

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 understand 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.

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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 surface, form, physical features, etc. Hydro-Electricity is science of utilising the natural configurations of the country 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 Tinnevely 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 Tinnevely District down to Koilpatti, and the repeated representations of the landholders of the Tinnevely 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 Tinnevely District were also intended to be improved by storing 2,000 million c.ft. of water in the Tambraparni 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 Tinnevely 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 masonry dam 176' high to impound 5,500 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 imbedded 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.

118 JOURNAL OF THE MADRAS GEOGRAPHICAL ASSN.

(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, Kallidai-kurichi 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 forecast worked conservatively shows a net return of 6.55% on the Capital outlay.

Owing to the present international situation, a temporary restriction of expenditure has been imposed on this Scheme totalling up to Rs. 1,39,00,000 in the initial stages but this, however, is not likely to affect the time of bringing the power station to commercial use at the earliest possible time, consistent with delivery of machinery ordered on English firms. The restriction of expenditure referred to above will have, however, the effect of limiting the height of construction of the Main Dam for some years.

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

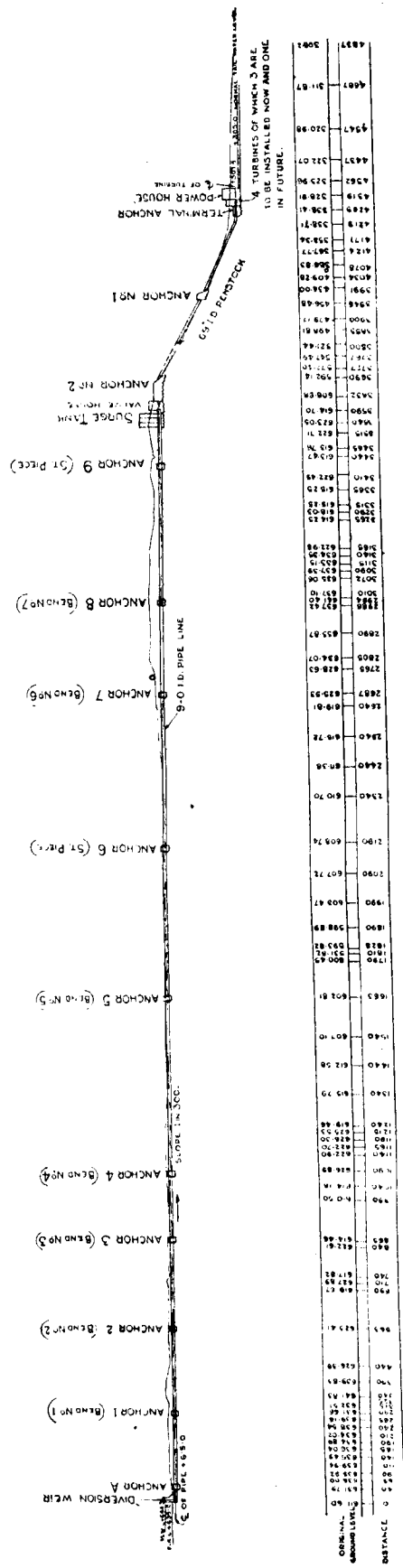
The installed generating capacity has increased from 19,650 KW in 1934 to 54,900 KW in 1939.

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

The total units generated rose from 10.9 Million KWH in 1934 to 131.1 Million KWH in 1939.

