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# SOME ASPECTS OF THE EARLY WORK OF H. F. BLANFORD AND SIR JOHN ELIOT ON PRESSURE DISTURBANCES OVER THE INDIAN LAND AREA-1867 TO 1893

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## 1. INTRODUCTION

Blanford and Eliot were founder members of the India Meteorological Department and it is therefore largely to their work to which one must turn in order to obtain a picture of the early years of the history of meteorology in India. To-day these two workers are chiefly remembered for three works, *The rainfall of India* (Blanford 1886), *The climates and weather of India* (Blanford 1889) and *A handbook of cyclonic storms in the Bay of Bengal* (2nd ed. 1900). Eliot is also remembered for his direction of the preparation of the *Climatological Atlas of India* (1906). However, it should not be forgotton that these two workers were also responsible for pioneer investigations into the nature and causes of eastern and western disturbances; or, as they were then called, south-west monsoon and cold weather storms. Indeed, they might almost be regarded as their discoverers, since, although thanks to the work of Piddington from 1840 onwards, there was at least a body of knowledge and theory concerning what Piddington named *the cyclone*, there appears to have been no knowledge of cyclonic disturbances penetrating deeply into the Indian land mass until the coming of Blanford and Eliot.

Part of the success which Blanford and Eliot achieved must be attributed to the India Meteorological Department itself, for without its organisation and network of weather observatories, very little work could have been accomplished. The men and the services were one, for while on the one hand neither Blanford nor Eliot could have continued without the data and facilities which the departmental machinery provided, its value would have been little without persons of such a calibre as Blanford and Eliot to serve it. It is the purpose of this paper to set out some of the results of their work.

The India Meteorological Department, founded in 1875, was not however without its predecessors. Meteorologically speaking, the most important step was taken in the 1860s with the setting up of various provincial organisations. The Bengal system was begun in 1867 with H.F. Blanford, lately retired from the Geological Survey, as its first *Meteorological Reporter*. On the appointment of Blanford to the post of organising the new India service, Eliot was given the Bengal post in 1874. From then on they were in very close contact with one another and the association was only broken by the death of Blanford in 1893. This study will therefore concern itself with the period of Blanford's official connection to Indian meteorology (1867 to 1893). For convenience each of the two weather types, eastern and western disturbances shall be treated separately, although in fact studies on both, went on concurrently.

## 2. THE EASTERN DISTURBANCE

Blanford's first major work on Indian weather was a report, written jointly with J.E. Gastrell, on the Calcutta cyclone of 1864 (Blanford and Gastrell 1866). This work is chiefly notable for its insistence upon the existence of ascending currents within the cyclone vortex, and of inward spiralling winds at the surface. Both at this time were matters of great controversey (Hildebrandsson and de Bort 1898 and 1907 gives a good account of this) and as late as 1888 Blanford was still able to continue the argument as to accending *vs* descending winds in a very sharp attack on Faye (1887), a firm adherent to the descending winds theory. As to Blanford's own theories at that time, it would appear that he subscribed in general terms to those of Dove who regarded storms as the outcome of a struggle between equatorial and polar air (Hildebrandsson and de Bort, 1893 p. 27). His first definite statement however did not come until later (Blanford, 1869) when he opposed Meldrum's thesis that cyclones originated as the result of friction between two opposing winds. Meldrum (1869), who was in charge of the observatory at Mauritius, had in fact restated an earlier idea by placing the lines of opposing winds (convergence lines) between neighbouring areas of high and low pressure instead of between the north-west monsoon (re-curved north-east trades) and the south-east trades (Thom 1845).

Blanford based his mechanism upon a local cause, strong evaporation over warm seas, leading to the production of a low, to which winds from a widening area were drawn. Blanford's theory was therefore essentially one of condensation, while Meldrum's argument was essentially mechanical. Blanford then postulated that the vortex once created would be the meeting place for three winds, *viz.*, S.W., S.E., and N.E. Blanford repeated his case as an appendix to his *The winds of Northern India* (1873); the first definitive account of land winds over India.

This argument might easily have remained of academic interest but for the fact that it was taken up by another Indian meteorologist, W.G. Willson, in a report on the Midnapore and Burdwan cyclone of 1874. Willson (1875) strongly averred the Meldrum theory, believing that in the Bay of Bengal the two opposing currents were represented, during the transition months, by the advancing or retreating north-east and south-west monsoon currents. Unfortunately Willson died soon after his report was published and therefore the scene of the argument was shifted.

Blanford's views were in effect taken up and expanded by Eliot (1877) in his report of the Vizagapatam and Backergunge cyclone of 1876. This





was his first major work on Indian meteorology and in it he came out as an opponent to the Meldrum/Willson theory. Hann, the doyen of Austrian meteorology, critically examined Eliot's report (Hann 1877, and quoted in the U S. Monthly Weather Review for Sept. 1877).

Hann talked of winds converging upon an area of diminished pressure and he criticised Eliot's ideas as to what happened when the latest heat of condensation was released. Eliot's reply came as a special chapter in his report on the Madras cyclone of 1877 (1879 pp. 90–115). Eliot, to say the least, was firm in his conviction that neither was it necessary for there to be an initial barometric depression in the Bay, nor was an incipient cyclonic or even a simple indraught required to produce the requisite initial conditions. Eliot expressed the two viewpoints very neatly when he remarked that whereas Hann's theory was *convergent*, his own was *divergent*, *i.e.*, that a cyclone grows from within. For Eliot, the cyclone was started by rainfall and driven by rainfall. As for Blanford, he had already subscribed to the condensation theory in an article to *Nature* in 1878. This report also contains what is probably the first public reference to an eastern disturbance; "*Mr. Blanford's examination of two storms during the rainy season of 1876.........established that they were revolving storms, which proceeded from the sea coast to the interior, where they gradually dissipated. This gave the first clue to the character of the storms of the rainy season*" (op. cit. p. 93). This was confirmed in the following year, 1877, when for the first time Daily Weather Reports came to be prepared as a matter of routine. The annual *Report of the Meteorology of India* for 1877 (Eliot 1879) also makes reference to the existence of *well defined cyclonic disturbances* during August and September 1877. The annual report for 1879 (Blanford 1881) published for the first time daily wind and pressure charts depicting the movement of what was called '*a land cyclone*' from the Bay to Rajputna.

Eliot (1882) followed with a memoir devoted to a storm of 1878. This study gave a series of daily weather charts and an isohyetal map of the storm rainfall over Bengal in relation to the path of the depression. From this map be attempted to estimate the total weight of water precipitated. This he calculated to be in the order of 50,000,000 tons over land, and 100,000,000 tons in all. Eliot stated that this memoir marked the commencement of the work of discussing the *minor storms of the Bay of Bengal*. Thus in the annual report for 1881 (Blanford 1883) the Department felt sure enough to make the following statement ;—

"*These cyclones, of slight barometric depression but extensive and very persistent, are now known to be characteristic feature of the monsoon rains. Generated over the Bay of Bengal, frequently on the coast of Orissa or the Sunderbuns, and occasionally over the land itself, they travel slowly to the west or north-west, following the trough of low pressure, which throughout the season as a rule separates the western from the eastern branch of the current. The cyclones or travelling barometric depressions which are of frequent occurrence during the rains, consequently followed this track and thus determined a heavy precipitation over the area above defined.*" (op. cit. p. 176).

Thus was the eastern disturbance first clearly described.

The intensity of these storms was much greater than the barometric depression would indicate and Eliot (1884a) realising that the south-west monsoon storm crossed hills which would have dispersed Bay of Bengal cyclones, put forward the idea that the eastern disturbance was really *a cyclone of high elevation*, whereas the Bay cyclone was one of *low elevation*.

This he argued could be shown from differences in the thickness of the monsoon airstream at the time of occurrence ; the south-west monsoon storm proper taking place in a deep current at the height of the monsoon ; the post-monsoon storm on the edge of a diminishing current. He again argued the case for the condensation theory, and, basing his data on Cunningham (1881) compared the rates of water release in storms with the rates of evaporation. Eliot published a further memoir on eastern depressions in the same year.

Eliot's work on these disturbances culminated in an exhaustive memoir covering the period 1877 to 1881. This paper ran to two-hundred and thirty pages and discussed forty-six storms (Eliot 1885). His method of attack was simple but effective, each storm was described in detail and in relation to the general weather tendencies for the year. He plotted depression tracks for each of the five years and for each of the twelve months of the year.

Eliot now clearly distinguishes south-west monsoon storms proper from those occurring on either side of the period 1st June to 30th September (op. cit. p. 429). He uses his 1883 argument (see also Eliot 1884 b) as to differences of depth etc., plus differences in the position of heavy rainfall with regard to the storm track; to the left for eastern disturbances and to the right for cyclonic storms in the north Bay. Eliot restated his position as to the scene of origin, '*the generation and motions of cyclones* (*i.e.* depressions) *in the Bay of Bengal is chiefly due to actions and conditions over the initial area of disturbance in the Bay, and not to conditions in distant regions*", (op. cit. p. 427). He had however shifted his position a little by referring to the creation of *much eddying motion* in front of the frequent advances of the monsoon current in the Bay (op. cit. p. 425). But these apparently were subsidary, for the *energy set free during the act of condensation .....supplies the motive power which initiates and maintains the large atmospheric motion of the cyclonic disturbance*". (op. cit. p. 428. see also p. 433).

It seems that what Eliot wanted was comparative quiescence in the north Bay for a few days prior to the formation of both classes of storms (op. cit. p. 427). This he saw confirmed by an interesting relationship between storm frequency and the strength of the monsoon during the period June/September. Depressions were most frequent during August and September and were nearly always preceded by a break in the monsoon (op. cit. p. 434). Hence, because strong monsoon conditions were inimicable to the formation of depressions, they were less likely to occur during June and July. On the other hand a strong southerly stream of humid air was necessary to keep the cyclone supplied with moisture.

