout. In these lakes the O_2 content also is uniform and shows no stratification.

Thienemann later on in 1920 rejected the third group and retained the first two groups. In 1928, he explained the scope of the two groups of lakes in still greater detail and while doing so, pointed out that all oligotrophic lakes would come under the first group and all eutrophic ones under the second.

Ruttner (1931) classified the lakes of Java, Sumatra and Bali into three groups on the basis of their oxygen conditions. The O_2 curves in these lakes generally followed that of the temperature in the three groups.

The first group consisted of all small lakes below two sq. Km. In this group there was a pronounced thermal stratification with a sudden fall in the thermocline region. Here the O_2 curves were nearly similar to the thermal curves. The surface layer was nearly saturated with oxygen, but lower down there was a gradual decrease and in the thermocline region there was a sudden fall. It was very poor in the hypolimnion being present only in traces or even entirely absent.

The second group consisted of the great lakes of the middle and south Sumatra of about 100 sq. Km. (excepting Tobasee). The epilimnion of these lakes extending upto a depth of 10 m. contained high values for O_2. In their thermocline, the fall of oxygen was more gradual and less steep than in the case of the first group and continued into the hypolimnion where it disappeared at a depth of 100 m, so that there is a general similarity between the oxygen and temperature curves. But the fall in O_2 is not so deep as in the first group owing to the greater surface area of these lakes and the consequent exposure of water to the mixing effect of wind.

The third group of lakes of more than 1000 sq. Km. area is represented by the two great Toba-basins of North Sumatra where the epilimnion extended down to a depth of about 30 metres and the thermocline was less marked and its lower limit could not be sharply differentiated from the deep hypolimnion. The oxygen conditions were also similar. The thick epilimnion extending to a depth of 30m. was saturated with oxygen. In the thermocline below the 30 m. layer the fall of oxygen was very gradual and merged into the hypolimnion where even at a depth of 425 metres zero value for dissolved oxygen was not reached.

As regards the Red Hills lake, it does not come under any of the above classifications. The thermal and oxygen conditions though similar are rather peculiar. A definite thermal stratification is observed in the lake but it does not remain undisturbed for a long time like those of the temperate region or of those of the East Indies. It does not, in fact, last continuously even for a single day. In the early morning there is no stratification, but as the day progresses, *a fairly* well expressed stratification is formed in the hot part of the day and is destroyed in the night. In the same way, there is a temporary oxygen stratification formed in the Red Hills Lake, which is daily formed in the afternoon and destroyed in the night. In the early morning the O_2 content of the several layers is the same, and as the surface layers get heated, the O_2 content also increases resulting in a fairly well expressed O_2 stratification, so that the temperature and oxygen curves resemble one another.

In Griffith's (1936) pool also which shows similar temperature conditions as those of the Red Hills Lake, the O_2 conditions are also similar.

(v) Temperature, Bright Sun-shine, Wind, Surface Area, Depth and Carbonic Acid.

Carbonic acid occurs in natural waters as free CO_2, or chemically combined with alkaline earth and alkaline metals. The latter is found in two different conditions: as "bound" CO_2 (mono. carbonates) and "half bound" CO_2 or bicarbonates. All the three forms are of great significance in the biological economy of lake waters. The free CO_2 is used by plants in water during photosynthesis. When all the available "free" CO_2 is used up, the "half-bound" CO_2 (from 4/5 to 5/8) is then attacked and utilised (Brige and Juday 1912). When the first two sources are exhausted, the fully "bound"

CO_2 (or monocarbonates) may be utilized (Schutow 1926, Maucha 1929, Neresheimer and Ruttner 1929—cited by Juday et al 1935).

(*a*) Free CO_2 was not found at any time and in any of the samples collected from different depths during 1934 and 1935. It was, however, observed once on 23-12-33.

The absence of "free CO_2" may be due to (a) photosynthesis (b) marl-forming organisms (c) agitation of water and (d) evaporation of water taking place in the Red Hills Lake (Welch 1935). During photosynthesis which takes place almost throughout the year by chlorophyll-bearing plants, consumption of free CO_2 takes place (Juday et al 1935, p. 6, and Ruttner 1931). Hence free CO_2 is absent. Its absence may also be due to the activity of marl-forming organisms, which are also present in the Red Hills Lake. The several groups of organisms concerned in marl-formation are bacteria, algae, mussels, chara, higher plants and plankton organisms (Welch 1935, pp. 176-182). The sandy, wind-swept beaches of the Red Hills Lake contain marl; the incrustations on the wave beating region of the laterite bund, and on pebbles in the sandy beaches of the lake contain fine calcium carbonate incrustations. Also, chara and higher plants like Najas, Potomogeton etc., are covered with marl incrustations. This is inferred by the evolution of CO_2 when hydrochloric acid is added to these incrustations.

The third factor which is responsible for its absence is the agitation of water, caused by wind action which is very effective in getting rid of "free CO_2 and finally, on account of evaporation, there is probably also loss of half-bound CO_2 resulting in precipitation of monocarbonate. "This form is greatest in shallow lakes of large area where evaporation is most effective" like the Red Hills lake. Welch (1935).

(*b*) *Distribution of carbondioxide, bicarbonates and carbonates in temperate lakes*

A brief review of the distribution of the three forms of carbon dioxide in temperate lakes especially at the time of their thermal stratification during summer is given below. Birge and Juday (1912) found definite stratification of free CO_2 in the Finger lakes of New York during periods showing thermal and oxygen stratification. They found that (i) the free CO_2 was absent in the epilimnion; was present in fairly large amounts in the thermocline and in abundance in the hypolimnion; (ii) a very small quantity of the bicarbonates was present in the epilimnion, a fairly large amount in the thermocline and a still greater amount in the hypolimnion;

(iii) the carbonates were present in the epilimnion but were absent in the thermocline and hypolimnion.

As regards the general alkalinity of the water, they found that this was not uniform throughout but was greatest near the surface and gradually decreased downwards. They attributed the high degree of alkalinity of water in the epilimnion to several factors such as the free exposure to the atmosphere, the absence of much decomposition, the photosynthetic activity of the plankton algae present and the amount of sunshine available. The low degree of alkalinity in the hypolimnion was attributed by them to the presence of the large quantity of the precipitated, dead planktonic forms and the consequent increased decomposition of organic matter. The thermocline shows conditions approximately intermediate between those of the epilimnion and hypolimnion.

In the lake waters of north-eastern Wisconsin, Juday et al (1935, pp. 15-27) found that the vertical distribution of free CO_2 and the carbonates was as follows: The free CO_2 was almost uniformly distributed from the surface to the bottom in the shallow lakes of 6-13m depth, the uniformity being due to these lakes being subjected to considerable wind action. (ii) " A rather large variation in the free carbon dioxide content of the lower water was found in lakes ranging from 15 to 20 m in depth." (iii) A more marked increase in the quantity of free CO_2 in the hypolimnion than in the epilimnion was found in lakes of more than 20m. depth and (iv) in a few lakes there was a smaller amount in the thermocline than either above or below this stratum.

As regards the carbonates, some lakes showed uniformity of distribution throughout the several layers, while in others a definite difference was noticeable between the upper and lower layers. According to them (Juday et al l. c.) these lakes could be classified under "seepage" lakes as the differences between the surface and bottom values were not so great as in the case, of the " drainage " lakes. They also found that the surface layers in drainage lakes had larger quantity of carbonates than the bottom layers. It must, however, be pointed out that in the case of shallow lakes (6-13 m) the carbonates were uniformly distributed from the top to the bottom. This was due to the mixing effect of wind action.

(c) *Distribution of carbondioxide, bicarbonate and carbonate in tropical lakes*

Several tropical lakes have been studied by Ruttner (1931, a, b), Jenkins (1932), Beadle (1932-34) and Worthington (1932) with regard to these factors. Ruttner (l.c.) found distinct stratification of carbon dioxide in the lakes of the East Indies. He found that there was stratification in "free CO_2" and that it was essentially similar to what Birge and Juday found in the North American lakes and to what Bronstead and Wesenberg-Lund found in European waters. He found that it was absent or present only in extremely small quantities in the surface layers, but that it increased gradually in quantity downwards. The absence of free CO_2 in the surface layers was attributed to the assimilatory activity of the plankton algae, and the gradual increase of CO_2 in the thermocline and hypolimnion to respiration of the organisms there and to the decomposition of organic matter. A close relationship was found to exist between their bicarbonate content and the geological character of their drainage basin. In most of the lakes, the bicarbonate content was found to be greater in the hypolimnion. The increase was attributed, just as in the case of temperate lakes, to the dissolution of the precipitated calcium carbonate by the accumulated free CO_2 present in the hypolimnion.

Beadle (l.c. p. 200) has found the alkalinity of the water of the lake Edward for example to increase from the surface downwards to about 70 metres or so, though there was practically no change in the alkalinity below that range.

(d) *Red Hills Lake*

In the case of the Red Hills Lake the vertical distribution of carbonates and bicarbonates was not the same in each month; its character though varying from month to month was not specially distinguishable for each period of the year. They were found either to decrease or increase or homogeneously distributed from the surface to the bottom or were present in larger amounts in the intermediate layers than those of the surface or bottom. This variation in the character of their vertical distribution is probably to be ascribed to the shallowness and the meteorological conditions prevailing in the lake.

(e) *Relation between the vertical distribution of carbonates and bicarbonates and the vertical thermal changes in the Red Hills Lake.*

A definite relation has been established between the vertical distribution of carbonates and bicarbonates and the vertical changes in temperature of temperate lakes (Birge and Juday l.c., Juday et al l.c.) and of tropical lakes (Ruttner l.c., Beadle l.c.) during the summer months. "The character of the vertical distribution is dependent to a large extent upon the thermal stratification which in turn depends chiefly upon the depth and area of the lake." (Juday et al p. 23 l.c.). In the case of the Red Hills Lake, a temporary thermal stratification is formed in the afternoon but this is not always accompanied by a gradual decrease of the carbonates and an increase of the bicarbonates from the surface downwards, as in the case of the temperate and tropical lakes cited above. The carbonates were found to increase or to decrease from the surface to the bottom or were found homogeneously distributed throughout from the surface to the bottom. Therefore, both the carbonates and bicarbonates do not exactly follow the thermal changes in the water. Similar cases have also been reported in temperate lakes. Juday et al (l.c.) themselves found in certain lakes a uniform distribution of bound carbondioxide e.g. in Beak Lake which is very shallow and so did not show any thermal stratification. On the other hand, they found the same to be the case even in crystal lake which is deep enough to be thermally stratified.

As regards the bicarbonates they found that (i) they were not uniformly distributed from the surface to the bottom in lakes of 6 m depth; (ii) they were found to increase near the bottom in lakes of 6 to 13 m depth, which showed a slight thermal stratification *e.g.*, Dorothy Dunn lake; (iii) a large variation of the lower water was found in lakes ranging from 15 to 20 m in depth, *e.g.*, Carr and Crystal lakes; (iv) a smaller amount in the thermocline than either above or below this stratum, *e.g.*, Anderson, Paliette, and Silver lakes. These decreases in CO_2 content of the water in the thermocline were due to the photosynthetic activities of the phytoplankton of this stratum.

All the four types of vertical distribution cited by Juday et al in the different lakes of the north-eastern Wisconsin have been recorded by me in the Red Hills Lake during the different seasons of 1934 and 1935.

Taking all the three items, free CO_2, bicarbonates and carbonates in the Red Hills Lake, there does not appear to be any relationship between these and of the thermal stratification when that is most pronounced.

Juday et al (1935, p. 6) found that the surface water was alkaline to phenolphthalein in all the " drainage " lakes investigated by them. They state " This alkaline reaction to phenolphthalein was due to photosynthetic activities of the various aquatic plants, chiefly to phytoplankton forms; these organisms removed some of the half-bound carbondioxide from the bicarbonates during process of assimilation, thus leaving a certain amount of normal carbonate in the water, which gave it an alkaline reaction." The lake under investigation (the Red Hills lake) is a "drainage" lake. It is very interesting to find that in this lake also the surface waters are alkaline to phenolphthalein at all seasons.

(vi) Temperature, Bright Sunshine, Wind Surface Area, Depth and pH.

From a study of the literature available on the subject, it is found that natural waters show a wide range in pH from pH 1·4 to 12·0. "Jewell and Brown (1929) obtained readings of pH 3·3 on the waters of pools in the Sphagnum Margin of Michigan bog lake and Skadowsky (1926) reported readings pH 3·4—3·8 for waters of some Russian bogs. Ström (1925) reported readings as low as pH 3·8 in the waters of peaty bogs of Norway. Yoshimura (1933) obtained a reading of pH 1·4 in a Japanese lake which received water from a volcanic region and the sulphate content of the lake water was 174 mg./l." (Juday et al 1935). Ueno (1934) has reported a pH value of 3·0 for a brook in North Shinano, Japan, which contained a large quantity of sulphuric acid.

All these records have been made on the water of temperate lakes only.

As regards the pH values recorded so far for tropical waters the pH values of the South African lakes range from a minimum of 3·7 to a maximum of 9·8 (Hutchinson et al 1932). Jenkins (1932, p. 547) has recorded values ranging from pH 8·3 in lake Naivasha to pH 12 in the lake Nakuru of the Rift Valleys in Kenya. Hem Singh Pruthi (1933) obtained a range of 7·4—9·0 for the pond water in the Calcutta museum.

A study of the seasonal and vertical changes in the pH values of the Red Hills lake shows that the lake water is definitely alkaline, the range varying between 8·4 to 8·9. In 1933 alone the lower limit reached was 7·7 due to heavy rainfall (Welch 1935, p. 114). Among the tropical lakes in this respect, it resembles the lakes of East Indies which have been stated to be definitely alkaline and above pH 8·0 (Ruttner l.c.).

(*a*) *Stratification in pH*

A few recorded instances of pH stratification in tropical lakes is given below:—Graham (1929, cited by Ruttner 1931) found in the Lake Victoria significant differences between the surface (8·5) and the bottom (7·4). In the lakes of Java, Sumatra and Bali, Ruttner (l.c.) found that the pH values of the surface water in almost all lakes was above pH 8·0 and those of the bottom layers varied from pH 7·2—7·4, showing distinct stratification.

Uniformity in pH values in all the layers (pH=6·8) was observed only in Danu Bratan in Bali by Ruttner (l.c.). This condition was attributed by him to complete overturning and circulation.

In the case of the Red Hills lake, uniformity in pH values was noticed from the surface to the bottom in all the months during 1934 and 1935, although on all these occasions a very weakly expressed thermal, and oxygen stratification was present. This might appear rather strange, for in almost all cases where thermal and chemical stratification (in O_2 and bicarbonates) have been reported, stratification in pH values also have been recorded. For example, in Plonersee, Wiebe (1931), Juday et al (1935) in Wisconsin lakes have found thermal stratification always being accompanied by chemical stratification also (in O_2, bicarbonates, pH etc.). In the latter case, the differences have varied from 0·2 to 2·8 pH units. (Juday et al l.c.). So, the absence of such a phenomenon in the lake under investigation is most probably due to very small differences (less than 0·2 unit) in the values which cannot be easily determined with the help of the Hellige comparator used in these studies. Gessner (1932) has come to a similar conclusion when using the Hellige comparator for pH estimations.

(b) *Diurnal variations in pH values*

Diurnal variations in the pH values of the surface water in lakes have also been recorded. A difference of 2·6 units (Skadowsky, l.c., cited by Juday et al 1935) was noted in some of the surface waters of lakes near Moscow, and of 2·45 units (Philips, l.c. cited by Juday et al 1935). Butcher et al (1930) found the pH values to be minimum during the hours of darkness and maximum at the time of the maximum oxygen content. Birge Juday (1911) on the other hand found no diurnal variation in Lake Mendota. Worthington (1930) found a change from 7·95 to 8·7 in the Lake Victoria; and Pruthi (1933) from 7·8 to 9·05 units in the Museum pond, Calcutta. The latter found that it was low in the morning and maximum in the afternoon, and had decreased after 5 P.M. He has also stated that this diurnal difference was "bigger" than that recorded so far in the case of any tropical water. He has stated further that the diurnal changes in pH of temperate waters is much less. But this appears to be incorrect according to Skadowsky and Philips, cited above. Variations in pH on the same day are noticed usually in ponds and pools which are fully protected and which contain plenty of aquatic vegetation, but in the larger bodies of water, they cannot be so easily detected (Welch 1935, p. 114). The latter's observations appear to be confirmed in the case of the Red Hills lake. Though observations on diurnal changes in pH values were not made, they have been made at different times of the day on different dates in different months and in one case in the same month. Thus, the pH value of the surface water at 6·14 A.M. on 3-4-34 and at 1·0 P.M. on 29-4-34 was 8·3 (Table XII, Ganapati 1934) showing that there was practically no diurnal changes in pH. This conclusion is also supported by Beadle (1932-34, pp. 179 & 188) who found in Lake Baringo a change of 0·1 only from 6-30 A.M. *(8·7) to 12-30 P.M. (8·8 pH) ; and 0·2 unit only from 12 midnight* (9·4) to 12 midday (9·6) in Lake Rudolf. Or it might be due to the apparatus, used, as has been stated previously.

(c) *A Brief Review of the Factors influencing pH*

The important factors which regulate the reaction of natural waters are (i) CO_2, (ii) carbonates of calcium, magnesium, sodium and potassium, (iii) salts of strong acids and weak bases, and (iv) humic acids.

(i) *Carbonic acid.*—Carbonic acid is a weak acid and its mode of formation has been explained already. Its quantity is responsible to a large extent for the changes in the chemical condition of the water. These changes are brought about by the withdrawal of CO_2 by various causes mentioned before. So, the effect of CO_2 upon the pH value of natural waters is to increase or decrease the value. Neresheimer and Ruttner (1929), Wiebe (1931), Maucha (1929) and Schutow (1926)—all cited by Juday et al (1935) have shown that if both free CO_2 and bicarbonates are entirely used up, the assimilation does not stop at least with the higher water plants as they use " bound " CO_2 or monocarbonates. Above a pH value of 8·0 there can exist no " free " CO_2 in water (Smith).

In the case of the Red Hills Lake, free CO_2 has not been detected excepting on one ocassion i.e. on 23-12-33. The presence of free CO_2 is attributed to heavy rainfall in that month, so that the pH value also was as low as 7·7. On all other occasions, when free CO_2 was absent, the pH values were higher and ranged from 8·4—8·9. Its absence indicates that either it is used up as soon as it is formed or the amount that is regenerated is not sufficient to convert all the monocarbonates into bicarbonates. So, "free" CO_2 by itself does not seem to be an important factor in influencing the reaction of the Red Hills Lake water.

(ii) *Carbonates of calcium, magnesium, sodium and potassium:*—Calcium carbonate in the form of pure calcite gives a limiting value of pH = 9·0. Atkins (1919-22), Moore et al (1921) have shown that sea water may become as alkaline as pH = 9·7 as a result of very active photosynthesis. This is due to the presence of magnesium salts since the limiting pH value of magnesium carbonate is 10·0, the same as for $Mg(OH)_2$. Values between 10 and 12 obtained with the lake waters such as those situated in the Rift Valley in East Africa are due to the presence of sodium carbonate derived from the volcanic rocks of their respective drainage basins (Jenkins 1932, Beadle 1932-34).

In the case of the Red Hills lake, the pH values range generally from 8·4—8·9. This indicates therefore the presence of the salts of calcium in greater amounts than those of magnesium; sodium, and potassium are present in the Red Hills lake water. This conclusion is further borne out by the results contained in Table No. XI Ganapati (1934, 1935).

(iii) *Salts of strong acids and weak bases:*—For those lake waters in which the pH value is less than 6·0, the presence of strongly dissociated acids or salts of strong acids and weak bases with small amounts of buffer salts or humic acids is indicated Hagland (1912 cited by Lonnerblad 1931) and Schaperclaus (1926) have attributed the low pH values to the presence of free sulphuric acid in the waters examined by them. Strom has obtained values lower than 4·0 for Norwegean waters and attributed the figures to the presence of humic acids (cited by Lonnerblad 1931). Yoshimura (l.c.) and Ueno (l.c.) have obtained pH values of 1·4 and 3·0 respectively and have attributed the low figures to the contamination of these waters with sulphuric acid. "Water in the outlet of a thermal spring in Japan has been reported to have a pH of 2·2" (Welch 1935). "In general however, readings below pH 4·0 are not found in natural waters except under extreme bog conditions or in cases of pollution with mineral acids" (Juday et al 1935).

Red Hills lake water is not contaminated with waters containing strong acids like sulphuric acid, and therefore is always distinctly alkaline.

(iv) *Effect of Humic acids:*—Most bog lakes are acid in reaction due to the presence of humic acids, and Oden (1922) has established a pH value of 4·5 for this effect. So humic acids are absent in Red Hills lake.

Relation between the vertical changes in pH and the thermal changes in the Red Hills Lake

Usually in all temperate lakes in the summer months, when there is thermal stratification, it is always followed by stratification in chemical conditions such as dissolved oxygen, carbonic acid, pH etc. A few examples in support of this are the Wisconsin lakes of United States, Central European lakes etc.

In the case of tropical lakes also, a similar relationship has been recorded. Jenkins (1932, p. 457) found in Lake Nakuru a fall in pH from the surface (12·0) to a depth of 1·75 m (10·1); Beadle (1932-34) found in Crescent Lake at midday a fall of 1·3 pH units from the surface (9·1) to a depth of 18 metres (7·8) on 23-11-30; and a fall of 0·1 unit from the surface (8·5) to the same depth (8·4) on 26-2-31. Ruttner (l.c.) also has recorded similar relationship in the lakes of East Indies. Worthington (1930, p. 336-337) found a stratification in pH which was dependent upon the thermal stratification in the Kairrondo gulf in the Lake Victoria. The pH value of the surface water was found to rise from the morning till the afternoon and to decrease after 3 p.m. till next morning corresponding to the rise and fall in the case of temperature. Worthington and Ricardo (1936) found an intimate relationship between the temperature and pH values in the deeper portions of the East African lakes. The temperature and pH values showed temporary stratification upto a depth of about five metres by midday and mixing till that depth only by night.

In the case of the Red Hills Lake, there is a temporary thermal stratification by the afternoon, but it is not accompanied by definite changes in pH. This might probably be due to the shallowness and vast surface area of the lake, which prevents the development of a thermocline.

Classification of the Red Hills Lake based upon its pH values.

Birge and Juday (1911) consider lake waters acid if they contain more carbonic acid than is necessary to convert the carbonates into bicarbonates. But waters which are acid to phenolphthalein show an alkaline reaction with methyl orange. Discrepancies of this kind have been removed by the use of the more exact methods which have been recently introduced for determining the hydrogen ion concentration of water. pH values of lake waters have been used as basis for classification of lakes. Wehrle (1927) divided lakes and ponds into four groups: — (i) those with very acid waters which are buffered by salts of humic acids; (ii) those with moderately acid waters, weakly or not at all buffered; (iii) those waters showing in summer a diurnal variation between an alkaline and a moderately acid reaction; and (iv) those with a permanently alkaline reaction. According to the above classification, the Red Hills Lake will come under the fourth group of Wehrle's as its water is permanently alkaline (pH 8·4-8·9).

Fritsch (l.c.) has briefly summarised the relation between hydrogen ion concentration and the chief types of water as observed by other workers as follows:—"Naumann (89, p. 302) emphasises that neither in oligotrophic nor in eutrophic lakes are any marked extremes of hydorgen ion concentration to be observed, so that the conditions admit of the development of a large diversity of organisms, and other factors than pH determine the quality of the phytoplankton (and no doubt of the algal flora generally). In eutrophic lakes, however, there is a marked difference of pH between the upper and lower layers of water (12, p. 34). According to Skadowsky (124, p. 114) also the pH is very constant in deep lakes with hard waters and in acid waters. He points out that in eutrophic waters the variations in pH are the greater, the smaller the concentration of dissolved salts and the shallower they are, and both he and Naumann (89, p.302) ascribe this to the high plankton productivity. The influence of the latter on the reaction of the latter type evidently varies with its nature, the highest degree of alklinity being produced by a Myxophyceous plankton." In the Red Hills Lake also which approaches the eutrophic type of lake marked extremes of hydrogen ion concentration are not noted as the range is only between 8·4 and 8·9. But, unlike the eutrophic type of lakes referred to by Fritsch, in the Red Hills Lake, there is no difference between the surface and the bottom layers since no stratification in pH value is seen.

Juday et al (1935, p. 5 & 47) classify lakes of the North-eastern Wisconsin into two groups: "seepage" and "Drainage". Seepage lakes are "those bodies of water which have temporary or permanent outlets." They state that "the seepage lakes, in general, contain a smaller amount of dissolved inorganic substances which will serve as buffers than the drainage lakes, and that this produces a characteristic difference between the two types with respect to their hydrogen ion. Their pH results show the characteristic difference between the two types of lakes. Generally speaking, the pH values of the surface waters of the majority of the seepage lakes range from 4·4 to 6·5; while those of the drainage lakes range from 6·6—8·9 (Juday et al, 1935 p. 47).

In the case of the Red Hills Lake, which constitutes an intermediate type in as much as it has got both an inlet and several outlets all through the year, the pH values (8·4—8·9) of the surface water approach those of the "drainage" type referred to above.

(vii) RAINFALL, TEMPERATURE, GEOLOGICAL CHARACTER OF THE CATCHMENT AREA, DEPTH AND PHOSPHATES (P_2O_5)

The major portion of the phosphates found in fresh waters is derived by the leaching action of chemicals from the surrounding land after each rainfall. A small portion is also obtained from the decay of plants and animals.

They occur only in very small quantities and are found in two states. (i) organic and (2) inorganic. In the former case, *the phosphorous is found in combination with the organic materials* in the water such as the dead material of the plankton and other organic debris, and "a certain part of it may consist of dissolved *phosphorous that is not in a pentavalent state*" (Juday et al 1927). In the latter case, it is found commonly as phosphates of sodium, potassium and ammonium and their double salts (Kenwood 1930). *These salts are in a state* of solution and are readily available for plants in the water. A certain portion of this is usually lost from the main body of the water by being absorbed by the bottom deposits (Black 1929).

It is very interesting to note that though the water of the Red Hills Lake was examined for phosphates every month during a period of two years, on not even a single occasion phosphates were found at any portion of the lake.

The experience of other workers with the temperate and tropical waters has been found to be as follows: Some have established a seasonal variation in the quantity of phosphorous while others have not found any such correlation.

Range of variation in temperate lakes.

MacHargue and Peter (1921, cited by Juday et al 1927) found that the soluble phosphate content varied in the springs, streams and rivers of U.S.A., and that it depended upon the nature of the geological strata. Clark (1924) found that it varied from a mere trace to 0·133 mg/1 in the river and lake waters of the U.S.A. Atkins (1923-1925b) found in the natural waters and reservoirs of England, Scotland, extremely small quantities of soluble phosphates (less than 0·05 mg/1) and that anything above 0·5 mg/1 was indicative of sewage pollution.

dissolved in the upper layers and the diatom growth. In Lake Wingra, the correlation between the two was not so marked (Tresler and Domogalla 1931). Atkins and Harris (1924) have shown that the content of silicates of fresh waters varies with rainfall and that an increase of temperature and alkalinity favour the solution of silicates in suspension. Pearsall (1923b) has stated "The presence of considerable amounts of organic matter is understood to imply the appearance of large proportions of dissolved silica, though the connection if any is not understood." Yoshimura (1930) found in 10 waters of Japan a variation of 3·3 to 57·5 mg/l and in most cases it was found to increase with depth.

(b) *Tropical Lakes.*—A maximum value of 41—69 mg/l was obtained by Jenkins (1932) for the water of the Lake Naivasha in June 1929. Beadle (1932-34) found an apparent decrease of silicates with an increase of alkalinity in the Rift Valley lakes of East Africa. This is apparently a contradiction to what has been observed in the case of the temperate lakes (Atkins and Harris l.c.) But Beadle attributes his observation to errors in the existing technique for the estimation of silicates in the highly alkaline waters of the type he has met with in East Africa.

The experience of Ruttner (1931) was different in the case of the lakes of East Indies. He found it to vary from a minimum of 1 mg/l in Danu Bratan to a maximum of 97 mg/l in Ranu Klindungen. In the latter lake, he found the silicate content to increase with depth. In Tjigambong he found the silicates to decrease with depth. and in the lakes Bratan, Batur, and Toba to be nearly homogeneously distributed.

In the South African pans and lakes, Hutchinson et al (1932) found the silicates to vary from a minimum of less than 1 mg/l to a maximum of 30 mg/l.

(c) *Red Hills Lake.*—The silicate content is not so great as that recorded for the highly alkaline lakes of East Africa. But it resembles the values recorded for those of Lake Toba North (Ruttner l.c.)

As regards the vertical distribution, three types have been recorded during the course of a year; (i) uniform distribution from the top to the bottom as in Danu Bratan (Ruttner l.c.) (ii) increasing with depth as in Ranu Klindungen (Ruttner l.c. and Yoshimura l.c.) or decreasing with depth as in Tjigombong (Ruttner l.c.)

There was no general correlation of silicates with temperature or season or with depth in the Red Hills Lake.

(ix) Rainfall, Temperature, Bright Sunshine, Geological Character of the Catchment Area, Surface Area, Depth and Nitrogenous Compounds.

Lakes obtain their nitrogenous substances from rivers or streams flowing into them, more from their catchment area if it is composed of inhabited and agricultural lands than from a wild unsettled area, from the decomposition of organic material and excretions of aquatic animals. They occur in varying amounts in different waters and also vary with the seasons, the amount of pollution and the abundance of plankton life. They occur in two forms: organic and inorganic. *Organic nitrogen* is found partly in suspension and partly in solution. *Suspended organic nitrogen* is that which is found in the millions of bacterial cells, in the phyto-and zoo-plankton and other floating organic materials in water. These can be easily separated from water by filtration or centrifuging. The soluble organic nitrogen (in true and colloidal solution) results from the decomposition of dead organic matter by bacterial action; and from excretions of aquatic animals.

The inorganic form of nitrogen consists of ammonium salts, nitrites and nitrates. Free ammonia or ammonium salts result from the decomposition of organic matter by saprophytic bacteria and from free ammonia and ammonium salts result nitrites, and then nitrates by the action of nitrifying bacteria. Free nitrogen and ammonia can be formed by the action of denitrifying bacteria on nitrites and nitrates. Therefore the total quantity of inorganic nitrogenous compounds will be dependent upon the proportion of nitrifying to those of denitrifying bacteria.

(*a*) *Distribution of nitrogenous substances in temperate lakes.*—Very valuable work has been done upon the Wisconsin lakes by Peterson et al (1925), Domogalla et al (1925, 1926). They estimated quantitatively twelve different forms of nitrogen; and established a seasonal variation in their quantities. Tressler and Domogalla (1931) found that the ammoniacal nitrogen followed the nitrate nitrogen in a general way; the latter was higher in winter than in summer, and was also found to vary inversely with organic nitrogen. Organic nitrogen was found in maximum in spring and summer when vegetation was abundant. In other Wisconsin lakes nitrites and nitrates were found in traces or were absent completely (Progress Biol. Inq. 1926).

Pearsall (1921a) has correlated the nitrate content of lake waters with the nature of their drainage basins. He found that in the case of the English lakes, those with rocky drainage systems and shores have relatively low nitrate maxima and the other lakes which have a greater proportion of soil on their basins have higher nitrate maxima. He concluded therefore that the nature of the drainage systems plays an important role in developing the nitrogen reserve in lakes.

(b) *Distribution of nitrogenous compounds in tropical lakes.*—As regards ammoniacal nitrogen, Ruttner (1931) found that it was present in largest amounts at the bottom layers but that it gradually decreased upwards and was almost completely absent in the surface layers of deep lakes.

As regards the records for the presence of nitrites and nitrates in the tropics very little is known. Hutchinson et al (1932) state that nitrites were found in traces in all the pans and lakes of South Africa. Beadle (1932-34) found traces or nil of nitrites and nitrates in the Rift Valley lakes of East Africa.

(c) *Red Hills Lake.*—In the case of the Red Hills Lake, albuminoid nitrogen alone was found to show seasonal variations as in temperate lakes. It was found to be higher in the hot weather and south-west monsoon seasons than in the north-east monsoon or cold weather periods. This finding is in agreement with that of Tressler and Domogalla (loc. cit.)

As regards the other three forms of nitrogen, while in all temperate lakes they have either been found in varying amounts in the different seasons or to be found in traces or absent, it is rather surprising to find only traces of ammoniacal nitrogen and a total absence of nitrites and nitrates in this case. The lake is a very shallow one and the phytoplankton is fairly evenly distributed from the surface to the bottom layers. The phytoplankton readily utilised any available nitrogen that may be present in the water. This process probably takes place during their photosynthesis which must naturally be very active owing to the strong tropical illumination and also its longer duration in the tropics (Atkins 1932-33).

In the deeper tropical lakes such as those of Sumatra, Java and Bali investigated by Ruttner (l.c.) the amount of ammoniacal nitrogen increases downwards—probably on account of the deeper layers not receiving as much illumination as the upper layers and the consequently less photosynthetic activity. Again the quantity of phytoplankton also decreases downwards according to this author (Ruttner 1931 b), meaning thereby less photosynthetic activity there. These facts are probably responsible for the nitrogenous compounds being utilised in the upper more illuminated layers and being less utilised in the deeper and less illuminated layers.

A second factor may possibly also be at work. It is just possible that the absence of nitrites and nitrates is due to the activity of the denitrifying bacteria. The studies of Drew, Macclendon (cited by Pia 1934), Atkins (1926-27), Harvey (1926, '28) and Cooper (1937) for sea water show that denitrifying bacteria thrive more richly in the warm seas than in the cold seas. These bacteria are very active at higher temperatures (27°—30°C) or slightly more but are not so active when the temperature is below 15°C (Pia 1934). The presence of nitrites and nitrates in the temperate waters is probably to be ascribed to the lower temperature of these waters and the consequent lesser activity of these denitrifying bacteria; whereas in the case of the Red Hills Lake, the temperature, even at the bottom rarely goes down below 27°C during any part of the year, which temperature is most favourable for the activity of these organisms. So any nitrites or nitrates that may be formed in the water will be immediately reduced by these organisms. Their absence in the Red Hills lake is in slight conformity with the finding of Beadle (l.c.) who has stated that they may sometimes be totally absent as in the Rift Valley lakes of East Africa.

(x) Rainfall, Temperature, Bright Sunshine, Wind, Character of the Catchment Area, Depth, Surface Area and Organic Matter

Organic matter in inland lakes is derived chiefly from phyto-and zoo-plankton, and to a smaller extent from higher plants growing in lakes and from washings of the surrounding soil after each rainfall.

Compared with other inland tropical lakes, the quantity of organic matter which is present in this lake water is considerably low. As has been stated above, organic matter is derived chiefly from the death and decay of phyto-and-zoo-plankton. The former depends upon nutrients salts like phosphates, and nitrates for their growth and multiplication. These salts are not present in the lake water. Probably they are present in traces and are utilised by the algae in presence of bright sunshine as soon as they are formed. But other factors such as temperature and sunshine are found in optimum without the nutrient salts of biological importance being found in fairly large quantities.

The absence of a reserve of these nutrient salts can be traced to the absence of a strongly expressed thermal stratification, which in turn is due to the shallowness and the vast area of the lake, which is unprotected on all sides against wind action.

Further, the character of the catchment area is such that no nutrient salts are likely to be washed into the lake after heavy rainfall during the north-east monsoon season.

Therefore, the productivity in the lake is comparatively limited. Still variations in its quantity are seen. The maximum quantity being found in August or September might be due to low level, concentration of water, and death and decay of vegetable matter due to smaller hours of bright sunshine; and the minimum in December or January might he due to dilution after heavy fall.

(xi) Rainfall, Temperature, Bright Sunshine, Character of the Catchment Area and the Bacteriological Conditions of the Lake Water.

Bacteria are usually washed into a lake after a heavy rainfall from the surrounding soil, and thus their numbers are increased. Further, if the margins of the lake are thickly populated, the lake water will be further polluted.

Most of the bacteria, especially the disease producing organisms easily succumb to high temperature and longer hours of bright sunshine which prevail in the tropics.

Therefore, we find the lake water to be of very poor quality during the north-east monsoon season and of fair quality during the hot weather and south-west monsoon periods, bacteriologically.

(xii) Rainfall, Temperature, Bright Sunshine, Wind, Character of the Catchment Area, Depth, Surface Area, and Phytoplankton

Free floating microscopic plant organisms or phytoplankton depend upon bright sunshine and upon the nature of substances dissolved in water for their nourishment. The latter are obtained usually in two ways. They are obtained from the soil surounding the lake after a heavy fall. They are also obtained from bottom sediments containing the highly complicated organic substances, which are first decomposed by bacteria into simpler substances and later on are converted into inorganic nutrient substances. They are formed in the hypolimnion during the period of thermal stratification (in summer, in the case of temperate lakes) and are brought to the surface during periods of "turn-over," when they are utilised by phytoplankton in presence of bright sunshine. In the absence of any thermal stratification, which is ordinarily prevented by vastness of surface area, shallow depth of the lake and wind action, the first source naturally attains greater significance.

Among the phytoplankton in any piece of water, three important groups of algae attain their maxima at one time or other. They are green algae, diatoms, and blue-green algae. The last group with which we are more concerned plays an important role in summer in shallow temperate lakes and its dominance is usually correlated with high organic matter, low nitrates, and phosphates (Pearsall 1921).

Fritsch (1907) considers this group as being the very characteristic organisms of tropical waters. Rich (1932, 1933) found that *Microcystis flos-aquae, M. aeruginosa,* and the genus *Aphanocapsa* were very common in East African lakes. Ruttner (1931 b.) found that the lakes of Java, Sumatra and Bali were characterised by the predominance of the smallest *Schizophyceae* (*Dactylocopsis, Anabae nopsis, Lyngbya*). Hutchinson et al (1932) found *Microcystis flos aquae* as the most important blue green alga in the larger waters and also in a variety of smaller habitats of South Africa. Beadle (1932-34) found *Microcystis* in abundance in lakes George, and Baringo, in smaller numbers in lake Edward, and little or none in lakes Naivasha and Rudolf. He found *Arthrospira* in plenty in Lake Hannington.

In the Red Hills lake, phytoplankton is not found in as great numbers as in our temple tanks. The two most dominant algae among them are *Aphanocapsa elachista var novo* and *Oscillatoria limnetica Lemm,* both belonging to the Myxophyceae group.

The chief factors favouring the development of blue green algae in the tropics are bright sunshine, high temperature of water, phosphates, nitrates and carbon dioxide. The first two are found in optimum while phosphates and nitrates are absent in the Red Hills lake. Their absence in the lake is probably responsible for the poor development of the algal flora as compared to those found in our temple tanks. Their absence is also due to the character of the catchment area and to the absence of a strongly expressed thermal stratification, which in turn is to be attributed to the shallowness and vast surface area of the lake.

SUMMARY AND CONCLUSION.

1. The most important problem of tropical limnology is the occurrence or absence of a stable thermal stratification. In the Red Hills lake, it is found that a weakly expressed thermal stratification is formed at all seasons at about midday; its duration is very brief and daily mixing of the surface and bottom layers seems to take place. In this respect, it resembles the Rift Valley lakes of East

Africa and differs from temperate lakes and those of Sumatra, Java and Bali.

2. The absence of a stable thermal stratification is due to meteorological and morphological features of the lake.

3. The absence of a stable thermal stratification is also indicated by the absence of a stable chemical stratification.

4. The presence in traces of free ammonia, and the absence of nitrites, nitrates and phosphates in the lake water are factors of great biological significance. Their absence is explained. The geological nature of the catchment area is such that it is composed essentially of iron oxide, silica and alumina. So, during the north-east monsoon season, when the lake is filled up with water from its own catchment area, the water is either free from phosphates and nitrates or contains them in such minimal amounts as to be used up immediately by algal denizens in the water, in presence of bright sunshine.