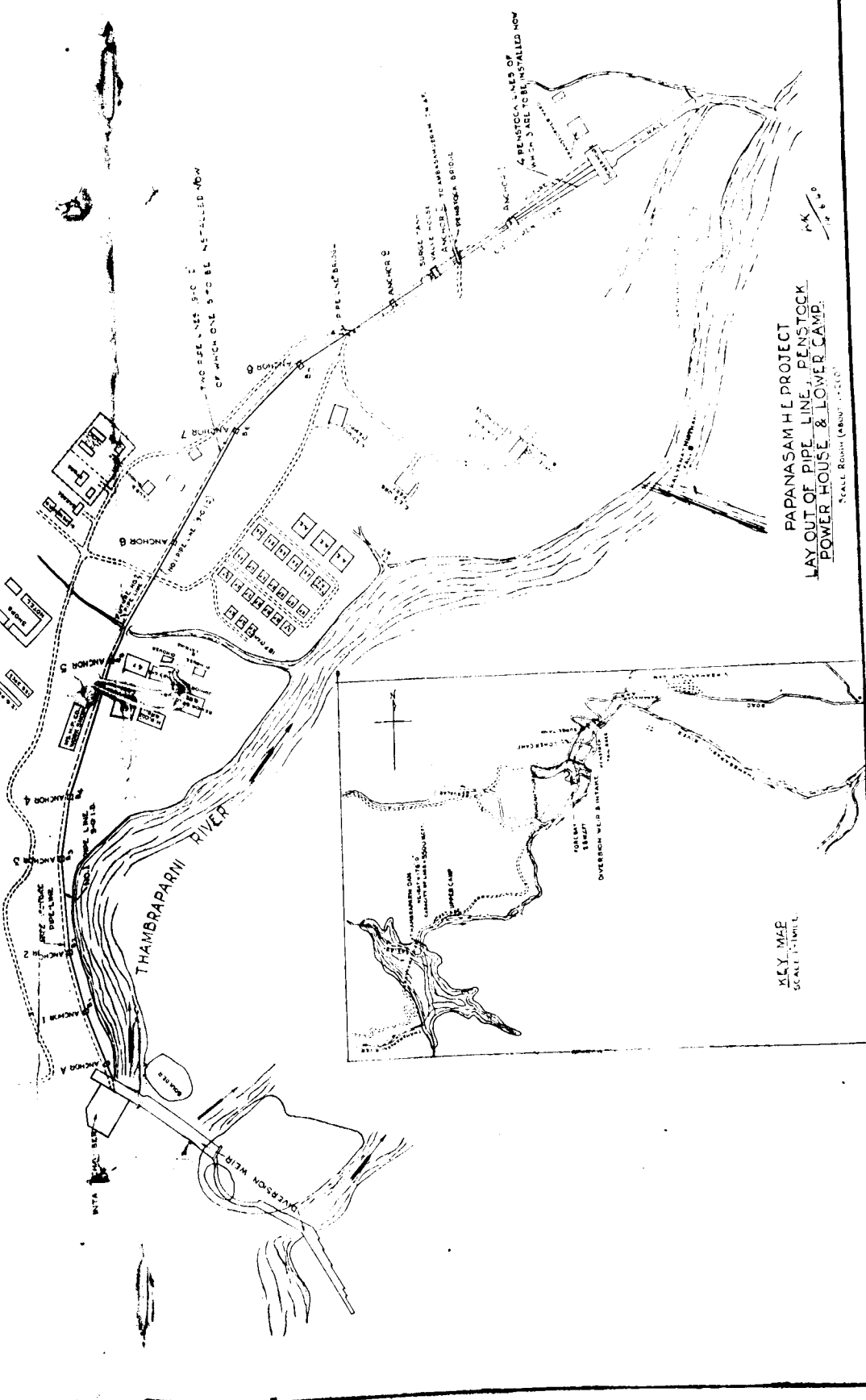
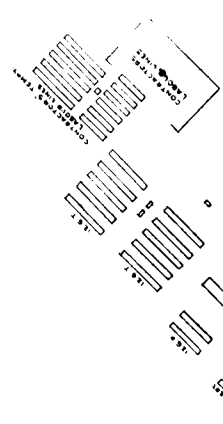
The total length of Transmission Lines Single Circuit is shown in the following table in both 1934 and 1939:—

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 1936
22 do. ..	166	615
11 do. ..	115	788



DETAILS OF THE TURBINES

NO. OF TURBINES	3 NOW + 1 FUTURE
GROSS HEAD	330'
CUT-OUT EACH MACHINE	9830 H.P.
SPEED	600 R.P.M.