As to the continued motion of the eastern disturbance across the Peninsula, Eliot was less certain. He saw that this only occurred during the period July to September and considered that there must be some *interaction* between the Arabian Sea and Bay of Bengal branches but rejected (vide Meldrum) any idea of frictional rotation between the easterlies and westerlies; preferring instead to regard this line of convergence to be one of least resistance (op. cit. p. 438)

Eliot makes a passing reference in this memoir to the occurrence of rainfall in association with cyclonic depressions in Madras during the so called north-east monsoon but Eliot's picture in the matter was made much clearer in the annual report for 1887 (Eliot 1889) where he refers to rainfall along the Madras coast being caused by *diffused depressions* and *slight disturbances*. The myth to the effect that the north-east monsoon winds passing over the Bay brought rain to Madras had long before been exploded by Blanford (1873).



Thus Eliot and Blanford succeeded in drawing to the conclusion that Bay of Bengal was *the cyclone cradle* (Blanford 1878) and that rainfall over northern India was to a large extent due to pressure systems of various orders of intensity. The descriptions which they gave are to this day the only detailed ones commonly available and, if only on that account, are still worth reading. His insistence upon the condensation theory and upon initial causes lying within the Bay of Bengal are noteworthy.

## 3. THE WESTERN DISTURBANCE

The western disturbance, or rather the cold weather rains that were produced by them, were of sufficient singularity to have excited comment before proper meteorological data were available. And it would be true to say that neither Blanford nor Eliot were as successful as to causes, judged by present day explanations, as they had been with eastern disturbances.

Blanford (1873) made the first attempt to account for these rains on the basis of then commonly held theories of the general circulation (Maury 1869) adapted to suit Indian conditions. This was, that the anti-trades flowed northwards above the north-east trades from the summit of the equatorial belt of ascending winds, and carrying moisture, descended in the doldrum area to continue their northward path toward the poles as rain bearing westerlies. Blanford placed the scene of descent in Punjab, calling the anti-trades the anti-monsoon, and argued local cooling as the attractive force. The anti-monsoon was therefore conceived by him to be a counterpart to the south-west monsoon ; it had two branches, the Arabian Sea and the Bay of Bengal branch, it brought its moisture from the equatorial regions, and, by striking the Himalayas, brought mainly orographic rains. The two branches were of course necessary in order to explain winter rainfall along the whole of the Himalayas.

Bearing in mind the paucity of observations at that time, and a complete absence of them in areas to the west of India, there the matter might have rested. However, Blanford (1878) inversely related heavy and late winter snowfall to the strength of the succeeding monsoon. Blanford saw this as a possible relationship between the abnormally persistent cool dry north-westerlies over north-western India, the snows (which cooled the winds) and the monsoon whose thermal mechanism was thereby damped (op. cit. p. 96).

Hill (1879) on the basis of a statistical study "confirmed" Blanford, added that Archibald (1877) had earlier found a similar relationship, and suggested that there might be a *direct* relationship between insolation over the equator, the strength of the anti-trades, and the sun spot cycle.

Eliot (1879 b) accepted the anti-trade explanation, but like Blanford (1873) noted a movement of surface easterlies toward the disturbance. But in the year following, Blanford (1880) rejected the anti-monsoon theory. The daily weather reports were once again having an immediate effect and Blanford was now able to describe a disturbance. He concluded, "*these rains are not as I at one time believed, caused by the descent of the anti-monsoon wind in India, but are accompanied by southerly winds that extend over a large part of India.*" (op. cit. p. 130).

Blanford next described (1882) the first recorded cold wave, and thus having identified most of the more important features of the westerly disturbance he proceeded to put forward in 1884 (a) a theory of winter rains. His argument, that the disturbance originated in the upper air from energy supplied by evaporation at the surface over the riverine tracts of Punjab and grew by drawing in a surface inflow of maritime air, was essentially one of local causes. Chambers (1881), who had already pointed out that the monthly strom track charts of the U. S. Monthly Weather Review showed depressions moving from west to east across India, stated (Chambers 1884 and 1885) that the U. S. Monthly Review was, by plotting depressions moving into India from Europe, providing a far better explanation. Blanford would not accept this.

Blanford also published in the same year a definitive account of his theory on the connection between spring snowfall and the south-west monsoon (1884 b). His last Annual Reports (1886 and 1887) also gave further evidence (see also his Rainfall of India Pt II p. 233, 1887).

From 1886 (Eliot 1887) the reports were written by Eliot, and in his first report the question of the cold weather rains was taken up in some detail. Eliot reintroduced Blanford's old idea as to the causes of winter rainfall over the Himalayas. Because winter rainfall was highest on the higher southern slopes of the Himalayas, and lowest on the plains, this was '*an almost conclusive proof that the upper (south-west) return current* (Blanford's 'anti-monsoon') *advances as far as the Himalayas, and passes in part, if not entirely, to the north across them*', hence, '*the western Himalayas perform the same role to the upper humid south-west current of the North East Monsoon. as the Western Ghats play to the low humid current of the South West Monsoon*', (op. cit. p. 216).

The report for 1887 (Eliot 1889) showed that it was at last realised that the Himalayas received their main supply of snowfall during the course of the winter and that western disturbances could occur during March and April. The techniques were improving too, and in the report for 1888 (Eliot 1890) the use of pressure changes and pressure departures as the best means of identifyng western disturbances was acknowledged. That Eliot was giying a great deal more attention to the whole problem is now clear, and the report for 1889 (Eliot 1891) devoted most of its attention to cold weather rain. It also promised a memoir on the whole problem.

This memoir was published in 1893, and ran to nearly three hundred and fifty pages. It covered the period 1876 to 1891 and closely followed the method used for the 1885 memoir, with the addition of separate sections on pressures, winds, temperature and humidity. In all, fifty five storms were examined, and Eliot hoped, by giving a very full analysis of each storm, that '*a fairly complete account would be more likely to lead to a comparison by European Meteorologists between these storms and cyclonic storms of the temperate zone which they appear to resemble in their more important features*,' (op. cit. p. 819). For he was certain that they differed completely from the monsoon depression and the cyclonic storm.

In this memoir, Eliot again drew attention to the extraordinary depth of the cold weather storm and now placed the seat of their origin in a zone 10,000 ft. to 25,000 ft. above sea level. Cirrus cloud observation had already revealed that at this level there was a westerly air stream of great steadiness, and he therefore concluded that western disturbances were '*large whirls in this upper current, a current which is remarkably steady in direction and probably of considerable velocity*' (op. cit. p. 866; Hill, 1887, had suggested similar steering effect). He had followed only three disturbances from as far west as the Mediterranean, the remainder appeared to originate further east; in either Persia, Baluchistan or north-west India. Therefore, '*the cold weather storms of India are not the continuation of European storms*' (op. cit. p. 829). He was equally certain as to the influence of the surface easterly current in the Ganges valley, '*any extension of the cyclonic circulation takes place from within outwards, and hence, in the passage of these storms across Northern and Central India, the easterly winds in the Gangetic plain and Bengal are produced by the indraught of the advancing storms*', (op. cit. p. 833).



Allowing a European origin only in exceptional cases, and reducing the surface easterlies to an effect rather than a cause, Eliot had to find his source of moisture from some other direction. He therefore suggested, '*the upper atmospheric current in which these storms appear to form and move is a humid current, as it is undoubtedly in part the continuation of the ascending current over the equatorial belt. It is hence probably strongest and charged with the largest supplies of vapour during the period when the equatorial ascentional movement in the Indian monsoon area is steadiest and strongest, that is, during the north-east monsoon or cold weather months*', (op. cit. p. 866). A view almost identical with Blanford's in 1873.

From the surface charts Eliot divided a disturbance into two parts; a primary, which took a more southerly course and which was the part that moved right across India from west to east, and, a secondary, which, lying to the north, passed across Punjab and lasted for little more than 48 hours. The secondary was by far the more active portion and in its northern and eastern quadrants lay the heaviest precipitation. The secondary depended upon inward moving upper southerlies, and therefore, the primary, as it moved eastwards, would eventually cut off the supply of moist air to the secondary; thus accounting for the latter's short life.

The warm wave ahead of the disturbance was attributed largely to the reduction in nocturnal radiation caused by the canopy of cloud that extended ahead of the disturbance; a conclusion which was based upon the warm wave being more noticable if one examined night temperatures (op. cit. p. 386). Eliot noticed that there were certain similarities between the Indian and the American cold waves, and although he quotes Ferrel (1889) to the effect that this was 'caused' by intense terrestial radiation in the clear dry atmosphere which follows a disturbance, was of the opinion that in India the cold wave was the result of a cooling of the descending winds by contact with the Himalayan snows. A cooling which was sufficient to offset a Fohn effect. The cold wave was therefore a shallow affair.

## 4. CONCLUSION

In this memoir Eliot once again succeeds in providing matchless descriptions of a weather phenomenon, and because of the presence of the Himalayas was able to give a three dimensional picture. On the other hand, Eliot's continued adherence to the anti-monsoon or anti-trade concept may seem somewhat strange. The answer may lie in his complete faith in the condensation theory, which, having provided a very satisfactory answer in the case of the eastern depression, ought to have succeeded in this instance. The seat of the disturbance lay in the upper air, the heaviest precipitation also occurred at high elevation, and the disturbance appeared to move outwards at the surface, and therefore being unable to accept a European or even Atlantic origin (because this would have required a southerly path at some point), he was thrown back upon the only other source of possible energy; the so called anti-trades. It is possible that Blanford realised that Eliot was going to utilise the anti-trade theory in this memoir for there is an interesting paper, written a year before his death in 1892, on the winter storms of northern India, in which Blanford states that '*we must clearly distinguish between barometric depressions which appear like the trough of a great atmospheric wave of great extent both in longitude and latitude and the vortex, which is as a rule merely a local and subordinate feature of the former*' (op cit. p. 492). Was Blanford making his position clear to Eliot and to other meteorologists as to his rejection of the anti-monsoon theory? It may never be known, but we may ponder over a verse of poetry which Blanford quoted in this last of all his meteorological papers:

> These fair tales we know so beautiful,
> Show only finer than our lives to-day
> Because their voice was clearer and they found
> A sacred bard to sing them (Lewis).