The absence of a stable thermal stratification of long duration prevents the regeneration and accumulation of free ammonia, nitrites, nitrates, phosphates and other substances of biological importance from the bottom deposits by bacterial action.

Also, the absence of nitrites and nitrates might show either that the free ammonia resulting from decomposition of organic matter even during the period of temporary thermal stratification, is utilised by phytoplankton before it reaches the stage of nitrates or that they are consumed by algae as soon as they are formed.

5. Therefore, the meterological, morphological and geological features—included broadly under the term "geographical"—appear to be responsible for low productivity in the lake.

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REFERENCES

1. *Apstein* C. (1907).—Das Plancton im Colombo—See auf Ceylon. Zool. Jahr. (System). Vol. XXV., p. 201—244.

2 *Atkins, W. R. G.* (1919-1922).—The hydrogen ion concentration of sea water. Jl. Mar. Biol. As. U. K., Vol. XII, p. 717-771.

3. *Atkins, W. R. G.* (1923-25a)—The hydrogen ion concentration of sea water in its relation to photosynthetic changes. Jl. Mar. Biol. As. U. K., Vol. XIII. p. 93-118.

4. *Atkins, W. R. G.* (1923-25b).—The phosphate content of fresh and salt waters in its relationship to the growth of algal plankton. *Ibid.* p. 119-148.

5. *Atkins, W. R. G.* (1923-25c).—On the vertical mixing of sea water and its importance for algal plankton. *Ibid,* p. 319-324.

6. *Atkins, W. R. G.* (1923-25d).—Seasonal changes in the phosphate content of sea water in relation to the growth of the algal plankton during 1924. *Ibid,* p. 700-721.

7. *Atkins, W. R. G.* (1923-25e).—On the thermal stratification of sea water and its importance for the algal plankton. *Ibid,* p. 693-699.

8. *Atkins, W. R. G.* (1926-27a).—Seasonal changes in the silica content of natural waters in relation to the phyto-plankton. *Ibid,* Vol. XIV, p. 89-99.

9. *Atkins, W. R. G.* (1926-27b).—The phosphate content of sea water in relation to the growth of the algal plankton. Part III, *Ibid,* p. 447-467.

10. *Atkins, W. R. G.* (1929-30a).—Seasonal changes in the nitrite content of sea water. *Ibid,* Vol. XVI, p. 515-518.

11. *Atkins, W. R. G.* (1929-30b).—Seasonal variations in the phosphate and silica content of sea water in relation to the phytoplankton. Part V, *Ibid,* p. 821-852.

12. *Atkins, W. R. G.* (1932-33).—The chemistry of sea water in relation to the productivity of the sea. Science Progress, Vol. XXVII, p. 298-312.

13. *Atkins, W. R. G.* and *Harris, G. T.* (1924).—Seasonal changes in the water and Heleoplankton of fresh water ponds. Sc. Proc. Roy. Dub. Soc., Vol. 18, N. S. No. 1. p. 1-21,

14. *Beadle, L. C.* (1932-34a).—Scientific results of the Cambridge Expedition to the East African lakes. 1930-1. No. 3. Observations on the bionomics of some East African Swamps. Jl. Linn. Soc. Lond. (Zool), Vol. XXXVIII, p. 135-155.

15. *Beadle, L. C.* (1932-34b).—Scientific results of the Cambridge Expedition to the East African lakes. 1930-1. *No. 4. The waters of some East African lakes in relation to their* fauna and flora. *Ibid,* p. 157-211.

16. *Bharadwaj, Y.* (1940).—Some aspects of the study of the Myxophyceae. Presidential address to the Section of Botany, Twenty-seventh Indian Science Congress, Madras.

17. *Birge, E. A.* (1908).—Gases dissolved in the waters of Wisconsin lakes. Bull. Bur. Fish., U. S. A., Vol. XXVIII, Part II, p. 1275-1292.

18. *Birge, E. A.* (1916).—The heat budget of American and European lakes. Trans. Wis. Acad. Sc. Arts. and Let., Vol. XVIII. p. 166-250.

19. *Birge, E. A.* (1916).—The work *of wind in warming* a lake. *Ibid,* p. 341-389.

20. *Birge, E. A.,* and *Juday C.* (1912).—A limnological study of the Finger lakes of New York. Bull. Bur. Fish., U. S. A., Vol. XXXII, p. 529-609.

21. *Birge, E. A.,* and *Juday, C.* (1911).—The inland waters of Wisconsin. 1. The dissolved gases of the water and their biological significance. Bull. No. XXII, Wis. Geol. and Nat. Hist. Survey.

22. *Black, C. S.* (1929).—Chemical analysis of lake deposits. Trans. Wis. Acad. Sc. Vol. XXIV, p. 127-133.

23. *Brandt,* (1929).—Cited by Wiebe, 1930.

24. *Bronsted, J. N.,* and *Wesenberg-Lund, C.* (1912).—Cited by Minder, L. 1924.

25. *Butcher, R. W., Pentelow, F. T. K.,* and *Woodley, J. W. A.* (1930).—Variations in composition of river waters. Int. Rev. Hydrob, B. XXIV, p. 47-80.

26. *Carter, G. S.* (1934-36).—Results of the Cambridge Expedition to British Guiana. Jl. Linn. Soc. (Zool.), Vol. XXXIX, p. 147-193.

27. *Carter G. S.* and *Beadle L. C.* (1930-32).—The fauna of the swamps of the Paraguayan chaco in relation to its environment.—1. Physico-chemical nature of the environment. Jl. Linn. Soc. Lond. Zool., Vol. XXXVII, p. 205-258.

28. *Clark, F. G.* (1924).—The composition of the river and lake waters of the United States, U. S. Geol. Sur. Prof. Paper No. 135.

29. *Cooper, L. H. N.* (1937).—"Organic' Phosphorons in sea water from the English Channel. Jl. Mar. Biol. As. U. K., Vol. XXI., p. 673-677.

30. *Cunnington, W. A.* (1905).—Cited by Ruttner (1931).

31. *Downes,* (1911).—Cited by whipple et al, 1927.

32. *Domogálla, B. P., Juday, C.,* and *Peterson W. H.* (1925).—The forms of nitrogen found in certain lake waters. Jl. Biol. Chem., Vol. LXIII., p. 269-285.

33. *Domogalla, B. P., Fred E. B.,* and *Peterson, W. H.* (1926).—Seasonal variations in the ammonia and nitrate content of lake waters. Jl. Am. W. W. A. Vol. XV.

34. *Forel,* (1895).—Cited by Whipple et al, 1927.

35. *Fritsch, F. E.* (1907a).—The subaerial and fresh water algal flora of the tropics. A phyto-geographical and ecological study. Ann. Bot. Vol. XXI, p, 235-270.

36. *Fritsch, F. E.* (1907b).—A general consideration of the subaerial and fresh water algal flora of Ceylon. A contribution to the study of tropical algal ecology. Part I. Subaerial algae and algae of the Inland fresh waters, Proc. Roy. Soc., Lond. B. Series. Vol. LXXIX, p. 197-254.

37. *Ganapati, S. V.* (1933, '34, '35, '38).—Annual report of the Water Analyst for 1933, '34. '35 and '38. The Corporation of Madras.

38. *Graham,* (1929).—Cited by Ruttner, F. 1931(a).

39. *Gessner, F.* (1932).—Schwankungen im Chemismus Kleiner Gewasser in ihrer Beziehung zur Pflanzen—assimilation. Arch. f. Hydrob. B. XXIV, Suppl. p. 590-602.

40. *Griffiths, B. M.* (1936).—The limnology of Long Pool, Butterby Marsh. Durham, An account of the temperature, oxygen content, and composition of the water and of the periodicity and distribution of the phyto-and Zoo-plankton. Jl. Linn. Soc. Bot., Vol. L. N. 334, p. 393-416.

41. *Hagland,* (1912).—Cited by Lonnerblad, G. (1931).

42. *Harvey, H. W.* (1926).—Nitrate in the sea. Jl. Mar. Biol. As. U. K. Vol. XIV, p. 71-88.

43. *Harvey, H. W.* (1928).—Nitrate in the sea. Jl. Mar. Biol. As. U. K., Vol. XV, p. 183-190.

44. *Hutchinson, G. E., Pickford, G. E.,* and *Schuurman, J. F. M.* (1932).—A contribution to the Hydrobiology of Pans and other inland waters of South Africa. Arch. f. Hydrob. Suppl. B. XXIV. p. 1-54.

45. *Iyengar, M. O. T.,* (1929-30). Dissolved Oxygen in relation to Anopheles breeding. I. J. M. R., Vol. XVII, p. 1171-1188.

46. *Jenkins, P. M.* (1929).—Biology of lakes in Kenaya, Nature CXXIV, p. 574.

47. *Jenkins, P. M.* (1932).—Report on the Percy Sladen Expedition to some Rift Valley lakes in Kenya in 1929—1. Introductory account of the biological survey of five fresh water and alkaline lakes. Ann. Nat. Hist. Mag., Vol. IX, 10th series p. 533-552.

48. *Juday, C.* (1915).—Limnological studies on some lakes in Central America. Trans. Wis. Acad. Sc. Arts. and Let., Vol. XVIII. p. 166-250.

49. *Juday, C.* and *Birge, E. A.* (1931).—A second report on the phosphorous content of Wisconsin lake waters. *Ibid,* Vol. XXVI, p. 352-382.

50. *Juday, C.* and *Birge, E. A.* (1932).—Dissolved oxygen and oxygen consumed in the lake waters of North-eastern Wisconsin. *Ibid.* Vol. XXVII, p. 415-467.

51. *Juday, C., Birge E. A., Kemmerer, C. I.,* and *Robinson, R. J.* (1927).—Phosphorous content of lake waters of north-eastern Wisconsin. *Ibid,* Vol. XXIII, p. 233-248.

52. *Juday, C., Birge, E. A.,* and *Meloche, M. V.* (1935).—The carbondioxide and hydrogen ion content of the lake waters of North-eastern Wisconsin. *Ibid,* Vol. XXIX, p. 1-82.

53. *Kenwood, H. R.* (1920). Public Health Laboratory work, H. K. Lewis & Co., London.

54. *Lonnerblad, G.* (1931).—Zur Kenntnis der Chemie einiger Humusseen Arch. f. Hydrob, B. XXII, p. 355-368.

55. *Marquardsen, H.* (1916).—Cited by Ruttner, F. 1931.

56. *Maucha, R.* (1929).—Cited by Juday et al, 1935.

57. *Minder, L.* (1920).—Zur Hydrophysik des Zurich und Walensees nebst Beitrag Zur Hydrochemie und Hydrobakteriologie. Arch f. Hydrob. B. XII, p. 122-194.

58. *Minder, L.* (1924).—Studien uber den Sauerstoffgehalt des Zurich-sees. *Ibid,* Supplem. B. III. p. 107-155.

59. Moore, B. *Whitley, E.,* and *Webster, J. A.* (1921).—Studies of photosynthesis of Marine Algae. Proc. Roy. Soc., B. Series, London, Vol. 92, p. 51-60.

60. *Muttkowski, R. A.* (1918). The fauna of lake Mendota. Trans. Wis. Acad. Sc. A. & L., Vol. XIX, p. 562-593.

61. *Marshall, M.* (1929-30).—A study of the Spring Diatom increase in Loch Striven. Jl. Mar. Biol. As. U. K. Vol. XVI., p. 853-873.

62. *Marshall, S. M.* and *Orr, A. P.* (1926-27).—The relation of the plankton to some chemical and physical factors in the Clyde Sea area. *Ibid*, Vol. XIV, p. 837.

63. *Neveu le Maire* (1904).—Cited by Ruttner, F. (1931).

64. *Neresheimer, E.* and *Ruttner, F.* (1929).—Cited by Juday et al. (1935).

65. *Pearsall, W. H.* (1921a).—The development of vegetation in the English lakes considered in relation to the general evolution of glacial lakes and rock basins. Proc. Roy. Soc. B. Series, Lond. Vol. 92, p. 259-284.

66. *Pearsall, W. H.* (1921b).—The aquatic vegetation of the English lakes. Jl. Ecol., Vol. VIII, p. 163-201.

67. *Pearsall, W. H.* (1922).—A suggestion as to factors influencing the distribution of free-floating vegetation. Jl. Ecol. Vol. IX, p. 241-253.

68. *Pearsall, W. H.* (1923a).—The phytoplankton of Rostherne Mere. Manchester Memoirs, Vol. 67, Part I., No. 3. p. 45-55.

69. *Pearsall, W. H.* (1923b)—A theory of diatom periodicity, Jl. Ecol. Vol. XI, p. 165-183.

70. *Pearsall, W. H.* (1924).—Phytoplankton and environment in the English lake district. Rev. Algolog. T. I, No. 1, p. 53-67.

71. *Pearsall, W. H.* (1930).—Phytoplankton in the English lakes, I. The proportions in the waters of some dissolved substances of biological importance. Jl. Ecol. Vol. XVIII, p. 306-320.

72. *Pearsall, W. H.* (1932).—Phytoplankton in the English lakes. II. The composition of the phytoplankton in relation to dissolved substances, Jl. Ecol., Vol. XX, p. 241-262,

73. *Pruthi, H. M.* (1932).—Investigations regarding a recent epidemic of fish mortality in the tank in the Indian Museum Compound with remarks on the causation of such epidemics in general. Int. Rev. Hydrob, B. XXVI, p. 242-257.

74. *Peterson, W. H., Fred E. B.*, and *Domogalla, B. P.* (1925).—The occurrence of amino-acids and other organic nitrogen compounds in lake water. Jl. Biol. Chem., Vol. LXIII, p. 287-295.

75. *Progress in Biological Inquiries*, (1926).—Bur. Fish. Doc. No. 1029, p. 544-546.

76. *Pia, J.* (1934).—*Die* Kalkbildung durch Pflanzen, B. B. C., B. LII, p. 1-72.

77. *Ruttner, F.* (1931a).—Hydrographische und hydrochemische Beobachtungen auf. Java. Sumatra und Bali., Arch. f. Hydrob. Supplm. B. VIII, p. 197-457.

78. *Ruttner, F.* (1931b).—Die Schichtung in tropischen Seen. Verhandl. d. Internat. Vereng. f. theor. u. angu Lim. B. V., p. 44-67.

79. *Rich, F.* (1932).—Reports on the Percy Sladen Expedition to some Rift Valley lakes in Kenya in 1929. Part IV, Phytoplankton. Ann. and Mag. Nat. Hist., Vol. X, 10th Series, p. 235-262.

80. *Rich, F.* (1933).—A survey of the flora and fauna. Scientific results of the Cambridge Expedition to the East African lakes. The Algae. Jl. Linn. Soc. (Zool.), Vol. XXXVIII, p. 249-275.

81. *Schmidt, W.* (1915).—Cited by Ruttner, F. (1931).

82. *Schutow, D. A.* (1926).—Cited by Juday et al (1935).

83. *Sewell, R. B. S.* (1926-27). Investigations regarding an epidemic of fish mortality in the Indian Museum compound, Calcutta, Jl. and Proc. Asia. Soc. Bengal. Vol. XXII, p. 177-201.

84. *Smith, M. W.* ( ).—Physical and biological conditions in heavily fertilized water. Jl. Biol. Board of Cañada, Vol. I, No. 1, p. 67-93.

85. *Thienemann, A.* (1918-1920), Arch. f. Hydrob, B. XII, p. 1-65; 1914—Cited by Minder, (1924).

86. *Thienemann, A.* (1925).—Die Binnengewasser Mitteleuropas, Band I.

87. *Thienemann, A.* (1928).—Die Binnengewasser, Der Sauerstoff im eutrophen und oligotrophen, See. Band, IV.

88. *Thienemann, A.* (1930).—Die Deutsche Limnologische Sunda-Expedition "Tropische Binnengewasser." I. Arch. f. Hydrob. Suppl. VIII.

89. *Thienemann, A.* (1931).—Tropische Seen und Seetypenlehre. Arch. f. Hydrob. Suppl. IX. p. 205-231.

90. *Tressler, W. L.* and *Domogalla, B. P.* (1931).—Limnological Studies of Lake Wingra, Trans. Wis. Acad. Sc. Arts. and Let., Vol. XXVI, p. 331-351.

91. *Ueno, M.* (1934).—Acid water lakes in North Shinano, Arch. f. Hydrob., B. XXVII, p. 571-584.

92. *Waksman, S. A.* etal, (1937).

93. *Wehrle, E.* (1927).—Studien uber Wasserstoffionen Konzentrations verhaltnisse und Besiedelung an Algenstand Orten in der Umgebung von, Freiburgh im Breisgau. Zeitsch. f. Bot., B. XIX, p. 209-287.

94. *Welch, P. S.* (1935).—Limnology, McGraw-Hill Book Co., New York and London.

95. *Wiebe, A. H.* (1930).—Investigations on plankton production in fish ponds. Bull. Bur. Fish., Vol. XLVI.

96. *Wimmer, E. J.* (1929).—A study of the two limestone quarry pools. Trans. Wis. Acad. Sc. A. & L., Vol. XXIV, p. 363-396.

97. *Whipple, G. C., Fair G. M., and Whipple, M. C.* (1927).—The Microscopy of drinking water. John Wiley & Sons, New York.

98. *Worthington, E. B.* (1930).—Observations on the temperature, hydrogen ion concentration and other physical conditions of the Victoria and Albert Nyanzas. Int. Rev. d. Ges. Hydrob, B. XXIV, Heft 3/4, p. 328-357.

99. *Worthington, E. B.* and *Beadle, L. C.* (1932).—Thermocline in tropical lakes. Nature CXXIX, p. 55-56.

100. *Worthington. E. B. and Riccardo, C. K.* (1936).—Scientific results of the Cambridge Expedition to the East African Lakes 1930-1.—No. 17. The vertical distribution and movements of the plankton in lakes Rudolf, Naivasha, Edward, and Bunyoni, Jl, Linn. Soc. (Zool.), Vol. XL. (No. 269).

101. *Yoshimura, S.* (1930).—Seasonal variation of Silica amount of Takasuka-numa, Saitama, Jap. Jl. Geol. & Geog. Vol. VII, p. 112-123.

Topographical Surveys

BY

RAO BAHADUR K. N. NARASIMHACHARY,
Assistant Director of Survey, Madras.

There are different kinds of surveys, such as Marine Surveys, Land Surveys, Geological Surveys, Archaeological Surveys, etc. Land surveys only will be dealt with here. By land surveys is meant the surveys of the features on the earth's *surface*. Land surveys consist of two main branches :—" Topographical Surveys" and " Cadastral Surveys."

TOPOGRAPHICAL SURVEYS

Surveying is the process of accurately determining and recording the features on the earth's surface. Topography is the process of delineating these features in a map. Thus topographical surveying is the process of accurately determining and recording the natural and artificial features on the earth's surface and delineating them in a map. Natural features are rivers, hills, forests, lakes, etc., and artificial features are towns, roads, railways, and in short, whatever features are brought into existence on the earth's surface by human hands.

Only such features as can be legibly shown should be delineated in a map. Thus the amount of features that can be shown in a map depends upon the scale of the map and the nature of the country. In a small scale map—say 1 inch = 4 miles—only important details or features can be shown, whereas in a larger scale map—1 inch = 1 mile—more features can be shown. In a country where features are numerous, only such important ones as can be useful should be shown. The scale on which topographical surveys are carried out is generally 1 inch = 1 mile. Unless the surveys done and the maps prepared are accurate they are not only absolutely of no value but are misleading. Hence, for any work accuracy is most essential. For this purpose topographical surveys consist of two distinct process :—

(1) Triangulation or Trigonometrical Surveys to serve as framework, and

(2) Surveying and delineating the physical features on

the framework or the skeleton prepared on the basis of triangulation.

TRIANGULATION.

Triangulation is the process of covering the country with a net-work of triangles. Triangulation commences from a measured base and closes on another measured base. The process of triangulation as preliminary to topographical surveys was conceived only in 1735. The first country that was dealt with was South America and that by scientists from France and Belgium. It was only in 1745 the process began in England and it was not until 1792 it was completed. India was not far behind England in the commencement of such surveys. This work was started in India about 1800 and Madras was selected as a place to commence this operation as in the "Madras Observatory" observations for Longitudes and Latitudes were being taken since 1787 and calculated with reference to Greenwich; and thus it would be a proper fixed point to which the values—Longitude and Latitudes of the various triangulation points may be referred so that the map of India when prepared might occupy the place on the globe relative to the other countries. Thus the "Madras Observatory" is very important in the topographical survey of India.

Triangulation consists of three distinct branches:—

(1) Selection of sites for base lines,
(2) Construction of range of triangles, and
(3) Check on triangulation by astronomical observations for Latitude and Longitude.

As already stated triangulation was first commenced in Madras; and a flat place near Madras was selected for a base. This base runs north to south; the north end of the base is in the Race Course and the south end is on the Perumbakkam Hill. The length of the base is 7½ miles. The base is measured with absolute care with chain or steel tapes several times, and after applying corrections for sag, expansion due to temperature, alignment, slope, etc., the measurement is reduced to mean sea level and then utilised in the computation. The accuracy of the measurement of the base is of utmost importance as the measurements of the sides of the range of the triangles depend on this measurement.

Then points are selected for the construction of range of triangles. These points are generally on tops of hills, temple towers, church steeples and such eminent points so that large triangles may be obtained. Series of triangles are so formed and observations are taken at these points for angles, heights or depressions. The first series or range of triangles started from the Madras base and went westward to Bangalore and closed on a similarly measured base. This series was started by Col. Lambton. The series went up to west coast from Bangalore to Mangalore. Again another series started from Bangalore to Cape Comorin in the south and to Delhi in the north. These series are called Lambton's series. Several other series were also run along the coasts, parallel to and perpendicular to Delhi series, etc. Thus the whole of India was covered with a net work of triangles. Between these series several ranges of triangles were also run to cover the country fully.

Accuracy of the triangulation was checked at intervals by observations taken for Latitude and Longitude. For this purpose proper points in the series at intervals were selected and values of these points were computed direct from these observations and compared with those obtained by the solution of triangles—it must be remembered in passing that these triangles are spherical and not plane—starting from the measured base. Check is also exercised by comparing the measurement obtained by calculation of the base at the terminus of the series with that obtained by actual measurment of the base. For example, for the series from Madras to Bangalore, the length obtained by measurement of the base at Bangalore was compared with that obtained by the calculation of triangles.

As already said above, the Madras observatory was the starting fixed point for calculating the values of the various points fixed by triangulation. With reference to the values of this observatory the values of triangulation points were computed with a view to project or plot them on paper to serve as framework for topographical surveys.

For purposes of survey and issue of maps the whole of India is divided into quarter degree sheets and degree sheets, the former being on scale 1 inch = 1 mile and latter on 1 inch = 4 miles. Topographical survey—field observation—is carried on 1 inch=1 mile scale. Hence a skeleton or a framework showing the triangulation points fixed at the trignometrical survey is prepared for each quarter degree on scale 1 inch=1 mile. It is mounted on a plane table head and taken to field for delineating the physical features in that part of the country.

The plane table is then set up on one of the fixed points and aligned in proper position by sighting other fixed points projected on the sheet. Then the magnetic meridian is marked by placing the magnetic compass on the table to indicate the magnetic north to facilitate the setting up of the table in other places.

Then the delineation of the features of the country round begins. To important physical features rays are drawn from the point after sighting them through the sight-vane. Temple towers in a village site or other prominent buildings, important bends along a road, or rivers etc., are generally sighted. Then the table is taken to another fixed point and another set of rays is struck to the same points. Thus the positions of these points are fixed by intersection and these are verified from a third fixed point. Thus the features are filled in by plane table survey minor details being sketched in by the eye.

Prismatic compass is also freely used in delineating the details. The whole sheet is thus filled in with details or features. The plane table surveyor should not only cover his sheet but also a portion of the sheets adjoining his so that there may be no difficulty in the combination of the sheets for a small scale map—say a degree sheet on 1″=4 miles. In the case of big lakes and forests the outer boundary is fixed by inter-section, interpolation, compass survey etc. In drawing the contours of hills, clinometer is generally used in ascertaining the heights at different points along the slopes; and contours are marked by a process called stepping, *i.e.*, by marking the intermediate points between two clinometer heights where the slope is roughly uniform. There are different methods of exhibiting the contours by joining the points of equal heights by continuous lines, by vertical hachures, by layers etc. Thus the whole sheet is completed in field and sent to office for further work of publication.

There was at first no printing office in India. Hence the original plane table sheets had to be sent to England for publication. Even in England there was no Government department for printing maps. The work had to be entrusted to private agencies. Aaron Smith brought out in 1822 his atlas of South India based on Lambton's triangulation on scale 1″=4 miles in 18 sheets from Krishna to Cape Comorin. The work of publishing the maps of the rest of India was entrusted to Mr. John walker who came of a family of engravers. For the purpose of publishing maps the whole of India, Burmah and Ceylon was divided into 177 sheets each sheet to measure 40 inches by 27 inches. It was not until 1868 that arrangements were made to have the publication of maps done in India. By that time Mr. Walker had completed engraving of 84 sheets. Ever since, maps of India are being published systematically. Now degree sheets on scale 1″=4 miles and quarter degree sheets on scale 1″=1 mile are being issued and re-edited regularly by the survey of India Department. In 1877 a very useful and valuable map of India on a scale of 64 miles to an inch was completed. Later on a general map of India on double the above scale was also published.

It may be of some interest to mention here that long before the publication of the map of India based on trigonometrical surveys, Major Rennell, the father of Indian Geography, brought out his famous map of India in 1788. This map was compiled mainly from route surveys carried out by the military staff at various times during the 18th century. When Bengal was acquired by Lord Clive Major Rennell began his survey of the Province and after completing that survey he returned to England and spent his time in bringing out his atlas of Bengal and his famous map of India. This is the starting point in the history of Indian Government map-making.

In conclusion it may be said that topographical surveys have very materially helped towards the completion of our knowledge of the physical geography of the vast tracts of India. The Indian topographical surveying by theodolite and plane table based on major and minor triangulation cannot be excelled for general accuracy and rapidity. These surveys on scale 1″=1 mile are very useful for engineering, military, administrative and geographical purposes.

Paddy Cultivation in Tinnevelly District

BY

SRI M. SUBBIAH PILLAI B.A. B.SC. (AGRI)

Officer-in-charge, Government Rice Research Station, Ambasamudram.

Introduction.

The Tambraparni Valley is one of the best paddy growing areas of the Madras Presidency. There is a belt of rich fertile lands on either side of the river Tambraparni; and the average acre yield of paddy here is about 2000 lbs., the maximum out-turn recorded being 5200 lbs. The total area under paddy cultivation is somewhere in the neighbourhood of three lacs of acres representing about 20% of the cultivable area of this district and of this roughly two third area is irrigated by the perennial river Tambraparni and its tributaries and the remaining one third area, chiefly confined to the taluks of Nanguneri, Sankarancoil and Koilpatti, is irrigated by purely rainfed tanks, and jungle and mountain streams rising from the Western Ghats during the north-east monsoon.

Soil of the tract.

The Tambraparni valley may be broadly divided into three portions. 1. The upper or head portion. 2. The middle portion. 3. The tail end portion of the valley. The conformation of the land in this valley is undulating and the fields are well drained. The soil is a red sandy loam with an impervious substratum of gravel at a depth of 1′ to 1½′, especially in the higher regions of the valley; and hence these light open soils respond to manuring immediately with very good results and unless these fields are replenished with plant food year in and year out the fertility of the soil cannot be maintained at its high level. The middle portion is mostly of clayey loam with a very good capacity to retain moisture. The lands at the tail end of the river are somewhat heavy clayey loams with alkaline patches near the coastal region. The wet lands in the higher regions of this valley are all double crop wet lands as there is an early receipt and never-failing supply of water but in the lower regions the lands are classified either as single or compounded double crop lands because the supply of water is not always assured. But there is a bright future for this valley when the construction of the Papanasam-Reservoir is completed. Though it is mainly intended for generating hydro-electric power, it may no doubt go a long way in augmenting and supplementing the supply of irrigation water during years of subnormal rainfall and thus averting the catastrophe of complete failure of paddy crops in the valley.

Rainfall and paddy season.

The average rainfall of this valley is about 40 inches and the paddy season commences with the advent of the south-west monsoon which usually breaks out late in the month of May or in early June. When the monsoonic symptoms are signalled in the Western Ghats where the river Tambraparni and its tributaries rise, the ryots start their kar nurseries well in advance with the help of water from wells or ponds nearby. The south-west monsoon on an average records about 5 to 6 inches of rain and the freshes received in the river from the month of June facilitate the kar cropping. Dogging at the heels of the south-west monsoon, the north-east monsoon sets in from the middle of October and extends upto the end of December and brings in its train heavy rains, ample enough to fill up the rainfed tanks, and facilitate the semi-dry paddy cultivation in normal years. The north-east monsoon precipitates about 20″ to 25″ of rain and it is in this period the main paddy crop is taken in the single crop wet lands of this district and it synchronizes with this pishanam or 2nd cropping of the Tambraparni valley. Thus there are two well defined cropping seasons for paddy in this tract namely—kar season (June to September) and pishanam season (September-March) besides the Manavari season (December-March) in which a manavari crop which is chiefly confined to the tracts where the supply of water is conditioned by the vagaries of the north-east monsoon.

The hot weather period, January—April records about 4 to 6 inches of rain and the summer showers during the period are often helpful to the ryots to take a cash crop like senna or gingelly or blackgram especially in the single crop wet lands. In the upper regions of the valley with the aid of summer rains, the wet lands are brought to a fine tilth for broadcasting kar seeds.

As a whole, the fairly even distribution of the average rainfall of 25 to 30 inches of rain in the main paddy season (September to February) may be considered sufficient to raise a good crop of paddy.

Cultivation Routine—Kar Season.

The varieties grown during the kar or first crop season are of short duration ranging in age from 110 to 120 days. The main variety that rules over the whole area of the Tambraparni valley is Kar-samba red; and some of the other varieties grown are kar-samba white, vari-samba and Katti-Samba. As a rule, transplanting is always adopted. But in the upper regions, broadcasting is done in the light type of soils when the lands have been brought to a fine tilth fit for broadcasting with the help of summer shower ploughings. It may be recorded here that it is the experience of the ryots that the yield of a timely broadcasted crop gives a better out-turn than the transplanted crop and so for the light types of soil, that is, sandy red loams the summer ploughings are not found to be injurious to the succeeding paddy crop. This finding, however, should be tested and confirmed by conducting regular cultural experiments. The kar nurseries are generally dry ploughed with the help of summer showers and kept in a fine tilth and the seeds are sown in dry seed beds in June at the receipt of water in the Channel or earlier with the help of water from ponds nearby or with the soaking showers received in the latter half of May.

Preliminary Cultivation.

After the harvest of the Pishanam crop, the fields are ploughed dry, when the lands come to condition. If this opportunity is lost for some reason or other, the lands are wetted in March before the channels are closed and then ploughed when fit for dry ploughing. Subsequent ploughings are given to the fields as many times as possible at the receipt of summer showers in April and May. Generally in normal years, 9 to 12 ploughings with the country plough are given to the fields and brought to a fine tilth for the Kar crop.

Planting.

Should the tilth of the fields to be transplanted be in a very good condition, water is let into the fields and the planting is done straight away by women with seedlings 25 to 30 days old lifted from the dry nurseries previously kept ready without giving any further wet ploughings to the fields. But if the conditions of the fields are not good, 2 or 4 ploughings are given with the country plough, levelled and immediately transplanted, lest the soil should get hardened. The former method is largely practised as it saves lot of time and labour during the busy transplanting season. The ploughings given to the field are very shallow, the depth being 2 to 3 inches and so the use of the iron ploughs like cooper No. 25 or

11 for the light and porous nature of soils especially should be strongly advocated as it is not only beneficial but also more economical. Two ploughings with iron ploughs followed by the working of the puddling implement devised by the Agricultural Research Engineer twice or thrice bring the soil to a fit condition for transplanting. The puddler brings the clods, making the particles into as fine a condition as possible so that the irrigation water will not drain down too rapidly and thus it facilitates to prepare the wet land into an ideal condition for the paddy crop. The puddler can be worked by a normal sized pair of animals and it can cover 2 to 3 acres in a day of eight hours working. By this improved method a ryot can easily save a rupee for an acre in getting his lands prepared for *transplantation.—usually for pulling out seedlings and* transplanting an acre about 20 women are required. The practice is bunch planting, about 6 to 9 seedlings even per hole, distanced 6 to 9 inches apart either way. It may be noted that the optimum spacing that can be adopted for kar crop is about 4 to 6 inches with two or three seedlings per hole.

Pishanam season.

In the Pishanam season a long duration fine variety like Anaikomban 160 days from the date of sowing to harvest is usually grown. Some of the other second crop varieties cultivated are Sendhinayagam, Sembuli, Milagi and Arikiravi.

Soon after the harvest of the kar crop in the last week of September, the fields are ploughed and kept in a puddled condition fairly over a month or so as the consensus of the ryots' opinion is that a well rotten puddle for the pishanam crop is very conducive to its vigorous growth. Generally 6 ploughings with the country plough are given to make the kar stubbles rot well. It is here also the puddling implement is immensely useful as it serves to bury the stubbles and weeds quite effectively into the soil. Bunch planting 6 to 9 seedlings distanced at 9 inches to one foot apart is a common practice for the second crop also. The optimum spacing for the second crop may be 6 inches apart either way with two seedlings per hole.

Manures and Manuring.

For the Kar or the first crop, the fields receive before transplantation 20 to 25 cart loads of village cattle manure to an acre or sheep penning is done i.e., about 1200 to 1500 sheep per acre and for the pishanam or second crop invariably no manure is supplied. But of course, a few well-to-do ryots manure the pishanam crop also with one or two cart loads of green manure like Kolingi or Avarai.

The analysis of the soil samples of the Rice Research Station which may in a way represent the mechanical and chemical composition of the upper regions of the tract reveals that though the soils contain fair amount of available nitrogen and phosphorus, they are low in humus content and so attention to the copious addition of organic matter to the soil seems to be the main consideration in the improvement of the paddy fields of the tract. The manurial problem of this tract is no doubt as acute as in any other paddy growing areas of this Presidency. What little cattle manure is available is hardly sufficient for manuring the nursery and Kar fields and so the only avenue opened to the paddy farmer is to explore the ways and means of raising the right kind of green manure *'in situ'* and so various kinds of green manures, to wit, kolingi, Sun-hemp pilli Persara, daincha, cow-pea, and indigo etc., were being tried at the Rice Research Station, Ambasamudram and the results of the past seasons seem to indicate that the growing of the green manure daincha soon after the harvest of pishanam in March is very successful and on an average an acre yields 10 to 15 thousand pounds of green stuff which would be quite sufficient to manure 3 acres.

Rice Research Station, Ambasamudram.

The Rice Research Station, Ambasamudram was opened in 1937 in pursuance of the policy to provide facilities for the improvement of the paddy crop in each of the most important paddy sub-tracts, as it is not the case, as a rule, that the good performance of a strain evolved under certain climatic conditions should be equally so over a wide range of land with different agronomical and seasonal conditions and as such the selection work for a particular tract should be done in that tract only. The fundamental object of the station is the improvement of the local paddy crop by the evolution of pure strains on the basis of yield duration etc. by means of pure line selection and hybridization and also to tackle the manurial and cultural problems pertaining to this tract. For the present, at this station, pure line selections have been made in the major varieties of kar and pishanam and the promising strains are under various stages of comparative yield trials at the station and it is gratifying to note that there are some good high yielding strains in each variety and the best strains after thorough testing will be released for general distribution to the ryots after 3 years or so. This apart, inter-varietal trials with kar and pishanam duration varieties and strains obtained from other parts of this district are conducted to observe whether any exotic variety can replace the local ones with better results.

Industries and Occupations of Tinnevelly District

BY

D. SANKARANARAYANAN, DIP. GEOG.

The census of 1931 shows that 47·1% of the population in the Thambaraparni Basin do really no work of any kind being either too old or too young or dependant on others for their sustenance, and that the actual workers, their working dependants and those of them who have more than one occupation form 62·9%. The corresponding figures for the Presidency are 44·5 and 63·5. A large body of non-working dependents may be due to the actual workers being employed outside the area in Ceylon or in the Straits and supporting their relations by money remittances. The percentage of people actually depending on agriculture is 25·8.

The ordinary artisans, the carpenters, the goldsmiths, the blacksmiths and the potters exist in most village communities and their work is much the same as elsewhere.

In a recent year there were 102,109 acres in the Basin under cotton cultivation. Of this area 96% is under indigenous cottons mainly Karunganni and Uppam. Pullyichi or Mailam was cultivated as mixtures in varying proportions. Only 4% of the cultivated area was under Cambodia cotton and half of this grown under irrigation and the rest treated as rain-fed crop. There are two large spinning mills one at Papanasam and the other at Tuticorin. Hand looms for the production of cloth exist throughout the area. A few spinning wheels are still at work as a result of Khader propaganda but the activity is not so progressive as in 1920-21. The Tinnevelly mills in Vikramasingapuram village in Ambasamudram taluk which are driven by water power represent a very great advance on the idea first put forward by Lord Napier in 1869. Mr. F. Harvey engaged in the cotton trade of the District proposed in 1883 to build a mill at the foot of the hills of Papanasam by diverting the Tambaraparni river water above Papanasam falls to get the immense power developed by the water in its descent from the crescent of the hills to the plains. In 1885 his scheme bore fruit and the mill was started with 10,000 spindles. A second and much larger mill was started in 1908 and in 1930 after the amalgamation of the Tinnevelly and Madura mills a further extension was carried out and now 1,700 employees work on 60,000 spindles. The supply of water from the rivers thus works two sets of turbines which develop between them 1,350 H.P. and after use the water returns to the river below the Kodamelagian dam. Further extensions took place in the middle of 1930 and a mill to accommodate 100,000 spindles was opened and now 25,000 spindles are working in it. The building is one of the most modern fire proof construction and this new mill will eventually provide employment for 3,000 workers. These 85,000 spindles consume 4,600 tons of cleaned cotton annually from Tinnevelly, Madura, Ramnad and Coimbatore districts and their annual output of yarn is 4,200 tons in counts from 2s to 44s.

The Coral Mills of Tuticorin was started in 1888 and is under the management of Messrs. A. & F. Harvey. Now there are 73,560 spindles engaging 2,000 labourers. The consumption is 3,800 tons of cotton annually and the out-turn is 3,400 tons of yarn.

The hand gin was in vogue for a long period and it is said that this forms one of the wedding presents to the bride-groom among the Kammavar community. It is called a Pirai and a good number of them still exist in the black soil country. The Steam ginning factory was introduced in 1894 and now small ginneries from 2 to 8 or 10 gins are to be found in villages all over the cotton growing area. Cleaned cotton had to be pressed to reduce the bulk and now there are 7 power-driven presses in Tuticorin of which 6 belong to European firms. The growth of the mill industry in India and the consequent large consumption of cotton has reduced the supplies available for export with the result, that some of the presses are doing very little work.