PAPANASAM HE PROJECT
LAY OUT OF PIPE LINE, PENSTOCK
POWER HOUSE & LOWER CAMP

KEY MAP
SCALE 1:1000

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 pamphlets 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 manufacture 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.	$1\frac{1}{2}$ to $3\frac{1}{4}$ 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 Tinnevely 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 Tinnevely District.

The figures¹ on page 126 show the area irrigated by different systems in the several taluks of Tinnevely district:—

¹ The Gazetteer of the Tinnevely 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		60,000
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		56,356
Tinnevely	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	26,335
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 Tinnevely 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 wells² 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 Nanguneri and Tenkasi taluks, serve as supplemental sources to the existing canals and Sankarankoil taluk would have proved to be a desert but

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 1906⁴ 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 Tinnevely 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, Sankaran-koil, 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. Tinnevely 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, Sherma-devi 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	Invest-	Rs. 40 for 2	Six H.P. Rs. 1,500	Six H.P. Rs. 550
	ment and cost of	Mhotes.		
	installation.	Rs. 360 for 2		
		pairs of cat-		
		tle.		
		Total Rs. 400		
Cost of irrigating		Rs. 3-8-0 to	Rs. 1-12-0 to	Rs. 1-8-0 to
an acre—Lift 40'.		Rs. 3-12-0.	Rs. 2-4-0.	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 mholes, 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, Cholan, 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 Kanga-yam 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 and 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 Udampet 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 Tinnevely 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 balled variety of *Gossipium herbaceum*). Some are of opinion that uppam is an exotic to the district, as it is known 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. 118ff.

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 Tangasseri the crop is grown to a more or less extent. Angengo and Tangasseri 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

134 JOURNAL OF THE MADRAS GEOGRAPHICAL ASSN.

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 Tinnevely 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 Tinnevely 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 un-irrigable 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. Tinnevely 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 Tinnevely Cotton (Indian Science Congress Paper, Lahore, 1918).

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 crack⁽¹⁹¹⁷⁾, 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 resorted 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

¹⁰ Tinnevely District Gazetteer, Vol. I, p. 158.

¹¹ Wheeler: Handbook of Cotton in the Madras Presidency.

the Tinnevely 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. The work had been carried on.¹⁴ Govt on which

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 Tinnevelles 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 inter-cultivation 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

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 Tinnevely District.

19. *ibid.*

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

Cotton and Cotton Markets in the Tinnevely District

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

By

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

Tinnevely 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 Tinnevely 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 Sankarancoil 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-

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 Tinnevely 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 *Tinnevely 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 *Tinnevely 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."

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

2. Vol. I, p. 193.

A simple, but conclusive proof of the efficiency of the Tinnevely 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, Tinnevely has the "highest annual mean temperature" 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 Tinnevely. That two of these Mills are located in the Tinnevely 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 Tinnevely 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 Tinnevely 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.

144007.

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.

GEOGRAPHICAL ASPECTS OF RED HILLS LAKE 153

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 $13^{\circ} 4'$ north and longitude $80^{\circ} 15'$ 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 Tamarappakkam 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 Kortalar 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 observa-

tory, 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 normal 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 was 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 year 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 maximum 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 was reached in July; and again from July onwards there was a gradual increase in the number of hours of bright sunshine till December; (ii) maximum number of hours is recorded in the cold weather 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 hours 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 increase 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) to 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 is lowest in February and highest in May.

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

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

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

(c) *South-West Monsoon Season (June, September).*—In June, July and August, the velocity was slightly less than the normal in 1933 and 1934 but was much higher than the normal in 1935. In September, it was only slightly higher than normal in 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 but the maximum was recorded in 1935.

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

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

(e) *Summary of the Meteorological Conditions During 1933-1935.*

(a) *Cold Weather Period.*—The mean temperature varied between 75°-77°F., rainfall practically nil; hours of bright sunshine ranged between 6-10; and the wind velocity between 150-225 miles per day.