Eliot with this memoir completed a triology, the 1885 monsoon depression memoir, the 1890 cyclonic storm handbook and the 1893 account of western disturbances. Each in their way had something new and original to say, none are without interest to-day, and all are monuments to the early days of the India Meteorological Department. To compare his work with that of Blanford would be impossible; the two men stand as complementary to each other. Both were pioneers in a field, which until their coming, was more notable for climatological fictions, than meteorological facts.

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# PROBLEMS OF SOIL IN PAKISTAN

BY

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The civilization of our country is based upon its soil resources and agricultural industries. The two wings of the country possess such a combination of variety of soils and climates that they are admirably suited to agriculture, providing a wide range of crops, and resulting in a well balanced agricultural economy. About 90% of our people today are directly or indirectly engaged in agriculture.

## CAUSES AND EFFECTS OF SOIL EROSION

Climatic conditions ranging from heavy to low rainfall in some regions to severe draught in others though are the principal cause of both water and wind erosion physical, social and economic factors too have contributed immensely to the spread of this menace in Pakistan. Accelerated erosion is the result of conflict between man and nature of man's necessary interference with natural processes of land stabilisation in order to provide himself with the necessities of existence. Under a blanket of vegetation, nature protects the soil from the erosive forces of wind and rain and her protection is almost complete. Soil losses under natural conditions of vegetation cover are negligible, so small, in fact, that normal processes of soil building are generally adequate to compensate for them.

Soil erosion has become a national problem, particularly in West Pakistan owing to the way in which ploughing and grazing have destroyed the plant cover which nature originally provided to protect the land surface. In East Pakistan soil erosion is a problem of a smaller order of magnitude. Wind erosion is not at all a serious problem. Water erosion, indeed is a problem but is mainly restricted to the Chittagong Hill Tracts. Here cultivators follow the practice of clearing forest growth from the hill sides for purposes of raising crops, which result in the removal of top soil cover and ultimately in the abondoning of the fields. As rainfall is considerable, nature again reclothes the eroded areas with a thick growth of natural vegetation which in its turn hampers the process of water erosion.

The harmful effects of the three forms of soil erosion viz: sheet, wind and gully erosion go far beyond the removal of the valuable top-soil on which plants depend for their nourishment. One direct effect is of course gradual decline in crop yields which more than off-sets any gains brought about by seed selection and manuring. The direct effect in pastures and grazing land is to reduce the capacity of land for carrying livestock, for good pasture may carry a cow per every two acres, but the eroded pasture land may not keep a cow properly on ten acres.

Of the indirect results of erosion the most important for us in Pakistan is the dumping of large quantities of sand in the river beds so that the beds are inevitably raised and thus aggravate the effect of floods. Another effect is to increase the severity of the intervening drought periods. This is because each small stream in the foot hills discharges perhaps 80 or even 90



percent of heavy storms within an hour or so, and only a very small part of the rain soaks into the bare ground.

The water-table is apt to shrink except in the case of rivers, because the amount of percolation or seepage through the soil into the underlying rocks and subsoil is less. The reserves of water stored underground, feed springs and wells but these reserves dwindle because eroded soil will not allow rain to penetrate underground, so that wells dry up, springs are reduced to a trickle, and rivers that once flowed all the year round now fail in the dry period. Apart from the above mentioned harmful effects, erosion also carries with it consequences of vast importance to the permanence of investments of large sums of money in navigation, power, municipal water supply and irrigation developments.

## DEFORESTATION AND SOIL EROSION

The progressive deterioration of the natural vegetation of Pakistan is well demonstrated by two simple examples. It is on record that when Alexander came to this region in 326 B.C. his army and elephants camped in a *sal* forest somewhere near present Lahore, but now there is not a single *sal* tree within hundreds of miles of Lahore. A second example is the discovery of skulls and teeth of elephants in the ruins of Taxilla which show that at that time the country was covered with tropical forests which could harbour elephants[1]

One of the greatest calamities with which we are confronted at present is the destruction of our forests and the consequent erosion of our land surface. This has already destroyed the fertility of many of our agricultural lands and is at the present day exercising a great influence on the destiny of our people. Deforestation and soil erosion not only intensify floods and reduce the cold weather discharges of surplus streams but they threaten the sub-soil water supply and impoverish the soil and reduce the output of agriculture. In fact, these two demons threaten the very basis of civilization and economic life.

Erosion results from the misuse of the surface covering of the earth, whether it be by the destruction of the forest which covered it, by the misuse of arable or pasture land, by bad methods of cultivation, by burning or by over-grazing. There is sufficient evidence to show that West Pakistan is faced with the very grave danger of her river catchments being denuded to such an extent as to increase floods during the periods of heavy rainfall, decrease river supplies for irrigation and navigation during the dry season, increase siltation of the rivers and throw large areas out of cultivation.

## AREAS OF SEVERE DAMAGE

The area of greatest moisture type variation in West Pakistan is the semi-arid and dry sub-humid zone. It comprises the sub-montane strip of the Indus plain, the Potwar plateau and the Western Hills[2] (Fig. 1). In this region run-off is heavy and soil erosion wide-spread. In the Pabbi-Hills of the Kharian Ridge in this zone, the maximum run-off in the aforesaid areas is less than 30 m. per second per square-mile while is areas[3] devoid of any forest cover it is as high as 480 m. per second per square-mile. This percentage of run-off in the latter areas is very high and is of the order of about 90% of the torrential downpours.

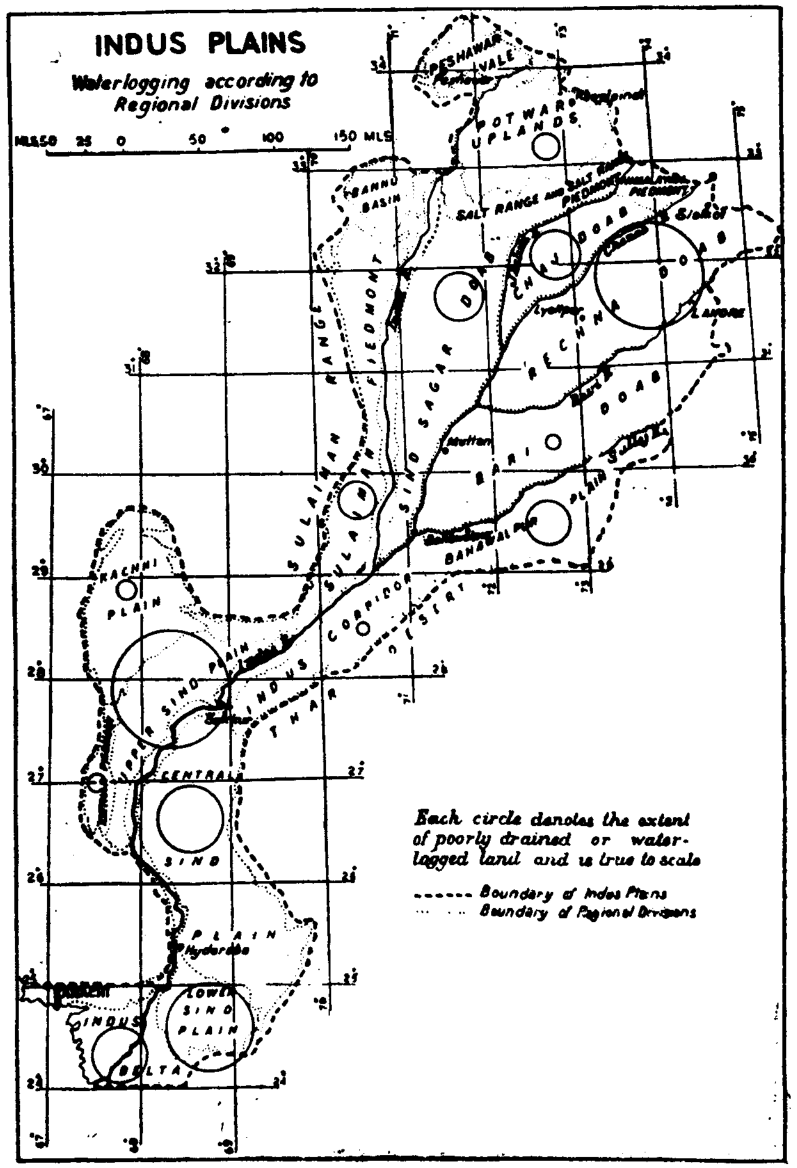


Fig. 1

The uplands of West Pakistan which include the whole of Potwar plateau and the rolling foot hills of the Himalayas in Gujrat and Sialkot districts in the south east, and Peshawar and Mardan districts in the north-west, provide one of the finest examples of gully or ravine formation in the world. Millions of acres of these uplands are subject to sheet and gully erosion which has gone unchecked for a very long time. This has resulted in a vast physical destruction of land. These uplands are a physiographic region of the country. Their elevation varies between 1000 to 2000 feet. The intermontane valley lands, like Quetta Valley, are not included in the uplands. The topography of the land is undulating to rolling, forming chains of parallel ridges and troughs. An extensive net-work of deep gullys or ravines has developed throughout the area, especially in the Potwar Plateau.



The total area of West Pakistan is 310,236 square miles or 187·4 million acres. It is estimated that about 125 million acres comprising the upland regions is suffering from wind and water erosion. Approximately 35 million acres of this upland is used for growing of arable crops. Erosion has been so severe in this area that as much as 40 to 50 percent of good arable land has been rendered unproductive by gully formation alone. It is estimated that in the whole of West Pakistan about 35,900 acres of cultivable land is being lost every year due to soil erosion and gully formation.[4]

The fertility of the soil lies in its top crust and the removal of 1·5 inches of the surface soil which nature takes a long time to create, amounts almost to a disaster. The unproductiveness of newly exposed sub-soil is well-known and one might almost say that once the surface has been destroyed, fertility has gone for ever as far as the present generation is concerned. In Pakistan erosion by wind is a constant menace and is one of the most important factors that contribute to the low crop yield in the country.