The weaving of cotton is a hereditary employment of the Kakkalayans, Pattasalayans and Pattunulkarans and forms the chief occupation of a large number of Muhammadans and Iluvans and a few Kolia Parayans. Their streets are characterised by width, lined with two rows of trees to give shade to the workers at the long line of out-stretched warps. The most prosperous centres of the industry are Ambasamudram, Kallidaikurichy, Viravanallur, Pottalputhur, Tenkasi and Kadayanallur. Pattunulkarans are numerous in Viravanallur, Vellangudi and Palamcottah. Muhammadam weavers are found in Kallidaikurichi, Pottalputhur, Melapalayam, Kayalpattanam and Sedunganallur. Iluvans are common in Ambasamudram and Srivaikuntam taluks. Till the import of machine-made cloth in 1860 broad cloth of the district found a ready sale in European markets. At present weaving is a profitable industry only in a few centres where the existence of a class of capitalists has rendered possible a combination of workers and a fairly large and continuous out-put of woven fabrics. The rich Brahmins of Kallidaikurichi had their brokers, or tharagans in all the villages of Ambasamudram taluk. They advance money to the local weavers for the purchase of yarn etc., and buy the finished products from them and till recently were sending them on to Malabar, Cochin and Travancore where they owned their own shops. In Kallidaikurichi alone there are more than 1,500 looms. Altogether there were 20,000 looms all using mill yarn from 20s to 60s though yarns of finer counts were used to a considerably lesser extent. Weaving of coarse cloth is done by Kakkalayans and Adidravidas. Street sizing continues and warping to a great length as 190 yards is not rare and a warping mill exists for every 10 weavers' houses. In warping for great lengths ten or fifteen weavers join together. Coarse cotton sarees 13 cubits long for lower classes are largely made and exported to the plantation coolies to Ceylon and the straits. Sankaranayanarkoil, Pulliyankudi, Kadayanallur and Viravanallur are the chief centres for the sarees and they range from 2 to 6 Rupees and an average weaver earns about Rs. 10-8-0 a month. Towels $3 \times 1\frac{1}{2}'$ cubits are in great demand locally and among the Malayalis. Melapalayam continues to be the largest centre and the annual export of cloths is to the extent of Rs. 15 lakhs. There are 4,000 Mussalman families engaged in weaving and 800 looms are fitted with fly shuttles. The products range from lungis to sarees and the chief foreign markets for these goods are Ceylon, Burma, Penang, Singapore and Travancore. Cheap varieties of lungis are in great demand among the Singhalese for under-wear. Cheap Japan yarn is now used for Lungis and an average weaver earns As. 8 a day. The Pattasalayans and Pattunulkarans of Shermadevi, Viravanallur and Kallidaikurichy produce superior kind of dhoties for men known as mundus and nariyals in which there may be borders of silk and lace. Sarees of pure silk in warp and weft are woven by about 50 Pattunulkarans' families especially in Viravanallur. For less costly sarees cotton is used in the weft. They get their silk dyed ready from Kumbakonam and there is a clean profit of Rs. 8 for each silk saree. The Pattasalayans have taken to this work also. At Vadakankulam the mission authorities are trying silkworm rearing.

Nattukottai Chetty management. The East Indian Distilleries started work in Kulasekarapatnam in 1912 but in 1925 the factory had to stop work for want of adequate supply of jaggery and sweet juice both to Kulasekarapatnam and Nellikuppam factories.

Gingelly oil is the chief oil produced in the area by the Vanniyar community and Pettai is a good collecting centre. It is used for bathing and edible purposes. Kerosene oil is now common in towns and even in villages. Castor oil for lighting and medicinal purposes is used. Oil from the seeds Illupai and Pinnai is used for lighting lamps but it becomes solidified in the cold season. Margosa oil is used for children for convulsions. Coconut oil is generally imported from Malabar and Colombo. Tomco oil is at present largely used for caking purposes and the Tata Oil Company supplying the Tomco Oil is located at Cochin. Bell metal wares are made in a number of places the chief centres being Vagaikulam, Mannarkoil, Seythinganallur, Eral, Tinnevelly, Narasinganallur and Sankaranaynarkoil. The liquid metal an alloy of lead and copper in a certain proportion when poured into the moulds hardens in twelve hours. Vatils and eating plates are greatly in demand in Ceylon. Tumblers and Sombus are a speciality of Sankaranaynarkoil while Kujas, cups and vessels with broad mouths are a speciality in Seythinganallur. There are about 100 houses in each village doing bell-metal work. Brass plates are imported and Kannasaris work on them usually with bell-metal workers. Hindu idols are made at Vakaikulam, kudams or water pots are made at Sankarankoil and Pettai and other places are noted for broad mouthed vessels as koparais.

The Avaram bark is used for tanning purposes and good leather exported to Europe is produced in a tannery near Pudukottai, other factories meet the local demand and the ordinary Tinnevelly slippers are noted for their strength and neatness.

Beedi manufacture of late is an important industry. Every village with a fair Muhammadan population has a small factory where beedies are made. In Mela Palayam 5,000 Muhammadan families are engaged in this work. Mukudal has risen in recent years where Sokkalal Beedies are patented.

Fishing is the occupation of hundreds of Paravars in the seacoast villages and the total catch at Tuticorin has been estimated to be half a lakh of Rupees per annum. From Tuticorin, Manappad and Alanthalai large quantities of salted dried fish are sent to the villages in the interior and even shipped to Ceylon. The valai is the commonest kind; others are sardines, the seer, the sea bream and the red mullet. The pearl fishery industry in 1925 lasted from 17th February to 27th March with a catch of 1,648,312 oysters which brought a net revenue of Rs. 26,802 to Government. Another fishery was held in 1927 when 103·6 lakhs of oysters were fished and the net revenue was Rs. 157,383. The chank fishery of the Gulf of Mannar is another large item. The shells are scattered about and the divers have to move from place to place. A diver earns about Rs. 1-8-0 to Rs. 6 per day and in 1929 to 1930, 612,680 chanks were collected getting a revenue of Rs. 246,651 to the State. They are mostly exported to Calcutta and heavy demand comes for the chank bracelet from the women of Tibet.

Trade Centres of Tinnevelly District

By

Dr. V. Krishnan, M.A., Ph.D., Dip. Geog.

Stuart writing about the Tinnevelly District observes that it is an 'epitome of the Madras Presidency.' Almost all the economic activities of the Presidency are carried on in the District to a smaller or bigger scale depending on the circumstances favourable or otherwise to the growth or decay of such activities. The factors that have contributed to the growth and development of various trades in the different centres in the district are of a permanent and natural character. Artificial stimulus like the patronage of courts to particular kinds of trades in particular centres has not done much to create trade relationship between one centre in the District with another in the same District or outside the District.

The differences in the peoples themselves, the differences in the stage of industrial and agricultural development, the differences in the resources of respective lands are the main factors that have brought the existence of some of the main centres of trade in the District. For example, Ambasamudram and Tinnevelly situated in the clayey basin of the Tambraparni Basin are important export centres of paddy and other raw products of the forests nearby like timber to the far remote drier regions of Nanguneri and Koilpatti Taluqs. Tisianvillai in the Nanguneri Taluk is the place where the exchange of products grown in drier regions round about takes place for those raised in the river valleys of the Tambraparni.

The configuration of the country, the differences in soil fertility, the adequacy of roads and railways and convergence of the same in particular places have given rise to another set of trade centres. Koilpatti in the centre of the black-cotton tract and Tenkasi, Alangulam, Sankarankoil in the red soil tract are centres which export cotton and chillies and other garden crops in exchange mainly for food crops of cheaper variety from the clayey region of the Tambraparni valley.

The products of the well used mountains and those of the well developed plains must for ever be different. The full utilization of mountains therefore means minerals, cutting wood, collection of minor and major products and conserving the same, fruit culture, mining and quarrying industries. The mountain people want the products of the plains which can be only paid for with those raised in mountains. Such is the trade that now passes between the 'teri country' in the Trichendur Taluq and the adjoining taluks of Trichendur. The chief exports of Elangudi, Naduvakurichy and Kuthiraimoli theri are palmyra jaggery, leaves, fibre, and baskets and they import mainly consumption staples like paddy and other manufactured cotton fabrics.

The District has also got a maritime sea-board. The shoreland of the Srivaikuntam, Trichendur and Nanguneri Taluqs have got an enduring trade with the interior regions of Tenkasi, Ambasamudram, Tinnevelly and Sankarankoil Taluqs in fish, cereals salt, chanks and palmyra products. Kayalpatnam, Trichendur and Tuticorin are some of the important ports through which products of the well developed interior region in and outside the district pass.

The trade centres of the district may be divided into those which play an important part in the international commerce, those which play a chief part in the distribution of products from this district to other districts and those which act as centres for the distribution of products between one region and another or between one portion of the Taluq and another portion. To this class belong the numerous shandies in the district which are held in more than 80 villages.

Tuticorin, Kulasekarapatnam and *Kayalpatnam* are the three important sea port towns of which Tuticorin with its harbour is the most important, possessing a rich hinterland producing different types and varieties of crops. In the earlier days compared with Kayalpatnam and Kulasekarapatnam this port was of no importance at all. During the American civil war it suddenly shot up to prominence consequent on the large export of cotton through this port on account of the phenomenal rise that took place in the case of Indian cotton. Since then its progress has been very rapid and so much so Kayalpatnam and Kulasekarapatnam are nowhere when compared with the commerce of this port. Yet some native crafts ply between Tuticorin, Kulasekarapatnam and Kayalpatnam, where the products of the palmyra the chief crop of the hinterland such as jaggery, molasses, jaggery mats baskets and fibre are assembled by the local paravans for export to Tuticorin. Onions, a local crop of importance is exported from this place to Colombo on a large scale. Manufactured articles main-

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ly of cotton brought from Panagudi, Melapalayam, Munnirpallam and other weaving centres nearby are also exported to Colombo. The main industry of Tuticorin is that connected with the treatment of Raw cotton. Besides cotton spinning, senna pressing was prominent in those days. The local chank industry is also likewise only of historical interest. The salt produced in and round this port is exported through this port.

Ambasamudram, Koilpatti, Sankarankoil and *Kallidaikurichy* are some of the more important centres connected with the treatment of cotton mainly and trades in other products raised in and around those places.

Ambasamudram, situated on the Northern bank of the Tambaraparni river shortly after its emergence from the ghats is a bridge-town as well as a foot-hill town. Being situated on the great western main road between Tinnevelly and Travancore, at a place where the perennial Tambraparni is crossed by a bridge, at the meeting-place of the plains and the hills of the Western Ghats, it is a very good pooling centre for the agricultural specialities grown in Kadayam, Pavurchattram, and Alangulam and palmyra products of the red soil region of the southern portion of the Tenkasi Taluq. Thousands of bales of cotton yarn are exported from Ambasamudram, the product of the Harvey Mills at Papanasam. Unlike Koilpatti wherefrom also cotton yarn and lint are exported, Ambasamudram is not situated in the heart of the cotton-growing tract. The only factor that has contributed to the growth of the industry in this place is the availability of cheap motive power in the headwaters of the Tambraparni before it reaches the plains, which was utilized for the turning of the turbine. The availability of cheap labour was an auxiliary factor. The three mills have about 40000 spindles. The Cambodia Cotton of Sankarankoil area, and Tinnevelly of the Koilpatti region and cotton even from beyond Satur and Virudunagar occasionally, are brought to Vikramasingapuram direct, four miles to the west of Ambasamudram, at the foot of the Western Ghats on the northern bank of the river Tambraparni, on the road which girdles the Western Ghats connecting Tenkasi, Sankarankoil and Srivilliputtur with Ambasamudram. On account of these factors Vikramasingapuram has become an assemblage centre for raw cotton. The importance of Vikramasingapuram is further increased by the first bridge across the Tambraparni being situated to the south of the village. The completion of the hydro-electric project which is in progress now will make it still more important. It is likely that in the near future with the help of cheap hydro-electric power available locally, with excellent climate, abundant supply of cheap and trained labour force, coupled with the enterprise of the big financiers of the village just on the other bank of the river, it may become another 'Manchester.'

Hand-woven cloth is exported from Ambasamudram and Kallidaikurichy by rail and road to the Travancore State and other parts of the District. Once the entire trade in cloth of the District with Travancore was in the hands of the Brahmins of Kallidaikurichy whose vast riches (which have gone down now) are attributable only to this. Enterprising as they are by nature the Brahmins of Kallidaikurichy have specialized in a system of Banking comparable to that of the Chettiars of Ramnad District and were financing the whole of the cottage industry of the region nearby. Ambasamudram towels in this Presidency and Ambasamudram and Kallidaikurichy 'Muris' and 'Mundoos' in the Travancore State are some of the familiar trade names; and these articles command a good market even to-day.

Vagaikulam in the vicinity of Ambasamudram is an important centre in bell-metal industry. Some of the biggest and finest Bells and Idols in the well known temples in the Presidency are made here by the local 'Kannans'.

Tinnevelly.—All roads lead to Rome, so also all roads in the District lead to Tinnevelly. The convergence of all roads at this place has made it an important nodal town. Its importance is further increased by its being situated right in the centre of the District. With its satellite town of Pettai it controls the entire internal trade of the District. Grocery trade is mainly concentrated in Tinnevelly and the trade in oils, oil-seeds, and fancy goods is concentrated in Pettai which directly imports the latter from Bombay and Madras.

The bulk of the inter-taluq exchange of products is done through weekly shandies held in some 80 villages in the District. These shandies are temporary centres of intense trade activity on specified days. This institution called 'Shandies' has greatly influenced the human geography of the region by giving rise to a particular class of traders whose main economic activity is to carry products from one shandy to another. A sort of seasonal rythm is brought about in the lives of the people of the district by these shandies. For example, a market trader and a shandy bandy-walla have come to mean a certain occupational group of people as distinguished from others. A market trader may start from Ambasamudram with paddy to Tisianvillai, about four days journey by road, and sell it there and return with vegetables, visiting the various shandies on the way at Kalakkad, Panagudi, Mela Kallur, Pattamadai and Sermadevi, Kallidaikurichy, etc. The shandy trader does not follow a particular course or route. Like a tramp vessel he visits places wherein he could get business. Thus the shandy or market trader may return to his place within a week or fortnight, the length of the period depending on the condition of the market on his way. These shandies have further given rise to particular subsidiary occupations like shandy money-lending, shandy broker etc.

Certain centres of pilgrimage and famous shrines become seasonal trade centres where big fairs are held in connection with the festival of some local deity to worship whom huge congregations of people come from far and near. Cattle fairs are held only on such occasions. The fairs last for over a month though the festival proper is for shorter duration, say, ten days. New heads of cattle for agricultural operations in the District are supplied only by these fairs. Exchange of used cattle for new ones and out-right purchase of new cattle to the value of thousands of rupees, is done in each of these places like Kalugumalai (Thai Poosam and Panguni Uttram festivals), Sivalapperi (cattle fair, Navarathri fair) Alwarthirunagari (cattle fair etc.) Sankaran Koil (Audi Tapasu and fair).

Population of Tinnevelly District

BY

M. P. RAJAGOPAL, B.A., L.T., DIP. GEOG.

Introduction

This district which is the most southerly in the Presidency is bounded on the north by Ramnad, on the east and south by the sea, and on the west by Travancore. Under Sir William Meyer's redistribution scheme the taluks of Srivilliputhur and Sattur (excepting 21 villages of the latter) in the old Sattur division of the District was transfered to the newly constituted Ramnad District. In G. O. No. 1127 Press, dated 18th, June 1927, the taluks of Anjengo and Tangasseri were detached from Malabar District, and included in Tinnevelly District with effect from 1st. July, 1921. So the District is now made up of the nine taluks of Ambasamudram, Kovilpatti, Nanguneri, Sankaranayinarkoil, Srivaikuntam; Tenkasi, Tinnevelly, Tiruchendur; and Anjengo and Tangasseri. The addition and the revision of the frontier so far has brought down the area of the District to 4, 315 sq. miles.

Population

According to the census of 1931, the District had a total population of 2,046,907. Tinnevelly District comes tenth in the order of population among the districts of Madras and is above Madras average (1,797,696). There are no less than 19 towns of over 10,000 inhabitants and numerous villages of over 5,000. The following Table classifies the population in towns and villages:—

Total No. of inhabited towns and villages	Population	Under 500		500–1000		1000–2000		2000–5000	
		No.	Pop.	No.	Pop.	No.	Pop.	No.	Pop.
999	2,046,907	180	46,589	199	149,947	317	446,330	244	712,795

5000–10,000		10000–20000		20000–50000		50000–100000		100000 & above
No.	Pop.	No.	Pop.	No.	Pop.	No.	Pop.	
40	272,194	13	176,371	3	72,330	3	168,508	Nil

The largest towns in the order of population are Tuticorin, (59945) Tinnevelly (56591), and Palamcotta (51972). Tuticorin is one of the largest ports in the Presidency. Tinnevelly, at least from the times of the Nayakkan rulers, forms the headquarters of the district to which it gives its name. Palamcotta with its fort, three miles from the town of Tinnevelly on the opposite side of the river Tambraparni assumes importance as a strategical position, and from the early days of the Company's interference in the District became the military headquarters.

Graph on p. 287 shows the growth of some towns in the District from 1891-1931. In the District there are many towns which have increased little or have actually declined during the decade as compared with the pronounced growth of Tuticorin, Tinnevelly, Palamcotta or Tenkasi. Sermadevi, Alwar Tirunagari and Srivaikuntam are instances. The number of people living in Towns in the District is very high being 25%.

Density of Population

The District stands ninth among the districts in the Presidency (Madras excepted) in regard to the density of its population, with an average of 474 persons to the sq. mile. The density is above Presidency average 329. The distribution of population in the District is as shown below :—

Taluk		Area (in sq. miles)	Occupied houses.	Males.	Females.	Total Pop. (in 1931)	Density per sq. mile
Ambasamudram	..	490	50,428	96,059	106,451	202,510	413
Nanguneri	..	693	9,303	119,267	135,282	254,549	367
Kovilpatti	..	1085	76,963	174,807	182,110	356,917	329
Sankaranayinarkovil	..	634	59,230	132,888	135,192	268,080	423
Tenkasi	..	403	56,432	123,526	125,943	249,469	609
Tinnevelly	..	326	56,020	113,042	124,163	237,205	728
Tiruchendur	..	323	57,286	111,068	126,103	237,171	734
Srivaikuntam	..	361	57,640	113,311	120,929	234,240	649
Anjengo & Tangasseri	.	1	1,140	3,191	3,575	6,766	6766
District Total	..	4,315	474,442	987,159	1,059,748	2,046,907	474

Diagram 1 also shows the distribution of population in the taluks in the descending order of strength.

A glance at the Population Map clearly shows that the taluk with the largest area—Kovilpatti—is the most thinly populated, and Tiruchendur the most densely inhabited. Diagram 2 clearly shows that the density is below District average (474) in Kovilpatti, Nanguneri, Ambasamudram and Sankaranayinarkoil. The river-side taluks are all above the District average and come in the following order—Tiruchendur (734), Tinnevelly (728), Srivaikuntam (649), and Tenkasi (619). Ambasamudram's figure of 413 would be much higher if forested areas were left out of account from the total area. The lowest densities come from extreme North-east and South-west, i.e. Kovilpatti and Nanguneri respectively. These are dry areas with uncertain rainfall.

Variation in Population

Owing to the fact that the district was reconstituted in 1910, it is impossible to gauge correctly the increase of its population over any considerable period. The following table compares the population as ascertained at the census of 1931 with those of the previous census. (Previous census figures have been adjusted to allow for inter-district transfers, i.e. to show the population existing at these enumerations in the areas now forming the District. On account of changes in 1901-1911 in the District constitution, it is not possible to make such adjustments for census earlier than 1891).

1931	1921	1911	1901	1891
2,046907	*1,907,314*	*1,796,191*	*1,663,312*	*1,535,442*

1921-31	1911-21	1901-11	1891-01
139593	111123	132879	127870

Net variation in the period 1891-1931 :—511,465

Males

1931	1921	1911	1901	1891
987159	929,338	868323	806424	746571

Females

1931	1921	1911	1901	1891
1059748	977976	927868	856888	788871

A reference to the census figures relating to the old district of Tinnevelly shows that, in spite of the great famine of 1876-1878, the population increased slightly by 0·3% in the decade 1871-1881. In the next ten years the rebound usual after scarcity took place, the advance being as much as 12·7%. In the period 1891-1901 the growth of the population was 8·3% or slightly greater than the Presidency average. In the decade 1901-1911 the increase was 8%, a figure slightly below the Presidency average. In the intercensal period 1911-1921 the population increased by 6·2% and in the next ten years the increase was slightly higher 7·3%.

Graph on p. 287 shows the variation in population from 1891-1931. The subjoined statement in the following table shows variations in the taluk figures :—

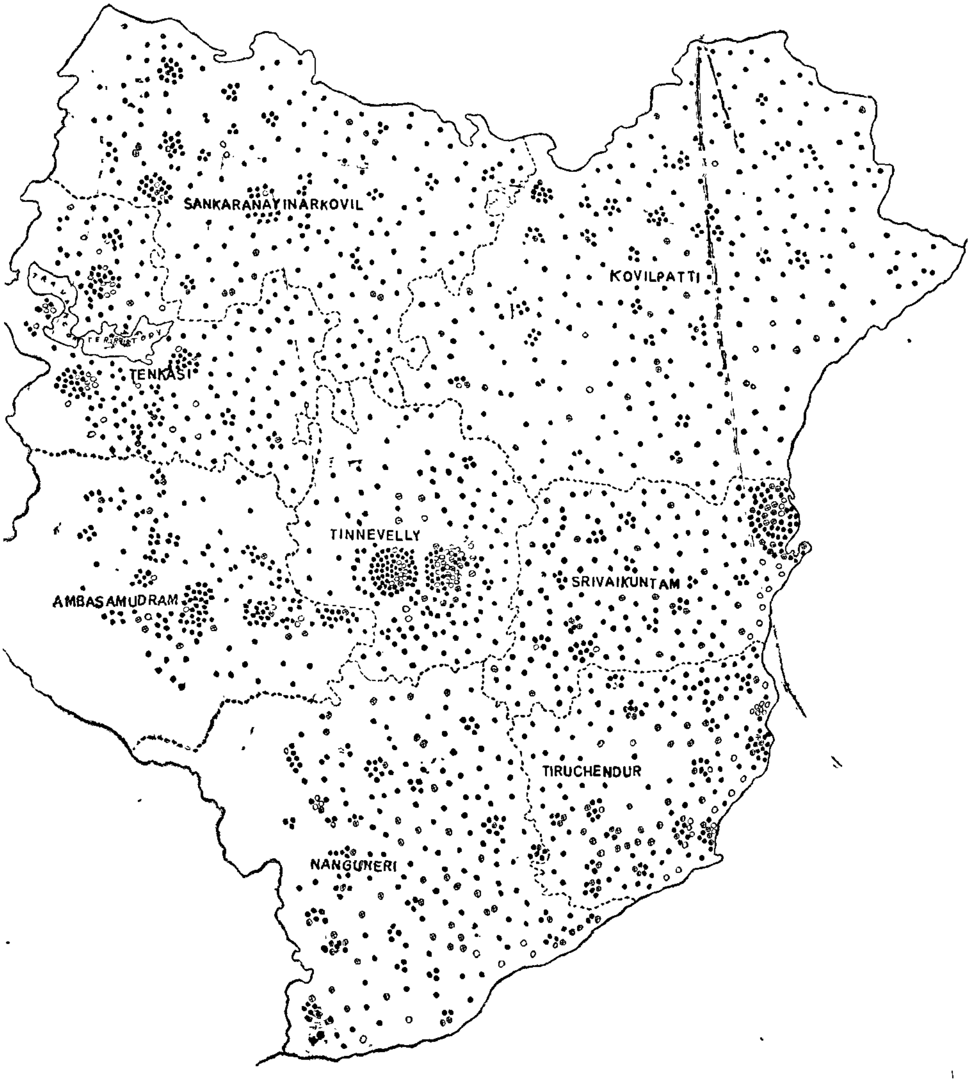
Taluk		Loss or gain of pop. percent between				
		1891–01.	1901–'11.	1911–'21.	1921–'31.	1901–'31.
Ambasamudram	..	—0·6	+6·0	+0·1	+3·7	+10·9
Kovilpatti	..	+4·6	+3·9	+3·2	+2·5	+10·1
Nanguneri	..	+16·1	+3·6	+12·2	+8·2	+25·7
Sankaranayinarkovil	..	+10·2	+9·7	+10·0	+6·7	+28·5
Srivaikuntam	..	+7·1	+21·9	+6·5	+8·9	+41·4
Tenkasi	..	+12·6	+11·8	+14·1	+12·1	+43·0
Tinnevelly	..	+5·4	+8·7	+4·5	+7·3	+27·8
Tiruchendur	..	+14·7	+3·6	—0·3	+11·3	+15·1
District	..	+8·3	+8·0	+6·2	+7·6	+25·3

The Tiruchendur Taluk shows a decrease in 1921 of over 0·3% over the figures of 1911 (which had been inflated owing to the occurrence of the Masi festival held at the time of taking census). The census of 1931 recorded an increase of 11·3% over the population in 1921. While all the taluks returned during the 20 years (1911-1931) an increase in population,—the district increase being 13·5%, the advance was most marked in Tenkasi 26·2%, Nanguneri 20·4%, Sankaranayinarkovil 16·7% and Srivaikuntam 15·4%. Tiruchendur taluk returned an excess of 11%, Tinnevelly 11·8%, Kovilpatti 5·7% and Ambasamudram 3·8% only. The gain of population per cent between 1901-1931 is highest in Tenkasi 43·0%. The reason is due to the rich irrigation at the foot of the hills in that taluk and its industrious Nadar population who have taken largely in these parts to well cultivation. Srivaikuntam ranks next 41·4%

TINNEVELLY DISTRICT MAP

SHOWING POPULATION.

One dot=1,000 persons.



Solid dots represent Hindus, hollow dots, Muslims, and hollow dots with cross inside, Christians.

due to the growing prosperity of the port of Tuticorin and partly to the extension of wet cultivation under the Srivaikuntam irrigation system.

The Growth of Population in the District *

There are two factors governing the growth of population in any country, namely, 'Natural increase' and 'Migration.' By the term 'natural increase' is meant the excess of births over deaths while the term 'migration' comprises the difference of immigration over emigration.

In Tinnevelly District during the last decade, from 1923 onwards the birth-rate exceeded that of the Presidency. The following table shows that throughout the period there had been excess of births over deaths:—

Ratio per 1,000 population of

Births.

1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
30.6	32.1	34.7	36.3	35.9	38.6	37.7	40.9	38.5	39.9	37.1

Deaths.

1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
18.8	20.6	21.9	27.1	27.6	27.5	24.4	28.1	31.2	26.3	24.2

Presidency average.

Births.	Deaths.
34·6	23·9

The death-rate in the district is not high as the general health of the district as a whole is good. The following table shows the causes of deaths in the District:—

Ratio of deaths per 1,000 of population

District average for:—

Cholera	.. 1·60	Dysentery & Diarrhoea	.. 2·28
Small-pox	.. 0·15	All other causes	.. 18·41
Plague	.. Nil		
Fever	.. 5·08	Total	.. 27·52

*The population problem in India—P. K. Wattal (p. 11).

Fever accounts for about one in six of the total number of deaths in the District, and mortality from Cholera is not much as it was before. The District is free from plague.

As in other districts in the Madras Presidency, we find in this District a greater percentage of female population than male population. Graph 3 shows the growth of Male and Female population respectively. Emigration during the decade was affected to some extent by the passing of the Emigration Act of 1922, which brought under control all assisted emigration to Ceylon and Malaya. Though no reliable figures are availabe there is reason to believe that there has been a rapid decrease, in the decade 1921-1931, in the total number of emigrants from the District.

Hence the 'Natural increase' and the decrease in 'Migration' during the last decade, together account for the rapid growth of the population in the District.

Mother Tongue.

The principal language of the District is Tamil which is the parent tongue of about 89·8% of the total population. Telugu is the language of about 8·6%; for a smaller section, Canarese, Hindustani and Malayalam are the languages; while Saurashtri, Marathi and other non-Presidency languages are spoken by still smaller section. Diagram 3 shows the distribution of population per language in the District. Tamil is spoken wholly in Ambasamudram, Nanguneri, Tinnevelly and Tiruchendur; and Telugu is spoken by a large number in Kovilpatti and Sankaranayinarkovil taluk, and by a smaller number in Srivaikuntam and Tenkasi taluks. The Nayudu and Reddi communities constitute the bulk of the Telugu-speaking section. Telugu Brahmins are sprinkled over the District in small groups.

Religion

In the District about 83% of the total population are Hindus, 5·9% are Muslims and 11·1% are Christians. Diagram 4 shows the percentage of Hindus, Muslims and Christians to the total population in the District as a whole, and in each taluk in particular. The proportion of Christians to the total population is higher than in any other district in the Presidency. The following table gives the rate of increase of the different communities in the District:—

DIAGRAM I

COMPARISON OF THE POPULATION OF THE TALUKS OF THE TINNEVELLY DISTRICT ACCORDING TO THE CENSUS OF 1931

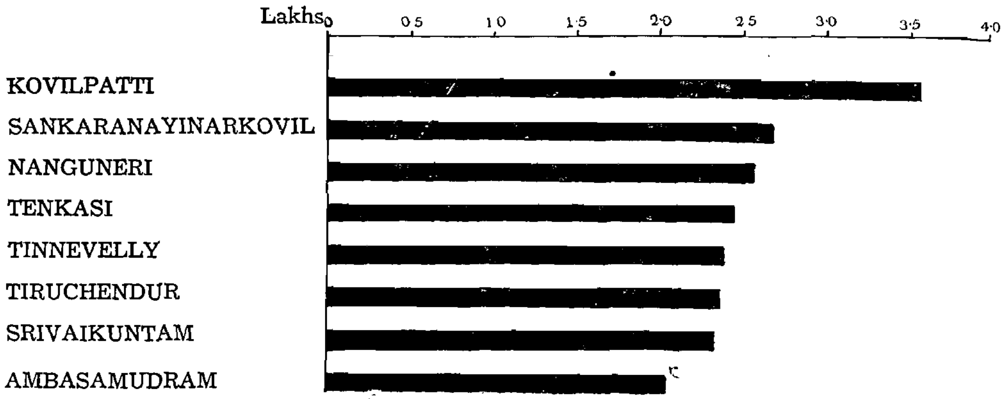
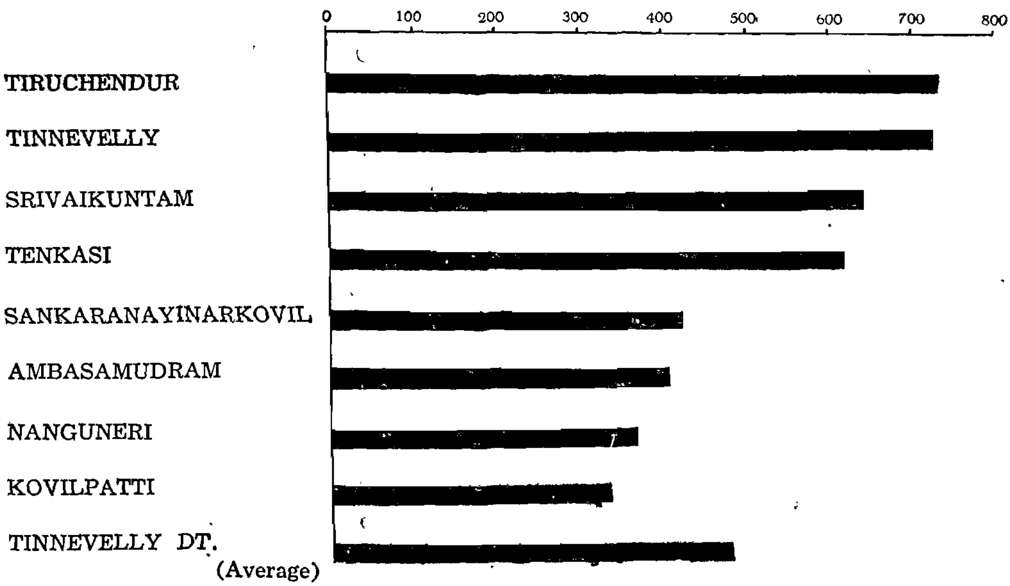


DIAGRAM II

COMPARISON OF THE DENSITY OF POPULATION PER SQUARE MILE OF THE TALUKS OF THE TINNEVELLY DISTRICT



Percentages of rate of increase

		in 1891–1901.	in 1901–1911.	in 1911–1921.	in 1921–1931
Among Hindus	..	+7·4	+6·2	+6·0	+6·2
Among Muslims	..	+6·1	+10·4	+3·4	+10·3
Among Christians	..	+9·7	+16·7	+9·3	+18·3
District.	..	+8·3	+8·0	+6·2	+7·3

Christians.—In the decade 1921-1931, the Christians (almost entirely Indians) increased by 18%. In the Tiruchendur Taluk which contains several villages wholly inhabited by Paravars (fishermen mostly converted to Roman Catholicism), the Christians comprise nearly a fourth of the total population (25·3%). Nanguneri (19·2%) and Srivaikuntam (14·5%) come next. The Christians have gained ground markedly during the last four decades, evidently by conversions. The Protestant Missions have been successful chiefly among the Nadars and the Roman Catholic Missions among the Paravar fishermen.

Muslims.—Muslims who constitute only 5·9% of the population of the District are concentrated in the three taluks of Tinnevelly (12%), Tiruchendur (9%) and Tenkasi (9%). They belong to a class usually known as 'Labbai.' The Muslim population is distributed more along the coast than in the interior, as Muslims are a sea-faring people.

Hindus.—The Hindus constitute the bulk of the population. The Brahmins form only 2·6% of the total population.

The principal castes other than Brahmins are:—the Nadars found along the sand-dunes, and known as the palmyra-climbing and toddy-drawing castes and who are mostly converts into Christianity; the Maravars; the Vellalans who come next to Brahmins in the social scale; the Vadugars and Kammans (commonly known as Naidus) and Reddis concentrated in the Black Cotton lands; and the Iluvans who are mostly weavers.

Literacy.

Judged by the census returns, Tinnevelly District stands fourth among the Districts of the Presidency, in regard to the literacy of the population as a whole. The census of 1931 discloses a great advance in education in the District. 25·7% among males were returned as literates, or an increase of 12·2% in 20 years. Literacy among women is marked—4·7%, an increase of 80% over the figures for 1911. The Hindus are the least in literacy (13%), and Christians the most literate (29%), the Muslims coming in between them with 20·5%. The high value of literates among Christians is due to the advanced state of women education among them. In point of general literacy Tiruchendur containing some important missionary centres, comes first among the taluks; next come the taluks of Srivaikuntam, Tinnevelly, Ambasamudram and Nanguneri, the least literate taluks being Sankaranayinarkovil, Tenkasi and Kovilpatti.

The proportion of illiterate males and females to the total population are 74·3% and 95·3% respectively. The following table gives the number of literates among males and females in each taluk :—

Taluks.	Education in 1931. No. of literates. Males.	Females.	Literates per 1,000 of pop. Males.	Females.
Kovilpatti	37,396	3,448	214	19
Sankaranayinar-kovil	24,440	1,626	184	12
Ambasamudram	26,185	4,620	273	43
Nanguneri	28,915	7,232	242	53
Tenkasi	25,467	2,331	206	19
Tinnevelly	34,907	7,908	309	64
Anjengo and Tangasseri	1,131	980	354	274
Srivaikuntam	39,328	8,834	347	73
Tiruchendur	36,236	12,994	326	103
Dist. Total	254,005	49,973	257	47
Hindus	194,077	23,115	234	26
Muslims	20,163	1,930	377	28
Christians	39,753	24,928	369	207

Life and Occupation of the People

In Tinnevelly District, Pastoral and Agricultural occupations form the most important occupations and support 24·1% of the total population (as against 28·2% of the population in the Presidency who are found to be actually engaged in agriculture). Among

DIAGRAM III

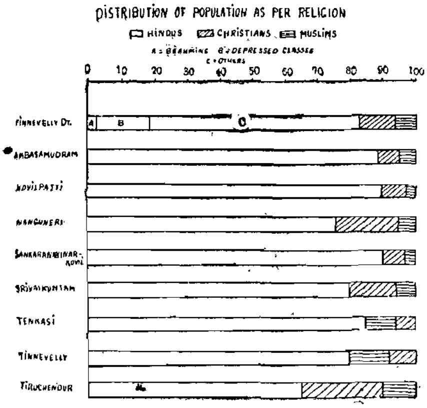
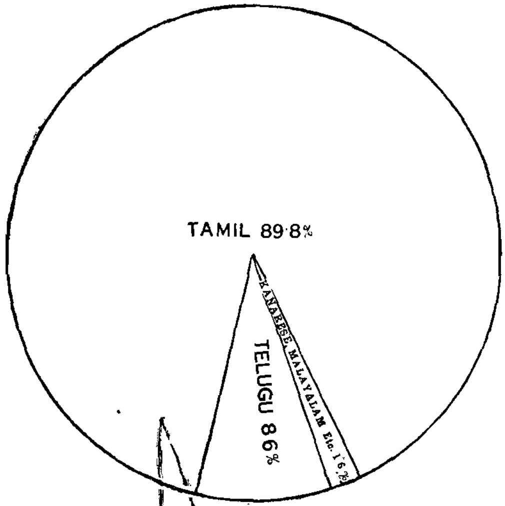
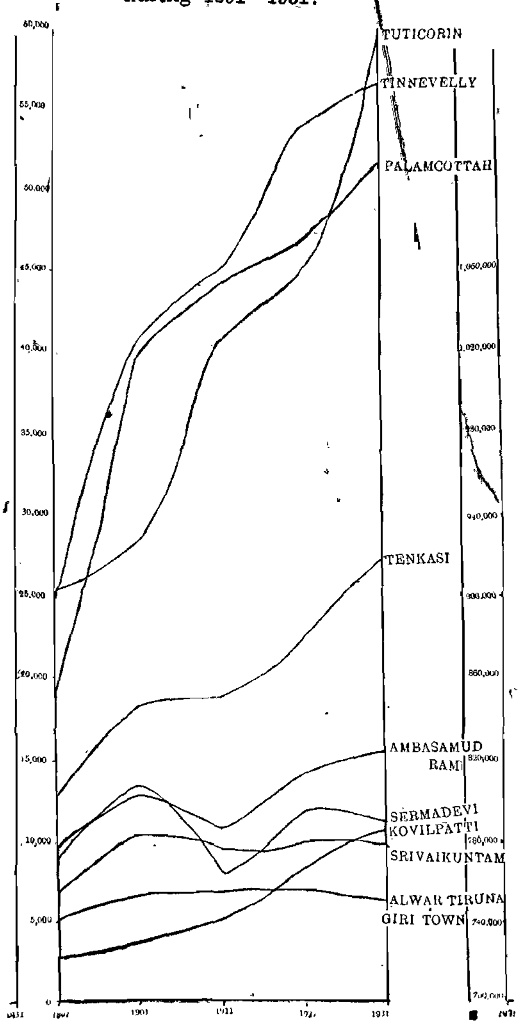


DIAGRAM IV

Distribution of population as per language.



Variation in the population of some of the towns of Tinnevelly District during 1891—1931.



the agriculturists, the cultivating landowners form 9·5% of the total population, and non-cultivating landowners only 0·8%. As many as 14,342 people were returned by the census of 1931 as being actually or partially deriving their livelihood from the palmyra.

The cotton cultivation and cotton industry provide occupation for a large number of individuals. There were in 1931 a total of 21,306 weavers and spinners as against 12,800 at the census of 1921. The weaving of cotton cloths is the hereditary employment of the Kaikkilaiyans, Pattasalaiyans and Pattunulkarans, and forms the chief occupation of a large number of Muslims.

Domestic service comes next to agriculture and employs 13·8% of the population. About 6% of the population is supported by industry while only 2·6% is engaged in trade.

According to the census of 1931, about 47·2% of the total population are non-working dependents. The large body of non-working dependents in the District, with its trade connections outside India may be due to the actual workers being employed outside the District and supporting their families at home by money remittances.

The following table shows the classification of the people in the District according to their hereditary occupations :—

Occupation.	*Pop. supported by the occupation.*	*Percentage of the Pop. to the total pop.*
Pastoral and Agriculture ..	493,379	24·1
Domestic Service ..	282,564	13·8
Industry ..	124,961	6·1
Trade ..	53,331	2·6
Others ..	1,112,672	53·4

LIST OF REFERENCES

1. *Tinnevelly District Gazetteer,* Vol. 1 and 2.
2. Census Report, 1931, Madras. Parts 1, 2 and 3.
3. Statistical Atlas of the Madras Presidency, 1936.
4. The Journal of the Madras Geographical Association—
   Vol. 11, July 1936.
   Vol. 12, October 1937.
   Vol. 13, June 1938.
5. The Population Problem in India by P. K. Wattal.