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

(c) *South-West Monsoon Season.*—The mean temperature varied between 83°-88°F., rainfall between 0.8"—9.0"; hours of

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 different 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 20 cm. 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 (Muttikowski, 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 tempera-

ture 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; 26.4°C.-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:—

$$1933 = 26.6^{\circ}\text{C.} - 31.5^{\circ} \text{ i.e. } 4.9^{\circ}\text{C.}$$

$$1934 = 26.4^{\circ}\text{C.} - 32.6^{\circ} \text{ i.e. } 6.2^{\circ}\text{C.}$$

$$1935 = 25.2^{\circ}\text{C.} - 31.4^{\circ} \text{ i.e. } 6.2^{\circ}\text{C.}$$

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 4.8°C., and in 1935 was 4.5°C. (25.4°C.-29.9°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 epilimnion thermocline and a hypolimnion 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 cc/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 Feb-

ruary) 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 O 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/l—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/l or 13.3% sat. (August) and in 1935 1.22 cc/l or 24.2% sat. (October). In both the years, in February, the difference was fairly high (0.44 cc/l, 8.6% in 1934; 0.48 cc/l, 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.

A. *Maximum and Minimum values.*

(a) *Carbonate ion*:—The carbonate ions varied from a minimum of 4.0 mg/l to a maximum of 22.5 mg/l in 1933; from 6.0 mg/l to 19.2 mg/l in 1934; and from 7.5 mg/l to 15.0 mg/l in 1935. The maximum amount recorded during the three year period was 22.5 mg/l (in October 1933) and the lowest 4.5 mg/l (in March 33).

Considering each of the three years separately, the maximum for 1933 was 22.5 mg/l (in October); for 1934, 19.2 mg/l in September and for 1935, 15.0 mg/l (in March, June and July). The minimum amount for 1933 was 4.5 mg/l (in March); for 1934, 6.0 mg/l (in February) and for 1935, 7.5 mg/l (in December).

(b) *Bicarbonate ion*:—The bicarbonates varied from a minimum of 86.9 mg/l to a maximum of 113.6 mg/l in 1933; from 79.3 mg/l to 103.6 mg/l in 1934; and from 99.1 mg/l to 142.2 mg/l (in August 1935) and the lowest 79.3 mg/l in January 1934.

Taking each of the three years separately, the maximum for 1933 was 113.6 mg/l (in May); for 1934, 103.7 mg/l (in June) and for 1935, 142.2 mg/l (in August). The minimum for 1933 was 86.9 mg/l (in December); for 1934, 74.3 mg/l (in January) and for 1935, 99.1 mg/l (in January).

B. *Seasonal Variations*:—A comparison of the carbonate content of the three years shows that (i) the carbonate content reaches its maximum during the south-west monsoon season; (ii) that it decreases gradually from January to February or March and then increases till the maximum is reached in September or October. These changes were more pronounced in 1933 and 1934 than in 1935.

Comparing the bicarbonate values for the three years, it is seen that (i) they are highest in 1935 and least in 1934 the maximum figure is reached generally in the hot weather period or the south-west monsoon period and the minimum in the cold weather period or north-east monsoon period. Generally speaking, there is always a gradual rise from January to August and then a decline till November followed by a rise again in December. The curve for bicarbonate is generally the opposite of that of the carbonates.

2. *The carbonate and bicarbonate content of the middle layer (3 metres) and its seasonal variations during 1934 and 1935. (Maximum and Minimum values)*

(a) *Carbonate Values*.—These figures varied from a minimum of 9.0 mg/l to a maximum of 19.5 mg/l in 1934; and from 9.0 mg/l to 16.5 mg/l in 1935. The maximum figure recorded was 19.5 mg/l (in September 1934) and the lowest 9.0 mg/l (in March, November and December of 1934, and in January and August of 1935).

Taking each of the two years separately, the maximum for 1934 was 19.5 mg/l (in September) for 1935, 16.5 mg/l (in June). The minimum for 1934 was 9.0 mg/l (in March, November and December); the minimum for 1935 also was 9.0 mg/l (in January and August).

(b) *Bicarbonate Values*.—The bicarbonates varied from a minimum of 79.3 mg/l to a maximum of 100.6 mg/l in 1934 and from 100.6 mg/l to 142.2 mg/l in 1935. The maximum figure recorded during the two year period was 142.2 mg/l (in August 1935) and the lowest 79.3 mg/l (in January 1934).