Severe wind erosion is a great menace in many semi-arid and arid parts of West Pakistan especially in Thar desert along with the adjoining cultivation of Nara and Indus valleys and the whole of Lower Indus Valley upto a distance of about 150 miles from the sea coast; Cholistan and the parts of Bhawalpur and Multan Divisions lying adjoining to the north of the Sind-Rajasthan Desert; Thal tract lying between the Indus and the Jhelum-Chenab rivers. That the desert conditions are advancing due to wind erosion has been confirmed beyond doubt by no less an authority than Major Westland Wright of the Survey of India. At the occasion of the Sixth Indian Silvicultural Conference held in 1945, by a comparative study of a number of aerial photographs made from 1870 to 1935, Major Wright, demonstrated that during this period of 65 years, the Sind-Rajasthan desert had advanced into fertile tracts north-eastwards and north-westwards to the extent of nearly 33 miles, thus giving a rate of about half a mile a year.[5] R. M. Gorrie, also demonstrated that the desert was advancing at the rate of about half a mile per year north-westward out of Sind.

Upto the beginning of 1956 total area afforested in Thal by the Forest Department with the help of canal irrigation including the area occupied by the shelterbelts was about 19,000 acres.[6] There is indeed a real need of raising shelterbelts in Thal for the purpose of safeguarding and developing agriculture. Shelterbelts so far raised are only along roads and canals. In the Thar desert about 200 acres[7] of *Babul* tree (Accacia arabica) have so far been successfully raised with canal irrigation by the personnel of Arid Zone Research Station at Chor, situated at the western fringe of the desert. Efforts are now being made to raise wind-breaks of only xerophytic species without using the canal water.

In spite of the fact that there are immense possibilities very little has been done upto the present in the way of establishing protective shelterbelts and wind-breaks in our extensive semi-arid and arid areas. There is much preliminary work to be done in the fields of research and demonstration before taking up any large scale planting of shelterbelts in various areas. In addition to the above measures it is very essential for us to consider a few other important matters such as control on grazing, restrictions on shifting cultivation, stabilization of sand-dunes and also if circumstances necessitate, enactment of a suitable legislation to tackle the huge task of reclaiming large tracts of our wind eroded lands.

Soil erosion is the most potent of all the factors which are seriously impairing the productive capacity of land in Pakistan. It is unfortunate that upto date statistics of areas affected by erosion are lacking in our country and in the absence of these it is difficult to arrive at any correct estimate of the extent of damage done to our lands. It has been estimated that 77% of the total land area is affected by erosion, most of which has been deprived of its topsoil either partially or wholly by sheet, wind or gully erosion Aridity is a problem of great magnitude particularly in the western wing of the country where three-fifths[8] of its total area has become an arid and semi-arid waste as a result of rapid erosion by wind and water caused mainly by extreme paucity of forest cover.

## SALINITY AND WATER-LOGGING

Salinity and water-logging are two other menaces which are responsible to a great extent for the present food shortage in the country. Lack of proper care of land and defective irrigation practices have resulted in vast areas of once fertile land in Pakistan to develop salinity (Fig. 2). Salinity causes the appearence of a white efflorescence of sodium salts over pulverised or swollen earth, which are highly deleterious to the growth of vegetation. When these salts come upto the top layers of soil in sufficient quantities, they kill the vegetation and do not let it thrive. The devastation caused by salinity is extremely disturbing for approximately 7 million acres are badly salinised and another 12 million acres partially in the whole of West Pakistan and to which 70 thousand of acres are added annually.[9] The main cause of the accumulation of salts, either on the surface or root zone of crops may be attributed to the scanty irrigation supply and to remedy this defect more water is required to push down the salts by frequent irrigation and to grow crops with a high water need so as to maintain a downward movement of salts. Field experience has proved beyond doubt that salinity is not a permanent disease and that soils so affected do not loose their fertility for ever, but instead there are some cases where reclaimed soils have given better yeilds than the adjacent areas.[10] In order to check salinity and for purposes of dependable and profitable agriculture, it is necessary to determine the optimum water requirements for the soil conditions obtained at a particular place and for this soil surveys are an essential pre-requisite.

Seepage of water from big canals unevenly distributed rainfall, and absence of gravitational outfall for purposes of natural drainage are some of the factors which cause a rise in the sub-soil water-table and result in water-logging. It is fortunate that the menace of water-logging is quite insignificant when compared with that of salinity. Dr. H. Vlugter, an expert from the Netherlands during the course of his lecture on " Some aspects of Water-control in West Pakistan " delivered at the occasion of the Twelfth Pakistan Science Conference, held at Hyderabad, in January 1960, remarked that a rise of one foot of ground water table per year has been observed in the former Punjab especially in the northern Thal area. During the years after the Jinnah Barrage was completed the ground water on an average has risen by as much as 3 feet per year. Fifty years ago it was 50 to 70 feet below the natural surface, now in the irrigated areas it has come very near to it, resulting in water-logging; trees are, therefore, dying in the Shalimar Gardens.



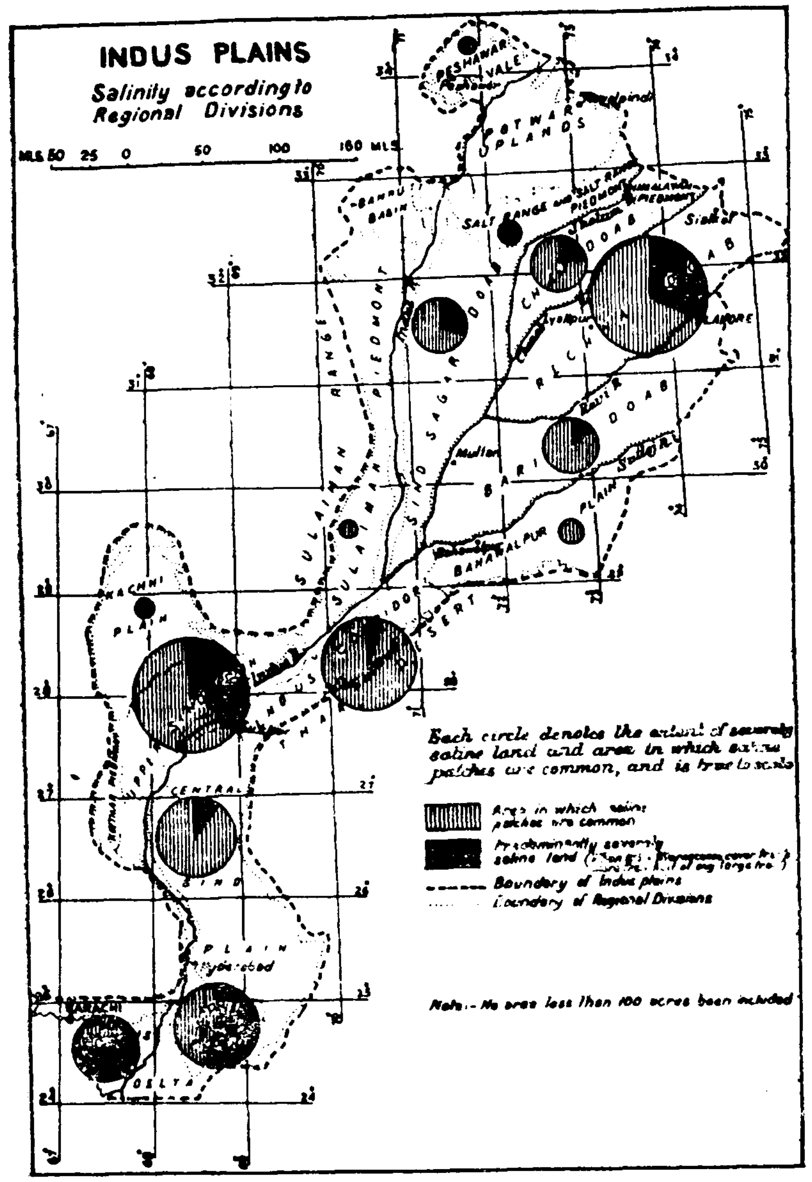


Fig. 2

Large regions of former green lands now give the impression of being snowy landscapes. Village dwellings, once built in the desert now float on lakes and roads are damaged and bumpy. Such is the condition of our present soils as viewed by a foreign expert.

In the former province of the Punjab, which has the largest share of canal irrigated area (over 9 million acres), 22,000 acres[11] have so far been lost to agriculture due to this cause. In another 160,000 acres the ground water table is about 5 ft. below the ground surface while in still another 120,000 acres sub-soil water table stands between 5 to 10 feet. Water-logg ing is thus becoming a serious problem particularly in the canal irrigated areas of West Pakistan, in view of the absence of proper drainage facilities. A drainage system should have been provided along with the existing canals to avoid this calamity. It is, however, fortunate that we have now realised this mistake and steps are being taken to remedy this defeat. New canals are now lined to stop percolation of water from the beds, seepage drains are provided in water-logged areas and tube-wells installed to pump out sub-soil water from such places. Many such tube-wells are working particularly between the Jhelum and Chenab for purposes of reclamation.

In the former Sind water-logging and salinity are most rampant along the Rohri canal which takes off from the Sukkur Barrage on the left side of the river Indus. The sub-soil water since the opening of the canal in 1932 has come up to the very surface in the vicinity of the canal. It was about 15 to 20 feet below the ground level during the pre-barrage times and rose to 5 feet below the ground level over an area of 34 square miles within one year of the opening of the canal. The area completely submerged in water was 6 square miles in 1954 and 31 square miles in 1957. Area thrown completely out of cultivation was 16 square miles in 1953 and rose to 56 square miles in 1957.[12] About 200 villages were affected from 1933 to 1957 and the number of those completely deserted stood at 35 in 1957. The pumping stations installed in the former Khairpur State throw out 200 causecs of water back into the canal as against the water which seeps with a speed of 1,600 cubic feet per second from its sides. This measure indeed appears to be very inadequete and at the same time very ridiculous.