The 'Race' Idea, and the Present Conflict

BY

NAFIS AHMED, M.A., B.E.S.,

Professor of Geography, Islamia College, Calcutta.

Racial hatred was deliberately worked up in Europe as an instrument of national policy and even before the present conflagration started, it succeeded in spreading the poison of mutual hatred among the peoples of the Continent. It went a long way in destroying good neighbourly feelings among the European states and certainly influenced the outlook of many an ambitious political party elsewhere. There seems hardly any consolation in the fact that such an idealogy of hate was utilized merely as a cover to hide ugly political and economic motives and to divert the attention of distressed millions from real issues to vague and vain-glorious idealism. To the protagonists of the 'race' idea, the conception of the 'human race,' 'the brotherhood of man,' and the like notions relating to the common destiny of mankind, are a misreading of the evolution of human society. They can only visualise 'blood groups' which have been engaged in a ceaseless struggle to obtain places in the sun!

Thus it was that an aggressive fascism exploited the idea to justify its brutality and ruthlessness.

Nazi Racial Theory.

By a curious turn of events a people of Europe, whose contributions. to modern scientific thought speak for themselves, are to-day the most ardent upholders of the *race* idea. To the Nazi philosophers it is the revelation of a new religion, which, all other so-called scientific notions and religious gospels had criminally shut out from the minds of men (to the detriment of the Germans!); according to them a people is a 'unity, totality and value' only to the extent that it incarnates a superior race. Herein lies the purpose of the racial state—the 'race' is the pivot of common life and certainly an instrument to beat the 'inferiors' out! The 'race' is to be kept pure at all costs and for Germany the race can mean only the 'Aryan' or the Nordic race. Alfred Rosenberg, the Director of Culture and the brain of the Nazi party declares that 'the belief embodied in the sublime knowledge that Nordic blood represents that mystery which has replaced and vanquished the ancient sacraments' should be the Gospel. If it is suggested that perhaps, except in very tiny localities, nowhere in Germany did there exist a 'Nordically' pure race, then the 'racial' megalomaniac is ready with his retort—by careful selection the Germans could again be 'Nordicised' (what about the horses and pups—and dear intellectuals, you forget the great Spartan ideals!).

Task of the Geographer and the Anthropologist.

What is the answer to such sheer nonsense? The Geographers and the Anthropologists scratch their heads and fall back upon the resources of their sciences. To them who have had their training in the School of Scientific inquiry, free conscience and rational approach, the topic sounds like the best joke in the garden of racial humour! Then what is their answer? Certainly racial prejudice is another name for ethnological ignorance. The Social Sciences are being challenged by forces of reaction. And the totalitarian states have gone to amazing lengths in making perverted use of anthropology and sociology in advancing their views. According to Professor Griffith Taylor, geographers could do yeomen service to humanity by clarifying some of these issues by teaching tolerantly and scientifically what is becoming known as cultural geography. It will help to clear conceptions in drawing the much-needed distinctions between race, nation, language and religion, which are too often imperfectly grasped.

The Meaning of Race.

What is then the meaning of *race*? Can we speak of races as pure? What are the racial distributions of Europe? And who are the Nordics?

The origin of the word *race* is unknown, according to the late Dr. Herschfeld; some etymologists look upon Spain as its first European home, declaring that the Moors brought it thither, since they have a word 'ras' which means 'origin' or 'source'. Others derive it from the Latin 'radix' a 'root', and yet others from the old High German 'reis' which meant a line or fissure or cranny. This would connect it with the English 'raze.' But these are little better than speculations. Race can be said to be a biological term indicating major groups of people who share a common descent and hence display some similar characteristics, These characteristics, so far as they are physical and not mental may be such external features as the colour or quality of the hair, the colour and the form of the eye, the shade of the skin and the shape of the nose. The external characteristics are easy to study, as many of them are visible at first glance. Due to this simplicity, the popular classification into the white, yellow, red and black races had long been continued. But such external characteristics are poor guides to ancestry as they are susceptible to varied changes under the influences of geographical environment. The influence of 'Climate is most far-reaching, for example dark coloured people predominate *in hot climates and fair skinned people in lands that are cool and cloudy*' although complexion and *climate do not always* agree. Certainly as far as external traits are concerned it is difficult to draw the line between the influences of geographic environment and race, and they are, therefore, a poor guide in determining biological relationships.

Head-form provides a better criterion for race, because of the preservation value of the skull and the facility of studying human remains from past ages. Thereby the past can be compared with the present although the correlation between head-form and mental traits is slight and no study of bodily traits has yet gone far in showing any relation between race and innate ability. It is amusing to note mental differences between closely related individuals, or even between selected groups of people within a given race, are much greater than between any two living races as a whole.

All are agreed (with the exception of the racial maniacs!) that pure races in the form of great groups of people, exhibiting the same physical characteristics and the same biological descent no longer exist. The world has now come to be inhabited by all sorts of mixtures of races, who are really highly diverse, and it is perhaps by averaging together a great number of *individuals* or by classifying them into types, *that outstanding racial tendencies of different groups are recognized.* 'Hot-house' produced '*races*' *are there certainly* none and the myth of racial superiority vanishes before the logic of environmental influences.

Peoples of Europe.

How was Europe peopled? Very little is known about the earliest inhabitants. Geologically speaking, in that early period of human activity much of Northern Europe, including Scotland, Northern England, the Low countries, Denmark, North German, Polish and Russian plains, Scandinavia and Finland, were covered over with the huge ice-sheet, which retreated and advanced several times, before finally disappearing. The Heidelberg skull from Germany and the Piltdown skull from England indicate a primitive human type with ape-like jaws and powerful physique. Then came the Neanderthal man with long heads and broad noses, very much similar to the Australians and the extinct Tasmanians. The tall Cro-magnon man inhabited much of Western and South-Western Europe during the next period and has left a legacy of wonderful cave-paintings reflecting his high talents.

Then began a unique infiltration of new-comers to Europe from the heart of Asia and ushered in the period of the great migrating intruders who can be divided into three groups, regionally—the Mediterranean race in the south, the Alpine race in the centre and the Nordics in the north. Indeed, the change in climate from the rigours of the Ice-age to increasing mildness, must have exerted a 'push and a pull' upon these early peoples in the grassland interiors of Asia. The push from behind was, doubtless, due not only to increasing drought but also to growing density nearer the centres of the deserts. The pull in front was due to the attraction of the new ice-free unoccupied lands, which were gradually passing out of the grip of the glacial climate in Europe. No one can tell whether the pull was stronger or the push, but the passing away of the Glacial period presumably caused migrations into Europe to follow different paths at different times, according to the suitability of regions for human existence and the ease of movement dependent on relief.

The Mediterranean race was the first of the three main migrating (racial?) groups to reach Europe, probably via North Africa from Asia. These people were characterised by long heads, medium stature and dark hair and eyes, spread over the whole of the Mediterranean basin and extended through France into British Isles and even to Scandinavia. The Alpine group of intruders had broad heads, stocky build, short stature with dark hair and dark to greyish eyes. They chiefly penetrated into Europe north of the central mountains, spreading over to the Balkans, the Danube Valley and the Alps. They intermingled with the Mediterraneans over the plains of France and the lowlands of the Po. They later on pushed on to Spain, British Isles and Norway. The Slavs are very largely their representatives in much of Russia and the Balkans. The Nordics were the youngest group of intruders with long heads, fair hair, blue eyes and were tall. Many of their physical traits were developed in the environment of North-Western Europe. Later, the Nordics likewise spread to many directions. A body of Nordics, the Russ, migrated from Scandinavia to Russia (but according to the Nazis, the Russians are inferiors!) and gave their name to that country. They settled even in British Isles, Normandy and Iceland.

Thus, the area which we often call 'the Germanic lands' (Austria and the Sudetan areas of Czecho-Slovakia included) has been a cockpit of racial admixtures, chiefly the Alpine and the Nordic. In fact in coming to Europe these so-called racial groups have actively shoved one another aside, interpenetrated and mixed. With the change in environment, they have suffered mutation, their complexions, stature and figures have undergone radical changes. In Europe a noteworthy change has been the evolution of blondness in the North-west both among the Nordics and the Alpines. And similarly environmental influences have gone far, in all parts of the world, in marking their stamp on diverse human groups.

Exploding the Myth.

Magnus Hirschfeld, one of the leading modern sexologists in a comprehensive exposition, supported by elaborate investigations has exploded the myth of 'Nordic superiority' and its plenty of geniuses. Taking the example of the allotment of the Nobel Prize he says, "All such lists when made without bias, will show that persons of genius and persons of outstanding talent are not set apart from the rick by any peculiarity of stature, by their complexion, or the colour of the eyes, by a peculiar shape of the skull or the nose, by any ethnological characteristics whatever. What is decisive in human beings is not 'race', but individuality. A great individual, a 'genius' can appear anywhere and at any time as the outcome of a lucky assortment of gemes and an upbringing in a favourable environment." Thus science has *long since exploded the mythical* superiority of the Nordics or the 'long heads.' With a belief to the contrary the 'Germans' will have to dispense with such 'inferiors' as Luther, Beethoven, Nietzche, Goethe, Bismark and above all Hitler! For such luminaries of 'Nordic blood group' come from southern areas of acute intermingling in Germany—what an irony!

Why Racial Megalomania?

One might ask, why all this 'racial' megalomania? Germany! Hitlerite Germany to-day believes all its activities to be dictated by the need for self defence. Certainly the most provocative doings of the Third Reich are the outcome of defensive reactions.

It is usual for the people in a 'bad way' to ascribe their troubles to the criminal intentions of others. After the exhaustions and disappointments of the War, the humiliations of Versailles, the miseries of inflation and widespread unemployment, Germany was in an explosive and catastrophic mood ready to accept a leadership blindly. The reactionary leadership needed an 'idea' to cover their economics'—ruthless suppression at home and naked aggression abroad. 'Racism,' provided such a safety-valve and a means of release. Goebbels calls it a 'discovery', but certainly it was a clever 'invention.' Thus 'Racism' like war made it easy to hunt people out of their positions, deprive neighbouring regions of their freedom and reap the harvest of economic loot, all the time singing the hymns of hate punctuated with jingoistic utterances and celebration of victory. In his 'Racism', Hirschfeld points out: "It was possible for mass selfishness to parade behind the respectable mask of patriotism or Nationalism. Under racist auspices, too, it became easy for self-seeking to take the name of eagerness for public welfare. Internal and external hindrances to the cult of egoism having been removed, the apostles and energumens of racism in all good faith give free rein to impulses of which they would be ashamed did they realize their true nature—selfishness has been rationlized."

The Future!

Then what is to be done! The poison of racism is eating into the vitals of broader human understanding. The law of the jungle is prevailing. The goal of mankind seems to be a death struggle between warring groups—'superior races!' The 'racists' instil megalomania and intolerance into the minds of children, awakening prejudices which sooner or later would lead to strife at a scale which even the barbaric ages had not witnessed. Our immediate objective is a world of peace and it behoves us to counter-act the pernicious attempts of the false prophets.

Subjects like Modern Geography, sociology and anthropology are vital to such an education which must lead to a sympathetic understanding of world problems, especially those involving other nations and cultures. They dispel hatred and build up a free conscience—a preliminary to solve the problems of mankind. Thus when the agonies of the present conflagration are ended, education must primarily aim at the creation of an international citizenship which alone would succeed in saving a warring humanity from barbarism and destruction.

Select Contents

The Geographical Journal: June 1940.

Karakoram, 1939—By Eric Shipton.

Surveys on the Roman Frontier in 'Iraq and Transjordania—By Sir Aurel Stein.

Fact and Function in Anthropology—By J. H. Hutton.

The Geographical Journal: July 1940.

Botanical and Geographical Exploration in the Assam Himalaya—By Kingdon Ward.

Primitive Tribes in Madagascar—By Olive Murray Chapman.

Notes on the Northern Sea Route—By Professor Kenneth Mason.

The Geographical Journal: August 1940.

The West Indies in 1939—By Lord Moyne.

Geography: June 1940.

Ibn Khaldun's Prolegomena to History (*Trans.*)—By Abbas Ammar.

Irrigation in the Canterbury Plains—By Margaret F. Davies.

Children's Maps: An Experiment—By Ethel David.

The Geographical Review: July 1940.

Hawaii and the Pacific: A Survey of Political Geography—By Stephen B. Jones and Klaus Mehnert.

Stockholm: Its Structure and Development—By W. William-Olsson.

The World's Petroleum—By John W. Frey.

Depositional Environments of Sedimentary Rocks: A Review By Henry C. Stetson.

The Geography of the Monroe Doctrine and the Limits of the Western Hemisphere—By Lawrence Martin.

Proceedings of the National Institute of Sciences of India: Vol. VI, No. 2.

Studies on the Chemistry and Biology of the Slow Sand Filters at the Madras Water Works—By S. V. Ganapati.

University of Mysore : Department of Geology.

The Upper Cretaceous and Lower Eocene Beds of India—By L. Rama Rao.

Audit Union of the Workers' Agricultural Co-operative Societies, Limited.

The Co-operative Villages of Palestine in 1938.

Journal of the University of Bombay : July 1940.

Kathiawar Ports—By R. D. Tiwari.

Coir Industry and Trade on the Malabar Coast—By K. S. Venkataraman.

The Gold Thread Industry of Surat—By A. B. Trivedi.

A Sociological Study of the Kolis in Kathiawad—By B. L. Mankad.

Indian Information : July 15, 1940.

All-India Soil Survey.
Soil Map of India.

Indian Information : August 1, 1940.

India's Pearl Farms.

Indian Information : September 1, 1940.

Paper Manufacture in India. .
Madras Fuel Forests are being Regenerated.

News and Notes

Four ordinary meetings of the Association were held during the third quarter of the year. In the first two of them, held on 27th July and 3rd August respectively, Rao Bahadur K. N. Narasimhacharya (Asst. Director of Survey) delivered two lectures on *Topographical Surveys* and *Cădastral Surveys.*

* * * * *

In the third meeting held on 31st August, Mr. M. Subrahmanya Aiyar spoke on *The Defence of India: A Study in Historical Geography.* In the fourth meeting, held on 14th September, Dr. S. M. Hussain Nainar (of the University Department of Oriental Research) delivered a lecture on *Arab Geographers of India.*

* * * * *

In this issue of the Journal, the papers on *Sugar* and *Red Hills Lake* are concluded; and some of the remaining papers of the Tinnevelly Conference such as Paddy Cultivation, Population, Trade-centres and Communications are included.

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The 11th Geographical Conference of the Association will be held at the Rishi Valley in Chittoor District during next summer; and along with it a Summer School of Geography will also be conducted there. It is not yet decided whether there would be a separate Summer School at Saidapet also.

* * * * *

Four important Resolutions were passed at the business session of the Tinnevelly Conference, the first of which regarding the conversion of the Associate Members of the Association to Ordinary Members has been approved by the Executive Committee; and steps are being taken to have the rule altered before the next General Body Meeting.

* * * * *

As regards the other three resolutions—about the separate entry of the History and Geography marks in the S.S.L.C. book, the increase of the time for the question paper, and the inclusion of the World Regions for S.S.L.C. Public Examination—a copy of the resolutions has been submitted to the Board for consideration and necessary action.

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We are glad to note that Mr. V. Kalyanasundaram, M.A., L.T., Dip. in Geog., has been appointed Junior Lecturer in the University Department of Geography, Madras.

* * * * *

While none of the Colleges in Madras (except Queen Mary's) has started Geography, it is gratifying to learn that two colleges in Mysore State (at Mysore and Bangalore) have opened Geography at the Intermediate stage this academic year with the idea of continuing it in the degree course.

* * * * *

Of course, Aligarh stands pre-eminent with its well established M.A. and M.Sc. courses in Geography—thanks to the pioneering zeal and spade work of Dr. I. R. Khan of the U. P. Educational Service and the untiring zeal and steady work of Dr. S. M. Tahir Rizvi.

* * * * *

Dr. Rizvi is the President of the Geography and Geodesy Section of the Indian Science Congress Session to be held at Benares in January next. We are glad to learn that a good number of interesting papers have been contributed for this section—several from this province.

* * * * *

The All-India Federation of Teachers' Associations will meet at Udaipur from 27 to 30th December 1940. Teachers from South India who intend to attend the Benares Session of the Science Congress can make it easily convenient to attend the Udaipur Conference also on their way.

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Reviews

Food, Clothing and Shelter Geographies: *Book* 8—*The World for Senior Students*. By McD. Robison. (Macmillan and Co., Ltd). 1940. Price Rs. 2—4—0.

In reviewing the earlier books in the Primary Series in a recent issue of the Journal, we had pointed out that the central aim of the whole series has been to bring out man's efforts to obtain food, clothing and shelter, as indicated in the general title. "The pupils observe sparsely settled areas in their own neighbourhood. They apply their growing geographical knowledge to studying where and why man lives in small numbers and in large numbers in different parts of the world". This aim is more fully developed in the books of the Post-Primary Series of which the volume under review is one. These show the relationship between land forms, vegetation, climate and distribution of population.

In this eighth book of the series, there is a more advanced treatment of the World for Senior Students than in Book 7. The plan of the volume is as follows:—The first five lessons deal in order with Landscape, the Hydrosphere, the Atmosphere, Land Forms and Vegetation and Animals. The 6th lesson deals with the Major Climatic Regions of the World under the subdivisions (which are further subdivided) of Tropical Climates. Intermediate Climates, Polar Climates and Mountain Climates. The last three lessons treat about Man's Occupations and Settlements, Transport and Trade and Geographical Regions. The volume is well got-up and finely illustrated with numerous choice pictures, sketch-maps and diagrams; and as in the Primary Books of the series the exercises in Part B of each lesson serve both for revision and further work.

The Complete Geography Series: *The World*; *The Complete Geography Series*: *The Americas.* By Alys. Mamour. (Macmillan & Co., Ltd.), 1940. Price Sh. 4 each.

The above are two of the volumes in this series designed to provide a complete course in Geography for pupils aged eleven plus. The volumes are self-contained so that they can be used independently also.

The series comprise the World as the Introductory book and three "gores" of the world in order—the Americas, Asia and Australasia, Europe and Africa. The first two alone are under review here. The key-note of the series may be summed up in the words Realiability and Readability; but special mention should be made of two of the noteworthy features such as the exercises at the end of each chapter and the many short excerpts from travel books and authoritative volumes arranged and inter-woven as part of the text. In fact the latter feature is unique and characteristic of the volumes—serving to sustain interest, enabling pupils easily to follow and enjoy the facts presented.

Other important points in the series are the specially prepared maps, the numerous valuable illustrations from authoritative and reliable sources, suggestions on geography games, handwork and local study, and a *balanced* treatment of the various countries. Each of the volumes forms a complete course indeed.

The World and Ourselves. By Elsie White. (W. & A. K. Johnston, Ltd.).

This is a superb volume of World Geography for Children treated regionally in a simple descriptive way. Starting with the Lands of Ice and Snow, the child is taken round through Mountain lands, Lands of Corn and Cattle, of Fruit and Sunshine, of Sun helmets and Mosquito nets, Lands of Wind, Rain and Rice (India, China and Japan), Lands using Steel and Concrete (Britain, U.S.A., and Western Europe)—and brought to the neighbours of Britain, closing with the chapter on "London Calling the World." Altogether a splendid introduction to World Geography for Children with attractive get-up, bold print, fine pictures and useful maps. Provision is made at the end of each chapter for varieties of practical work including handwork and suggestions for further study.

A Map Book of North America: For Middle and School Certificate Forms. By A. Ferriday. (Messrs. Macmillan and Co., London). Price 1/9d. paper cover; 2/- cloth.

The teaching of Geography in schools has now-a-days ceased to be the dull, mechanical, bookish thing it was; and among the factors that contributed to it have been books of the type under review.

This Map Book of North America follows the plan of the previous books of the series, reviewed in earlier numbers of the Journal, namely that of presenting the main geographical features in map form with accompanying text on the opposite page. The questions included at the end of each lesson serve to test the pupil's capacity for illustrating his answers with sketch-maps. They include those taken from school certificate papers, being intended for school certificate forms, though the more straightforward ones might be attempted by pupils of middle forms.

Exact Knowledge Tests in Geography: The British Isles. By R. V. Taylor. (W. & A. K. Johnston, Ltd., Edinburgh).

This set of 7 outline maps of the British Isles, showing Towns, Rivers, Landmasses and Headlands, Islands, Seas, Railways, Coalfields, Industries, etc.—complete with answers, enables a simple accurate method to be applied in testing knowledge of map positions. These tests enable the teacher to test, mark and analyse as speedily and efficiently as in testing mental arithmetic with a great saving of time and energy for him, at the same time giving him an accurate and comprehensive record. The use of these tests in schools is strongly recommended for the reasons stated.

Journal of the University of Bombay, July 1940. Vol. IX (New Series), Part I, History, Economics and Sociology Section.

This useful volume contains besides several important historical articles, the following articles that may be considered to be having a geographical bearing though they are primarily of an economic nature:—Kathiawar Ports, Coir Industry and Trade in the Malabar Coast, the Gold Thread Industry of Surat and A Sociological Study of the Kolis of Kathiawad. In the article on Kathiawar Ports, Prof. R. D. Tiwari discusses the location of the several ports, facilities offered by them, artificial extensions, services regarding shipping and goods with statistics of recent years showing competition between the ports themselves and closes up with an indication of their future.

Books and Journals Received

The World and Ourselves: By E. White.

Exact Knowledge Tests in Geography: *The British Isles*: By R. V. Taylor.

Studies on the Chemistry and Biology of the Slow Sand Filters at the Madras Water Works: By S. V. Ganapati.

The World for Senior Students: (*Food, Clothing and Shelter Geographies, Book* 8). By L. McD. Robison.

The Complete Geography Series: *The Americas.* By Alys Mamour.

The Complete Geography Series: *The World.* By Alys Mamour.

A Map Book of North America: By A. Ferriday.

The Upper Cretaceous and Lower Eocene Beds of India: By L. Rama Rao.

The Co-operative Villages of Palestine in 1938.

Issledowania—Photometry and Sensitometrii, Book I (Moscow).

Issledowania—Kartografii (Moscow).

Issledowania—Geodessi (Moscow).

Trudia: *Centralanogo, Navno Issledowatelskogo*: *Books* 30, 31 *and* 33 (Moscow).

The Educational Review: June, July and August 1940.

South Indian Teacher: June, July and August 1940.

Journal of Indian History: April 1940.

Southern India Commerce: June, July and August 1940.

Indian Information: July 1, July 15, August 1, August 15, and September 1.

Quarterly Journal of Mythic Society: July 1940.

Kalaimagal: July, August and September 1940.

Journal of the University of Bombay: July 1940.

The Indian Journal of Political Science: July-Sept. 1940.

Geography: June 1940.

The Geographical Journal: June 1940.

Geographical Review: July 1940.

Indian Co-operative Review: April-June 1940.

Visvabharathi Quarterly: Aug-October 1940

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Geology of the Tinnevelly District

BY

PAUL GNANAPRAGASAM DOWIE, M.A., L.T., DIP. GEOG.

The following sequence of geological formations is to be met with in this area under review, and they will be considered in order from the oldest to the youngest:—

Formations.	*Age.*	
Soils.— Aeolian formations— The Teris and coastals sand-dunes Alluvial formations— Fluviatile, estuarine and marine	Recent	ARYAN ERA.
Marine calcareous grits along the coast	Pleistocene (?) and Recent	
Lateritic formations	Tertiary, Pleistocene and Recent	
Gritty sandstones	Tertiary (?)	
Crystalline limestones and quartz granular gneiss Biotite gneiss	These gneisses and their associated igneous rocks belong to the Vedic Era.	VEDIC ERA.

THE ARCHAEAN ROCKS.

By far the largest area is shown on the map as being occupied by the Archaean rocks; yet, over wide areas these rocks do not outcrop as the result of soil cover of varying thickness. This is particularly true of the black cotton region comprising almost the whole of the Koilpatti Taluk. Though much work is yet to be done, as far as our present knowledge of the area is concerned three types of formations may be recognised: (1) Granular quartz gneiss, (2) crystalline limestone, (3) biotite gneiss almost invariably containing garnet and occasionally hornblende. Though the relationship of the three formations with one another is not definitely known, it appears likely that the first two formations are of the nature of para gneiss, probably corresponding to the Bengal gneiss occurring over the biotite gneiss.

(1) *Granular Quartz Gneiss.*—The southernmost outcrop of the gneissic rock east of the Vaippar occurs in the form of granular quartz gneiss at Bommayyapuram exposed in some roadside road metal quarries. The rock appears to be inter-bedded with biotite-hornblende gneiss to be also seen in similar pits at Kodangipatti. A wide band of similar rocks outcrops in several hillocks east of Kovilpatti, as in the Minakshi hill south of the village Minakshipuram and Singampatti; and then it continues in the form of a ridge to Koilpatti peak. The ridge runs southward parallel to the railway line for about six miles and then strikes roughly south-eastward for about 18 miles, to about four miles south of Ottappidaram, and disappears under the black cotton soil. Several hillocks of biotite-hornblende gneiss having the same trend rise out of the cotton soil west of the railway line from Kovilpatti to Maniyachchi, north of Kadambur. Some granular-quartz-gneiss may be seen inter-stratified with it. A large number of detached masses of granular-quartz-gneiss, the relationship of which with those described above is obscure may be seen in several places as (1) a little west of Maniyacchi village; (2) in the form of a band at Timmarajapuram four miles S. S. W. of Melatattapparai; (3) the ridge situated about two miles N.E. of Sivalapperi; (4) the hillock to the west and south-east of Pudukkottai about eight miles S.W. of Tuticorin with a length of about 10 miles and width approximately five miles at its widest part, forming the Vallanadu ridge, requires special mention. The gneiss forms a big anticline and the S. E. limit is Sevalai and a small outlier occurs south of the Tambraparni about a mile S. E. of Karungulam.

South of the Tambraparni the granular-quartz-gneiss occurs in the form of two ridges south of Palamcottah; the northern ridge starts abruptly at Reddiyapatti hill and curves north-eastward to Krishnapuram and Paraikkulam; the southern ridge continues from the Sangani hill two and a half miles S.W. of Tinnevelly Town, to Taravai and Sivandippatti, and then is probably represented either in the hills occuring N.E. of the place or S.E. in the hillocks to be seen near Karungulam. In both the ridges the dip of the foliation appears to be northerly. Another important exposure occurs in the Melpattam hills, 519 feet in height situated about 3 miles N.E. of Palamcottah on the southern banks of the Tambraparni; when continued north of the river it appears to be continued in the Talaiyuttu ridge 517 feet in height; a good exposure of the rock may also be seen in Palamcottah, extending for about 2½ miles and then disappearing under the red soil eastward.

The quartz-granular-gneiss, on account of the light colours exhibited by them, and its barrenness the exposures being covered with reddish debris, forms a conspicuous feature of these parts. The rock simulates in appearance a coarse grained quartzite with whitish or pale reddish white colour, in weathering taking lighter red or yellowish colours. Occasionally pale pink felspar and scales of blackish green mica may be seen locally. As this rock appears to be of no use for building purposes, it is not quarried to any great extent anywhere.

(2) *Crystalline limestone*:—One of the most interesting occurrences is an outcrop of handsome pink and pinkish white coarse crystalline limestone seen a little east of Sengottai, which is, evidently, an extension of a much longer outcrop to be seen about 6 miles to the north-north-west of the place and outside the district limits,, *viz.*, the Pandalakudi limestone bed. Near Sengottai the limestone is exposed in the off-flow channel of the tank situated east of the village and the thickness of the bed may be about 20 feet. The limestone is inter-calated with hornblendic beds containing pink calcite. The red-gneiss outcropping at Nagalapuram appears to belong to the same series as the crystalline limestone, as it has the same trend.

(3) *Biotite Gneiss.*—This is a granite gneiss showing distinct banding chiefly consisting of quartz and felspar with a small proportion of biotite and occasionally hornblende, but almost invariably certain innumerably tiny garnets. As it is the chief type

noted near Cape Comorin, it has been called by R. B. Foote as th Cape Comorin Gneiss. As the banding is of various strikin colours as white, grey, and pink, it has a pleasing appearanc The various outcrops occurring in Tinnevelly and adjacent area are to be related to the rocks constituting the Western Ghats which also consist of the same gneiss ; hence, the trend of the out crops, which are more numerous near the Western Ghats is roughly W.N.W. to E.S.E. The more important exposure south of the Tambraparni are the following:—(1) About 11 mile S. W. of Palamcottah there occurs a typical exposure of the gneis near Singikulam Pudugramam. It is in the form of a ridge 500 fee in height and the trend when continued north-westward coincide with that of the high and beautiful Kolundumamalai 1953 feet i height. Several smaller hillocks may be seen between hills havin the same strike. (2) North of the road leading from Nanguner to Kalakkadu there are several hills having the same trend; th most important of these is the Piranda Malai (Narayanan Pothai which is 1379 feet ; detached outcrops of this series may be see in two hills south of Pothaiyadi and further south-eastward to th north and east of Vijaya Narayanam, where the strike is roughl E.S.E. (3) About three miles south of Nanguneri there may b seen several hills having a general trend N.W. to S.E. betwee Usilankulam and Kannanallur. (4) S. W. of Eruvadi there occur a remarkable cluster of bare rocky hills, the most important o which is Shuttu Pottai, 1623 feet in height and presenting a nearl perfect cone. The gneissic banding may be seen clearly on accoun of varying shades of the bands. (5) Several hillocks showing simi-lar banding may be seen near Vadakku Valliyur, Terku Valliyu and Terku Kallikulam. The dip of foliation in the Shuttu Potta appears to be south-westerly, but in Valliyur northerly. Thoug in most cases the gneiss may be called a biotite one, hornblend also occurs in a good many of the outcrops *e.g.*, that at Manpotta about four miles south of Parakkudi; at Erukkan durai, seve miles S. E. of the same place ; and north of the Vijayapatti inlet In the last place there is one occurrence of hornblende gneiss which also contains calcite, coccolite, and wallastonite. The gneis may be seen forming a reef along the sea-shore a few hundre yards from the shore; at places it projects out of water as (1) nea Kuttankuli ; (2) at Idindakarai ; (3) about a mile westward o this place several projecting gneiss masses occur extending fo more than three miles; and off Kullapuli also some gneissic rock are visible.

One very striking feature of the gneissic rocks of the Tinnevell district is the absence of intrusive dykes. The only occurrence o a dioritic intrusion is to be seen in the form of scattered blocks in the sandy surface near the Cape Comorin Base line south end. A large number of small veins of granite are reported permeating the gneiss in a very irregular manner about three miles S.W. of Palamcottah. The absence of a large number of dykes, especially basic ones, appears to indicate that the area was at no time affected by major faulting since its upheaval.

North of the Tambraparni the out-crops of the garnetiferous biotite gneiss occur only outside the district limits along the valleys of the Vaippar and its tributary the Vijayanadi as (1) near the village Golvarpatti where the Arjunanadi joins the Vijayanadi (2) near Gollappatti (3) in the Odai Karai hill. The general direction of the foliation is E. N. E. to W. S. W. with high dips of about 60°.

GRITTY SANDSTONES DOUBTFULLY BELONGING TO THE CUDDALORE SERIES

Pettaikulam outcrop. Gritty sandstone beds which are probably of Cuddalore age are to be seen in well-sections to the north, east and south-east of Pettaikulam three miles S.W. of Tisiyanvilai. The beds are covered over by blown sand or alluvium. No fossils have been reported from these beds.

Nambiyar Valley Section. Similar mottled highly false-bedded deposits with no fossils are revealed in the valley of the Nambiyar at the junction of the Anaikkulam nalah with it. The beds rest on gneiss and are overlaid by highly kankarized pebbly sandstone of probably alluvial origin.

Sanganapuram Pallivasal outcrops. About half a mile west of the above village some whitish grits are exposed overlaid by argillaceous sandstone of recent age containing Ostrea, Arca, Cytherea etc. Apart from their lithological characteristics, there is no other evidence to fix the age of those beds as belonging to the Cuddalore series. The same beds are also to be seen in well-sections at Pakkaneri about a mile west of the above outcrop.

Idindakarai Cliff Section. A little east of the sea-coast village Idindakarai these relatively softer beds occur below the hard calcareous shaly sandstone of recent age in the surf-beaten cliff. The base of the grits is covered over by sand and debris, but as the gneiss outcrops a little S. W. of the village the thickness may not be great probably not more than 15 feet.

Kudangulam Outcrop. Mottled reddish grit is exposed in a rain gully to a depth of about three feet on the northern side of the Kudankulam plateau below the calcareous beds of recent age.

Doubtful Outcrops. Near Perumanal a poor and weathered exposure of unfossiliferous calcareous grits may be seen on the right bank of the mouth of the Hanuma Nadi. The colour of this grit is white and it appears to extend below the alluvium of the Hanuma Nadi and extensively further west below the red soil which flanks the Western Ghats; in the latter area good sections may be seen in the valley of the Uppar and its various tributaries. Further eastward, argillaceous friable sandstone is exposed in the Panakkudi Nalah at and above Perungudi village. Another doubtful outcrop of horizontally bedded brown gritty sandstone with infiltered calcareous material occurs in bed of a nullah which flows out of the large tank north of Neddenkulam situated about 3½ miles W. N. W. of Sattankulam. The thickness is only 2 or 3 feet and no fossil has been detected in it. A similar coarse argillaceous sandstone is exposed in a well-section about 3 miles N. N. E. of Sattankulam.

LATERITIC FORMATIONS

Bruce Foote has included under this head all ferruginous gravelly conglomerates and sands. These two types follow each other in successive bands from west to east; the conglomerates occupy the higher ground along the western side of the lateritic area, which extends as a band of irregular width between the gneissic area and the coast alluvium; the sandy lateritic bands cover the eastern slopes and extend down to and disappear under the western edge of the overlying or inter-calated alluvium. The greater part of the area shown in the map as made up of Cuddalore series, and the lateritic series belong to the latter. As a rule the lateritic formations which are of gneissic origin and which occur south of the river Vaigai is characterised by so little iron that the gravel or sand has merely been stained yellowish brown or yellowish red. It may be recalled here that they bear a very close similarity to the Conjeevaram gravel occurring north of Conjeeveram.

The Perunali lateritic band.—The area which occurs between the gneissic area on the west and the coastal or river alluvia of the Gundar river on the east, south-east and south is only a very approximate one, as the region is covered over and hence masked extensively by the black soil. In the *northern part,* however, where the black soil is absent one may meet with reddish sandy laterite which gives place here and there to dark coloured ferruginous lateritic conglomerate. North-west of Peruneli the area is covered discontinuously by sheets of gravelly and shingly laterite extending from the large tank at Paralechchi north-westward to Mandapa Salai. The laterite is mainly a well-rolled granular quartzoze rock cemented here and there to a coarse ferruginous conglomerate. A good number of rude as well as finished palaeolithic implements made of greenish brown or brown chert have been reported by R. B. Foote in this tract. In the *southern part* of the area one sees only pale yellowish quartzoze gravel exposed either in well-sections or in tank-bunds below the alluvium. The same kind of deposit may also be seen west of the Perunali tract in well-sections occurring below the black soil north of Vilattikulam on the banks of the Vaippar. South of the Vaippar the lateritic gravel deposit cannot be seen over a long stretch of country, though it may occur in detached patches below the thick cover of the black cotton soil spreading over an extensive area to the mouth of the Tambraparni.

South of the Vaippar pale coloured shingle here and there mixed and consolidated with ferruginous cement may be seen over the gneissic area, the gneiss itself protruding through it at many places. One such occurrence may be seen starting from Timmarajapuram about a mile S.W. of Peruvani and extending in broken patches to about a mile south of Vagaikkulam on the Tuticorin-Srivaikuntam main road.

Gravel talus deposits on a small scale containing rounded and polished granular quartz pieces occur along the eastern foot of the Vallanadu hills and further westward at the base of the Sangani hill.

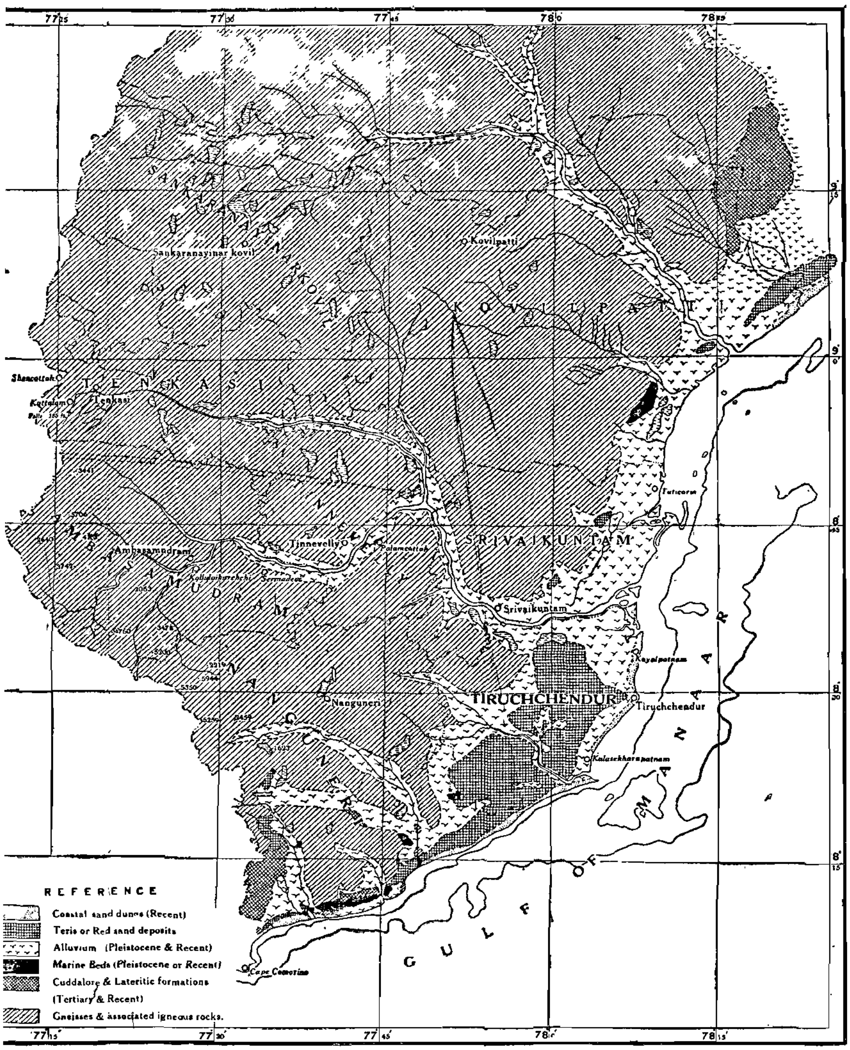
South of the Tambraparni except in the gneissic area of the southern half of the Nanguneri taluk, hardly any deposit of pale gravel may be seen. A very thin sprinkling may be noticed about half a mile east of the village Munanjippatti about 15 miles S. S. E. of Palamcottah. Several such thin patches may be recognised scattered over in the Nanguneri taluk along the high road from Vadakku Valliyur to Radhapuram and on to Vijayapatti and 3 or 4 miles further westward.

MARINE FORMATIONS OF RECENT AGE

A series of marine beds, usually consisting of calcareous grits of cream to brown colour occurring in narrow and rather broken out-crops fringes along the coast from Cape Comorin to Melmandai and still further outside the district limits to the Pambu Channel and the Pamben island. These patches occur over the gneiss or members of the Cuddalore series and are covered extensively by younger deposits, chiefly the Teris or the coastal and river alluvium or sand dunes. Where the beds have been deposited in quick waters, they dip at very low angles to the east or south-east or are horizontal; but more frequently, as characteristic of shore deposits, they exhibit cross or oblique bedding. As some of these inliers occurring south of the Tambraparni (e.g. the Kudairai Moli Teri and the Sattankulam Teri) have been seen at heights slightly more than 200 feet above the sea-level, it appears evident that these areas have been elevated about 200 feet since their deposition: elsewhere the elevation is not so much and at Kudankulam it is 150 feet. The various outcrops may be described from the South-west to the North-east.