A comparison of the carbonate content of the two years shows that (i) it is greatest in June or September i.e. south-west monsoon season; (ii) that it rises gradually from January to September and then decreases till December; that the carbonate curves of the surface and the middle layers were quite similar during the two years.

Comparing the bicarbonate values of the middle layer for 1934 and 1935, it may be seen that they are higher in 1935 than in 1934; the maximum figure is reached in the hot weather (May) or south-west monsoon season (August) and the minimum in the cold weather period in (January) or north-east monsoon season (December). Generally speaking, there is a gradual rise from January to August and then a decline till October or November followed by a rise in December. The bicarbonate graphs take ordinarily the opposite course to those of the carbonates.

3. *The carbonate and bicarbonate content of the bottom layers and its seasonal variations during 1934 and 1935.*

A. *Maximum and minimum values.*

(a) *Carbonates*:—The carbonate ions varied from a minimum of 9.0 mg/l to a maximum of 18.0 mg/l in 1934; from 6.0 mg/l to 16.5 mg/l in 1935. The maximum amount recorded during the two years period was 18.0 mg/l (in September 1934) and the minimum 6.0 mg/l (in October 1935).

Considering each of the two years separately, the maximum for 1934 was 18.0 mg/l (in September); for 1935, 16.5 mg/l (in

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/l (in July 1935) and the minimum amount recorded was 79.3 mg/l (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 (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
Dinophyceae	.. 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.

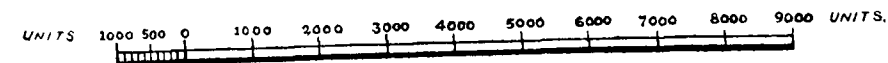
As the figures are in millions of acres, let us assume 1,000,000 acres as one of the areas to be represented.

$$\begin{aligned} 1,000,000 \text{ acres} &= 1562.5 \text{ sq. miles} \\ \pi R^2 &= 1562.5 \text{ sq. miles} \\ \text{or } R &= \sqrt{\frac{1562.5}{3.14}} \\ &= 22.3 \end{aligned}$$

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 concomitant 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 responsi-

bility 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 Poónamalle, 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, Tinnevely.
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 Tinnevely 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. Venkatasubbaityar : 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

- The Geographical Journal* : March 1940.
The Yunnan-Burma Road—By Patrick Fitzgerald.
- The Geographical Journal* : May 1940.
The Irrawaddy River—L. Dudley Stamp.
A Journey along the Chinese-Tibetan Border—By J. Hanson-Lowe.
- The Scottish Geographical Magazine* : May 1940.
Finland : Its Land and People—By Viola Gerard Garvin.
The Emigration of the Jews : Israel in China—By the Rev. T. Torrence.
- Geography* : March 1940.
The Creed of a Teacher of School Geography—By C. C. Carter.
The Concepts of Human and Total Environments—By S. J. Jones and F. Walker.
The Use of Folk-Tales in the Teaching of Geography—By H. B. Hodgson.
- The Geographical Review* : April 1940.
American Raw-Material Deficiencies and Regional Dependence—By Robert Burnett Hall.
The Economic Development of the Outer Provinces of the Netherlands Indies—By Jan O. M. Broek.
Crossing the Hindu Kush—By Felix Howland.
- International Review of the Hungarian Geographical Society* : LXVII-No. 2, 1939.
Le Caractere Anthropogeographique des Regions—par le Dr. A. Hezser.
Geographical Factors of the Iron and Steel Industries—By F. Koch, D.Sc.
- The South Indian Teacher* : May 1940.
School Excursions (A Review)—By K. Govindachary.
- Indian Information* : March, 15, 1940.
India's Mineral Resources : Work of the Geological Survey.
- Indian Information* : May 1, 1940.
Surveying India from the Air.
- Indian Information* : June 15, 1940.
Irrigation in India and Burma.

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.

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.

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 Tinnevely 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.

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 ques-

tions 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.
Renasant 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 formulae. 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

200 JOURNAL OF THE MADRAS GEOGRAPHICAL ASSN:

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.

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