Incidentally, anti-water-logging measures also indirectly help in preventing salt formation by keeping the water-table below 10 feet of the ground surface. In the former Punjab Province, with comparatively steep slopes and coarse soil, these measures are often effctive at a moderate cost, but in the former Sind, with its flatter slopes and finer texture soil which is more susceptible to water-logging, comparatively costlier anti-water-logging measures are required. It is a healthy sign that a Soil Reclamation Board has been constituted by the government under the Soil Reclamation Act of 1952, to undertake reclamation projects. This board consists of members from various fields e.g., agriculture, forest, irrigation etc. The Board has already started work on many projects which are in different stages of execution.

## CONCLUSION

Soil erosion by wind and water is a greater menace to the economy of Pakistan than even salinity and water-logging. Surveys are still in progress, but, according to the White Paper (1958-59), "the irrigated area which is free from errosion covers 19 million acres of unirrigated land in suffering from wind and water erosion in varying degrees[13]." Thus accelerated soil erosion presents the country with a physical land crisis of enormous importance to the continuing welfare of agriculture in particular and the entire social structure in general. There can be no permanent cure of floods or prevention of stream and reservoir silting until run-off is better controlled, all the way from the crust of ridges down across the water sheds where floods originate and silt loads are picked up on the very channelways of streams which have limitations upon their carrying capacity. The solution of this problem further necessitates that the present forest cover, which is 4·6 percent of the total land area of West Pakistan as against the standard minimum of 25 percent, should also be considerably extended. A



sum of Rs. 9·4 million was provided, in the Five Year Plan, for soil conservation programme and Rs. 1·3 million for Soil Surveys which sum is indeed very small keeping in view the magnitude of the problem[14]. This figure becomes all the more insignificant when we learn that the Boyd Orr committee had estimated that the reclamation of an eroded area of 4·7 million acres in the districts of Attock, Rawalpindi, Jhelum, Gujrat, Sialkot, Shahpur and Mianwali would require at a modest rate an expenditure of Rs. 850 million.

Control of soil erosion is the first and the most essential step in the direction of correct land utilisation. It must be performed if a country is to avoid an inconceivably bad land situation. Italy, Japan, the United States of America the Union of South Africa etc, have reached the same conclusion and are now engaged in a fight against erosion in their respectives countries. It is heartening to find that systematic surveys are under way to classify land for treatment and use according to its capacity for sustained production. Steps are also being taken to test, evaluate and demonstrate engineering, agronomic, forestry and other agricultural methods for adoption by the farmers for water conservation, erosion control and increased food production. It is hoped that Pakistan would adopt adequate means to control soil erosion at the earliest, for it has now become a constant menace to our own security and the security of the posterity.

According to the First Five Years Plan, salinity and water-logging, had, by 1955, already affected over 6 million acres of land, to which over 50,000 acres are being added annually[15]. The rise of sub-soil water table resulting in salinity and water-logging has done incalculable harm to the country in many ways. During the past few decades, countless prosperous villages and other habitations have been partially or wholly wiped out and many a fertile land laid waste resulting in the shifting of people to other suitable sites.

It is heartening to note that a new method of arresting the seepage flow has recently been evolved and developed in U.S.A. by the Bureau of Reclamation in collaboration with the Agricultural and Mechanical College, Fort Collins, Colorodo. It consists in introducing in the flowing canal water, properly graded and treated colloidal particals of substance known as Bentonite. Particles of Bentonite have a wonderful property to attract fine sand and clay particles and ultimately in sealing the seepage passages, stopping entirely water percolation by forming a highly impervious clay lining. This method is cheap as compared to other forms of lining. Its cost is only 2 percent of the other standard types of lining per square foot of canal bed. As the employment of this method does not need the closure of canals and as it excellently suits our conditions we should, therefore, waste no time in implementing this measure.

During the course of his lecture Dr. H. Vlugter further suggested some measures to prevent salinity and water-logging. He said that he was convinced that a combined irrigation and drainage system would work out well under the meteorological, hydrological, agricultural, economic and social circumstances existing in Pakistan. According to him, if ground water-table is fixed at 3 to 4 feet below the surface, it will completely check water-logging. Although evaporation from such a water-table will be somewhat greater than in the case of 10 feet deep one, but it will not exceed one tenth of that of a free water-surface. In order to prevent salinity he suggested that rain plus irrigation water percolating through the soil must be more than the evapotranspiration at that place. This equation according to him will help in calculating the maximum quantity of water required for irrigation purposes.

It has now become clear from the foregoing that in a country like Pakistan where the economy entirely depends upon agriculture the three pronged attack on its soils viz: erosion, salinity and water-logging, presents the country with a physical land crisis of enormous importance to the continuing welfare of agriculture in particular and the entire social structure in general. It is these three demons that are mostly responsible in contributing to the low crop yeilds and in consequence aggravating the food situation in the country. In short they threaten the very basis of our civilization and human life. The conquest of soils, therefore, has to be made, and that too on the basis of national emergency lest the entire western wing of the country may be turned into a barren and dreary landscape not in a very distant future.

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10. Ibid, ... P. 41
11. Khan, M. I. R., ... Water and Soil Problem in Arid Regions, Pak. Journ. of Science, Vol. VII, No: 2. 1955, P. 91.
12. Ba Yunus, Ilyas., ... Water-Logging along the Rohri Canal, "Lyari", Karachi Vol. II/x/58.
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15. Orr, Boyd., ... Report of the Pakistan Agricultural Enquiry Committee, 1951-52, P. 12.
16. The First Five Year Plan, ... 1955-60 (Draft), Vol. II. 1956, P. 174.

# DRY FARMING IN PENINSULAR INDIA *

*By*

MRS. K. SITA

Agriculture in many parts of India is still a gamble in annual rainfall. In Bombay, Madras and Andhra there are extensive tracts which, for crop production, are mostly dependent on rainfall. The rainfall in these tracts is inadequate and extremely uncertain, both in quantity and seasonal distribution. For cultivators in these dry and precarious tracts the struggle for a livelihood is extremely hard and consequently their standards of living are low. The Royal Commission on Agriculture in India observes that "The problems of cultivation in such tracts in which the crops are entirely dependent upon rainfall are deserving of far closer attention than they have received from the agricultural departments. In the earlier years of their history the departments applied themselves first to research on those crops which offered the best prospects of success and which in the main were crops grown under irrigation. It happens, moreover, that those crops which have received least attention from the departments of agriculture, are amongst the typical crops in most irrigated districts" [1]. Though the problems of the farmer in unirrigated areas of sparse rainfall, have, during the last 50 years, received attention in many parts of the world, much more remains to be done in this field.

Dry farming, is defined as "the profitable production of useful crops without irrigation on lands that receive annually a rainfall of 20" or less. In districts of torrential rains, high winds, unfavourable distribution of rainfall and other water dissipating factors, the term dry-farming is also properly applied to farming without irrigation under an annual precipitation of 25" or even 30"[2]. In arid and semi-arid regions the main problem is the conservation of natural precipitation. The fundamental principle underlying dry farming is the most effective storage in the soil of the rainfall. Even under a rainfall of 12", if only half the water could be conserved, which experiments have shown to be feasible, there is a possibility of producing 30 bushels of wheat per acre every other year which ensures an excellent harvest on money and labour invested in the production of the crop[3]. In India also, 12" of rainfall, if well distributed, is sufficient to mature certain cereal crops.[4]

Nearly all the great civilisations of antiquity arose and flourished in arid and semi-arid countries as Egypt, Mesopotamia and the Indus Valley. As Hilgard has suggested, history teaches us that a high civilisation goes hand in hand with a soil that thirsts for water. In view of these facts it may be inferred that dry farming is an ancient practise. It is true that the great ancient nations, found it much easier to construct irrigation works which would make it possible to grow crops with a minimum of soil tillage than to till the soil so thoroughly with imperfect implements as to produce certain yields without irrigation.

* Adapted from a Dissertation submitted for the B.Sc. Hons. degree of the University of Madras.

1. *Royal Commission on Agriculture,*, Report, p. 116.
2. Widtsoe, J. A. *Dry Farming*, 1921, p. 1.
3. Widtsoe, op. cit,, p. 20.
4. Agricultural Journal of India, *Editorial*, 1908, p. 385.

The principles underlying dry-farming could be seen in the order of agricultural practices in many parts of the Indian sub-continent also. Henderson says that "a very interesting and an absolutely correct adoption of the principle is exemplified in the *bosi* and *sailaba* cultivation of Upper Sind. The difficult problem is the production of *rabi* crops such as wheat and oil-seeds. The cultivator, however, taught by ages of experience, first gets his land flooded, and keeps the water on as long as he can, by small bunds. As soon as the land dries so as to permit bullocks on it, it is carefully ploughed until a fine tilth is produced. Thereafter the ground is gone over with a heavy log and the surface carefully consolidated. This corresponds to the American sub-soil packer. A final light ploughing may be given. The ground will be left till sowing time in October or November or later, and sown by a small seed drill. This does not turn up the soil, and so the minimum of evaporation is secured. On good retentive soil, a fine crop can be raised without any further moisture being received, by irrigation water or rainfall"[5].

But the modern science of dry-farming originated in the U. S. A., where there are extensive areas receiving less than 20" of rainfall. The first dry-farming experiment was carried out in Utah in 1863, and soon after dry-farming was developed in California, Washington and the Great Plains. Soon it began to be realised that probably nearly all the arid and semi-arid sections of the U. S. A., could be made to produce profitable crops without irrigation.