Perumanal outcrop.—The first two small patches may be seen on either side of the strip of land between the mouths of the Uppar and the Hanumanadi near the village Perumanal. The beds, which occur at heights varying between 2 to 5 feet, consist of calcareous grits and is of small interest on account of the paucity of fossils. The beds appear to extend westward below the teri or red-sand deposits to Kanagappapuram situated at the boundary of the district for a distance of about four miles where a richly fossiliferous patch of gritty limestone is exposed. The small outcrop of gritty limestone occurring east of the mouth of the Hanumanadi is covered up on the east by a narrow band of teri extending for a length of about three miles. A narrow patch of gneiss outcrops south of this teri along the sea-coast.

Kudamkulam outcrops.—North of the narrow band of Teri mentioned above rises a limestone plateau reaching to a height of 157 feet, about two miles long from west to east and three quarters of a mile wide at its greatest width. Eastward a small narrow valley dissects the plateau from another one 166 feet in height extending for about three miles and gently sloping to form a ridge called the Idindakarai ridge, and then steeply to Vijayapati creek. The limestone may grade from so pure varieties as to form on weathering a white chalky surface to slightly calcareous grit; the usual colours are greyish-white and drab to light-brown. The gritty varieties (e.g. to be seen in S. W. extremity of the eastern plateau) contain a good proportion of quartz sand. The dip is northerly at very low angles or the beds are more or less horizontal. This evidently implies that since their deposition and



Geological Map of the Tinnevelly Dist.

their elevation they have been tilted down towards the north either during the latter phenomenon or subsequently. The thickness of the limestone may be about 60 feet and it appears to be underlaid by a pale mottled grit as could be seen on the northern side of the plateau along a foot path leading south from the village Kudangulam. Though there appears to be no great demand for good building material in the region, the limestone may form fairly good building stones. The beds consist of a good proportion of comminuted shells and the fossils reported include *Purpura, Litho-domus, Balanus,* etc. There is every likelihood of these beds having once extended further northward over the gritty sand-stone; probably relics of these beds may still occur at places covered over by the red soil.

Idindakarai section.—What appears to be an eastward extension of the same calcareous sandstone occurring over a somewhat similar mottled grit described above is to be seen in a cliff situated about half a mile east of the village Idindakarai. The drab or white calcareous sandstone, which contains a large number of recent marine shells, is to a great extent masked by teri deposits which have developed at their junction with lower calcareous sandstone a thick deposit of limestone as the result of percolation of what changed into calcareous matter from above. The thickness of the calcareous sandstone may be about 10 feet, but it thins out further westward; the thickness of the lower mottled grit cannot be known as due to the action of breakers, the base has been covered by debris and sand; as a small ridge of gneiss is seen off near the coast, south of this village, it seems to rest on the gneiss. Fossils include *Turritella, Trochus, Nerita, Arca, Ostrea; Balanus,* etc.

Vijayapati outcrop.—A small patch of dark impure marine limestone with plenty of fossils occurs immediately north and east of the Vijayapati creek; the outcrop is much covered over by a thick growth of Acacia and other thorny bushes and by the village Vijayapati itself. The bed appears to rest on the gneiss which is exposed in the bed of the river.

Nambiyar outcrop.—Calcareous grits and sandstones of various degrees of coarseness are also exposed at the mouth of the Nambiyar river some four miles north-east of the last described outcrop. The outcrops are very narrow being visible for about half a mile along the banks of the river, and the western one can be traced for about half a mile along the coast; the western one is covered up on the west by the teri-deposits and on the east of the eastern outcrop are found the teri-deposit and the coastal sand-dunes. Fossils are found in abundance, especially in the finer beds and the more important ones are:—Cyprea, Conus, Purpura, Turbo, Torchus, Carithium, Ostrea, Arca, Cardium, Cytherea, etc. On account of the hardness of the rock, these are very difficult to be extracted and as characteristic of shore deposits, the beds are highly false-bedded.

Vellava Odai outcrop.—A little west of the small village Sanganarpuram Pallivasal is found a bed of arenaceous and calcareous clay containing recent fossils like Arca, Cytherea, Ostrea, etc., and at one place intercalated with gritty sandstone apparently resembling the Cuddalore series, but with no fossils. The calcareous clayey beds which are yellowish or brownish in colour are poorly exposed owing to the small thickness which does not exceed 4 or 5 feet and the occurrence over them of the alluvial sand. A fairly good section may be seen on the south bank of the Vellava Odai and in the banks of a rain gully running into it. The beds may be traced in patches for about a mile N. W. along the stream and they appear to rest on gritty sandstone of Cuddalore age; which is underlaid by the gneiss.

Tisaiyanvilai outcrop.—A patch of hard calcareous rock ranging from fairly pure shell limestone to coarse calcareous grit is exposed in numerous artificial depressions in the south-western end of the extensive Sattankulam Teri a little north of the Tisaiyanvilai village. The beds, which are cream to pale brown in colour exhibit much current or false-bedding and the fossils are too much broken to be properly identified except Balanus, Ostrea, and Pecten. Here the rock is quarried on a large scale and made into troughs, pillars, building stones, etc. The Anglican Church at Idaiyankudiyiruppu was built by Bishop Caldwell of stones quarried in this place.

In addition to the fairly important occurrences stated above, the calcareous sandstone has been noted in many places either in very small outcrops or in well-sections in the high ground occupied by the teri deposits as: (1) About 1½ miles S.S.W. of Pulimankulam Paracheri, a tiny outcrop of grey limestone was observed in the teri. (2) Well-sections at and near Tisaiyanvilai exhibit the same yellow-brown calcareous sandstones with many fossils as Venus, Dentalium, etc. (3) Mottled yellowish-white calcareous sandstone may be seen in well-sections in Suviseshapuram about three miles N.W. of Tisaiyanvilai. (4) Bishop Caldwell reported the occurrence of a small outcrop of similar beds in the very centre of Sattankulam teri; evidently, this has been covered over by the teri deposits subsequently. (5) An estuarine bed with Cytherea, Potamides, etc., may be seen about a mile north of the Puthan Taruvai Lake; the beds have been much dissected with trenches in order to gather the shells to be burnt into quick-lime. (6) A small outcrop of gritty sandstone was seen to occur below the coast dunes at the small fishing village Elanjune about two miles south-west of Periya Talai. This sandstone appears to extend into the sea as a small spit running along the coast to Manappad. (7) At Christianagaram about half a mile west of the large village Udangudi shelly limestone of several feet thickness containing Venus was met with in well-sections. A little east of the village a small outcrop of shelly marl yielded Cytherea and Helia; the latter bed is proverbially slightly younger than the former. (8) According to Bishop Caldwell, a marine formation abounding in sea-shells of existing species outcrop all along the coast near Kulasekharapatnam; he also reports the occurrence in these beds of historically very recent pottery. [R. Caldwell: *A Political and General History of the District of Tinnevelly,* 1881, p. 5.] (9) About three miles N.E. of Sattankulam at Panamparai, the calcareous beds are exposed in quarries where they are widely quarried for building purposes; the beautiful Anglican Church at Mengnanapuram was built of stones cut out of this place. The beds, which are cream-coloured to brown, are more or less horizontal or they dip gently towards south-east and the chief fossil is *Balanus.* (10) As a small outcrop of brown calcareous beds were seen in a small furrow about 2½ miles S. E. of Nazareth in the Kudirai Moli Teri high ground, which is about 206 feet above sea-level at its highest place, it is inferred that very probably the whole of the teri-deposits here is underlaid by these marine beds. South of Sattankulam, the teri-deposits reach a height of 220 feet, where also the marine beds have been seen. This makes us infer that the region under review has been elevated about 200 feet since the deposition of these beds in the Pleistocene or Recent times.

North of the Tambraparni calcareous gritty beds occur at two places. The first occurrence was noted in well-sections a little south-west of the village Dalavaypuram about nine miles north-north-west of Tuticorin. The beds, which apparently rest on the gneiss, evidently, extend below the thick black cotton soil of the region to more than a mile S.W. of Dalavaypuram and in the

N.E. about 2½ miles up to the village Vedanattam and then disappears below the alluvium of the Kallar stream. A good section is offered in the quarries situated a little south-east of Vedanattam, where the stones are quarried extensively and sent to Tuticorin for building purposes. The pale white, pink or brown coloured beds, which show false-bedding, frequently contain an abundance of broken shells, the easily identifiable one being the Crustacean Balanus. What appears to be an outcrop of similar calcareous gritty sandstone bed was noted in a small pit near the road a little south-west of the small village Velayudapuram about one and a half miles S.W. of Melmandai about five miles north of the mouth of the Vaippar. No fossils, however, have been reported from this place.

Age.—The beds, where fossiliferous, have yielded only recent forms as Purpura, Lithodomus, Turritella, Trochus, Nerta, Arca, Ostrea, Turbo, Carithium, Cardium, Cytherea, Pecten, Venus, Potamides, Dentalium, Balanus, etc., and hence, the age may be inferred as recent. But as Bishop Caldwell reports the occurrence of historically very recent broken pieces of pottery imbedded in the gritty stone of marine origin near Kulasekharapatnam, a port of some antiquity, it appears likely that part of the marine formations may be also historically recent.—[R. Caldwell: *A Political and General History of the District of Tinnevelly*, 1881, p. 5].

ALLUVIAL FORMATIONS.

A good portion of the area under review is shown on the map as consisting of alluvia, marine, estuarine and fluviatile; but their relative distribution can be only approximately marked off on account of lack of proper sections and relevant data revealing the formations in contact one with another. Besides, the region has been under cultivation for many thousands of years, and hence, the land surface has been slowly and extensively elevated by human activity so that features like local elevation, and valley incision cannot be made out definitely; what is more interesting is even in the coastal strip of land where there appears to be some evidence of elevation, instead of one seeing an incised valley one meets with an artificially bunded one. Broadly speaking, east of the line starting from Sanganapuram Pallivasal near the mouth of the Nambiyar at the junction of the N.W. tributary with it, and passing through Tisaiyanvilai, Sattankulam, Nazareth and then north of the Tambraparni through Sayerpuram and Dalavaipuram, one may find marine deposits or marine beds intercalated with estuarine beds ; west of that line, however, one is likely to meet with fluviatile alluvium in the valleys of rivers and streams.

Fluviatile Alluvium.—The alluvium of the most important river of the district, *viz.*, the Tambraparni consists of coarse arenaceous pale reddish soil. A good amount of kankar deposit which has cemented the gritty particles of weathered gneiss may be seen on its banks and bed near Tinnevelly; on these calcareous conglomeratic layers, which form a platform, small temples have been built. Though Foote expected to find fossils in these kankar deposits, I do not think there is much chance of finding many fossils in them ; for calcareous deposits do form excellent material for the preservation of fossils when they occur in beds, but not necessarily suited for fossilization when they occur in superficial deposits as kankar. Kankar owes its formation to capillary action which brings to the surface underground water charged with dissolved materials of which the chief salt is calcium carbonate.

Distribution of Kankar.—This calcareous deposit is so abundant in places, chiefly in the beds of rivers, streams and tanks, that it forms a sheet-like formation. Extensive deposits of nodular or vermicular kankar are also seen in the beds of streams in South Tinnevelly; the more important occurences are as follows:— (1) In the valley of Sivandippatti stream from Sivandippatti to Ayyanarkulampatti, about seven miles S.E. of Palamcottah. (2) The channel north of Teruku Kari Seri displays a good spread of kankar ; the same deposit may also be seen in the bed of a small stream flowing past Arasakulam. (3) A little west of Eluvaramukki about 3½ miles south of Nazareth, a considerable spread of kankar may be seen ; it also occurs at intervals in the cart-track leading to Mudalur about three miles S.E. of Sattankulam, especially at the ford of the Karamanaiyar river. (4) Kankar covers several hundred acres north of Sattankulam. (5) Massive kankar may be seen at Neddunkulam about 3½ miles W.N.W. of Sattankulam and further south. It reappears a little further south at Pudukkulam. (6) Probably the most extensive and thickest occurrence of massive kankar may be seen either in well-sections or in surface in the western side of the Sattankulam or the Ittamoli teri, at Vaganeri about a mile north of Suviseshapuram it forms such a thick deposit, that solid hard limestone-blocks are quarried for building purposes. It continues further southward to Selvamarudur about a mile west of Tisaiyanvilai, around Idaiyankudiyiruppu and north-eastward to within a mile or so of the western limit of the Puttan Taruvai lake. (7) South-westwards extensive sheets of kankar have been formed intermittently in the valley of the Vellare Odai, the tributary of the Nambiyar, especially at Kailasaperi, around Vadachari around Samugarangapuram, at Darmattipatti and near Kadambankulam. Frequently, the kankar encloses small segregations of semi-transparent brown chert with a flint-like appearance. (8) In the valley of the Vijayampati Odai, further southward, one can make out good deposits of kankar south of Radhapuram around Udaiyathur, further southward as far as Kamaneri and at Kuthankulli about 2½ miles N.E. of Vijayapati village. (9) In the valley of the Hanumanadi kankar deposits are not prominently formed, but they can be seen less strikingly developed around Perungudi, and north-east of Vadakkankulam.

Foote, probably taking into account the fact that these occurrences were mostly confined to river beds, explained these kankar beds as calcareous tufa "formed by the deposition of lime by evaporation of the water which brought the calcareous matter in solution from more distant sources." But their nodular and pipe-like structure clearly explains this mode of occurrence as due to segregative forces working in the soil and in the superficial altered zone of rocks, chiefly as the result of capillary action bringing up to the surface water charged with lime from the lower levels. As the region under review is subjected to very little rainfall, there is possibility of water percolating to some degree in the soil and the sub-stratum only in the valleys of rivers and streams and this percolated water is sucked up by capillary action to the surface and evaporated in the dry season; the dry S.W. monsoon may help greatly in the drying process of the surface layers.

Marine and Estuarine Alluvia.—As already stated the boundary between the distribution of the marine and estuarine alluvia and the fluviatile alluvium roughly runs from Sanganapuram Pallivasal near the mouth of the Nambiyar at the junction of the north-western tributary with it, through Tisaiyanvilai, Sattankulam, Nazareth and north of the Tambraparani through Sayerpuram and on to Dalavaipuram; but the exact boundary is impossible to be worked out as the whole region is covered up either by red or white sandy deposits of aeolian origin or locally by fluviatile deposits.

Bishop Caldwell had identified the ancient sea-port of the Pandyan kingdom, namely, Korkai with Kolkhoi of Ptolemy, the great geographer, who lived about 180 A.D. It is also said to have been visited by a Greek merchant about 80 A.D. as mentioned by him in his "Periplus Maris Erythraei" or The Circumnavigation of the Erythraean or Red Sea, by which we are to understand the whole of the Arabian Ocean from the mouth of the Red Sea to the Bay of Bengal. This place Korkai is now situated about 4½ miles inland and thus since that time up to the present the land has gained on the sea by about five miles (R. Caldwell, *op. cit.*, pp. 17, 18). The estuarine alluvium here consists of about 6 feet of stiff clay with estuarine fossils underlaid by gritty sandstone of about a foot in thickness with comminuted sea-shells; this is underlaid by fine grained white marine sand with plenty *of sea-shells as chanks, etc. The thickness of the sand and what* was underneath it cannot be found out on account of the abundant springs of water. Excavation by Bishop Caldwell near Korkai revealed that the 'level of the ancient city Kolkai was situated about eight feet below the present level where pieces of pottery and other evidences of human habitation were found. [R. Caldwell, *op. cit.*, pp. 284, 285. *The Indian Antiquary*, March 1877].

The same eminent authority has identified Palayakayal or Old Kayal with "Cael" of Marco Polo who visited India in A.D. 1292. This place is now situated 2¾ miles from the sea; here the old *chunammed* floor of the ancient city was discovered at a depth of two or three feet consisting of alluvial soil with plenty of pieces of Chinese porcelain and Arabian pottery. (R. Caldwell, *op. cit.*, pp. 285, 286. *The Indian Antiquary*, March 1877).

From Kulasekharapatnam up to Tiruchendur below the Kalampalli Taruvai, extending along the coast there occurs a loose unconsolidated bed of dark clay containing estuarine and marine shells as, *Cytherae, Arca, Potamides,* etc. R. Caldwell refers to the occurrence of pieces of broken pottery found imbeded in a gritty bed with marine fossils near Kulasekharapatnam; it appears probable that he is referring to some gritty beds resting on the claybeds and hence, these gritty beds also form part of the coastal alluvium. The pieces of pottery, evidently, represent bits washed down to the margin of the sea.

At Tuticorin, Bishop Caldwell reports the occurrence of a thin layer of only a few inches thickness of fine-grained grit-stone called locally *uppu kal* or salt-stone at a depth of about two feet; below this one finds somewhat stratified sea-sand which include deep-sea shells as *chanks, pectens, oysters,* including the pearl-oyster. The grit-bed has been found to extend as far as Korampallam situated about four miles inland. As this place is at a height of about 17 feet above the sea-level, and as the marine forms reported therefrom now live at depths of about 30 feet from the surface, it appears likely that the region has been elevated by about 45 feet since the formation of the deposits. [R. Caldwell: *op. cit.* pp. 75, 76.]

Further northward, two more exposures of estuarine beds of dark clay with fossils were observed; the first occurrence is a little west of Melmandai a little north-east of the mouth of the Vaippar, and the second is at Sevalpatti, just across the border on the northern side of the Vembar. In both cases the material was thrown out in the deepening of drinking water tanks, and in neither was there seen any marine bed. In the first place *Cytherea* was found and from the second *Cytherea*, *Cardita*, and *Ostrea*.

As may be seen from the geological map and as pointed out elsewhere, the Kudirai Moli and the Sattankulam teris are underlaid by marine sediments of recent age; thus we find a broad bulge of coastal and estuarine alluvium just south of the Tambraparni; as, generally speaking, the sediments carried by a river are deposited either immediately in front of the mouth or on either side of it, this feature is very remarkable. The only river, which drains this teri is the Karamanaiyar river, which is too small to account for the broad accumulation of sediments. In almost all the rivers which fall into the Bay of Bengal an interesting feature is that they turn N.E. ward in the region of their own coastal alluvium; in other words, there is a greater accumulation of sediments on the southern portion of the river than on the northern portion; the same feature may also be recognized in the Tambraparni and instead of running east at its mouth, it turns gently north-eastward. This interesting feature appears to be due to the activity of the N.E. monsoon which causes a S.W. flow of oceanic currents in the Bay of Bengal during October, November and December, thus carrying the sediments further southward than they would otherwise be deposited. Though the S. W. monsoon is more powerful and steadier than the N.E. one and may be expected to counter-act the effect of the latter, its effect on the waters of the Bay of Bengal appears to be not so great, as the peninsula gives its waters a good protection. Further, the effect of the S.W. flow of marine currents in the Bay of Bengal must be greater in the Gulf of Mannar than elsewhere as the current which follows along the coast will be forced between the mainland and the island of Ceylon.

The above explanation, though very probable, appears to the author insufficient to explain the great accumulation of the coastal and estuarine alluvium south of the Tambraparni. Hence he feels that there is strong evidence in favour of the Tambraparni having once embouched into the Gulf of Mannar further south somewhere between Nazareth and Sattankulam. Though we cannot definitely state at present how and at what place the diversion occurred, there appear to be two probable courses, *viz.*, the one west of Velur Adichchanallur *via* the Kalvay and the Tenkarai kulams to Nazareth or Pillaiyanmanal, where it must have joined the sea; or the course might have followed the two bands of alluvium—one running N.N.E. to S.S.W. joining the Tambraparni and the other east of Terku Kariseri, a little further south running N.W. to S.E. east of Munanjippatti joining the alluvium of the Karamanaiyar and embouched into the sea near Sattankulam. It appears also strange that the Tambraparni should be bunded on its southern bank by flood embankments of 20 feet or more in height starting from Velur Adichchanallur and extending to its mouth; this appears to the author as an attempt to keep the river from a more natural southerly course which it undoubtedly would have taken in the past (probably historic ?). Strangely enough between the two bands of alluvium suggested above as might have formed once a probable course of the river there is a band of black soil (as also indicated by the meaning of the word kariseri in Terku kariseri) which represents the only patch of such a kind of soil south of the Tambraparni; as has been shown elsewhere, there appears to be great probability that the black soils of Tinnevelly and Ramnad districts represent, accumulations of humic soils in lower levels of the country as in tank and river beds, or in marshy areas crowded with thick vegetation.

Age.—Bishop Caldwell reports the occurrence of some stone implements found near Shermadevi and Puthugudi; these were, according to the same authority, taken to Berlin by Dr. Jagor; as the sides of these implements were rounded and the curves symmetrical, they were referred to the Neolithic Age. (Caldwell's Puthugudi may be identified with Velur Pudukkudi near Adittanallur situated on the southern banks of the Tambraparni opposite to Srivaikuntam). As a large number of sepulchral urns were found entombed in the alluvium, and as the urns contain excellent polished pottery and copper ornaments we may infer that a good part of the river alluvium must have been deposited during the period of human settlement in that area; hence, the age must be younger alluvium, geologically speaking.

At Korkai, Maramangalam, etc situated in the mouth of the Tambraparni, Bishop Caldwell recognised that the upper-most layer for about 6 feet consisted of stiff alluvial clay with estuarine fossils underlaid by gritty sandstone about one foot in thickness with comminuted sea-shells. This was underlaid by fine-grained white marine sand with plenty of sea-shells as conus, etc. Excavations near Korkai revealed that the level of the ancient village Kolkoi was situated about eight feet below the present level where pieces of pottery were found. At Palayakayal, the site of the ancient village 'cael' of Marco Polo was found at a depth of about three feet below the present surface; in the field itself plenty of pieces of pottery of Arabian or Chinese origin may be gathered in abundance. These facts clearly indicate that a good portion of the estuarine alluvium also must be historically speaking not very old and hence, may be classed under younger Alluvium.

The occurence of pieces of broken pottery found imbedded in the gritty bed with marine fossils near Kulasekharapatnam has already been referred to; R. B. Foote has recorded the occurrence in the loose unconsolidated beds of dark clay below the Kalampalli Taruvai of Cytherea, Arca, Potamides etc. all of recent age. At Tuticorin Bishop Caldwell reported the occurrence of a thin layer of only a few inches thickness of fine-grained grit-stone called locally *Uppu Kal* or salt-stone at a depth of about two feet; below this, one finds somewhat stratified sea-sand which include recent deep-sea shells as *chanks, pectens, oysters*, etc., including the pearl oyster. These beds extend as far as Korampallam situated about four miles inland. As already referred, recent fossils like *cytherea, cardita, ostrea* etc., were reported from a little west of Melmandai, a little north-east of the mouth of the Vaippar, and at Sevalpatti on the northern banks of the Vembar: All these facts indicate that a good portion of marine and estuarine alluvium also must be recent.

EOLIAN DEPOSITS

The Teris and the coastal sand-dunes. Nowhere in South India are the Eolian deposits more important than in the Tinnevelly District and in the southern coast of the Madura District. No doubt, they owe their presence to the continuous strong and dry S.W. monsoon winds which blow steadily for four months, *viz.*, June, July, August and September, after precipitating the moisture content mostly in the west coast and to a smaller extent on the eastern slopes of the Western Ghats. Two important types of deposits may be recognised. (1) *The Teris* or red sandy deposits [Theri or தேரி is a Tamil word meaning sandy wastes] which are decidedly more important as they cover a more extensive area and (2) the coastal sand-dunes occurring in narrow-bands along the coast and consisting of white quartz sand. The former deposits are due to the accumulation of fine red dust and quartz sand stained red swept up by the S.W. monsoon from the dry slopes and the red shingle-covered regions of the west and deposited in the moist rather slightly elevated surface near the coast. The N.E. monsoon helps in the consolidation of the deposits. Wherever the Teri deposits have been deeply cut, the highly false-bedded character reveals their eolian origin frequently the surface of their deposits especially in the valleys becomes coated and consolidated by iron due to capillary and segregative forces, so that at present only a thin superficial layer is affected by the wind.

The most southerly deposit begins about a mile S.W. of Kanagappapuram and extends along the coast for more than five miles to Panjell in the form of two narrow bands, the inner one reddish in colour forming the Teri deposit and the other consisting of coastal sand. East of Panjell the coast dunes become unimportant, but the Teri continues in the form of a narrow strip skirting the southern side of the western limestone plateau at Kudankulam. It then becomes intermittent and may be seen feebly north of Idindakarai. East of Vijayapati creek both kinds of deposits become important; near Kuttankuli the former is 91 feet in height and the sand is dark red in colour. The height appears to have been even greater in the past as many Palmyra trees have the roots exposed to a depth of 6 to 10 feet by the removal of the deposit by wind. Wherever it has been cut deeply into, one may see the highly false-bedded nature; indicating an eolian origin and as the greater part has been consolidated by the action of rain and hardened by ferruginous or calcareous cement at the top by capillary and segregative forces, only a thin sprinkling of sand is affected by the wind at present.

Idaiyankudiyiruppu Teri. The Kuttankuli Teri extends northeastward to the mouth of the Nambiyar and then gradually widens as far as Pudur and then continues more or less of the same width to Idaiyankudiyiruppu and widens slightly to Puthan Taruvai and the Taruvai lake. The distance from the mouth of the Nambiyar to Puthan Taruvai is about 12 miles and the average width from Pudur north-eastward about two miles; the height of the Teri S.W. of Idayankudiyiruppu is 172 feet and in most places more than 100 feet. The thickness of the deposit cannot be definitely made out and it appears to be underlaid by marine calcareous beds of recent age as a small outcrop of the latter was observed at a height of about 60 feet in the south-western part of the Idayankudiyiruppu Teri.

The Puthan Taruvai lake north of the village of that name, as pointed out by Foote is no doubt due to damming up of the drainage on three sides by the Teri deposits ; it appears to have been in the past larger than what it is and the stream, which runs south of Tisaiyanvilai, flowed into it. On the northern extremity a small stream drains the lake and connects it with the Karamanaiyar river. The landscape one gets when viewed on a clear summer day from the S.E. extremity of the lake towards N.W. is a marvellously beautiful one ; the fore-ground studded with palmyras and banyan trees in sharp contrast with the red sloping surface ; the blue and silvery surface of the lake surrounded on all sides by palmyras beyond ; the line of high red sand hills forming the Sathankulam teri with groups of palmyras here and there ; a little beyond the thick covering of palmyras so characteristic of S. E. Tinnevelly ; and finally, to crown all, the glorious blue sharply cut spurs of the Western Ghats with the back-ground of the blue sky—these mark the landscape as a unique one amongst those of South India.

Sathankulam Teri. North-west of the Puthan Taruvai lake is the finest, most picturesque and the highest teri called the Sathankulam teri as it lies south of that village. The highest point, which is 220 feet is situated now roughly at the very middle of the teri, but appears to have been located more than 1½ miles to the southward as shown by the quarter-inch map of 1883. As Bishop Caldwell had reported an outcrop of marine limestone bed near the latter place, it is evident that the Teri deposits have been formed on an elevated small plateau of calcareous sandstone ; the outcrop, however, is now covered over by drift sand and hence cannot be located now. The area covered may be about 15 to 20 square-miles and the sand-dunes, which are very irregular in shape and direction of movement, may not be more than 20 feet.

Kudirai Moli Teri. An equally extensive and important teri called the Kudirai Moli Teri is located north of Mengnanapuram and south-east and east of Nazareth. Here also there is reason to believe that the red sandy deposit rests on marine calcareous sandstone of recent age and Foote estimated that the thickness of the former deposit might be "somewhat over 100 feet."

Drainage features in Teris. One interesting phenomenon may be seen in all the teris, namely, as the deposits are loose and porous rarely one finds surface run-off during rains; and the water which easily percolated down issues in the form of springs on the sides of the teris. This may be beautifully noted in the northern side of the Kudirai Moli teri, where channels have been excavated and the water utilised for cultivation on a small scale. The percolating water, in addition gives rise to ferruginous and siliceous cementation resembling lateritic agglomerate in the channel sections. Besides, the sandy-deposits act as sponges in absorbing the little rain the region receives and storing it in the lower layers and this water is tapped by wells in the valley depressions by the inhabitants; thus a large number of such wells may be seen in the depressions between the Sathankulam and the Kudirai Moli Teris and those between Tisaiyanvilai and Idaiyankudi teri, especially north-east of Sathankulam, around N.W. of Mengnanapuram, near Mudalur and near Kuttam and Periya Talai and in the Pudur-Idaiyankudiyiruppu teri. The third note-worthy feature is the dwindling in size of many of the tanks situated N.E. and east of the teri as the result of the advance of these towards the coast, e.g., the Puttan Taruvai lake, the tank east of Sastavinallur, the tank west of Lakshmipuram; the one south of Manadu has shrunken so enormously that the once flourishing village has become an unimportant one.

Teris, north of Tambraparni. The teri deposits are not significant north of the Tambraparni. The small teri north of Pannaivilai is too poorly formed. Slightly more important is the teri west of Sayarpuram; but that is also being rapidly denuded away. But this teri is of great interest in that on the southern side of the centre of it in the loamy surface exposed below it "numerous small cores and flakes of a reddish chert quite foreign to these parts" and similar to those found near Jabalpur together with fragments of burnt pottery and a few flakes of quartz were found by Foote. North of the Kallar Odai small teris may be seen trending N. E.-ward parallel to the coast, and they become fairly well marked between Kulathur and Vaippar on the south bank of the Vaippar. North of the Vaippar river it reappears a little south-east of Melmandai and widens so that east of Surangudi it is more than two miles and extends outside the district limits to the mouth of the Gundar. The Kulathur-Surangudi teri is thickly covered with palmyras and scrub-jungle and the height also is generally small.

Rate of advance. The continuous movement of the teris is frequently a serious problem as it buries cultivated fields, gardens and houses, covers up tanks, and alters the drainage system of the region; the big bend in the Karamanaiyar east of Sathankulam appears to be due to the advance of the *Sathankulam or Ittamoli* teri N. E. ward and the receding of the Kudiraimoli teri; as already pointed out several small lakes, which the teri deposits themselves were responsible for the formation by damming up the drainage of the area, have been greatly diminished or completely covered up by their advance. Yet, the rate of advance is not great; it has been computed by Col. Lambton as approximately 17 yards per year and by R. B. Foote as 6 yards both in the east-south-east direction. Further, this teri does not completely consist of barren areas; as it contains a good portion of fine clay mixed with sand, provided sufficient water is available, it may be converted into a fairly productive soil. Almost all teris are fairly thickly grown over with palmyras, umbrella trees, and other thorny bush, which help in fixing the deposit from being moved by the wind; besides, the first two trees are also economically useful.

Age. In most localities the teri deposits have been found to occur over the calcareous marine sandstone containing recent fossils; about 2½ miles south-east of Nazareth fragments of calcified dicotyledonous wood and casts of *Helix* were discovered in hollows in the teri; in the teri occurring west of Sayarpuram in the hardened lower layers numerous small cores and flakes of a reddish chert together with fragments of pottery, flakes of limpid quartz were found. Hence we may infer that all the Teri deposits must be recent in geological age, that the upper layers may be also historically speaking recent and that they are being in the stage of formation even at the present time.

Coastal dunes. The most prominent development of coastal sand-dunes in the district may be seen from Periya Talai to Manappad. Here the dunes form a hard ridge in many places more than a hundred feet high, due to the occurrence in it of a good proportion of comminuted marine shells and the consequent solution of the calcareous material. Almost mid-way between Periya Talai and Manappad, the height is 178 feet, and at the latter place, it is 82 feet in height; continuous wind action has carved the ridge into peculiar fantastic shapes. The degree of consolidation is greater on the southern side, probably due to the heavy spray of the breakers, while on the north side loose sand is often drifted about partly burying houses and churches at Manappad village. About 9 miles north-east of the village, the coastal dunes become important at Tiruchendur on which stands the beautiful Subrahmanya Swami temple, the high gopuram of which is an important coastal land-mark ; the height of the dune here is more than 50 feet, and the hardened west-ward side, due to perculation of water charged with calcium carbonate and the consequent cementation, forms a fairly good protection against sea-action. The calcareous sandstone occurring in these coastal deposits is so hard that it may be used as a good building material.

Soils. Soils usually represent the youngest of the geological formations of a country ; but in Tinnevelly one of the two varieties, *viz.*, the red soil appears to be older than the coastal aeolian formation, the Teris ; as already explained the latter is derived from the former. The soils of the district fall into two big groups, *viz.*, the red soils and the black soils, the former occupying a larger area.

The black soil has been called ' regur ' though it differs from the true regur occurring over the Deccan trap region in that there has been found no transition between it and the underlying rock ; also the colour of the regur of Tinnevelly is not so black as that occurring over the Deccan trap. Practically the whole of the Kovilpatti and the Srivaikuntam taluks are covered over by the black soil except along the foot of hills (*e.g.* around Vallanadu hills, around Vagaikkulam etc.) and over the coastal belt formed by the coastal estuarine alluvia and covered over by aeolian deposits. South of the Tambraparni, the black soil may be seen in isolated patches south of Palamcottah as around Reddiyapatti between Sivandippatti and Terku Kariseri and north-west of Munanjippatti. These patches cover only an area of 5 or 6 square miles.

Origin. (?) From a distribution of the black soil it appears probable that it must have accumulated in either low lying marshy areas as river beds, tank beds, etc., or in areas where there must have once been thick forest vegetation making the soil rich in humus.

The red soil. The rest of the district is practically covered over by various types of red soil; and it occurs over the gneissic rock, the marine deposits and the coastal formations. The patches near the Western Ghats and around the gneissic hillock are usually gritty or coarse sandy while further east and away from these hillocks they are fine grained. Thick deposits of red loamy soil may be seen around Kuttalam washed down from the adjacent Ghats.

The strong S. W. monsoon has carried away the finer particles of the red soil occurring over the gneissic region and accumulated them near the east coast to form the peculiar kind of deposits called the Teris. It appears probable that this accumulation is favoured by the gentle elevation of the marine formations over which these deposits occur, and the counteracting effects of the sea-breeze near the coast. Seen from a distance against the red evening sun-light this thick dust laden atmosphere gives the appearance of gigantic and terrible forest fires, and the intervening non-illuminated dust-laden atmosphere resembles smoke.

(*Vide* R. B. Foote: Mem. G. S. I, Vol. XX, p. 86).

Another important feature of the red soil areas especially in S.W. parts of the district is the numerous white ants' nests; their height (which may easily reach 5 or 6 feet), their red colour, their large size, their peculiar serrated shape and their occurrence in thorny bushes make a characteristic feature of the topography of these parts.

ECONOMIC ASPECTS

Building Materials.

Calcareous Sandstones.—Building stones form one of the most important economic material of the district. The most important is the gritty calcareous sandstone of Pleistocene age. The variety quarried near Vedanattam, about eleven miles north of Tuticorin is pale white to pink or brown; it is also used for making troughs, pillars, etc. A fine cream or drab coloured to brownish variety is obtained at Panamparai, about four miles west-south-west of Mengnanapuram; this has been used in the building of the beautiful C.M.S. Churches at Mengnanapuram, and at Mudalur. A similar hard cream coloured building stone, which has furnished the building material for the C.M.S. Church at Idayangudi, is quarried in the south of Ittamoli teri. The rocks vary from nearly pure shelly limestone to coarse grit with a calcareous cement; troughs, pillars, etc., are also made, especially from the more calcareous varieties. The same variety of rock quarried near Kundungkulam is used in the making of door-frames, pillars, lamp-posts, paving stones, troughs, etc. Besides, the large and beautiful temple at Tiruchendur and outside the district a good part of the Rameswaram temple are built of similar gritty calcareous sandstones.

Between Tiruchendur and Manappadu coastal sandy deposits have been consolidated on the sea-ward side due to infiltration of calcareous water to such an extent as to become hard enough to be suitable for building purposes.

Coral limestone.—Large quantities of coral limestone, obtained from the various islands situated north of Tuticorin as Van Tivu or Church Island, Koswari Island, Vilangu Shuli Island, Kariya Shuli Island, etc., are widely used as building material at and near Tuticorin.

Crystalline limestone.—An outcrop of handsome pink and pinkish white coarse crystalline limestone may be seen a little east of Sengottai, where it is almost 20 feet in thickness; the limestone is inter-bedded with hornblendic rocks containing pink crystals of calcite. The limestone may be useful not only for building purposes but also for cement manufacture. The outcrop is an extension of the Pandalakudi limestone outcrop occurring about a mile south of Pandalakudi in the Ramnad District.

Biotite gneiss.—The granite grains, showing distinct banding chiefly consisting of quartz, felspar, biotite and pink garnets with occasional presence of hornblende, forms an excellent building material wherever it outcrops. It has a pleasing appearance as the banding is of various striking colours. But as almost all the outcrops are situated in South Tinnevelly far from places where there is likely to be a good demand, the gneiss is not so widely quarried as near Madura.

Granular quartz gneiss.—The granular quartz gneiss on account of its extremely brittle and friable nature, appears to be of no use for building purposes and is, hence, not quarried to any great extent anywhere.

Quick lime.—North of the Puttan Taruvai Lake occur estuarine beds full of partly fossilized shells; these are collected by digging trenches for burning into quick lime. Good lime is also manufactured by burning shells of pearl oyster after obtaining the pearls, in various places where they are collected between Vaippar and Manappad. In several places in South Tinnevelly sheet-like deposits of kankar occur as described elsewhere as near Sivandipatti, Teruku Kariseri, South of Nazareth, north and west of Sattankulam, etc., in all these places they are collected for burning into lime.

Salt pans.—Along the coast due to evaporation of sea-water in enclosed backwaters, there occurs bitter brine, which is made use of in the manufacture of common salt. The more important places are:—Arumuganeri and Tuticorin and the less important Kuttankuli, Kulasekharapatnam, Arasadi and Veppalodai.

Pearl and Chank.—Successful operations for the *pearl* oyster and the *chank* are conducted along the coast from Vaippar to Manappad; but on account of the large amount of sediment brought by the river, the pearl oyster thrives only locally; the oyster is locally called *Suran*. But the chank is got in good abundance as sand is no impediment to their thriving; it is exported to Bengal, where it is made into chank-bangles, etc., which find a good market in Tibet, Assam and Bengal.

Garnet sand formed as the result of weathering of the biotite gneiss is an economically important mineral, which is as yet not exploited. Some thousand tons were exported in the year 1914 for use as an abrasive and the workings were closed in the subsequent year. Large quantities of garnet sand is available along the coast near Cape Comorin. [E. H. Pascoe: Rec. G.S.I., Vol. LII, p. 291].

Though no economically important deposits of monazite have been discovered in the district, the mineral has been found to occur very widely in the older dunes, and in the dry beds of streams draining eastward from the hills. [G. H. Tipper: Rec. G.S.I., Vol. XLIV, p. 195].

As monazite is an accessory mineral in the Charnockites, it is inferred that these may be also representatives of the interesting series of rocks either in the district or in the neighbouring region; a detailed re-survey of the region in the light of modern advancement in geography is hence bound to be of great interest and value.

Place–Names of the Tinnevelly District

BY

SRI T. S. SUNDARAM AYYAR, B.A.

The Tinnevelly District which has an area of 4,315 sq. miles has a population of 20,46,907 distributed among 33 towns and 966 villages. The names of each town or village have two parts, each of which has some significance. To some extent, these parts indicate the origin of the names.

I

The causes that give rise to the names of places are of three kinds: (A) *Geographical*, (B) *Historical* and (C) *Religious*. *First let us take the suffixes or the latter parts of the place-names* and try to classify them.