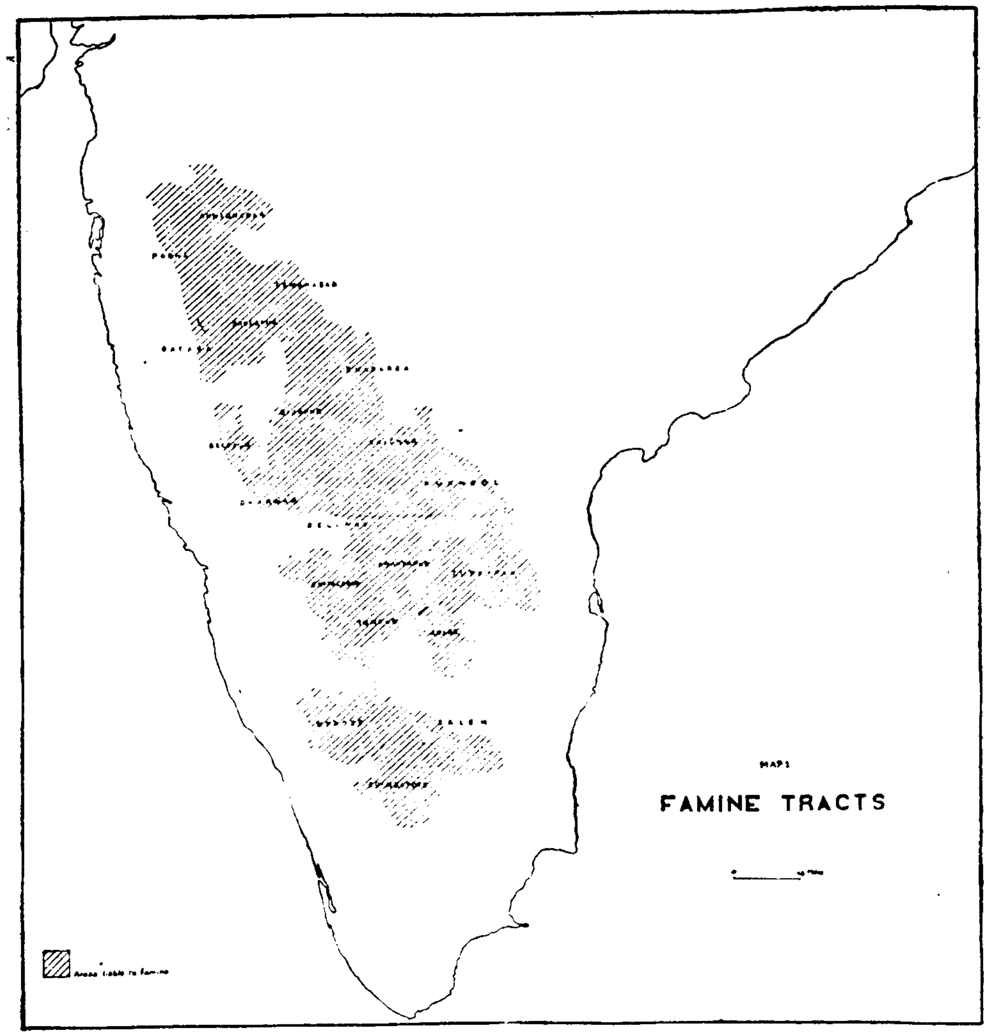
In India, in 1923-24 Dr. H. Mann, then Director of Agriculture (Bombay Presidency) was responsible for the first experiments along modern lines in the arid areas of Bombay[6]. Due to the inadequacy of local finances, proposals were made to the Imperial Council of Agricultural Research to carry out research. A grant was made to the Bombay Presidency and this was followed by grants to Madras, Punjab and Hyderabad (now Andhra). With the help of these grants a chain of 5 research stations were set up between 1933 and 1935 at Sholapur and Bijapur in the Bombay Presidency, Raichur in Hyderabad State, Hagari in Madras Presidency and Rohtak in the Punjab. Of the 5 experiment stations, four; Hagari, Sholapur, Bijapur and Raichur are in Peninsular India. Research at all these stations followed, three main lines of inquiry - (1) the conservation of water, (2) the study and improvement of soil conditions, and (3) the study of plant growth.

There are extensive tracts in South India, where nearly 90% of the agricultural lands are entirely dependent on the annual rainfall, which is not only very precarious, but has an unfavourable distribution from the point of view of crop production. It is these tracts which have suffered from famine very frequently (Map 1) It has been computed that nearly 1/3 of the total area of the Bombay state is very liable to produce famines and scarcities due either to total failure of rains or their unsuitable distributions[7]. The tract embraces the districts of Ahmadnagar, Sholapur and Bijapur in Eastern Deccan and eastern parts of Poona and Satara districts. Another 1/3 is also liable to famines though less frequently.

In Andhra Pradesh, the districts of Gulbarga and Osmanabad are liable to produce famines[8]. Other areas are the eastern parts of Kurnool,

5. Henderson, G. S *Indian Dry Farming*, A J. I, 1909, p. 84.
6. For more details see *Indian Farming*, Vol. V, No. 1, 1940, pp. 29-30.
7. Bombay Dry Farming Research Scheme, *Report*, 1933-35, p. 2.
8. Dry Farming Research Scheme, *Report*, Hyderabad, p. 2.

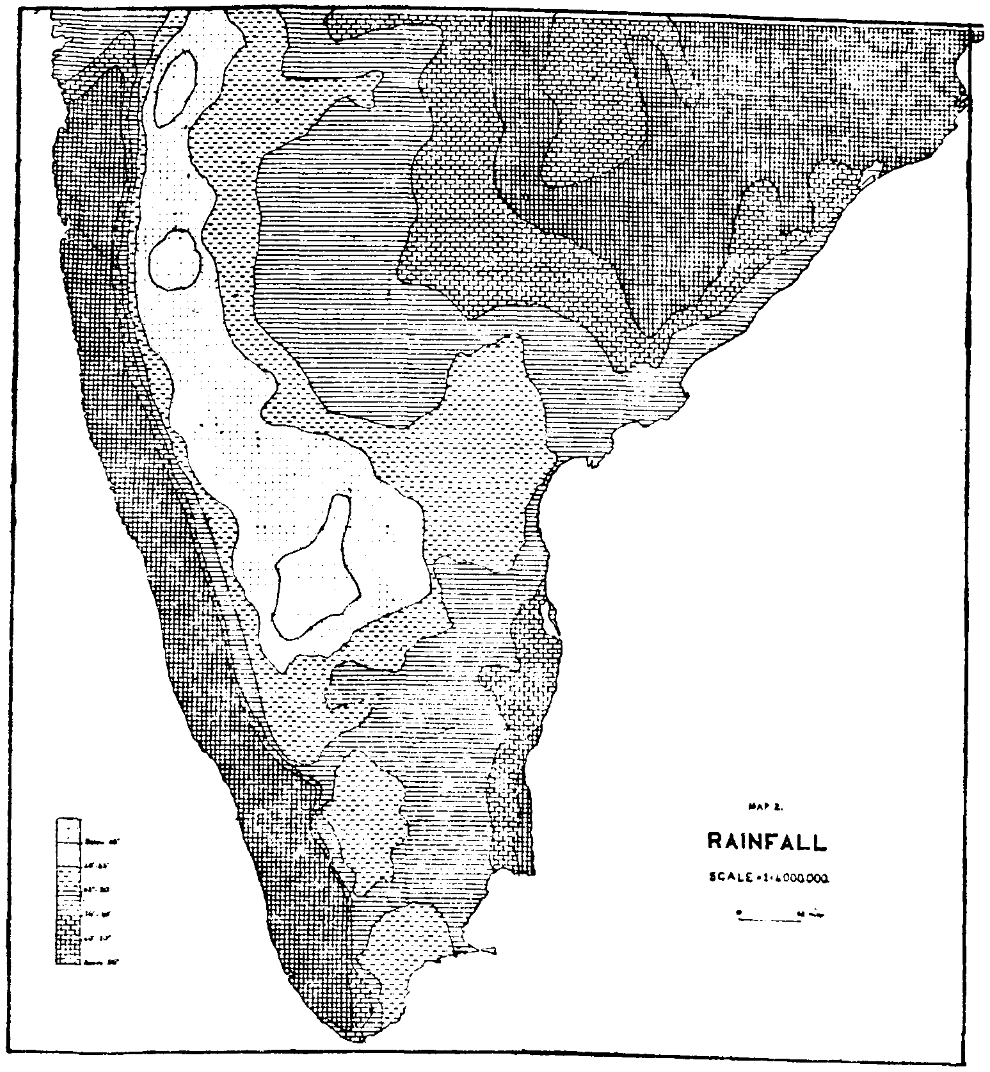





Bellary, Anantapur and Cuddappah, which have suffered from famine during the last 100 years. The middle part of Coimbatore district, Kollegal and the southern parts of Salem are the famine areas of Madras State. In Mysore State the chief famine areas are - Kolar, Dharwar, Belgaum and Chitaldrug districts.

In all the famine tracts the average annual rainfall is below 20"; it averages about 18" to 25" only in the year (Map 2). The problem of determining the effectiveness of precipitation is rendered complex by the fact that the amount of moisture available for plant growth depends not only on

9. Krishnaswamy, S. Y. *Rural Problems of Madras*, 1946, p. 106.
10. Ibid, p. 106.




the amount of rainfall but also on the loss by evaporation of which very few records are available. Thornthwaite devised a method by which the precipitation – evaporation temperature, and monthly precipitation are known. He has not taken other factors such as vapour pressure, wind and atmospheric pressure into account, as per him, "the resulting error makes no significant difference in the results,"[11]

He treats all lands having a P-E index of 16–31 as semi-arid and these having an index greater than 32 as humid. The P-E indices calculated for the 4 dry farming stations show that they all fall within Thornthwaite's 'semi-arid' province (Table I).