A. SUFFIXES INDICATING A GEOGRAPHICAL CAUSE:—

(a) *Suffixes meaning a village, town or hamlet.*

1. Ur. (village) *e.g.,* Attur, Maruthur, Pavoor, Palavoor.
2. Nallur *e.g.,* Veravanallur, Kodaganallur, Narasinganallur.
3. Nagaram (city) *e.g.,* Kondanagaram, Patemanagaram.
4. Nagari (city) *e.g.,* Alwarthirunagari.
5. Puram (town) *e.g.,* Radhapuram, Naranammalpuram, Ariyanayagipuram.
6. Puri (town) *e.g.,* Alagapuri.
7. Pathi (town) *e.g.,* Vijayapathi.
8. Pattanam (town) *e.g.,* Kayalpattanam, Kulasekaranpattanam.

   (*N.B.* Pattanam is another form of Pattinam meaning a place near the sea-coast).
9. Puvanam (world) *e.g.,* Tenthiruppavanam.
10. Nadu (country) *e.g.,* Murappanadu, Vallanadu.
11. Desam (country) *e.g.,* Brahmadesam.
12. Patti (a small village) *e.g.,* Koilpatti, Chockampatti, Singampatti.
13. Cheri (hamlet surrounded by fields) *e.g.,* Pirancheri, Solaicheri.
14. Kudi (habitation) *e.g.,* Pudukkudi, Pappakkudi, Udangudi, Panangudi.

15. Kudiyiruppu (habitation) *e.g.*, Idaiyangudiyiruppu.
16. Kurichi (village) or Kurinji (hill) *e.g.*, Kurichi, Kallidaikurichi, Karakurichi, Nadunakkurichi.
17. Peri *e.g.*, Sivalapperi, Alangarapperi, Ravuttapperi.
18. Padu (place) *e.g.*, Manappadu, Kunnilampadu.
19. Talai (place) *e.g.*, Sugantalai, Alantalai, Marugalthalai.
20. Vadi (resting place) *e.g.*, Eruvadi.

(b) *Suffixes meaning some parts of a town or village* :—

1. Chatram (inn) *e.g.*, Pavurchatram.
2. Pettai (suburb or adjoining part of a town) *e.g.*, Ammapettai.
3. Nattam (open space) *e.g.*, Mela and Kila Nattam, Melavarayanattam.
4. Chalai (road) *e.g.*, Kurukkuchalai.
5. Rasta (road) *e.g.*, Rasta.
6. Valai or Vilai (an enclosure) *e.g.*, Tisayanvilai, Pillaivilai, Pandaravilai.
7. Madam (a rest house for Monks) *e.g.*, Pillaimadam, Tattanmadam, Servaikaranmadam.

(c) *Suffixes indicating connection with water* :—

1. Aru (river) *e.g.* Kayattar, Vaipar, Vembar.
2. Eri (lake) *e.g.*, Padmaveri, Kesavameri, Udayaveri.
3. Odai (stream) *e.g.*, Veppalodai, Mailodai.
4. Uttu (spring) *e.g.*, Talaiyuttu, Ayyanaruttu.
5. Urni (a small tank) *e.g.*, Kallurni.
6. Kulam (tank) e.g. Alankulam, Senkulam, Pappankulam, Vilathikulam.

   N.B. There are very many place-names ending in *Kulam* in this district and most of these are to be found outside the Tambaraparni Valley.

7. Kuttam (small tank) *e.g.* Paraikuttam.
8. Kal (canal) *e.g.*, Pallakal, Idaikal, Ilavelankal.
9. Kinar (well) *e.g.*, Naraikinar, Alankinar.
10. Vari (water) *e.g.* Irappuvari.
11. Karai (bank or shore) *e.g.*, Manakarai, Idindakarai, Vadakarai.
12. Koodal (junction) *e.g.*, Mukkudal.
13. Turai (ford or ferry) *e.g.*, Kurukkuthurai, Mundanthurai, Erukkanthurai.
14. Kayal (backwater) *e.g.*, Punnaikayal, Palayakkayal.
15. Samudram (sea) *e.g.*, Ambasamudram, Gopalasamudram, Ravanasamudram, Dalapatisamudram.

(Evidently Samudram here should mean only some source of water-supply. The places are not even near the sea).

16. Taruvai (land-locked lake) *e.g.*, Puttantaruvai and Vairavantaruvai (tanks); Tharuvai (village) at the junction of the Pachaiyar and Palayan Channel.
17. Totti (tub) e.g., Vauvaltotti.
18. Thoni (boat) *e.g.*, Marathoni.

(d) *Suffixes denoting connection with agriculture* :—

1. Kavi (a land measure) *e.g.*, Mukkavi.
2. Pannai (field) *e.g.*, Elayirampannai, Pannai, Tholappanai.
3. Veli (hedge) *e.g.*, Tirunelveli, Puvalveli.
4. Madai (sluice) e.g. Pattamadai, Palamadai.
5. Pattam (the portion given to the land-owner by the cultivator) *e.g.*, Melapattam, Kilapattam.
6. Pathu (field) *e.g.*, Sattupathu, Padukkappathu.
7. Tiruthu (reformed land) *e.g.*, Tiruthu.

(e) *Suffixes denoting the surface features* :—

1. Malai (mountain or hill) *e.g.*, Tirumalai, Uttumalai, Sayamalai, Kurumalai, Kalugumalai.
2. Venkadam (mountain or hill) *e.g.*, Tiruvengadam.
3. Sailam (mountain or hill) *e.g.*, Sivasailam.
4. Giri (mountain or hill) *e.g.*, Sivagiri, Rayagiri.
5. Achalam (mountain or hill) *e.g.*, Trikutachalam now contracted into Kuttalam.
6. Parambur (a mound) *e.g.*, Uchiparambu (no village) between Pettai and Melakkallur Railway Stations.
7. Tiradu (raised ground) *e.g.*, Sanganthiradu.
8. Thittu (island) *e.g.*, Kovilthittu.
9. Parai (rock) *e.g.*, Mattalamparai, Maipparai, Tattapparai.
10. Pallam (low ground) *e.g.*, Munnirpallam, Korampallam, Vairavanpallam.
11. Kuli (pit) *e.g.* Kuttanguli, Vellanguli.
12. Seval (red soil) *e.g.* Melacheval, Nelkattancheval.
13. Eral (land above flood level) *e.g.*, Eral on the Tambraparni newly formed in 1827 as the lower regions were flooded.
14. Kadu (forest) *e.g.*, Kalakkadu, Urkad, Avarangadu.
15. Teri (a dune of red sand) e.g. Kudiraimoliteri, Sengateri,

B. SUFFIXES INDICATING A HISTORICAL CAUSE:—

1. Agaram (a village—gift to Brahmins) *e.g.*, Melagaram.
2. Mangalam (a contracted form of Chadurvedi-Mangalam which means a gift by a ruling chief of the Chola or Pandya Dynasty) *e.g.*, Karisuzhnthamangalam, Kattarimangalam, Arumuhamangalam, Rajakkamangalam.

   There might be many names from which Mangalam might have been dropped later.
3. Mahadevi (a gift by or in the name of a queen) *e.g.*, Shermadevi. The full name was Seravanmahadevi-Chaturvedimangalam. It was named after the daughter of a Chera king who once occupied that part of the district.
4. Kottai (fort) *e.g.*, Palayancottai, Ukkirankottai, Talaivankottai.
5. Pâlayam (camp), *e.g.*, Melappalayam, (a village near west of a palayam *i.e.* Palayamcottai).
6. Padaiveedu (military camp) *e.g.*, Manapadaiveedu. This must have been used by the Pandya rulers
7. Kottaram (a palace) *e.g.* Kottaram on the Tambraparni.
8. Vilaham (a battlefield) *e.g.*, Madavarvilaham.
9. Endal (a chief) *e.g.*, Ilaiarasanendal, Mudithanendal, Vannikonendal.

C. SUFFIXES DENOTING RELIGIOUS ORIGIN:—

Koil (a temple) *e.g.*, Sankarankoil, Mannarkoil, Appankoil, Sorimuthayyankoil, Sankaranayinarkoil.

There are other *suffixes which do not come under any of the above classifications*: e.g., Chintamoni, Virasikamoni, Suthamalli, Surandai, Nallumavadi, Viramanickam, Munradaippu, Maniyachi, Melamandai, Melakarandai, Ottapidaram, Eppodumvendran, Milavittan, Kuttappanjan, Marudanvalvu, etc.

II

Let us now see whether *the first part of the place-names* admits of any kind of classification:—the first part may be

1. the name of a person by whom the place was founded or after whom it was called:—*e.g.*, Sundarapandyapuram (name of a Naik king). Ettiyapuram (name of a poligar); Nambittalaivanpattayam (name of a headman); Kasimesipuram near Kuttalam (named after Casimajor, the Company's Commercial resident from

1800 to 1806 A.D.): Levingepuram, Todhunterpuram and Patemanager (named after officials); Kansahibpuram (probably name of a leading merchant); most of the names are historical.

2. The name of a community:—*e.g.*, Reddiarpatti, Ravuthapperi, Idaiyangudiyiruppu, Vannarpet, Maravarkurichi.
3. The name of a *plant or tree*:—*e.g.*, Panaiyur, Panandalai, (Panai-palmyra) Aladiur, Arasur, Kallikulam, Udangudi, Karuvelangulam, Puliyangudi, Erukkanthurai, Avarangadu.
4. The name of an animal:—*e.g.*, Puliyur, Singampatti, Manur, Naraikanar, Kalugumalai, Kurivikulam, Kudiraimoli.
5. The name of a geographical feature:—*e.g.* Kallur (Kal-stone); Mettur (Medu-a raised ground); Malayankulam (malai-mountain); Attankarai; Attur (Aru-river); Marukakurichi (marukal-outlet from a tank); Karisalkulam (karisal-black soil).
6. Or, it may indicate relativity: *e.g.*, Palayakayal (palaya-old); Pudukudi (pudu-new); Melacheval, Kilacheval, Melappavur, Kilappavur, Tenkasi (Ten-South); Vadakarai (vada-north). For administrative purposes Ambasamudram is divided into Mela and Kila Ambasamudram.
7. Or, it may have a religious significance:—*e.g.* Koilpatti (a village round a temple) Koilkulam. The prefix Tiru is invariably found in all places of religious importance *e.g.* Tirunelveli, Tiruchendur, Tirukkurungudi, Tirumalai, Tiruppudaimaruthur. The Sanskrit form of Tiru is Sri as in Srivaikuntam.
8. Or, it may be a number:—Padinalamperi (padinalu-14). Mundradaippu (Mundru-3), Elayirampannai (Elayiram-7,000).

III

Historical Places

There is a puranic story which accounts for the name Tirunelveli. The present site of the town was once a bamboo forest in the midst of which was a *Sivalingam*. One Vedasarma was performing puja. During a great famine the priest with much difficulty managed to get a handful of paddy and spread it on the ground to dry. When he was bathing in the river, there was a heavy downpour of rain. Fearing that the paddy would have been washed away by the rain water, the priest hurried to the place where the paddy had been spread. To his great astonishment, he saw that the paddy was dry and a hedge had been formed round it. So Vedasarma named the deity "Nelvelinathan". Hence the name Tirunelveli. The original name of the deity was Vinuvaneswarar.

A. NAMES OF PANDYA, CHOLA AND CHERA ORIGIN.

Before the district came under the administration of the East India Company, it was ruled by the Pandya Kings from 650 A.D. to 1516 A.D. and then by the Naik kings of Madura from 1563 A.D. to 1731 A.D. During the Pandyan rule the district was divided into small divisions known as *Nadus*, e.g., Aryanad (South and North), Mullinad, Vembanad (Mela and Kila), Vallanad, Vazhuthivalavanadu, Manad, Nanjilnad etc. The Pandya kings have been ruling over Tirunelveli from Madura, the chief capital of the Pandya Kingdom; but some of them have ruled from places within the district, e.g. Korkai, Tenkasi, Karivalamvandanallur, Kayatar, Rajanallipuram, Tirunelveli.

Sometimes the Pandyan king was subjugated by the neighbouring Chola or Chera kings. Hence we find names connected with Chola or Chera kings also.

Korkai.—(now an obscure village four miles from the mouth of the Tambraparni) was the seat of the Pandyan kings who were known as "கொற்கையர்கோன்" in Tamil literature, and an ancient seaport at the mouth of the river. It is referred to as Kolkhiai by Greek writers, the author of Periplus (A.D. 800) and Ptolemy (A.D. 130) as the centre of pearl fishery. It was the first port touched by the Greeks after they rounded Cape Comorin. It is now in ruins. Coins of Sinhalese and Pandya origin were found in large numbers there. The name is probably due to Porkai Pandyan who according to the legend had his own right hand cut off.

Akkasalai (=a mint).—The name of an adjoining hamlet, *Manappadaividu* (= place where the king's army encamped) and *Kottaram* (= place where the king's palace was located) are "suggestive of vanished greatness."

During the days of Arikesari Maravarman (650-80 A.D.) Tirunelveli and Kuttalam were visited by Sage Tirugnanasambandar who composed hymns in praise of the deities there. It was this sage that gave a death-blow to Jainism in South India. There are several places in this district where Jains lived, e.g., Valliyur, Viyanamkottar (Pudukkottai), Virasikamani, Kulathur, Kalugumalai, Mandikkulam, Sivalapperi, Vindanallur, Korkai, etc. In some of these places Jain images are to be seen even to-day. The deity in the temple of Radhapuram has been named Varaguneswarar after Varagunapandyan (A.D. 810-830). The old name of the place as described in a brass plate was Raja-Rajapuram. This Rajaraja was probably the name of the Chera king (King of Travancore territory), for the place lies within the area occupied at frequent intervals from the 15th century onwards by the rulers of Travancore.

The origin of *Sermadevi* has already been referred to. Seravanmahadevi whose name has been given to the village was married to a Pandya king named Viranarayanan Sadayam. Later Kumara Krishnappa Nayakkan built four streets and gave them to Brahmans. These streets now form Pudugramam, while the original part of the village forms Palayagramam. Inscriptions of Chola and Pandya kings are to be found in the temples in and adjoining the village. Ramaswami temple contains the inscriptions of Rajaraja and Rajendra Chola I, and Baktapriyar temple contains those of Kulottunga Chola I (A.D. 1074-1118) and Vira Pandya (A.D. 1252-67).

Sivalapperi (*Srivallabapperi*) at the junction of the Chitranadhi and the Tambraparni bears the name Srivallaba Pandyan (about A.D. 1011). This place was known as Mukkudal as the Kothandaramanadi also joined the Tambraparni here. Probably for the whole of the 10th Century the Pandyans were subjected to Chola rule. Eleven inscriptions of Rajaraja exist in the Alagar temple at Sivalapperi. Even the name of the Pandya capital Korkai was changed into Cholendrasimha Chadurvedimangalam and the Pandya kingdom became a province of the Chola Empire under the name Rajaraja Pandinadu.

The Pandyans were not submissive subjects. They had to be reduced once again by the Chola rulers and Chola-Pandya viceroys were appointed to administer Pandyan territories.

Gangaikondan.—A village 12 miles from Tinnevelly takes its name from either Rajendra Chola I (A.D. 1011-1014) who bore the title of "Gangaikondan" on account of his conquests in the north, or Gangaikonda Chola who was appointed by his father Virarajendra II (A.D. 1062-70) to administer the Pandya province. The full name of the place as it occurs in one of the inscriptions, is Gangaikonda Chola-Chadurvedimangalam.

Kalakkad.—At the foot of the Ghats, lies on the road from Sermadevi to Travancore. There are the traces of an old fort to the north of the village. The Kalakkad District which embraced Tirukkurungudi and Panangudi was occupied by the Travancoreans in the 15th and 16th centuries and later in the 18th century. It has been the scene of battles for several years. From old records it is seen that the fort in the place was of considerable size 900 by 600 yards, with walls 6 feet deep and 15 feet thick. Kalakkad may be split up into Kalam + kad which may mean a battle-field adjoining a forest or a forested area which was a battle-field. Manaparavannallur on the Tambraparni and Sundarapandyapurm in the Chitranadi valley have been named after Pandyan rulers; Virakeralampudur had probably a Chera origin. At the beginning of the 12th century, the Pandya dynasty revived. Maravarman Sundarapandyan II (A.D. 1238-1251) was a contemporary of the Hoysala Someswara and was also his nephew. He built a village in the name of Someswara and called it Somadeva Chadurvedimangalam (modern Muruppanad). In the 13th century the Pandya kingdom was in a flourishing condition. *Palayakayal* now an obscure village, was a thriving centre of sea-borne trade. This is referred to as Cail by Marco Polo who visited the Tirunelvelly coast in A.D. 1292. In the 14th century the Muhammadans invaded South India and established their rule for over 40 years. But in 1365 A.D. Kampana Udayar, a prince of the Vijayanagar Royal line brought Madura under his rule. Then followed a succession of chieftains of Telugu extraction who shared Madura and Tinnevelly territory.

Arikesari Pandyan (A.D. 1422-61) ruled from *Tenkasi.* He is said to have defeated the chieftains of eight places; Singai, Irasai, Vindai, Vaippar, Senbai, Arandai, Mudalai and Anurai. The first three are identified as Vikramasingapuram, Rajavallipuram and Vindanallur. Once the Pandyan wanted to go to Benares. God Viswanatha appeared in his dream and asked him to erect a temple for him in his own place. The temple was built and hence the place came to be called Tenkasi. The Gopuram of the temple was built by Arikesari's brother Alagan Perumal Kulasekara Pandyan, but it is now in ruins owing to a fire that occurred in the early part of the 19th century.

Vira Pandyan (A.D. 1551-64) : grandson of the temple-builder ruled from Tinnevelly. His victory over "Vallam" was described in "Viravenbamalai" by Kasikkaliyan poet. But this work is not extant now. This Pandyan is also said to have won a victory over Vettumperumal of Kayatar at Ilavelankal. Virapandyan pattinam, 7 miles south of Tiruchendur is said to have been built by this king.

Jatilavarman Srivallaba Adivirarama Pandyan (A.D. 1562-67) ruled from Tenkasi nearly the whole of the Tinnevelly territory. He was a poet king. He is said to have built a village and named Adivirarama Pandya Puram. He was the author of Vettriverkai, Naishadam and other works. His brother Varatunga Pandyan ruled from Karivalamvandanallur. Every day he composed a stanza in praise of the Deity there. The name of the place means "The holy place round which the elephant went in adoration of the *lingam*." The place is ordinarily known as Karuvanallur.

B. PLACES OF NAYAKKAN ORIGIN

About 1559 A.D. a Madura ruler named Chandrasekara Pandyan appealed to the king of Vijayanagar to help him against a Chola king. The Vijayanagar ruler sent his general Nagama Nayyakkan to restore the Pandyan King, but Nagama after suppressing the disorder made himself ruler of Madura. Viswanatha, Nagama Naik's own son was sent to reduce his father to submission. This he succeeded in doing and Nagama was pardoned. Viswanatha placed the Pandyan on the throne of Madura, but took the supreme control in his own hands. He founded the Naik dynasty of Madura which ruled from A.D. 1559 to 1736. His great general Aryanatha Mudaliar is said to have built the village of *Ariyanayakipuram*, the *anicut* on the Tambraparni near that village and the Palamcotta fort. This fort was later used as a garrison and a jail in 1765, but by 1861 it had practically disappeared.

Krishnapuram, 7 miles east of Palamcotta, and Krishnapuram, 12 miles from Tenkasi, were built by Kumara Krishnappa (A.D. 1563). The first is now more or less deserted, but it has a Vishnu temple having exceptionally good sculptures. Krishnappa also built the Pudugramam of Sermadevi. (The villages of Vellanguli, Sattupattu, Pathai and Padmaneri are said to have been built or benefitted by him). The Pudugramam of Viravanallur and the Vishnu temple there were built by Rengakrishnamuthuvirappa Naikkan (A.D. 1682). Mangammal (A.D. 1689) queen-regent was the famous maker of roads and avenues. Vijayarenga Chokkanatha Naikkan has endowed the temples of Kuttalam, Sivasailam and Tiruppudaimaruthur with lands. Vittalapuram, Anantakrishnapuram, Gopalasamudram, Virasamudram, Ravanasamudram and Javantipuram are said to take their names from Nayak kings. Two Nayak women have given their names to two villages, e.g. Giriammalpuram and Ambasamudram.

The old name of Ambasamudram was *Ilankokkudi* which is understood to mean "a place inhabited by classes next to Brahmans" i.e., Vaisyas. It was at first on the bank of the river. Later a Nayak woman named Amba, is said to have built the village at some distance away from the bank. Hence the village is called Ambasamudram.

C. PLACES ASSOCIATED WITH POLIGARS.

Palayakkarans were chieftains whose services were at the disposal of the sovereigns, Pandyas as well as Nayaks. They were allowed to rule over a certain tract of country and to collect what revenues they could, provided they paid a tribute to the sovereign and also helped him with men in times of war. When the English first came to the Tinnevelly District there were many Poligars. The Eastern Poligars were Telugus of the Tottian Caste, the chief among them being those of Panchalankurichi and Ettayapuram. The Western Poligars, except those of Sivagiri and Alagapuri who were Vanniyans, belonged to the Marava caste. Their leaders were Puli Tevan of Nekattancheval and the Poligar of Chockampatti. Fifteen of the Palayappattus now remain over; but only ten of them are important: Ettayapuram, Attankarai, Kadambur, Maniyachi, Sivagiri, Talaivankottai, Alagapuri, Uttrumalai, Urkad and Singampatti. The others are Melmandai, Arendaiyapuram, Naduvakkurichi, Surandai and Chockampatti.

Ettayapuram 9 miles from Koilpatti, owes its origin, according to the traditional account preserved by the Zamindar's family, to one Kumaramuthu Ettappa Nayakkan who fled with his followers from Chandragiri (North Arcot District) when the Muhammadans overthrew the king of Vijayanagar. Ettappa Nayakkan took refuge with the Pandya king of Madura, but later moved south into the Tinnevelly District making his headquarters at a place which his followers called Ettayapuram in honour of their leader. When the eastern Poligars were all banded together in defiance of Company's authority, Ettappa Nayakkan allied himself with the British and rendered valuable service to them in putting down the revolt of Panchalankurichi. In return for this help the zamindar was rewarded with 79 villages out of the Panchalankurichi Palayam.

Nelkatiancheval was the stronghold of Puli Tevan who figured for many years as the leader of the Marava confederacy against the troops of the Nawab and the Company. Later the Zamindari was called Avudaiyarkoil, probably because the associations of the old names were too unpleasant. During the Panchalankurichi insurrection the Poligar seceded from the ranks of the rebels.

Chockampatti was second only to Nelkatiancheval in the early part of the conflict, but later it sided with the Company. The estate became extinct by 1866 A.D.

Sivagiri was next to Puli Tevan, the most dangerous power in the district from 1767-92 A.D. After 1792, the Poligar ceased to give trouble as he became the helpless victim of a most trouble-some son.

Vasudevanallur, which originally belonged to the Poligar of Nelkatiancheval, had a mud fort built of sun-dried bricks, 15 feet thick at the base. It has now been levelled for over a century.

Panchalankuruchi was the seat of the most notorious of the rebel Poligars, named Kattabomma Nayakkan who was the leader of the Eastern Confederacy of Poligars. Kattabomma was a family name, his real name being Karutha Pandyan or Vira Pandyan. One of his brothers was known as Oomayan as he was dumb. Kattabomma was captured by the British with the help of the Tondaiman of Pudukotta and the Poligar of Ettayapuram. He was hanged at Kayattar on 16th October 1799. On the left-hand side of the trunk road and about three quarters of a mile to the north of the village stands a large pile of stones which represents the offerings by the wayfarers of the past 140 years "for the repose of the soul of the victim." In 1801, the fort of Panchalankurichi was razed to the ground and the site was ploughed and sown with castor seed. The site of the place is two miles north of Ottapidaram. Kattabomma's minister Sivasubramania Pillai was hanged at Nagalapuram.

D. TUTICORIN THE CHIEF PORT

The Tamil form of the word is Tuttukudi which is apparently a corruption of a word derived from Dutch. It is however derived from turthu=(filling up) and kudi= (a habitation), i.e., a place formed by filling up (water-logged) low grounds.

Before the arrival of the Portuguese in 1532, Tuticorin was only a village inhabited by Paravans. The Dutch retained possession of the place from 1658 to 1784 and built a small fort there which was later demolished by the English. Tuticorin remained in English possession till 1818 when it was handed over to the Dutch. Finally it was transferred to the English on the 1st of June 1825.

E. PLACES CONNECTED WITH MISSIONARY ACTIVITY

There are several places of interest whose names have a Christian origin, (e.g.), Adaikalapuram, Asirvadhapuram, Christianagaram, Donavur, Hridyakulam, Ittamoli, Kadakshapuram, Megnanapuram, Meyyur, Nallur, Nazareth, Prakasapuram, Suviseshapuram, etc.

In 1803, the site of Nazareth was purchased by the Rev. J. C. Kohloff of the S. P. C. K., for the settlement of the "Tanjore Christians". The first name of the village was Mudalur (first village).

Sawyerpuram was named after Samuel Sawyer, a Portuguese merchant who acted occasionally as an agent of the S.P.C.K.

Rev. John Thomas started work at Megnanapuram in 1838 which to-day remains the special charge of a single family.

Idayangudi (Nanguneri Taluk) is memorable as the scene of the labours of Dr. Robert Caldwell for 43 years.

Vadakkankulam is the centre of the Jesuit Mission where the Jesuits made their first converts. The last two places retain their old names.

F. PLACES OF ARCHAEOLOGICAL IMPORTANCE

Adichanallur 11 miles from Palamcottah on the road to Trichendur, Korkai, the old Pandyan capital, and Kayal are sites of archaeological and historical interest. In these and fifteen other places sepulchral urns have been found. These places are: Agaram, Vadakku Vallanad, Vallanad, Murappanad, Vasavappapuram, Karunkulam, Vittilapuram, Kongarayakurichi, Srivaikuntam, Tiruppuliyangudi, Pudukkudi, Velur, Kalvay, Appankoil and Maramangalam. For a full description of the finds at Adichanallur vide Tinnevelly Gazeteer Pp. 424-428.

IV

PLACES OF PILGRIMAGE OR OF RELIGIOUS IMPORTANCE.

Most of the names have some puranic story or legend connected with them.

Alwarthirunagari is associated with Nammalwar, whose date is said to be the middle of the eighth century A.D. It was only Tirunagiri or Srinagari before the days of the Alwar. Nammalwar was born as the son of a local king. He was taken on the 11th day to the temple of Adinatha. The child refused to return with the parents who left him by the side of a tamarind tree which exists even to-day, but bears no fruit. The Alwar sat there in meditation for 16 years. When Lord Vishnu appeared before him, the Alwar's voice broke forth into verses which are known as the *Prabandam*. The festival in Vaikasi is the grandest and the most attractive event in the year.

Attalanallur (Atti=elephant and alam=deep water) is a village about four miles east of Ambasamudram and is said to have been the scene of Gajendra Moksha. The deity here is known as Adimoolam.

Kuttalam situated on an elevation of 550 feet has long been a summer resort both of Europeans and Indians. One of the most striking natural beauties of the place is the water-fall by which the Chittar makes its final descent into the level country. From its association with the waterfall the Kuttalam temple has become a place of pilgrimage. The origin of the name has already been referred to. It is said that sage Agastya found here a Vishnu temple, and was turned away from the door. On the advice of God Subramania at Ilanji, he put on a *namam* and tulasi beads and easily obtained admission. By his touch, the Vishnu idol was converted into a Sivalingam.

Mannarkoil two miles north of Ambasamudram is associated with the name of Kulasekara Alwar who was a Chera king. The Alwar spent his last days here. The place is visited by hundreds of people on the Vaikunta Ekadasi day.

Nanguneri the derivation is not clearly known. The name appearing in the early English records in Nangancheri or Nangalancheri. Nanguneri enjoys a wide reputation as the headquarters of the Vanumamalai Mutt whose Jeer is the religious head of the Tenkalai Vaishnavas. In North India, the mutt is known as "Todadri Mutt." Two festivals, one in Panguni and the other in Chittrai attract pilgrims.

Papanasam is formed of two words (papam=sin; and nasam =destruction). Here hundreds of people go to bathe in the river in front of the temple especially on new moon days. The place is famous for a magnificent cascade—the Kalyanatirtam. According to the story it was here that the sins which a brother and a sister had committed by marrying each other were destroyed and God appeared and granted them everlasting happiness. The tenth day of the annual festival of the temple falls on Chittrai Vishu.

Pottalpudur (near Ravanasamudram) means a village newly built on a Pottal or waste land or soil impregnated with soda. Probably the village is of recent origin, but the mosque which in respect of sanctity, claims to rank not below Nagore (Tanjore Dist.) is an old one (said to have been founded in 1674). It has its annual festival (Kandoori) which attracts not only Muhammadans but also Hindus, who form the greater number of the Andavar's devotees.

Sankaranainarkoil (temple of Sankaranainar or Shiva) is said to have been built by Ugra Pandya at the place where a lingam and a cobra were found, by the side of a hill. The special feature of the temple is an idol representing the unity of Siva and Vishnu (*i.e.*, Sankaranarayana). The temple derived its reputation mainly from Gomathi Amman the consort of Sankara. The festival of Adi Thapasu is the greatest local religious event of the year.

Shermadevi is visited by pilgrims on the Vyatheipadham day in Margali. Sri Muthian koil in the Singampatti estate is visited by pilgrims on Adi New Moon day.

Srivaikuntam means "Heaven of Vishnu". The Vishnu temple once served the Company as a fort and was one of the few strongholds which held out against Kattabhomma Naicken.

Trichendur (the beautiful town) is the place built by the Mukkani Brahmans on the spot where God Subrahmanya landed when he returned after his hard-won conquest over Sura Padma in his island fortress in mid-ocean. The Masi festival attracts thousands of pilgrims from all parts of the district and beyond.

Thirukkurungudi on the Nambiyar, is two miles from the foot of Mahendragiri from the top of which Hanuman took a leap over the sea to Lanka. It was founded by the famous Udaiyavar the author of Vaishnavism and the common priest of Vadagalais and Tenkalais. The place possesses peculiar sanctity as having been the last resting place of Tirumangai Alwar or Kalla Alwar, who was bidden by God Sriranganatha to go to "Terguvidu" or "abode in the South." Six miles up the hill is the Malai Nambi Kovil in which is found a temple dedicated to Siva who is known as "Pakkanindrar" (one who stands by the side). The temple celebrates three festivals a year.

Tirunelveli the mythological origin of this name has already been stated. The Nelliappar temple and the houses massed around it are surrounded on all sides by rice fields; hence the name is appropriate. But now many of the fields have been converted into building sites. The great festival of the temple is celebrated in Ani (June), the car festival attracting thousands of people from all parts of the district.

Tiruppudaimaruthur a village at the junction of Gadananadi and the Thambraparni derives its name from the fact that the lingam was found in a hole under an Arjuna tree (pudai-hole; maruda-arjuna). The Pushyam festival celebrated here in Thai attracts many people.

Valliyur derives its name from Valli, the chief consort of God Subrahmanya. The shrine of the temple consists of a cavity in a rocky hill. During the festival held in Chittrai the temple is visited by thousands of pilgrims.

Places associated with the march of Sri Rama to the south are also to be met with in this district *e.g.* Manur, Mayamankurichi, Mudavakurichi, and Pattakurichi. Rama first saw the deer at Mayamankurichi (mayaman=false deer) and lost it. He found it again at the Manur, wounded it at Mudavakurichi (Mudava=lame) and finally slew it at Pattakurichi (patta=died). Two miles north of Alankulam is a small hill called "Okkanindran Pottai" believed to mark the spot where the gods assembled to greet Rama after his victory. A temple dedicated to Rama, Sita, and Lakshmana is built here. The natives of Virasikamani (Sankarankoil Taluk) and Marugaltalai (Tinnevelly District) call the shallow rectangular beds carved out of a ledge of rock in a cave, the "Pancha Pandava Paddukkai". The caves are of Buddhistic origin especially the one at Marugalattai as it contains a Pali inscription. All the other rock-cut caves are thought to be the work of Jains.

V

NAMES OF MOUNTAINS AND RIVERS

Names of mountains, rivers and canals have their own tales to tell. E.g., Agastyampalli, the Thambraparni, and the Kannadian Canal.

Agastyampalli or Pothigai is named after Sage Agastya who was sent to the south to right the balance of the world at the time when all the gods and goddesses were assembled in Kailasam to witness the marriage of Siva and Parvati. The rishi is said to have retired to the hill after the achievement of his life's work.

Kattalaimalai now the property of the Jesuit Missionary Society was originally granted in pre-British times as an endowment to the Papanasam temple, the old Chockampati Poligar being the trustee (Kattalai—service to be rendered to the temple).

Kottaimalai (fort-hill) is a bare hill overlooking the Kattalaimalai from the north. Substantial traces of what must once have been a fort served the Travancoreans as a place of refuge during many of their incursions into the Tinnevelly Country.

Tambraparni has two parts (tamra=copper or red, and parna =leaf or varna=colour). Hence the word means " copper-coloured river or the river of red leaves." According to the Tambaraparni Mahatmyam the string of red lotus flower held in the hand of Agastiya rishi transformed itself into a damsel at the sight of Siva and Parvati who appeared before the sage after their wedding. At the bidding of Siva the damsel turned into a river.

The Kalyanathirtham waterfall is so called because it is believed that it was near that place that the sage Agastaya met Siva and Parvati just after their wedding. The tributaries of the Tambraparni in its mountain course have all Tamil names e.g., Peyar, Ultar, Pembar and Servaiar. In the plain stage, the Koraiyar and the Pachaiyar are Tamil names while *Gatananadi and* Chitranadi with its tributaries Jambunadi, Ramanadi, and Varahanadi are Sanskrit names. The Chitranadi (beautiful river) has also a Tamil name Chittar (small stream).

The Kannadian Channel flowing through Kallidaikurichi, is said to owe its name to a Brahman, a native of Kanara (Kannada). The Brahman who acquired enormous wealth consulted Agastya as to the form of charity he wanted to perform. The sage advised him to dig an irrigation channel, and, to mark its course, sent with him a cow. The channel was dug where the cow walked and tanks were made where it lay down.

The deity in the temple on the bank of the river at Ambasamudram is known as *Ericha-Udaiyar,* which name has something to do with the Kannadian. The priest who wanted to deprive him of his wealth which was entrusted to him was burnt to ashes; hence the name of the deity.

The channel passing through Ambasamudram is the *Nadivunni Channel.* It means a channel fed by the river but, when applied to the anicut, it may mean " that which raises the level of the river."

Communication Lines of Tinnevelly District

BY

N. SUBRAHMANYAM, M.A., L.T., F.R.G.S.

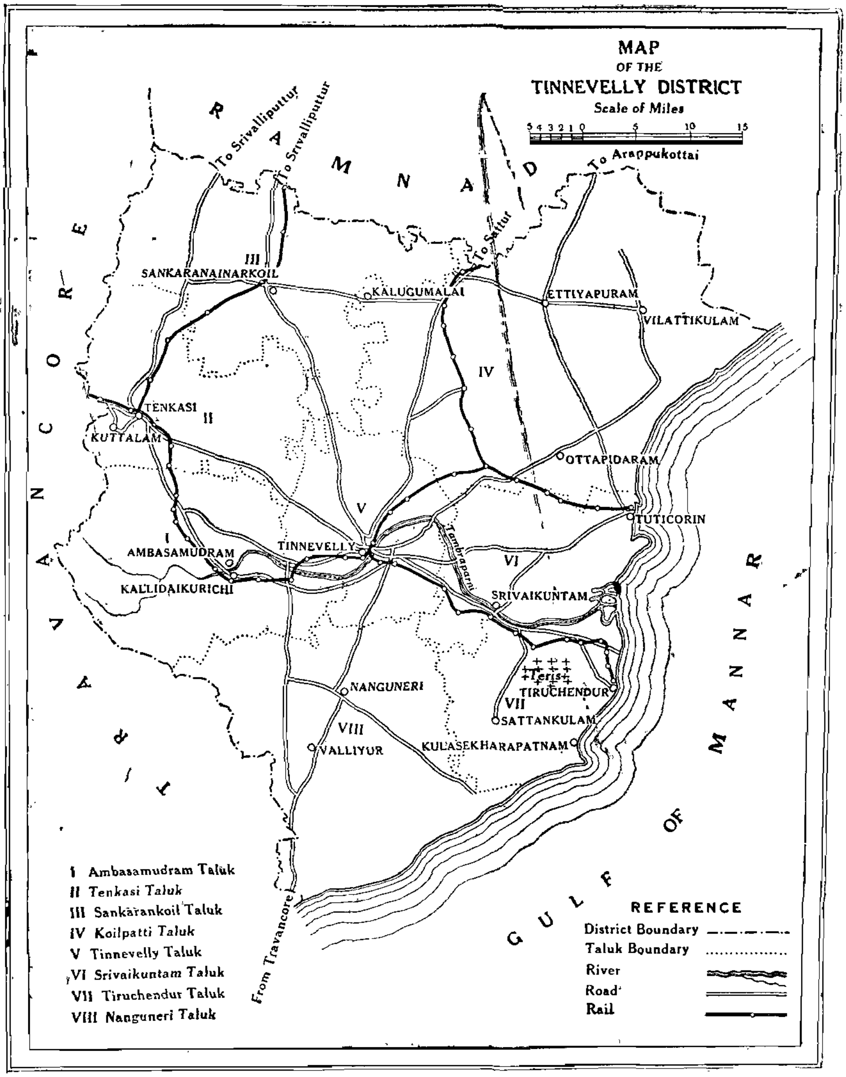
The communication lines of Tinnevelly District—both roads and railways present interesting patterns as the result of certain important controlling factors such as relief, rivers and structure as well as the need for linking up the sub-regions within the district and the rest of the country outside.

Roads.—Taking first the roads, which have come back to their own in this automobile age, we find nine of them radiating in all directions from the twin-nucleii of Tinnevelly-Palamcotta—the Head-quarters of the District (official and popular), located on either side of the Tambraparni and linked by a road bridge. They are thus listed in the Gazetter of Tinnevelly Dt. Vol. I, p. 240 :— "Following the direction of the hands of a clock, these are the roads :—

(1) To Ambasamudram and Tenkasi, with a branch to Papanasam.
(2) To Ravanasamudram (Joining No. 1).
(3) To Tenkasi *via* Alankulam and from Tenkasi to Quilon (Travancore) and Sivagiri.
(4) To Sankaranainarkoil (Srivilliputhur and Madura).
(5) To Koilpatti (and Madura).
(6) To Sivalapperi, Ottappidaram and Vilathikulam.
(7) To Tuticorin (branching from No. 8).
(8) To Tiruchendur.
(9) To Nanguneri, Panagudi (and Nagercoil, Travancore)."

The trunk road from Madras can be traced as the main north-to-south road—northwards through Koilpatti in the cotton region to Madras, and southwards to Nanguneri and Panagudi, continuing through the Aramboli pass to Nagercoil (Travancore), while a branch of it leads straight to Cape Comorin.

Four roads run westwards and northwards from the Head-quarters to the more fertile regions adjoining the Ghats. The first of them starting from Palamcottah runs up the fertile ribbon of the Tambraparni valley along its right (Southern) bank, crossing over to the left bank at Ambasamudram where it bifurcates—the older



Communication lines—Roads and Railways of Tinnevelly Dist.

one wheeling northwards to Tenkasi, while the other leading through the factory town of Vikramasingpuram to the Kariar (Upper Dam of the Papanasam Project). Starting from Tinnevelly runs another road along the north side of the Tambraparni, uniting at Ravanasamudram with the Ambasamudram-Tenkasi section of the first road. A chord road runs straight from Tinnevelly to Tenkasi, through Alangulam, continuing through the Ariankavu pass in the Ghats to Quilon (Travancore) in the West, with a branch running north from Tenkasi to Sivagiri. The fourth road from Tinnevelly runs north-westerly to Sankaranainarkoil, which is continued through Srivilliputtur to Madura.