11. Thornthwaite, *Classification of climates*, American Geographical Review, 1931.



Later in 1948, Thornthwaite tried to determine the potential evapotranspiration, and calculated the moisture ratio based on this instead of on actual evapotraspiration[12]. Yet, as he himself, has admitted—"though the computed values of potential evapotranspiration are of the right order of magnitude throughout the United States, they are nevertheless only approximate...whether or not the formula can be used without modification to determine potential evapotranspiration in equitorial and polar regions is uncertain"[13]. The whole area lies in the rain-shadow of the Western Ghats. Only hope is the retreating monsoon, when some cyclonic rainfall occurs.

The uncertainty of the total rainfall in these arid tracts is indicated by the variations in the normal rainfall at the 4 dry-farming research stations (Table 2)[14]. This indicates that the normal rainfall is not obtained for more than 31% of the year at any station, and in some places in only 22–23% of the years.

The high variability of the annual rainfall at the 4 stations is given below for the period 1921–39;[15].

| *Station.* | | *Average rainfall.* | *%Variability.* |
|---|---|---|---|
| Sholapur | ... | 26·44″ | 23·0 |
| Bijapur | ... | 20·67″ | 29·4 |
| Raichur | ... | 23·93″ | 24·0 |
| Bellary | ... | 19·46″ | 32·4 |

Hence Bellary has the greatest variability *i.e.*, 32% and Raichur and Sholapur have the lowest. In addition to the high variability at Bellary, the total annual rainfall is also low.

Even when the rainfall is adequate in total quantity, it is often so badly distributed that partial or complete failure is a common occurrence. According to the monthly distribution of rainfall in these dry areas, three distinct types of rainfall distribution could be recognised :—[16].

(1) In the first type are included stations which though receiving rain fall from the south-west monsoon also receive rainfall from the retreating monsoon. The rainfall received from the south-west monsoon varies from 40% to 55% of the annual total while that during the retreating monsoon amounts from 40% to 50%.

(2) The second type includes places where the retreating monsoon is more important, accounting for 45% to 60% of the total rainfall of the year. The maximum rainfall is received in September and October or even November. Sholapur and Bijapur are typical examples in the Bombay Deccan, while Bellary, Anantapur, Koilpatti and Coimbatore are examples from the Madras Deccan and the Karnatak.

(3) The third type includes stations with a well distributed rainfall in 5 or 6 months received from both the monsoon currents *e.g.* Kurnool. The scarcity conditions in these tracts is due to a lower rainfall in all the months and therefore the lower annual total.

12. Thornthwaite, *An opproach toward a rational classification of climate*, Am. Geog. Re., 1948.
13. Ibid, p. 72.
14 Kanitkar, N. V. *Dry-Farming in India*, 1944, p. 5.
15. Ibid, p. 58
16. Ibid, p. 12.

The number of rainy days is usually very small, however, and there are long and irregular breaks in between the rains, Sholapur and Bijapur commonly experience dry spells up to three weeks duration, and breaks of five weeks are not unknown. These breaks facilitate the loss of soil moisture by evaporation.

The intensity of the showers varies in different months at the 4 stations. It is very high at Sholapur and Bijapur in the months of September and October and moderate during the early part of the monsoon. At Bellary, on account of the lower annual and monthly rainfall, the number of intensive showers is small in comparison with that at Sholapur and Bijapur. But this does not mean that the rainfall is more effective. "In order to wet the surface 1" of soil of the stations in the south, at least ½" of rainfall is necessary. It is only the showers of more than ½" received in 24 hours that soak in and wet the lower layers of the soil. But when these showers are of great intensity, there is no time for the water to sink and therefore water accumulates on the surface and is lost as surface run of"[17].

The other climatic features of these tracts are such that in all places there are certain desiccating factors during the crop growing period such as, high temperature, high wind velocity or high water vapour deficit in the atmosphere. In all the four stations the average maximum reached by the temperature in May is over 100° F, and the lowest average maximum temperature never falls below 80° F. These high temperatures together with the low humidity accelerate evaporation.

The data on monthly evaporation show that the monthly as well as the annual values are several times the rainfall of that period. The rate of evaporation is highest during the hot weather months and indicates how the high temperatures affect the soils, which lose all their moisture during these months. The evaporation is high even during the cold weather months. The high rates of evaporation, during the crop growing period indicate the possibilities of high transpiration from the crop plants, which may adversely affect the growth in years of low rainfall and during periods of draught.

The high rates of evaporation in these tracts are also due to high wind velocities prevalent in these tracts. The highest wind velocities are in July when it ranges from 6 to 8 m.p.h. respectively. Hence the period of high wind velocity coincides with the season of *Kharif* crops.

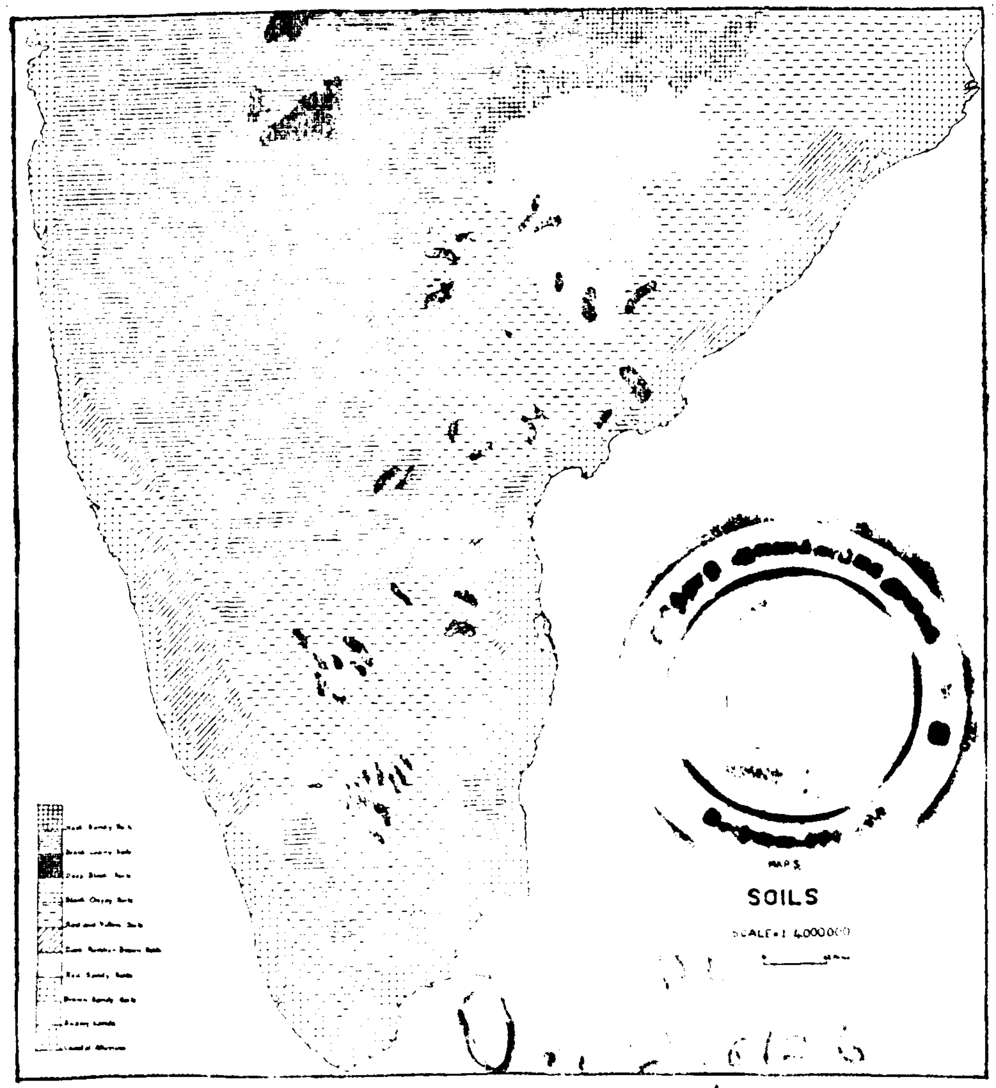
The areas which are chronically liable to famines consist of a series of undulations traversed by small or large *nallas* which from the natural drainage system of the tract, emptying all the surface washings finally into the Bay of Bengal. The surface is either hilly or rolling and only a limited area is of a level nature to be met with in the valleys. These topographical features make the retention of rain-water in the soil impossible, especially when rain is received in terrential heavy showers.

The scarcity tracts contain two great geological formations ;—(1) the Deccan trap, and (2) the granitic and gneissic rocks. The Deccan trap consists of almost horizontal layers of basalt rocks. On weathering these rocks give rise to the well known 'black cotton soils' or *Regur*. The two dry farming research stations at Sholapur and Bijapur are representatives of the region occupied by the Deccan trap and its associated soils. The other geographical system, consisting of crystalline granites and gneisses occupies

17. Kanitkar, N. V. op. cit.



by far, the largest part of the Peninsula. These rocks are usually associated with two distinct types of soil *i.e*, the red soil and the black soil. The two dry-farming research stations—Raichur and Hagari—are representatives of this area.




The successful growing of *Rabi* crops in these precarious tracts depends on the maximum absorption, and conservation of rain water. The storage capacity of the soil is primarily determined by the thickness of the soil layer. "Observations and experience (in the Sholapur and Ahmednagar districts) have shown that for conserving enough water to secure a *rabi* crop of *jowar*, the minimum thickness of soil cover is 18″"[18]. There is a very close relationship between the thickness of the soil cover and its position in relation to topographical features. Deep soils, having a depth of more than 18″ occur on the table lands of ridges and in the valleys, where the land is more or less level. It represents a fully matured soil and has undergone little erosion. In years of normal rainfall soils of this type can just hold enough moisture for crop production, where the slopes are gentle and erosion not very intensive, the soils vary from 9″–18″ in depth. Due to a greater degree of erosion, these soils have lost part of their 'A' horizons. Such soils can conserve moisture just sufficient for a moderate crop in a year of normal rainfall only under careful and proper cultivation. On steeper slopes, erosion has gone on to such an extent that the lands are composed of decomposed trap rock with very little soil left on the surface, the soils are less than 9″ in thickness and have lost the 'A' and part of 'B' horizons. Such lands are called "the *Mal* or *Maradhi*' lands[19] and are not likely to conserve enough moisture for growing *rabi* crop even with all due precautions. They are sometimes cultivated with *Kharif* crops.