From the District Headquarters the north-easterly road to Sivalapperi, Ottapidaram and Vilathikulam, and another running straight to Tuticorin serve a large part of the cotton region. Tuticorin is also reached by a road from Srivaikuntam, lower down the Tambraparni on the Palamcottah-Tiruchendur pilgrim road.

Besides the above, other importants roads (1) link up the cotton country with Tuticorin the Port, and (2) connect the main roads with one another.

On the whole, the Ambasamudram and the Tenkasi taluqs in the Western part of the District have better road communication, while the *teri* region of the south-east and the sandy and the swampy region of the eastern and the north-eastern parts of the District are the worst served in this respect.

A system of light railway is laid in the *teri* tract by the East India Distilleries Co., for collecting palmyra juice and jaggery from surrounding villages to the sugar refinery at Kulasekharapatnam. The District Gazetteer suggested a further extension of this mode of transport as suitable for this region; but so far nothing like that seems to have taken place. Innumerable rough country roads traverse all this dry region, where pack-bullocks and *kavadies* are also commonly used for transport purposes.

Good road materials are available in the District—in the shape of the numerous granite outcrops in the west as quartz and gneiss in the centre and south-east, and hard lime-stone in the black cotton land. Still the maintenance of the roads is a difficult problem in the District, owing to the long dry season of 9 months when no water is available and the fierce dry winds rage at intervals.

Many of the roads, especially in the western taluqs, are shaded by avenue trees, usually of banyan, *maruthai,* tamarind, and portia (*puvarasu*), while fruit trees are comparatively rare, *Railways.*—The South Indian Railway from Madras and Madura enters the district in the north and leaves it at Shencottah to enter Travancore through Aryankavu Pass.

From Virudhunagar to Tenkasi, the loop and chord lines form an enclosed figure, the former serving the headquarters and the Tambraparni basin above it. A branch from Maniyachi leads to Tuticorin, the chief port of the District, by which trade and passenger traffic leave for Ceylon and the outside world. The District Board Railway from Tinnevelly to Tiruchendur passes partly through rich paddy-country; and skirting the great jaggery *producing region of the district, it serves the important salt centre* of Kayalpatnam. The pilgrim traffic to Srivaikuntam, Alwar Tirunagari and especially to Tiruchendur is considerable. Still, the railway has to be protected from the competition of bus transport in the interests of the District Board.

The ubiquitous bus service snatches a good portion of local traffic in areas served by the railway, and has practically a monopoly of it in the southern parts of the district, where railways are absent.

The Port of Tuticorin

By

V. Thyagarajan, M.A., L.T., Dip. Geog.

The port of Tuticorin is important as it forms the southernmost port on the east coast and has the largest trade in South India next to Madras and Cochin. That is, among the minor ports of the Presidency it occupies the second place and carries on about 11 per cent of the sea-borne trade of the Presidency.

A knowledge of the nature of the coast is necessary for a clearer understanding of the position of the port.

COASTLINE

The coast of Tinnevelly, 85 miles in length, extends along the Gulf of Mannar from Vembar in the north to a point 4 miles east of Cape Comerin in the south. From Manappad northwards a series of rocky shoals extends up to the Vaippar. Off Manappad an outer shoal extends 10 miles north to south with an average breadth of a mile, and hence a lighthouse has been built at Manappad to guide the vessels off this reef. Another reef, dangerous in character, projects 3 miles north-east from Tiruchendur and gives shelter to small vessels anchored off the port of Virapandyanpatnam. A reef 3 miles from the shore fronts the town of Kayalpatnam enabling native craft to anchor in the calm water between this reef and the coast. This reef further affords good anchorage for small vessels at a mile off Punnaikayal and protects them during the period of the south and south-west winds.

Two miles south of the low sandy cape called the Devil's point begins a reef, on the northern continuation of which stand the islands of Punnaiyadi tivu, Cronjee Tivu and Pandyan Tivu, facing Tuticorin. Pandyan Tivu is also known as Hare Island. Silting has taken place on such a large scale that not only has the Devil's Pass been closed completely, but the three islands form one continuous stretch of land connected with the mainland. The islands extend northwards at intervals to the Vaippar, ending with the Sali Tivu group. The water off this part of the coast is shallow and calm and only small craft can pass between the islands and the mainland. Thus the Tuticorin harbour has the shape of a horseshoe with the opening towards the inside of the gulf of Mannar and has calm water throughout the year both inside and outside. Hare Island, on which is situated the lighthouse, affords protection to the lighters and other craft at the harbour from the south and south-east winds. The harbour is also protected by the Church Island in the period of the north-east monsoon.

TUTICORIN HARBOUR

As it is very shallow inside, ocean-going vessels anchor in the roadstead outside the Hare Island, 5 miles off the town and unload into lighters only such goods as can be man-handled and landed at all. Even coasting craft of large size has to remain at the roadstead. So a boat channel has had to be maintained to a depth of 10 feet from the 2-fathom line to the jetties for the benefit of the cargo boats plying between the vessels at anchor and the jetties. The local currents, acted on by the wind, operate with varying strength in silting the channel as well as the entrance into the harbour. Dredging has therefore to be continuous and the dredger 'Tuticorin' is employed to keep the passage open between the shore and the roadstead. The Grab Dredger—a small one—is employed in deepening round the jetties and wharves.

The port is supplied with six piers—properly speaking, three piers and three cross-jetties, and these have improved the wharfage considerably. One pier is kept only for coal. As the sea is receding further towards the east, reclamation has been rendered easy along the foreshore with the help of the material dug out by the dredgers. By such reclamation the foreshore has been extended, increasing the facilities for the landing, shipping, storing and clearing of goods. The South Indian Railway runs alongside the landing and shipping wharves, from which passengers and goods can be transhipped to launches and lighters. It is said that about Rs. 20,00,000 have been spent since 1911 in affording increased facilities at the port and the improvements include the 3 new cross-jetties of improved types, consolidation of reclaimed land for cart and motor traffic, electric installation, etc.

A SHORT HISTORY OF THE TUTICORIN HARBOUR

It is natural for any one to ask why a deepwater harbour was not constructed at such an important port as Tuticorin. It is not that no attempt was made in that direction. Even so early as in 1903 the necessity of dredging the harbour was much discussed and a dredger was brought from England at a cost of Rs. 3¼ lacs. A committee of officials and merchants was formed in 1906 to go into this question. In 1909 there was an interesting proposal to run a stone bank straight out to sea opposite the railway station and to excavate the harbour to the south of it. It was only in 1920, after the Great War, that a more serious scheme was put forth and it was to construct a dock with deep water quays near Hare Island and a dredging entrance channel 30 feet deep from the dock to the 5-fathom line. When borings were taken, it was found that the dredging alone would cost 87 lacs. The Harbour Engineer-in-Chief set forth an alternative scheme, which was to construct a narrow land-locked channel through the reef and Island with sidings for vessels to lie in. This scheme was sanctioned and after the first year's dredging the Engineer submitted further proposals involving additional expenditure. In the meanwhile (in 1924) the port was separated from the Eastern group of ports and a Port Trust was constituted. The Port Trust Board expressed inability to finance any scheme in excess of Rs. 60 lacs. The Government of India declined to make any grant for the purpose. So the scheme for the further development of the harbour had to be abandoned though the Port Trust Board had incurred an expenditure of Rs. 30 lacs on the habour works. It was not entirely the question of finance that prevented the development of a proper harbour at Tuticorin; we can see in this the opposition from vested interests, mainly from boat-owners and the large number of people who earn their livelihood by the carriage of goods and passengers; for, the development of a deep water harbour would spell ruin to them by depriving them of their job, besides leading to the scrapping of the boats in which they have sunk their capital.

Thus we see that Tuticorin, a very important port, serving five districts in that region of South India, has to carry on its trade with antiquated methods of landing and shipping. There is no doubt that with a complete deep water harbour the trade is bound to grow with the prosperity of South India. But with its time-honoured method it can hardly be expected to maintain its level of trade, especially with a powerful rival in Cochin. Till 1926-27 when the development of the Cochin harbour began, Tuticorin was second to none among the minor ports of Madras, and carried on about 15 per cent of the sea-borne trade of the Presidency. With the development of a modern harbour at Cochin more trade is attracted to it and Tuticorin with its old-fashioned means of handling the goods is playing a losing game. Within a decade Cochin has been able to steal a march over Tuticorin and handle twice as much trade as the latter; for, it is Cochin that now occupies the first place among the minor ports of Madras and is responsible for 20 per cent of the sea-borne trade of this Presidency, while Tuticorin is unable to get even 10 per cent.

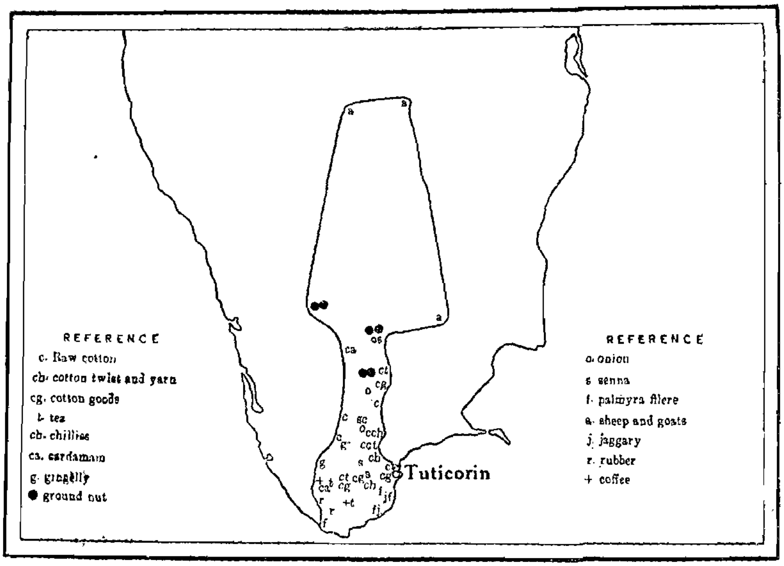
In spite of declining trade the town, however, shows no decrease in population. It registered an increase of 35 per cent of population between 1921 and 1931; at present the number is 80,000. Of the towns of the Tinnevelly district Tuticorin has the largest population. This apparent paradox is explained in the study of the town.

SEA-BORNE TRADE OF TUTICORIN—GENERAL

The sea-borne trade of this port is carried on by steamers and sailers. While steamers alone are used for trade with foreign countries, steamers and sailing vessels take part in the coasting trade; and of these two in the coasting trade, the sailers bulk large. An average for the 5 years (1934-'38) shows the following position:—

Description of the vessels.	*Number of vessels*	*Tonnage arrived*
Foreign steamers	112	454,500
Coasting steamers	413	1,067,000
Coasting sailers	593	36,000

From this it is seen clearly that the sailers are larger in number than the total number of steamers and that the average tonnage is seven hundred times as great as that of a sailing vessel. About 1,120 vessels visit the port and in them 1,560,000 tons are carried. Another noteworthy point is that in the matter of exports foreign trade is of greater importance than coasting trade, while the opposite is true in the import trade. That is, the port exports largely to foreign countries, and imports to a greater extent from the other parts of India. Secondly, till the beginning of the decade under review the exports were always greater than the imports. Such a statement does not hold good in the thirties; the exports and imports balance on an average. The explanation for this lies in the fact that while the raw materials of the hinterland are sent through this port, the import of specialised goods like motor cars, high-class machinery, etc., is more easily made in modern ports like Madras where proper facilities exist in the form of deep-water harbour, powerful cranes, extensive wharfage, etc. From 1930 onwards the exports fell acutely and though there has been a partial revival from 1935, the increase is not so much as to warrant a very favourable balance of trade. This fall in exports was naturally due to the world depression following the Wall Street Crash of 1929 and England's going off the Gold Standard in 1931; and the agricultural products in the form of raw materials which form the bulk of the exports of this port have been very much affected. The slight increase in exports for the past quinquennium is entirely the result of the gradual revival that followed later. The import, consisting as it does, more of finished products, was not much affected by the depression and so the fall in imports was not very perceptible.



Map of Exports Hinterland of Tuticorin.

Lastly, the war of 1914-'18 produced great changes in the quantum of trade and also in the commodities that were involved in it. The boom of the war period was followed by a post-war depression and after the setting-in of recovery the trade of the port reached the pre-war level apparently in 1923, though in reality 1925 would be a more correct year, when due allowance is made for the rise of commodity prices in the 'twenties. The peak year after the war as regards total trade of the port was

1925-26, when the exports reached Rs. 8·3 crores and the total trade Rs. 13·6 crores. The imports were the highest in 1927-28, which saw great activity in India in the starting of new industrial concerns. For the 'thirties the peak year was 1937-38, when the trade went up to Rs. 10 crores. There was nothing special in that year, and the progress made might have been kept up in the succeeding year, had not the European situation worsened with the fear of war and the consequent contraction of the volume of the ordinary trade and the diversion of materials to the manufacture of arms and ammunition.

The following may be helpful for a clear understanding of the above statements.

(Average for 5 years, 1934-'38.)

			Rupees.	
Exports :—	Foreign	..	2·7	Crores
	Coasting	..	2·1	"
	Total	..	4·8	"
Imports :—	Foreign	..	1·4	"
	Coasting	..	2·9	"
	Total	..	4·3	"
Total Trade :	Foreign	..	4	"
	Coastal	..	5	"
	Total	..	9	"

Pre-war figures (1912-13) are given below for comparison :—

		Rupees.	
Exports	..	6·5	crores
Imports	..	2·1	"
Total	..	8·6	"

EXPORTS

The following order of importance of the commodities is based on their value in the trade figures for 1938-'39.

Raw cotton, twist and yarns and piece goods.—A large portion of the Koilpatti taluk and a part of the Sankarankoil taluk contain black cotton soil and cotton is the chief crop grown over that area. Besides the cotton grown in the district it is brought to this port from other places like Sattur, Rajapalayam, Sivakasi, Virudhunagar, etc. Small ginning factories exist in all villages where cotton is grown. Large power-driven ginning factories in big towns do not exist at present and they have been replaced by smaller ones in the villages of the cotton area, for it is only in villages that purer cotton without any adulteration is available. A good part is consumed in the mills situated in 3 places of the district. The remaining portion is compressed under the steam-presses situated at Tuticorin and exported. The average value of the export of raw cotton for the last 5 years (1934-'38) is Rs. 83 lacs and the weight of cotton exported, 10,600 tons of 50 cubic feet. In 1938-39 there was a steep decline in the export caused by the slump in the price of raw cotton and by the contraction of demand on the part of Japan and Italy. The cotton generally goes to the United Kingdom, Japan, Germany and Netherlands.

There is a good export of cotton twist and yarn to the average value of Rs. 170 lacs. The yarn is produced in the Harvey and Loyal mills of the district. The trade is steady, and besides the foreign countries Calcutta and Karachi take a portion of the yarn.

Piece goods to the average value of Rs. 25 lacs are exported from this port. Besides the woven goods from the mills of the district, hand-woven cloths from places like Vasudevanallur, Sankarankoil, Viravanallur, Ambasamudram, Kallidaikuruchi and Kadayanallur are sent through this port. About 20,000 people in the district are engaged in spinning and weaving, the latter giving employment to a very large number. With about 25,000 looms in the district weaving is carried on by the Kaikkilaiyans, Muhammadans and Adi-Dravidas. Small towels, muris, saris, lungis and kailees of different varieties are made. There has been a steady rise in the trade. Coloured cloths bulk large in the export and they are taken to Ceylon, Strait Settlements, Malaya and Travancore.

Tea.—About 600 acres are under tea in Tirukkurungudi and Ambasamudram. Tea is also brought from the Cardamom Hills in the Travancore area. The average figure for 5 years (1934-38) of tea exported is Rs. 80 lacs in value and 10,000 tons of 50 cubic feet in quantity. For the first 3 years of the decade the annual export exceeded a crore. Afterwards there was a decline due to depression and recovery was made only in 1938-39. The tea is sent largely to the United Kingdom and other countries of Europe.

Spices (chillies and cardamoms).—Chilly is grown to a large extent in Tinnevelly and Koilpatti taluks of the district and in other places like Sivakasi and Sattur. Cardamoms are brought to this port from Bodinayakanur and Ambasamudram. There has been a rise in the trade, the average for the last 5 years being Rs. 30 lacs. Ceylon is the chief market for chillies, Italy and Germany for pepper, Germany for ginger. Cardamoms are taken to Sweden, Germany, United States of America and the United Kingdom.

Oilcake and cattlefood.—Gingelly is the chief oil seed of the district grown largely in Sankarankoil and Tenkasi. Though the district does not grow large quantities of groundnut, groundnut cakes are brought to this port from Dindugal, Madura and Pollachi and exported along with gingelly oil cakes. There is a slight increase in the trade, the average value being Rs. 11 lacs. The sesamum oil cake goes largely to Ceylon, while the groundnut cake reaches the United Kingdom, Germany, Denmark and Ceylon.

Fish (dried) and other provisions.—Hundreds of Paravans are engaged in fishing along the coast. Tuticorin is the best market and the catch per year amounts to half a lac of rupees. The hauls at Manappad, Kolachel and Alanthalai are also important. The Valai is the commonest fish; others are sardines, jew-fishes, the Indian rock-cod, the sea brean and the red mullet. There are 14 fish curing yards along the coast where the Government supplies salt at cost price, i.e., I anna per bag. The cured fish is exported from this port chiefly to Ceylon. The trade has been increasing during the quinquennium, the average value being Rs. 11 lacs.

Fruits and vegetables.—The extent under fruits and vegetables is the largest in the Tenkasi taluk. The chief vegetable for export is onions which are grown largely in Sivakasi, Dindugal and Tirumangalam and brought to this port. The trade is progressive and the average value of export is Rs. 10 lacs. The onions are sent mainly to Ceylon, Malaya and the Straits Settlements.

Grain, pulse and flour.—Though the bulk of the area under cereals in the district is occupied by dry crops, about 350,000 acres are under rice. Moreover rice is the staple food product in the district. It is inadequate for the needs of the district and some paddy is imported from Rangoon and Bangkok. Still there is some re-export of rice to Ceylon. The trade is not very steady, the average value of the export is Rs. 9 lacs.

Senna and other drugs.—The crop known as Tinnevelly senna was introduced into the district in the early years of this century by G. A. Hughes who imported the seed from Arabia. It is grown in the wet lands of several villages in the Tinnevelly taluk. It is grown in other places as a second or supplemental crop. Talaiyuthu and Thenmangalam in the district and Dindugal and Sivakasi in other districts grow large quantities of senna, which is brought to this port where it is pressed and exported to the United States of America, Germany and the United Kingdom. In three foreign countries the leaves are used in medical preparations. For the past three years there has been a fall in the trade and the average value of the export is Rs. 9 lacs.

Cattle and other animals.—No cattle are now exported from this port. Live goats and sheep are brought to this port from Kolar, Bangalore and Trichy and are exported mainly to Colombo. There are no cold storage facilities to send iced meat. The trade is slightly declining when compared with the value at the beginning of the decade. Annually about 32,000 sheep are sent and their value averages about Rs. 6·4 lacs.

Fibre (raw and manufactured).—Palmyras cover nearly 34 thousand acres. The *teri* lands are all palmyra jungles, and nearly two-thirds of the trees are found in the Tiruchendur taluk itself. In addition to sweet juice and toddy the trees supply fibre, which when beaten out is twisted into yarns and ropes. From Tisaiyanvilai, Kolachel, Nazareth and Tiruchendur in the district and from the Ramnad district and Cocanada the fibre is brought to this port and exported to Japan, Belgium, the United Kingdom and the United States of America, where it is made into brushes, ropes and brooms. The trade is steady, the average export being 2,500 tons of 50 cubic feet in quantity and Rs. 5·5 lacs in value. Trade in the manufactured product is negligible.

Manures (bones and fish).—There is a big bone crushing factory at Kadambur owned by Rodriguez and Co., which has 100 branches at other centres of South India. The crushed bones and bonemeal are sent to Tuticorin for export to highly manufacturing lands of Belgium, France, Ceylon, Japan and the United Kingdom which require them for intensive cultivation. The trade is increasing, the average value of the export being Rs. 3 lacs.

Oil-seeds.—The district produces gingelly and small quantities of castor and groundnut. Groundnut seeds are brought to this port from Dindugal, Pollachi and Madura. There is an export of these seeds to foreign countries, while the export of oil is of less importance. This is due to the inefficiency of the methods employed in extracting the oil. The ordinary country oil-mill generally used for this purpose leaves a good amount of oil in the cakes. Further the oil is not expressed under the best hygienic conditions. The average value of the export is a little more than Rs. 2 lacs. The largest amount exported for the past 10 years was Rs. 5·2 lacs in 1937-38. The groundnut seeds are sent to Netherlands, France, the United Kingdom, etc., and there has been a steady fall in the price of groundnuts.

Sugar.—Only 300 acres of the district are under sugarcane. But the amount of jaggery annually produced from the palmyra is very large. Though a good part is consumed within the district and is distributed to surrounding parts by rail, a fairly good quantity is consigned to Nellikuppam for refining. The average value sent is Rs. 1·8 lacs. There is in addition a small re-export in that commodity.

Rubber.—There is no rubber produced within this district. All the rubber in India is produced in the adjoining state of Travancore. Even in the beginning of the decade there was export to the extent of Rs. 17 lacs. With the development of Cochin more and more of rubber is sent to it for export and naturally the amount coming to this port has fallen considerably. The average for the last 5 years is a little over a lac of rupees. There has also been a fall in the export of this commodity from Cochin and this is caused by the lower percentage allotted to the export of this article under the quota system. Generally the product goes to the United Kingdom, the United States of America, Czecho-Slovakia, France and Germany.

Coffee.—About 300 acres in Tirukkurungudi and Tenkasi hills are under coffee. The area is less than under tea. But a large amount grown in Travancore is brought to this port for export. The average value of the export is Rs. 0·6 lac. In 1938-39 there was a sudden increase in export more than double that of the year previous to it. The coffee is sent to the United Kingdom, Belgium, Australia, France and Iraq.

Metals and manufactures (including plated-ware metals).—Bell metal vessels are made in a number of villages like Vagaikulam, Mannarkoil, Seydunganallur, Tinnevelly and Sankarankoil. The industry is the monopoly of the Kannaseri section of the Kammalan caste. The products include lamps, temple bells and the usual vessels of domestic use. Bronze vessels like tumblers, Koojas, chembus and cups are a speciality in Sankarankoil and Seydunganallur. Vatils or eating vessels made of bronze are sent to Ceylon where there is a great demand for them. Brass vessels are made out of plates of metal which are imported. Muhamadans, Maravars and Kannasaris, who are the chief workers in brass, are important in Sankarankoil and Pettai where they make kudams or water-pots, and broad-mouthed vessels called Kopras. The trade is steady and averages about Rs. 0·65 lac. The export is mainly to Ceylon, Strait Settlements and Malaya.

Oils.—The pressing of oil from Gingelly seeds is done on a large scale in Pettai, Kallidaikuruchi, Shermadevi and Tenkasi. The local gingelly crop being insufficient large quantities are imported into Pettai from the neighbouring districts. Groundnut is pressed for oil on a large scale in Pettai and Tenkasi. The export which is made mainly to Ceylon and Travancore is steady and averages about Rs. 0·24 lacs.

Hides and Skins.—The average value of the export is Rs. 0·2 lac. A steady decline in trade is perceptible. The raw goat skins are sent to the United Kingdom, the United States of America and Travancore. Trade in the cuttings of raw hides and skins has dropped heavily.

Dyeing and tanning materials.—The use of indigo as a dyeing material is almost extinct. Turmeric forms a chief item in this group. There is a little export of this material from this port. The bark of the avaram plant plays an important part as a tanning material and is obtained in large quantities in almost any part of the district. There is a small export of this material to Europe. The trade which averages about Rs. 0·16 lac shows signs of decline.

Shells (chanks and cowries).—An important commercial product of the Gulf of Mannar is the chank or conch. The fishery is conducted from Tuticorin as a Government monopoly. The shells are found scattered in about 7 to 10 fathoms of water buried in the sand on the sea bottom. The fishery takes place between October and May and is worked by divers almost every year. The catch should be handed over to the Government at one anna per chank of a particular size. The average annual output is 250,000. The chanks are sold at an average rate of Rs. 250 per thousand. Till now only 2 Valampuri chanks have been obtained and the divers got Rs. 62½ for each. The chanks have no local demand and are sent to Calcutta, for the demand for chank bracelet comes from the women of Tibet, Bengal and Assam.

Pearls.—The Gulf of Mannar is noted for pearl fisheries. The pearl banks are rocky outcrops of the sandy submarine plateau which fringes the coast. The Tulayiram Par (10 miles off Tuticorin) and Kudumutti Par (6 miles off Punnaikayal) have proved productive. The fishery takes place occasionally for the oysters generally take 3½ years to mature. Between 1801 and 1928 only 18 fisheries took place. From 1928 there has been no pearl fishery at all. Generally the fishery is held in Spring (February, March and April) and at times in Winter (November and December). The last 4 fisheries held in the years 1927 and 1928 brought to the state a gross revenue of Rs. 7 lacs. The Tinnevelly pearl is of small size, but is unrivalled in regard to colour and lustre. The buyers of oysters at the fisheries come mainly from Devakottai; they send them to Bombay where they are either sold or shipped to London or Paris. Hence there is no direct export of pearls.

IMPORTS

Grain, pulse and flour.—Among the imports the place of prime importance should be given to grain and pulse. It is a matter of common knowledge that the district has a greater area under dry crops. Paddy covers only 350,000 acres, and so is inadequate for the needs of the district as a staple food. So an import from Burma, Siam and Indo-China to the average extent of Rs. 180 lacs is necessary to feed the population of this district and of the adjoining districts of Ramnad and Madura. Import of dry grain, pulse and wheat is made to a small extent from Karachi, while dry grain and pulse alone figure in the trade from Bombay and Calcutta.

Raw cotton, twist and yarn and piece goods.—The native cotton grown in the district is short stapled and is useful for the manufacture of cloth of low grade. For manufacturing superior quality better varieties of cotton are to be used and so in recent years there has been an import of longer-stapled cotton, mainly from Africa—Kenya, Egypt and the union of South Africa. The average value of the import is Rs. 60 lacs, and it was only in 1938-39 that the import was as low as Rs. 35 lacs. The average weight of the raw cotton imported is 12,000 tons of 50 cubic feet. The cotton is distributed among the 3 mills of the District and those of Madura, There is an average import of Rs. 11 lacs worth of twist and yarn into this port. This is useful for the weaving industry—mills and handlooms. The Japanese yarn is used largely for the lungis as it is uniform and contains no knot or grit. There is a slight decline in the import due to increased production in the local mills. The import is mainly from the United Kingdom and Japan. Mercerised yarn from the United Kingdom and Japan declined in the value of the import. Sewing thread is obtained from the United Kingdom.

Piece goods are imported to an average value of about Rs. 20 lacs at this port. The two important countries that send this import are the United Kingdom and Japan. The difference between the imports from these 2 countries lies in the fact that finer fabrics come mainly from the United Kingdom and only ordinary and inferior varieties come from Japan. To a large extent these two countries are not competitors as they meet the needs of different classes of people. In 1938-39 there was a heavy fall of imports of this commodity, from Rs. 25 lacs to Rs. 9 lacs. The only quality that was not affected was the plain grey goods from Japan.

Seeds.—Seeds of various kinds are in demand in this district. Rape, mustard, copra, cummin, gingelly and groundnut are imported. The average value of the import is Rs. 35 lacs. The trade is somewhat steady and is prominent only in the coasting trade, for the articles are obtained mostly from Bombay and Karachi. Copra is imported from Malabar and Travancore. A good portion of the seeds is used in the human food, though they bulk large in the cattle feed.

Metals and ores.—The chief metals imported are the yellow metal (brass), tin and copper, for vessels made of these are used largely by the middle and upper classes. The trade is steady, though a slight fall is perceptible for the past 10 years. The average value of the import is Rs. 22 lacs. About 1000 tons of brass is obtained from the United Kingdom and Germany, while tin is got from the Strait Settlements. The import of copper is declining and only about 50 tons are got. Though there was a heavy import of iron from foreign countries like the United Kingdom, Belgium, Germany, Japan and Sweden, there has been a gradual replacement of the foreign products by hardware products manufactured in India. The value of the import in hardware and cutlery is Rs. 3·4 lacs. Iron bars and rods are obtained from Calcutta, the port near the largest Indian iron manufacturing station of Jamshedpur. Sundry iron articles like wire-nails, screws, pad-locks, etc., are got to the extent of about 40 tons.

Machinery and millwork.—This has become an item of increasing importance for the past 5 years. About 1,000 tons of machinery are imported every year and their average value is Rs. 12 lacs. There has been a large import of locomotive engines, tenders, and electrical machinery for the development of hydro-electric schemes and for the manufacture of cement. Belting for machinery to the value of a lakh is annually imported. The United Kingdom supplies the bulk of the machinery; next comes Germany, which is followed by the United States of America, Belgium and Switzerland.

Dyeing and tanning materials.—For the manufacture of leather from hides and skins materials like wattle bark are imported from South Africa, though avaram bark is available within the district. Indigo was once very largely grown in the district and there was also a large export of it. But the chemical dyes have replaced indigo and so there is an import of aniline and alizarine dyes from Germany. The trade is steady and the value of the import is Rs. 7 lakhs.

Tea chests.—For the transport of tea chests are in great demand. So chests to the average value of Rs. 4·6 lacs are imported mainly from the United Kingdom, Germany and Japan. There has been an increase in the value of the import and the maximum for the decade was reached in 1938-1939 when the figure went up to Rs. 8 lacs.

Paper and pasteboard.—The import of paper is made to the extent of 4·4 lacs. A slight rise is seen in the trade for the past 2 years; the increase being very perceptible in the case of writing paper. With regard to printing paper the import is made from Germany, Austria, Sweden, Norway, United Kingdom and Finland, which have large resources of forests.

Provisions and oilmanstores.—Miscellaneous kinds of food are got into this port to the extent of about Rs. 3 lacs. The trade is steady and there has been a slight improvement for the last 2 years. Condensed milk is imported from the United Kingdom and the Netherlands; farinaceous foods, biscuits, canned or bottled provisions from the United Kingdom and butter from Australia. The import is spread over the surrounding districts and is consumed by the richer classes.

Chemicals and drugs.—The import under this head amounts to Rs. 4 lacs. The import in drugs and medicine is from Germany, United Kingdom and the United States of America. But camphor is obtained from Japan. There has been a slight fall in the amount of chemicals imported. The United Kingdom, Germany and the United States of America are important in this respect and small quantities of chemicals are also got from Italy, Japan and Canada.

Coal.—Coal is imported into this port from the Raniganj coal-fields of Bengal through the port of Calcutta. The coal is mainly for the cotton mills of this and the surrounding districts, for except in the Papanasam mills the source of power in the other mills is coal. There is a separate pier for the import of coal. The import is 57,000 tons per year and the average value exceeds Rs. 3 lacs, and there has been a gradual increase in the quantity imported in recent years.

Spices.—Import of spices to the average value of Rs. 3·6 lacs is made into this port. The trade shows signs of decline, for at the beginning of the decade the amount stood at Rs. 9 lacs. From Malabar and Travancore are imported cocoanuts, pepper and ginger. Betelnuts are mainly from Ceylon, cloves from Zanzibar and Madagascar. Strait Settlements also consign spices to this port.

Jute manufactures.—For the movement of grains sacks are largely required. Canvas and strings and ropes made of jute are also used by the people. Jute manufactures, therefore, in the form of gunny bags, canvas and strings are imported to the value of Rs. 4 lacs. The import is from Calcutta as Bengal has monopoly in the growing and manufacturing of jute.

Building and engineering materials.—For the building trades materials have to be imported and tiles and cement are the chief items of import. Tiles are mostly got from the west coast, mainly from Calicut. The import of cement from foreign countries has fallen considerably on account of the development of the industry within the country. There has been therefore a steady fall in the value of the import from Rs. 4 lacs at the beginning of the decade to Rs. 1 lac at the end of it. The average for the last 5 years is Rs. 2·5 lacs.

Silk.—Silk to the value of Rs. 4 lacs is imported into this port. A heavy fall from Rs. 24 lacs in 1930-31 to Rs. 3 lacs in 1938-39 is noticed in the trade. In raw silk the decline is from 2,400 tons (of 50 cubic feet) to 300 tons. The chief cause is that it has been partly replaced by the cheaper fabric namely artificial silk. The silk—raw and manufactured—are from Japan and China. But the artificial silk is got from Japan, United Kingdom and Italy.

Oils.—About 120,000 gallons of oil, to the value of a lac of rupees are imported into Tuticorin. Burma is the chief supplier of oil; small quantities are also obtained from the United States of America, Iran and U.S.S.R. There has been a decrease in the value from Rs. 3 lacs at the beginning to Rs. 1 lac at the end of the decade. But the quantity has increased and so the decline is due to the fall in the price of petroleum. Besides petrol, Diesel and other fuel oils, kerosene oil and lubricating oils are imported.

Sugar.—The value of the import of sugar in 1931-32 was Rs. 13 lacs ; and the major portion was obtained from Java. But in 1938-39 the import amounted to less than a lac. Thus there has been a gradual decline in the quantity and value of the import of this commodity. This is due to the fact that India is becoming more and more self-dependent in sugar by increasing the area under sugar-cane. This has been rendered possible by the protection which has been given to the industry. The average value of the import for the last 5 years is Rs. 4 lacs.

Wood and timber.—Timber is needed in the building and cabinet-making trades. Burma is the chief supplier of teak, while sal and other varieties of wood are obtained into this port from Calcutta. The average value of the timber imported is Rs. 1·4 lacs.

Tobacco.—Import of this commodity to the average value of Rs. 0·8 lac is made into this port; and the trade continues to be steady. Unmanufactured tobacco is got mainly from the United States of America while cigarettes are got from Calcutta and the United Kingdom.

Matches.—The trade figures of this industry are very interesting, for while there was an import of Rs. 0·9 lac of this commodity in 1930-31, there was no import at all in the years 1937-38 and 1938-39. Such a decline in the trade leading to the complete absence of any import of the commodity is a proof positive of the growth of the industry *in the* locality itself.

For the sake of completeness mention may be made of two other ports of the district, i.e. Kulasekharapatnam and Kayalpatnam.

Kulasekharapatnam.—This port, 7 miles south of Tiruchendur, is situated on the southern apex of the bay enclosed by the headlands of Tiruchendur and Manappad. A reef extending from beyond Manappad protects the port, which is the first port of call for coasting vessels coming from the west coast. It forms a union with the adjacent villages of Udangudi and Manappad. The population is 11,000, of which the Muhammadans form a good proportion. Palmyra forests surround the port and the manufacture of palmyra mats forms a regular employment for the womenfolk of the tappers' families during the off-season. From this port large numbers of mats are shipped to Tuticorin and the west coast. One of the six salt factories of the district is situated here and the salt manufactured is light and white. In 1905 the East India Distillaries and Sugar Factories, Ltd., established a factory at this place for the manufacture of sugar from jaggery and also from the juice direct. Several miles of light railway were laid traversing the palmyra land. The juice was brought from tappers, placed on trollies and railed to a central station from which it was pumped through a pipe to the factory. It was found that chemical action affected the purity of the juice during the transit and the pipe line was therefore abandoned. The growing demand for jaggery and the smaller quantity manufactured in the district were against the economical production and so the manufacture of sugar at Kulasekharapatnam was discontinued in 1927. The company developed the tram line service into a light railway for passengers and goods and established a train service connecting the District Railway at Tiruchendur and Tissianvilai through Kulasekharapatnam.

The old godowns near the port point to the former importance of the place. The port was of some importance in the early years of the century and for the native craft its harbour was superior to Tuticorin at that time. Due chiefly to the improvement made to the port of Tuticorin, the port of Kulasekharapatnam has lost its former importance. In 1912-13 the value of the import was Rs. 7·6 lacs and the export Rs. 8·5 lacs. In 1921-22 the trade amounted to Rs. 14 lacs imports and Rs. 18 lacs export. The trade then steadily declined and resulted in Rs. 5 lacs import and Rs. 2·8 lacs export in 1930-31; this decline has continued to the present day. The port has very little foreign trade when compared with the coasting trade. The average foreign trade for the five years ending 1937-38 is Rs. 13,000 for import and Rs. 54,000 for export. The chief imports of this port are bricks, paddy, betelnuts and timber; and the exports are fish, gingelly, sugar and molasses and mats.

Kayalpatnam.—This is a small port about 5 miles north of Tiruchendur. A reef, 3 miles from the shore, fronts the town and the native craft anchor between this reef and the smaller reef near the coast. The place is inhabited almost exclusively by Muhammadans whose account is that they came from Arabia and obtained a tract of land by favour of the then Pandiyan king who had to win them to his side in order to oppose the Portuguese who threatened to assume a complete control of the fishery. To the present day the upper circles amongst the local Muhammadans claim to be pure bred and make the study of Arabic a part of the curriculum of the education of the boys. Mosques are very numerous in the town. A number of Muhammadans are engaged in weaving. As the place is situated in the palmyra land, manufacture of jaggery is carried on on a small scale. A superior kind of jaggery is produced by the addition of spices and the product is highly prized as a sweetmeat. A salt factory also exists in the town.

As a port it was always of less importance than Kulasekharapatnam. The trade of the port declined in favour of Tuticorin. In 1912-13 (a pre-war year) the trade amounted to Rs. 2·7 lacs import and Rs. 6·7 export. In 1921-22 the corresponding figures were Rs. 3·7 lacs and Rs. 5·5 lacs. Steep decline set in and the lowest figures were reached in 1925-26 when the imports and exports were Rs. 1·4 thousand and Rs. 2·8 thousands. Slight recovery took place afterwards and in 1930-31 the corresponding figures were Rs. 14 thousands and Rs. 9 thousands. As in the case of Kulasekharapatnam the foreign trade is of little importance, the average for the five years ending 1937-38 being Rs. 4·5 thousands (import) and Rs. 4 thousands (export). The chief article of export is sugar; the imports consist of spices, betelnuts, wood and timber.

Cadastral Surveys

By

RAO BAHADUR K. N. NARASIMHACHARYA,
Deputy Director of Survey, Madras.

It is a well-known fact that the bulk of the revenue derived by the Government is from land. The data on which this revenue is fixed are :—Area, nature of soil, source of irrigation, facility for marketing the produce, etc. Area is arrived at by a survey of the lands owned by various individuals. This survey is called " Cadastral- (field-war) Survey " or " Revenue Survey."

The object of the Revenue Survey is briefly stated by Clements R. Markham, C. B., F. R. S., as follows:—

"The Revenue Surveys of India are one of the bases on which the whole fiscal administration of the country rests. By their means the wealth of the various provinces is ascertained, as well as their food-producing capabilities and their power to bear taxation. The surveys furnish the information comprised in the agricultural statistics without which the statesman is deprived of the knowledge enabling him to improve the condition of the people, to increase their means of subsistence, to avert famine, to add to the wealth of the country and to adjust taxation."

After a consideration of over 10 years, the local Government decided in 1855 that a Revenue Survey is necessary for proper administration of the province and recommended the same to the Court of Directors and to the Government of India. After sanction, a department was organised in 1857 for the purpose. Before the revenue survey, revenue demand was based on unchecked statements of the Karnams who were all-in-all in the villages and the ryots were completely under their mercy.

For purposes of survey, revenue holdings, i.e., lands possessed by various individuals are grouped together to form a *survey* field which is the unit for survey and the several revenue holdings which lie within it are called sub-divisions.

The unit for the preparation of maps in the revenue survey is a village. For facility of mapping, a village is divided into small bits called " khandams," each khandam comprising an area of 100 to 200 acres. At important bends on the village, boundary stones of size 3 feet $\times$ 3 inches $\times$ 3 inches are planted with one foot above the ground. These stones bear marks $\triangle$ at village trijunctions and H at other points. Angles at these points are observed. Khandam boundaries also are similarly dealt with. This is called "Traverse Survey," and it serves the purpose of triangulation in topographical surveys, i.e., traverse survey furnishes a skeleton for the preparation of village maps. After the traverse survey is over, fields in the village are surveyed by dividing each field into triangles. The fields are then plotted in the traverse skeleton of the village with all " topo " details which cross the fields. Then the village map is prepared on scale 16 inches = 1 mile.

From the village maps which show all the " topo " details, taluk maps on scale 1 inch = 1 mile are prepared and from these maps, district maps on scale 1 inch = 4 miles are compiled.

The first operation in the Revenue Survey is the identification of the Trigonometrical Survey Stations. From one of these, the revenue survey traverse work—theodolite survey—commences and runs along village or taluk boundaries until it reaches a point wherefrom another trigonometrical station is connected. The revenue survey traverse distances are then compared with sides of the triangles of trigonometrical survey and the differences between the two are adjusted in the revenue survey distances to agree with the trigonometrical survey. Thus the work of the Madras Revenue Survey adapts itself exactly to the Trigonometrical Survey of India.

HOW A TALUK MAP IS COMPILED IS DESCRIBED BELOW:

A skeleton is prepared on scale 1″ = 1 mile by projecting all village trijunction points and all trigonometrical stations in that area; graticules or latitudes and longitudes referred to Greenwich Meridian are also drawn on it. The 16″ maps of all the villages comprised in the taluk are reduced to 1″ = 1 mile by pantagraph showing the village boundary and all topographical features in the village. These reductions are then superimposed on the skeleton in such a manner that the village trijunction points in pantagraph reductions exactly fall on the corresponding points already projected on the skeleton; then the " topo " details are traced on to the skeleton and the contours of the hills are traced and inserted into the skeleton from the 1 inch standard sheets of the Survey of India. Thus the rough original of the taluk map is prepared.

This rough original is enlarged by photography to twice the scale and a light blue print is obtained. In this copy all the topographical details are neatly inked in black and all the names neatly printed. This is the fair original. This is reduced to half the scale in 1" = 1 mile by photography and the plate from which final copies are printed is prepared by the process called Zincography. From this plate copies are printed in Rotary Off-set machine where the impressions are first transferred to a rubber blanket and thence to the paper. By a similar process district maps on scale 1" = 4 miles are published.

It will be remembered in this connection that all the topographical features shown in the taluk maps were fixed by measurements during the revenue survey unlike in the topographical surveys conducted by the Survey of India where they are fixed by plane-table rays, sketching, etc. Thus the physical features are shown more accurately in the taluk maps published by the Madras Survey Department.

It may be mentioned in this connection that since the Madras Revenue Survey was conducted in such details and in so accurate a manner as to be useful for the compilation of general maps, it was considered that the materials of this survey might be made use of by the Survey of India without unnecessarily doing a fresh elaborate topographical survey but by doing such supplemental surveys by way of bringing the details up-to-date. This was suggested and by agreement, maps are being supplied to the Survey of India by the Madras Survey Department since 1911. Thus the standard sheets now issued by the Survey of India have to a large extent the Madras Survey Maps as the basis.

I conclude this lecture by quoting the opinion of an eminent authority on survey.

"It (The Madras Revenue Survey) is designed to show all principal variations in the surface of the soil such as hills, jungles, woods, channels, tanks, topes, houses, cultivated and cultivable lands and the area of each field. The ideal survey while furnishing complete information for Settlement purposes, should be executed throughout on accurate principles and supply materials for compiling maps for general use. In the Madras Presidency alone has any approach to a compliance with all the demands been effected. The Madras Revenue Survey must therefore be considered as, on the whole, the best in India."

Changing Map of Europe

By

Prof. Nafis Ahmed, M.A., B.E.S.,
Lecturer in Geography, Islamiah College, Calcutta.

A mighty conflagration is on. The world is ferment. Europe the home of the possessors of empires, dominions and protectorates is on the dissection table. Events are moving at an enormous pace—And the map of to-day is certainly not the map of tomorrow.

But there is no denying the fact that while the war is actually proceeding, both as regards wider strategy and tactical detail, it is very largely conditioned by the facts of Geography. That is why a geographer may hazard an opinion on many aspects of the conflict. In fact, it need hardly be emphasised that the task of modern geography is a comprehensive interpretation of the stage on which the drama of history past, present, and future is enacted.

However, examining the problem, "The Changing map of Europe"—The man-made boundaries of Europe have ever been drawn and redrawn on the face of the Continent. A study of the basic map of Europe with simple facts of Geography is indispensable as a background for the outstanding past and contemporary changes.

Europe is sometimes called a peninsula of Asia and in its turn as a bunch of peninsulas tied together. All this signifies Europe's accessibility to the sea—one of the great advantages in so many respects—climatically and as an incentive to maritime activity etc. Physically the outstanding feature is a great plain bounded by highlands to the north and the south. A series of navigable rivers cross the plain and even the mighty Alps do not present a total barrier to movement.

It is this Europe which saw many a scene of human history. As soon as the Ice Age closed man began to make Europe a fit home. This is how history marched. A "push and a pull" prompted the great wave of the migrating intruders who marching onwards from Asia gradually occupied the Continent from South to North—The Mediterraneans, the Alpines, and the Nordics.

Hundreds of years later after the decay of the river valley civilizations of S. W. Asia dawned the heyday of Greek Culture and glory. That is how a part of Europe assumed the leadership of Civilization and has left to us such a rich heritage. "Rome was not built in a day"—but once the Roman Empire became a reality it served as the nucleus of progress and culture. Germanic Europe with its barbaric hordes refused to be coerced into submission to a superior culture and ultimately cut at its very roots —but not before the Romans had added a glorious chapter to the onward march of humanity. Imperial Rome crumbled and with it the leadership of the then Europe and the map changed once more. The young Islamic civilization filled up the gap. It was a day when in terms of material progress so many things became "Eastern."

Mediaeval Europe steeped in its spiritual slumber was brought to a sense of reality by the newborn conceptions of the Renaissance. The map of Europe changed once more and the Nation States rose one by one—England, France, Spain—Men of Europe ventured forth into the open seas and ushered in the incomparable period of the Great Age of Discovery—And then they fought for the mastery of the seas and the little Island Kingdom beat the rivals back and launched itself on an Empire venture. But not before Europe had seen some of the most profound changes in the map—Revolutionary Europe ended by being Napolean's happy playground for unlimited ambitions. The legions of France marched to nearly all the capitals of Europe. Waterloo however sent the ambitious corporal to die in St. Helena. The first serious threat for the invasion of England by sea thus ended.

While the new map was being drawn and redrawn the Industrial Age was already ushered in. Britain had a happy lead and her Industrial prosperity soon ripened into the fruits of Capitalism and Imperialism. Vast dominions were won and till the beginning of the last quarter of the 19th century her position was unchallenged—Indeed there were few or no competitors. But gradually the rest of W. Europe was finding its feet. The greatest rival rose in the shape of the newborn German Imperialism backed by its fundamental resources and the genius of its people. A conflict was inevitable between the new forces in Europe for world mastery.

Thus stood the major combatants on the eve of the conflict of 1914-1918, to reshape the map of Europe. After 1918 Europe was greatly reshaped—But how and why ?

The how is the easy to answer—by the superior force of the allies as against the Central powers—

But certainly it is obvious that the map-makers of 1919 were poor geographers—including the Professor of political economy (President Wilson). A great deal of liberating was combined with punishing unfortunately. The principle of self-determination served as the patent medicine of the quack and later gave Hitler his apology "for the justice of the Strong."

The Peace Treaties were five in number—Versailles with Germany. St. Germain with Austria, Neuilly with Bulgaria, Trianon with Hungary and Sevres with Turkey.

In Germany—In the west two small areas, townships of Eupen and Malmedy went to Belgium and the Provinces of Alsace and Lorraine to France as well the use of the Saar coalfield for 15 years. France failing to push the frontier to the Rhine succeeded in demilitarizing the Rhineland (Germany neither to fortify nor to keep troops). In the North, a part of Slesvig was transferred to Denmark. In N. E. Memelland with the port of Memel was given to the new State of Lithuania.

But on the Eastern frontiers most drastic changes were made. Provinces of W. Prussia and Posen went to Poland. Upper Silesia was divided between Germany, Poland, and Czechoslovakia the best mineral area going to Poland. The "Corridor" was created to give Poland access to the sea thereby separating East and West Prussia. Danzig was made a free city under International Supervision. With Lorraine Germany lost her 75% iron ore and in Silesia second best coal area.

However, most far reaching changes occurred in the case of Austro-Hungarian Empire, very appropriatly called the "Miniature of Europe"—a medley of nationalities, languages, customs, religions, and cultural levels. Here lived the Czechs, Poles, Slovaks, Croats, Serbs, Ruthenians, Magyars and Germans.

Austria after being refused union with Germany was made a republic and as a journalist remarked it came to possess simply two beautiful things—Vienna and the Alps.

Hungary inhabited by the Magyars was constituted into a separate state. But about one-third of the Magyars went to Czechoslovakia and Rumania. Thus grain producing Hungary was sandwiched between new neighbours. It has ever since been the foremost revisionist state.

Then also took its birth the wavy Cigar shaped or the lizard shaped Czechoslovakia, including Bohemia (an advanced industrial area of the late Empire and the home land of Czechs) and Moravia with 22% German minority on fringes. Slovakia and Ruthenia contained considerable minorities of Magyars. The state though economically most balanced and democratic in sentiment, started with a sackload of problems.

The birth of another new state was marked by the emergence of Poland. Originally the 'Curzon line' marked the Versailles award. But a youthful Poland grabbed a rather big piece of cake from the weak Soviet child!

A state which was greatly enlarged was Rumania with additions of Transylvania, Dobruja, and Bessarabia—the first a land of five nations, languages and creeds.

The little Serbia became big Yugo Slavia.

Italy was most disappointed, like a gambler who plays for big money and gets only counterfeit coins. She got South Tyrol and Triest and seized Fiume.

Turkey was reduced to a nonenity by Sevres but fought her way to self determination and regeneration.

The Soviet took its birth in the teeth of opposition and on the ruins of Tsardom. Finland declared independence, the Baltic States came into existence with the blessings of the Allies to strengthen the "Cordon sanitaire" between Europe of the Mediterranean Christian Civilization and Revolutionary Russia.

The war and post-war arrangements shattered the economic balance of Danubia: Nine national barriers cut across the Danubian basin. Each of the states sat behind an ever rising tariff wall.

The consequences of the alteration of the map of Europe on such lines were obvious enough, with the developing fever of economic nationalism, irrational self sufficiency and bitterness of feeling and certainly helped by the postwar short sightedness of the statesmen of the democracies, German industrialists found ready supporters in the rank conservative and Jingo yunkers and by appealing to the distressed middle classes produced the man with the "dabs." Thus rose Hitler's voice heralding the rebirth of German Imperialism. A wave of fascist idealogy swept over Europe determining the colour of the shirts worn and the angle of the salutes given. It was Europe under Fascism. Thus stood Europe once more, in battle array. A change in the map of Europe was imminent.

Coming to the changes themselves, the land slide started soon after the Nazis came to power (Jan. 1933). Saar went back to Germany (1935); Rhineland was occupied and militarised by a bluff (1936). But an aggression outside Europe, the rape of Abyssinia by Mussolini in defiance of all principles of political morality paved the way for bigger events. Ere long the fascist mad horses were let loose on Spain and stifled the democratic Republic. In fact the ruthless bombings of Barcelona and Madrid foretold the fate of the whole of Western Europe.

Austria came under the German heel in 1938. And at once Mussolini was revealed as junior partner in the firm of Adolf-Benito and Company, dealing in the fantastic propaganda of "Axis Claims." Soon after, Czechoslovakia, the last bastion of democracy in Central Europe was truncated by the Munich peace makers and within a few months was swallowed by the octopus of the Reich hungry for a "libensaraum." Memelland was snatched from Lithuania. Italy pinched Albania. Events followed in quick succession—at last faced with an inevitable Nazi advance Britain and France turned to woo Russia. The Anglo Soviet negotiations dragged on. There was always a hitch, either there were the free Baltic States unflinching in the preservation of their sovereignty or a reluctant Poland firmly refusing the appearance of a single Soviet soldier on her soil, yet Britain extended guarantees to Poland, Rumania and Greece. Now either Mr. Chamberlain was extremely poor in his geographical knowledge or obviously the urgency of the crisis was deliberately ignored.

The man in the street was already amazed but the news of the conclusion of the German-Soviet pact stunned him. From August 26th to September 1st was but less than a week! Thus the whistle was blown and the war was on. A year of war has brought far reaching changes in the map of Europe and the political Atlas is already in the waste paper basket. The story is simple to tell.

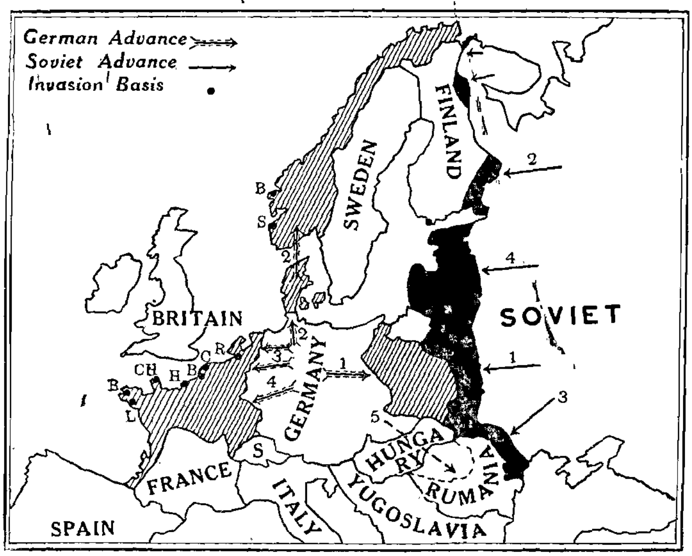
In a two-week campaign Poland was under the Nazis and Warsaw was a heap of ruins. By September 21st the Red Army was on the move and Eastern Poland went to the Soviet. Thus Germany once more completed the occupation of Upper Silesia and took the best Polish industrial areas minus Lwow and the Galician oil. Soviets took mainly agricultural and forest regions plus the industrial centres of Lwow, Przenysl and Stanislavov in South East and Grodno and Bialystok in the North East. Industries here are mainly based upon the rich forests and oil wells of W. Ukraine and the leather and textile factories of the North.

Then the war shifted to the West and entered its dormant phase for several months till the winter was over. But in the meantime Soviets went in action against Finland and ultimately forced a decision towards the end of February. That meant several changes in the map. As soon as Summer was in its stride Hitler struck and once more caught the Allies in indecision. Nazis occupied Denmark and most of Norway by an amazing move reflecting a mixture of efficiency and treachery. The belated British attempts to hold Northern Norway continued but the scene here closed with Hitler's mightly "Blitzkrieg" against the Low Countries and France. On May 10th the Nazi hordes swept over Holland and Belgium and also struck against France. By May 14th all was over—The Battle of the Meuse was lost and France's backbones broken—the drive to the Channel began and the onward rush of the Germans only ended with France's surrender and the occupation by Nazis of the entire W. European Coast from the Arctic to the Spanish border. This last phase revealed a few facts—the utter bankruptcy of French military leadership, the magnificent courage of the French soldier, the remarkable efficiency of German mechanized forces, Hitler's overwhelming preponderance in the air, and Britain's mastery of the seas.

On the collapse of France it seemed that the invasion of Britain by Hitler when he would be able to hurl down his powerful and hitherto victorious military machine against the Island, was merely a question of time. But here Geography played its part and the onrush of the Nazi wave was broken on the beaches of Dunkirk—beyond was the sea (though such a narrow one!) on which rested the strong arm of the Navy. It was obvious for Hitler to take the question of invasion seriously because the defeat of Britain would sooner than ever make him the complete master of Europe. All through the remaining part of the summer 1940 the invasion ports from Bergen to Lorient were filled with troops and equipment ready to be transported by barges and men-of-war. The long-range German guns thundered across the Channel from the French ports and the "Luftwafe" hurled thousands of bombs from hundreds of planes, over all parts of Britain to break the resistance and the morale of the defenders. But the peoples of

Britain turned their geographical position to advantage, gradually the R.A.F. grew in strength and the Navy maintained the command of the seas in spite of losses and risks. Hitler's armies could not cross the Channel and he was forced to look for adventure elsewhere.

On the other hand Italy's entry into the war brought the conflict to the Mediterranean and though she got only a few miles of territory along the French borders yet his hands were freed to come to grips with Britain and as soon as France was floored things began to happen in the East and the Balkans. The Baltic States, Estonia, Lativa and Lithuania realizing the futility of a precarious existence applied for incorporation into the Soviet Union. Thus Soviets added more than 60,000 square miles to their territory, increased the population of the U.S.S.R. by 6,000,000 and gained 750 miles of Baltic Coast line with important ice-free ports, thereby literally expanding the "window onto Europe" into a huge "gate-



Changing Map of Europe.

way"; yet this was not the end of Soviet's bloodless successes: on the last day of June Rumania handed over Bessarabia and Northern Bukovina. Thus the Soviets reached the Danube Delta. Thereafter followed, naturally, a period of political manoeuvring in the Balkans between the apparently friendly Nazi and Communist Camps.

The Nazis forced a weak Rumania to hand over Transylvania to Hungary and the Dobruja went to Bulgaria. Thus Rumania much reduced in frontiers and led on by fascist Iron Guardist elements fell in the orbit of the Axis and is to-day entirely under Nazi influence. Mussolini either in an attempt to imitate his senior Axis partner or under instructions from him invaded Greece from the Albanian frontiers. But the Greeks fought heroically on a difficult terrain and helped by the vital British assistance on the sea and in the air drove back the Italians into Albania. And at the time of writing that phase of the war is not yet ended.

The present lines of the Axis campaign seem to rest largely on three-point programme. Firstly, to continue the air offensive against Britain and the piracy on the seas. Secondly, to bring the greatest possible force to bear on vital and vulnerable areas the control of which would disrupt the British Commonwealth and might be expected to end British resistance. An attack on Gibraltar and the capture of the rock would close the Western gate to the Mediterranean. But an object more worthy of attention is the life-line to India—the Suez, and the overland road to the same country through Asia Minor. Here the Axis is faced with a difficult situation, the attitude of Turkey. And they know that the Turks would fight every inch of their ground to preserve their independence. Perhaps at the November meeting at Berlin between Hitler and M. Molotov, the former suggested pressure on Turkey by the Soviets. But as it seems, the Russian foreign minister was not encouraging on this point and that such attitude was also responsible for checking Nazi intrigues to drag Bulgaria into the Greco-Italian conflict. Thirdly, the Axis would do its utmost to keep America out of the war and maintain friendly relations with the Soviet as long as Britain fights on.

Looking at Europe to-day it is necessary to realize the tremendous advantage which the Nazis have gained. They possess Europe's entire iron ore, almost all the coal and all the oil fields; excluding grain, timber and fodder are at their disposal. But the keeping of armies of occupation all over the continent and growing starvation and hunger of the enslaved millions is bound to cause serious cracks in the Nazi armour of military hold.

The map of Europe to-day has changed beyond recognition. Countries like Czecho-Slovakia, Poland, Estonia, Latavia, Lithuania, Luxemberg have entirely disappeared and Norway, Denmark, Holland, Belgium and France owe their so-called free existence to Nazi make-believe. Rumania is a mere shadow of its former self while Finland had to make considerable concessions to the

Soviet. Millions of people have been moved out of their homes to find themselves in strange alien environments. The Poles were driven away from the Poznan province almost wholesale to provide homes for the thousands of German landlords evicted from the Baltic States.

Frenchmen have been pushed out of Lorraine and Alsace to increase distress in an already starving France and thus Hitler has created one of his dream provinces " westmarch "—and thus went on developing the complexities of the task of the future peacemakers and their frontier settlements.

To-day we have to reckon chiefly with three forces in the future reshaping of the Map of Europe—namely, the opportunist Soviet Union working for a world revolution, the British democracy and the Nazi aggressors with their Italian partners, flushed with a series of triumphs which they call by a hundred high sounding names, but what plain men call robbery. Thus a decisive struggle is developing between freedom and darkness and servitude. Will the forces of balance and sanity gather together in time to rid the world of tyranny ?

In all probability—Yes.

Proposed Syllabus of Geography for M.A. and M.Sc.

BY

PROFESSOR M. B. PITHAWALLA, D.Sc. (GEOGRAPHY), B.A. L.C.P., & F.G.S.,

Recorder, Geography Section, Indian Science Congress.

Introduction.

While some of our Indian Universities, notably Bombay, have treated Geography as a step-daughter and have neglected its study all these years, (the Senators having refused to recognise its value even as a branch of Science owing to their own ignorance of it), it is a very happy sign of the academic times that some other advanced Universities in India, e.g., Calcutta, Madras and Aligarh, adopting a more liberal and enlightened policy, have encouraged its studies right up to the degree courses. All credit is due to the Oversea Delegation of foreign geographers to the Jubilee Session of the Indian Science Congress held at Calcutta in 1938 and also to the Professors and Teachers of Geography in these centres of learning, who followed up their resolution adopted at the Session to give it a separate Section and a good scope in India for its development. At the above University centres, the progress is so good that it is now necessary to indicate the lines along which post-graduate studies in Geography (in both the Faculties, Arts and Science) should be directed for the benefit of all students. It is with a view to co-ordinate such studies in our Universities, to prevent any overlapping of activities and also with the object of helping our advanced students to make small but useful scientific contributions in their own special line of research that I give below my scheme of a syllabus for the M.A. and M.Sc. examinations.

Position of Geography in the near future.

Geography is bound to be recognised as a very important subject of study by all, after the present War is over. In fact, we are finding the conduct and results of this 'Geography War' to have been based on a sound knowledge of the geography of the countries involved. I therefore earnestly appeal, through the medium of this Journal, to the Vice-Chancellors and Academic

Councils of all Universities in India (no less than 19 in number now) to give Geography its proper place in the curricula of all examinations, Arts and Science.

If the proposed syllabus is approved and accepted by the learned bodies, it will be easy for us Indian geographers to lay down certain lines of geographical research for the higher (Doctorate) degrees, so that in a few years it would be possible for us to collect all the data necessary from the various natural regions in India and to produce a *comprehensive, authentic* and *authoritative geography* of *our dear country,* for which the whole civilised world will be grateful to us.

Developing a spirit of Research.

Provision has been made in the Scheme for stimulating a spirit of research among our Indian students for this comparatively young science of Geography, so that at least 200 out of the possible 800 marks (100 for a Paper and 100 for one Practical examination) are substituted for a piece of investigation or enquiry of the students' own choice, during the course of their study at the University for the Master's degree, in order that our science could be put on a par with the other branches of science already developed. I would like to give, if possible, a still greater scope for independent or guided research at this stage of training in the line, so that even more than 200 marks could be assigned to the thesis part at the discretion of the examiners and with the previous sanction of the Board of Studies in Geography.

The Proposed Syllabus.

Theory 600 marks. *Practical Examination* 200 marks. There shall be 6 Papers, each carrying 100 marks and 2 Practical examinations, 100 marks each as follows:—

Theory.

Paper I. *Physiography.*—This should include the latest theories of geological formations, geological history, history of erosion, evolution of land forms etc., taking typical examples from important countries of the world. An elementary knowledge of geomorphology is expected here. This paper should be compulsory for both Arts and Science students, as physical basis should be the foundation of all geographical studies.

Paper II. *Regional Geography of India and neighbouring lands.*—India should be given prominence at the post-graduate stage. The study should include physiographic divisions of India and of the countries which influence her, the problem of frontiers and boundaries, economic resources, the problems of water supply, climatic conditions and regions, vegetation zones, types of soil, land forms, animal life, land utilization and human occupations and settlements. Emphasis should be laid on the influence of physical conditions on human life, especially with reference to the historical geography of India and conditions, physical and others, of the lands in her neighbourhood, e.g., the Iran plateau, Tibetan plateau, Burma, China and Japan.

Paper III. *Study of one of the major zones of the earth.*—Candidates may choose *one* of the following belts and the countries falling within it:

1. Arctic and Antarctic zones.
2. Temperate zones.
3. Tropical zones.
4. Equatorial zones.
5. Mediterranean zones.

The idea is to make a regional study of the countries involved in each earthly zone with reference to their economic and commercial geography, lines of communication, exports and imports, and races of mankind inhabiting them. It is to be remembered that a thorough regional study can be made without the trammels of political boundaries, which are fast disappearing in Europe and Africa, and therefore the countries, as they are, are not prescribed as they are made by the whims and caprices of political leaders but the divisions are left to the natural conditions and the abilities of students to recognise natural, scientific boundaries only.

Papers IV and V. *Two of the following optional subjects.*

Group A (for *M.A.* students)

1. Historical Geography.
2. History of Geographical knowledge.
3. Survey of Geographical researches.
4. Townplanning and Military geography.
5. Anthropology and Archaelogy.
6. Economic and Commercial geography.

Group B (for *M.Sc.* students)

1. Geomorphology including study of landscape.
2. Geology and Mineralogy.
3. Meteorology and Climatology.
4. Ecology.
5. Oceanography.
6. River geography

The study to include the chief outlines and principles of the subjects chosen. Minor details and technicalities of the different branches of science are not required. A very wide and sufficient choice is given to the students without burdening the Universities and the Colleges affiliated to them with the necessity of engaging specialists on their staffs to teach them.

Though there are two different groups made of the optional subjects, it should not be quite obligatory to the students to stick to one or the other group. Either or both the optional subjects may be taken from them.

Paper VI. *Intensive study of one of the principal physiographic regions of India noted below:*

1. Western Highlands.
2. Greater Himalayas.
3. Middle Himalayas.
4. Sub-Himalayan Region.
5. Eastern Highlands.
6. Lower Indus Valley.
7. Upper Indus Valley.
8. Upper Ganges Valley.
9. Middle Ganges Valley.
10. Lower Ganges Valley.
11. Desert Province.
12. Rajputana Highlands.
13. Deccan Trap Region.
14. North-eastern Foreland.
15. Southern Plateau.

These 15 regions, marked as *Provinces* in the Physiographic Map drawn by me (*vide* My "Physiographic Divisions of India" (Jour. *Madras Geog. Assoc.*, Vol. XIV No. 4) are generally approved by experts, as they are scientifically made without any local prejudices or misgivings. Over these divisions all matters relating to climate, natural vegetation and even human problems drape themselves completely. The actual boundary lines are left to be drawn by the geographers belonging to the provinces concerned.

OR A piece of geographical research based on field or|and laboratory work.

In place of this paper No. VI candidates may be allowed to present a thesis or investigation of some geographical problem falling within their personal knowledge *e.g.*, geomorphology, water supply, population, food crops, money crops, forest products, ports, communications and industries, of particular localities chosen by the candidates.

N.B.—The problem selected should be first approved by the Board of Studies in Geography.

Practical Examination.

Practical I. *Cartography.*

1. Map reading. Reading of maps,—geological, historical, soils, ordnance, weather and population maps.
2. Map making. Preparation of maps and sections from given data, and map projections. Enlargement and reduction of maps.
3. Cartographical and diagrammatic expression of data, climatic, economic, etc.

   Diagrams, graphs, sketch maps etc., to be prepared from given data. Students to be allowed the use of blue books, meteorological records, census reports and other government, military and State publications.
4. *Viva voce* on journals and laboratory work of the candidates.

OR

Viva voce on the thesis submitted by the Candidate.

Practical II. *Field work, surveying and identification of specimens.*

1. Field work, surveying, use of instruments, such as chain, plane table, prismatic compass, theodolite, sextant, aneroid and mercurial barometer, B.P. thermometer, anemometer, rain gauge, planimeter and mariner's compass.

   Surveying, triangulation, plane surveying, trigonometrical surveying, astronomical surveying, nautical surveying and town-planning.
2. Identification of typical rocks, minerals, soils, plants, animals and agricultural products. (25 typical specimens of each to be prescribed and to be identified by physical and chemical tests.)

Let us hope that Geography may become a very popular subject among our Indian students and the time may soon come when the *whole* of the M.A. or M.Sc. may be taken by thesis only as a training degree.

Select Contents

The Geographical Journal: August, 1940.

The West Indies in 1939.—By Lord Moyne.

The Evidence for Ancient Mining.—By C. E. N. Bromehead.

The Geographical Journal: September, 1940.

The Bay Islands, Gulf of Honduras.—By R. W. Feachem.

Problems of Egyptian Geography: Review.—By G. W. Grabham.

Geography: September, 1940.

Population Trends in France.—By W. B. Fish.

On the Method of Direction Finding by Sun and Watch.—By Norman Pye.

Changes in the Tin Mining Industry of Malaya.—By Arthur W. King.

Seasonal Change at a Moroccan Tribal Market.—By Walter Fogg.

The Interests of the Children.—By Patrick Thornhill.

The Himalayan Journal: Volume XII, 1940.

Takpo and Kongbo: S. E. Tibet.—By F. Ludlow.

A Season's Work in the Central Himalaya.—By J. B. Auden.

The Jadh Ganga Valley and the Nela Pass—Lieut. J. F. S. Ottley.

Dunagiri, Gauri Parbat, Rataban, and Chaukhamba, 1930.—By Andre Roch.

The Upper Shyok Glacier, 1939.—By Lieut. I. H. Lyall Grant and Lieut. Colonel Kenneth Mason.

The Polish Ascent of Nanda Devi East, 1939.—By S. B. Blake and Jakub Bujak.

Some Quette Rock Climbs.—By W. K. Marples and R. O. C. Thomson.

The Lower Shyok and the Gyong La.—By Flight-Lieut. Arthur Young.

The Chorten Nyima La from the Tibetan Side.—By N. E. Odell and Peter.

Memories of Early Kashmir Climbing.—By Dr. Ernest Neve.

Calcutta Geographical Review: September, 1940.

Holy Places in South India.—By B. C. Law.

Old and new Approaches to Human Geography.—By O. H. T. Spate.

The Trail of a Past Climate.—By D. Sen.

Naturvolkers of Chittagong Hill Tracts.—By D. C. Dasgupta.

Kalimpong: Its Land and People.—By K. Bagchi.

Gneissic Topography of the Ranchi Plateau.—By S. P. Chatterjee.

The Teaching of Geography.—By C. A. Price.

The Value of Local Study in Geography Teaching.—By A. Nuttall.

Indian Information: November, 15, 1940.

A History of Coffee.

Irrigation Research in India.

Egypt through the Centuries.

Geographical Review: October, 1940.

Angolan Safari.—By Linton Wells.

The Expanding Settlements of Southern Brazil.—By Peston E. James.

Lands and Peoples of the Hadramaut, Aden Protectorate.—By Ruthven W. Pie.

The Australian Iron and Steel Industry as a Functional Unit.—By Clifford M. Zierer.

Suez Canal Problems.—By Halford L. Hoskins.

Mineral Economics and World Politics: A Review.—By Charles H. Behre Jr.

News and Notes

A meeting of the Association was held on 23rd November 1940, when Mr. Rao Bahadur C. M. R. Chettiar read a paper on "*the Geographical Distribution of Hindu Religious Centres in Tamil Nad.*" This paper will be published in the next issue of the Journal.

* * *

The remaining papers of the 10th Geographical Conference at Ambasamudram, on the Geology, Place-Names and Communication Lines of Tinnevelly District, and a summary of Mr. K. N. Narasimhacharya's lecture on "Cadastral Surveys" have been included in this issue.

* * *

Prof. Nafis Ahmed of Islamia College, Calcutta, delivered a lecture on "the Changing Map of Europe", under the auspices of the Calcutta University Geographical Society, which is also published in this issue. In this lecture he has presented with a proper historical background a clear and succinct account of the changes now rapidly taking place in the Map of Europe as a result of Nazi and Soviet conquests. It is too soon, however, to say what the ultimate shape of the map will be when final peace is restored.

* * *

We commend to the attention of public libraries and colleges the maps of the Permanent Atlas, issued from Geneva. These maps record as and when they occur all the politico-geographical changes and constitute in consequence the indispensable supplement to every atlas. Further, detailed statistics are annexed to the maps from first hand sources of information; and these are renewed on every occasion. In this period of rapidly changing frontiers, such issues are highly usefull.

* * *

The Executive Committee of the Association has taken steps to get the Rules altered in accordance with the Resolution passed at the Ambasamudram Conference, so that the present Associate Members may be treated as full members with voting powers as in the original Rules. It is hoped that membership of the Association will increase largely as a result of this change.

* * *

Regarding the other three Resolutions about the S. S. L. C. Examination in Geography, which were communicated to the S. S. L. C. Board, a reply has been received that in view of the proposed reorganisation of Secondary Education, it was not considered desirable to make any piecemeal changes in the existing scheme.

* * *

It was pointed out in some of the earlier issues of the Journal that the new Elementary School Syllabus in Geography, issued by the Madras Educational Department, is highly unsatisfactory, and that a revision of it has been generally called for and expected. Instead, we are surprised to find that the middle school syllabus in the subject, which has been acceptable as quite good, has been re-issued in a slightly revised form.

* * *

Prof. Pithawalla's proposed syllabus for M.A., and M.Sc., in Geography, published elsewhere in this issue may appear too premature and amibitious to those who have been responsible for keeping Geography at arm's length in some of the Indian Universities. But it is highly desirable that sooner or later, better sooner than later, all these Universities provide for advanced study in the subject and come into line with Universities abroad in this respect.

* * *

Meantime, the teacher of Geography gets his training in the pedagogy of the subject without caring to get qualified in the subject-matter of it for the simple reason that there is as yet no adequate provision for teaching it in the University Colleges.

* * *

In view of the proposed bifurcation of the courses of study at the end of the 4th Form into vocational and pre-University courses, the Madras Teachers' Guild has formed a study circle to investigate and determine the methods of testing suitable for finding out the aptitudes of the pupils for the one or the other course. It will be desirable for the Association also to consider ahead the sort of Geography that may be taught in each of the courses.

* * *

Reviews

Records: Vol. XXXVIII—1939 *of Mysore Geological Department*, pp. 142, Price Rs. 2.

This is the latest volume of the series issued by the Mysore State Geological Department. Apart from the routine work which occupies five of the six sections, the most valuable part is relegated to the sixth section entitled "Miscellaneous" which word therefore has not to be taken literally. It represents, to use the words of the Director, Mr. B. Rama Rao the results of the endeavour 'to extend the activities of the Department to investigations of public utility.'

The Report states that the Department is now equipped with the latest instruments for a geophysical survey of the State's economic deposits. They have since been successfully employed in tracing out concealed ore deposits like pyritic lodes at Chitaldrug and have also been usefully applied to determine the thickness of the laterite and the depth of the water-table in Shivaganga, thus disclosing the possibilities of this kind of survey in attacking geological problems connected with engineering matters. There is here a definite advance made in this method of prospecting which was initiated by the Department last year.

Archaeologists will note with particular gratification that the Geology Department carried out investigations in counteracting the evil effects of natural weathering on the giant statue of Gomateswara at Sravanabelagola. Their work has pointed out the utility of the French substance known as *flüate de magnesia* in counteracting natural deterioration.

The Report contains in its "Miscellaneous" Section, 9 papers on geological topics, the majority of them dealing with the economic minerals of the State and with their practical utilisation into finished products that would satisfy domestic requirements in India which, so long dependent upon the work of the foreign factories upon her own raw materials, finds itself unable to sell even these. This aspect of the activities of the State's Geological Department is specially commendable.

The following conclusions in some of the papers are of outstanding interest to keen prospectors and industrialists of the country.

The deposits of silica in the neighbourhood of Bhadravathi and elsewhere are used in the manufacture of ferrosilicon, carborundum and in the recently resuscitated glass industry in the State. Many more uses of this mineral are also indicated. A fresh possibility of utilising the Kyanite and Sillimanite deposits of the State is shown by T. P. Krishnachar in his proposed manufacture even from the country rock containing these two minerals, of refractory ware, which at present are made in the State from either decomposed granite gneiss or kaolin underlying the laterite. The same author after a survey of the asbestos in the Hole-Narsipur taluk extending over 3 years shows, from the experiments conducted in the Government Electrical Factory that an ideal mining centre can be formed there and a factory built to manufacture mill boards and asbestos cement products by using the State's own Chamundi Brand cement. The scheme appears to be sound and worth attempting in the hands either of Government or of enterprising capitalists. A plan is also suggested for the utilisation of the bauxite occurrences in the Kadur and Chitaldrug regions as there has been been a growing demand in India recently for various grades of this mineral in the metallurgical, ceramic, refractory and chemical industries. The Department relying on optimistic views of its chemists thinks that the fairly abundant resources of aluminous deposits in the State would support for a number of years a factory in the manufacture of commercial aluminium sulphate which has a large local demand.

The Report as a whole is interesting and couched in non-technical terms that should prove of value to prospectors and financiers, who look rather with disfavour on the dull character of the routine reports of pure geological surveys.

V. D. K.

The Himalayan Journal: Vol. XXII—1940. (Oxford at the Clarendon Press). Price 10sh. net or Rs. 6-8-0.

The 12th volume of this Journal contains several interesting accounts of Himalayan climbing as well as papers of geographical interest. Messrs. F. Ludlow and G. Sheriff started from Kalimpong in the last week of February, and reached the Tsangpo in South-eastern Tibet via Phari and Gyantse about the middle of May. The account of this journey is illustrated by a sketch which shows many passes on the inner Himalayan range—including the Tum La, the Tung La and the Shoka La. The photos and description of the new country give special importance to the paper. Mr. Auden gives an account of a season's work in the Central Himalaya, based upon the new Survey of India maps. Some interesting photos and accounts of the Upper Shyok glaciers and an account of journey in the Lower Shyok are also given. The volume also includes papers on the ascent of Dunagiri, Gauri Parbat and other peaks by a Swiss expedition, of Nanda Devi by a Polish expedition and an attempted ascent of K2 by an American expedition.

N. S.

Trichinopoly Hill Temple (Tamil).—By R. Panchanadam Pillai.

Cooum (Tiru Ilambiyam Kottur). (Tamil).—By Balasubramania Mudaliar.

In response to the general circular issued by Rao Bahadur C. M. Ramachandra Chettiar (Member, Hindu Religious Endowment Board), the authorities of each of the temples within his jurisdiction have commenced to prepare and publish useful guide books for the several temples, which contain very interesting information for the votaries. They contain Puranic and historical accounts of the temples, including inscriptions, and a description of the *mantapas* and other parts, and other useful facts. The brochure on Trichinopoly, for example, includes not only the above, but also the hymns and poems sung in praise of the Lord by the great Saivite Saints. That on Cooum contains also a chronological account of the inscriptions found in the temple. We welcome the publication of this interesting series, which is sure to be appreciated by the general body of visitors and worshippers.

Books and Journals Received

Mysore Geological Department: Records: Vol. XXXVIII—1939.

Puranic History of Cooum (Tamil): By M. Balasubramania Mudaliar.

Puranic History of the Trichy Rock Fort (Tamil): By V. Duraiswamy Mudaliar.

The Educational Review: September, October and November 1940.

South Indian Teacher: September and October 1940.

Journal of Indian History: August 1940.

Southern India Commerce: September and October 1940.

Indian Information: October 1, November 1, November 15 and December 1, 1940.

Quarterly Journal of Mythic Society: October 1940.

Kalaimagal: October, November and December 1940.

The Indian Journal of Political Science: October—December 1940.

Geography: September 1940.

The Geographical Journal: August and September 1940.

Calcutta Geographical Review: September 1940.

Adyar Library Bulletin: October and December 1940.

The Himalayan Journal, Vol. XII—1930.

Nagari Pracharani Patrika: Vol. 45—No. 1.

Annals of the Sri Venkateswara Oriental Institute: September 1940.

Geographical Review: October 1940.

Report of the Department of Industries and Commerce, Madras: for the year ending 31st March 1940.

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