In South and Central Bijapur, which are separated from north Bijapur by the river Krishna (which seems to be the southern boundary of the Deccan trap) the soils rest on rocks of older geological age, and are characterised by a great thickness. These soils have not been formed *in situ* by weathering of the parent rock but they consist of material transported and deposited by the River Don and its tributaries. After the original formation, they seem to have undergone great pedogenic changes under the arid climate conditions of the tract. The soil types belong to the typical 'black cotton soil' group, and as in the case of the soils formed *in situ* on the Deccan trap, could be grouped into three sub-types based on the degree of erosion undergone and consequent concentration of lime nodules or *Kankar*. The medium and limy soils contain a higher percentage of *Kanker*, which reduces the imperviousness, which is a typical character of the deep, black soil.

The soils of Sholapur and Bijapur are extremely clayey, the clay and silt together making up 80% of the whole soil. The clay content of the deep black soil at Sholapur is as much as 71%. But in spite of their high clay content, these soils are workable after the rains.

The water-holding capacity *i.e.* the moisteric equivalent of the soil types is very high[20].

Some single values of Sholapur and Bijapur Soils[21].

| Some single values | Sholapur soils | | | Bijapur soils | | |
|---|---|---|---|---|---|---|
| | Deep | Medium deep | Shallow | Deep | Medium | Limy |
| Moisture equivalent | 44·25 | 43·58 | 24·05 | 38·84 | 35·68 | 29·51 |
| Wiltering point | 21·23 | 20·10 | 13·03 | 13·92 | 16·84 | 14·27 |

18. Kanitkar, N. V. *Dry Farming in India*, 1944, p. 8.
19. Bombay Dry Farming Research Scheme, *Report*, 1933-35, p. 4.
20. Kanitkar, op. cit.
21. Ibid, pp. 95-96.



But the high water holding capacity of soils is counter balanced by their high wilting points. In this respect the Bijapur soils are superior to the deeper soils of Sholapur. Though the deep and medium deep soils of Sholapur are capable of holding a higher percentage of moisture, nearly half of this is unavailable, in the deep soil about 22%—24% of the soil moisture is available for plant growth, while the light shallow soil has only 11% available for plant growth.

Very little information is available regarding the soil types in the extensive dry tracts of the Andhra State. It is a continuation of the Deccan trap and therefore the soils derived from it are similar to those found in the Bombay Deccan. The southern district of Raichur, however, has another geological formation of the granitic and gneissic rocks of the Archean age. Raichur forms only a part of the vast area of southern peninsular India occupied by this ancient crystalline complex. In these areas, two main types of soils, red soils and black soils are met with.

The red soils of medium depth are also to be found in low-lying positions, while the red soils are usually met with on steeper slopes. The red soils have a high percentage of sand, which renders them porous, allowing easy penetration of rain water. These are most suitable for *Kharif* crops. The black soils, on the other hand, show a high clay content, which varies from 45%—68%.

Moisture equivalents, for a few samples of the black soil at Hagari, varied from 34.6 to 39.5[22]. The wiltring co-efficient for these soil is 18%[23]. Hence the moisture equivalent of these soils is lower than that of the Sholapur and Bijapur soils, and more than half of this moisture is unavailable for plant growth.

One important feature about all these precarious tracts is the fact they are primarily millet-growing areas, millets being the staple food grain of the bulk of the population. The most important millets grown are Sorghum or *Jowar*, Ballrush millet or *bajra*, Italian millet (*Setaria Italica*) and minor millets *e.g. ragi*. *Jowar* is the important millet in the Bombay Deccan and Andhra, while *Setaria* is more popular in the dry districts of Madras.

Experiments have shown that the water requirement of sorghum is influenced by the soil type. It is estimated that on the clayey soil of Sholapur a crop of sorghum, weighing one ton per acre would require 4.25″ of rain water for transpiration. This may, however, vary from 3″ to 5″ of rainfall in different years. The combined loss by evaporation and transpiration amounts to about 10″ of rainfall.

The outstanding problem of the precarious tracts is thus a problem of ensuring the successful growth of at least one millet crop every year under the peculiar climatological and soil conditions of the tract. Irrigation is undoubtedly the surest form of protection that could be given to these precarious tracts, but irrigation possibilities are strictly limited, as is shown by the following table[24].

22. Ibid, p. 97.
23. Madras Dry Farming Scheme, *Report*, 1938-39 p. 10.
24. Kanitkar, Ibid, p. 19.

*Areas affected by droughts and famines in South India* :
(in 1000 acres).

| *State.* | | *Total cultivated area.* | *Total irrigated areas.* |
|---|---|---|---|
| Bombay | ... | 12862 | 305 |
| Madras | ... | 13467 | 1248 |
| Andhra | ... | 13299 | 401 |
| Mysore | ... | 4877 | 415 |
| Total | ... | 44505 | 5069 |

Hence the total irrigated area represents but 11·4% of the total area cropped. For the solution of our problem, therefore, we are thrown back on purely cultural and agronomical methods that will ensure the successful cultivation of crops solely on the rainfall. Thus stated the problem of the the precarious tract, in its simplest and most immediate form, is problem of optimum moisture conservation, which, goes hand in hand with soil conservation.

As the rainfall is the only source of water for raising crops for nearly 90% of the land in the famine areas, investigations into the disposal of rain water naturally form an important plank in any work in Dry Farming. The following are the 5 ways of the disposal of rain water :—(1) surface run-off, (2) underground drainage, (3) evaporation in the air, (4) utilisation by vegetation, (5) retention in the soil.

The surface run-off is normally large and is a serious loss, especially in dry-farming regions, where the absence of luxurient vegetation, and the hard, sun-baked soils tend to increase the loss sustained in this manner. The results of the run-off experiments conducted at Hagari have shown that a large percentage of the rainfall is lost by surface flow.[25] In Bijapur also, the average run-off is also 41·10 [26].

Run-off results only when the soil is not able to absorb rain water as fast as it is received. The amount of run-off necessarily depends upon the intensity of the rainfall. It has been pointed out that in these tracts rainfall of more than ½″ intensity are really useful showers, as they can penetrate deeper in the lower layers, where they could be conserved for use of the crop, but it has been found that it is most of these showers that usually cause run-off.

The effect of run-off is only temporary but the loss of soil by erosion is a permanent loss, resulting in cumulative deterioration of the land. Intense storms not only contribute most to run-off but their scouring action does great harm and removes much of the valuable surface soil.[27]

The remainder of the rain water *i.e.*, that not lost by surface run-off, enters the soil layer. A portion of this water remains near the surface, and is rapidly evaporated back into the air. The depth to which the water penetrates depends on the soil type. It has been observed that one inch

25. Subba Rao, A. *Soil erosion and conservation of moisture in un-irrigated black soils*, M.A J., Vol 31, p. 7.
26. Kanitkar, op. cit., p. 134.
27. For details regarding the Hagari storm. See Subba Rao, op. cit., p. 8.



of rainfall received on dry land could moisten only a soil layer of two inch thickness in the case of clayey soils, whereas the same rainfall can penetrate and moisten a layer of 6″ thickness in the case of sandy soils. Results of experiments at Sholapur and Manjri, show that in years of average rainfall, the loss by evaporation is about 71% to 75% of the annual rainfall from clean fallow plots receiving frequent and shallow cultivation. In years of low rainfall or well-distributed rainfall, however, the loss by evaporation was either equal to the rainfall or exceeded the total rainfall as is in the years 1934-35 and 1936-37 respectively.

Experiments at Bijapur have shown that 68% of the annual rainfall is lost by evaporation, while at Hagari the loss by evaporation was 65% of the annual rainfall.

A part of the rain-water absorbed by the soil seeps through the soil and in the case of shallow soils is likely to be lost through underground drainage. In the early years of this century, some writers believed that the rainfall under dry farm conditions never penetrated beyond 3′ or 4′ deep[29]. But soil boring in the Great Basin revealed that moisture existed in considerable quantities even at a depth of 10′. Leather found that in the calcareous arid soils of India, the upper 5′ contained 18% of the water. But in general, where the the soils have a depth of more than 3′ or 4′, the loss of rain water by underground drainage is very limited. But in the shallow soils of the Bombay Deccan drainage is an important water dissipating factor.

The rain water absorbed by the soil, and which is not lost either as evaporation or drainage, constitutes the soil moisture. Plants take up moisture from the soil through their roots, but they are unable to absorb all the moisture contained in it. The extent to which a soil parts with its water depends on the soil. Soil moisture below a certain point is unavailable for plant growth, and therefore when the moisture content falls below this point, plants wilt or wither. The weathering coefficients of the different types of soils found in the scarcity tracts has already been pointed out, and it has been pointed out that more than ⅓ the soil moisture was unavailable for plant growth.

It is clear that the quantity of water, required to produce a crop of sorghum weighing one ton from one acre of medium deep soil at Sholapur, has been found to be about 4″ of rainfall. The fact that the average yield of the sorghum crop obtained in these areas is less than half ton of total dry matter per acre, indicates that out of an average rainfall of 26″, the available quantity of water is less than four inches.

As water is the primary limiting factor in crop production in the scarcity areas, the experiments carried out at the various dry farming research stations to determine the disposal of rain water have thrown light on the causes of crop failures, and indicated practical measures or remedies to be adopted for preventing the frequent failures of crops in the scarcity tracts. The practical methods evolved for these tracts, known as *dry-farming* methods may now be briefly reviewed.

It has already been pointed out that on an average 35% to 40% of the rain which falls in the form of effective showers of more than ½″ in 24 hours, or nearly 20% of the annual rainfall, is lost as surface run-off. The large

28. Kanitkar, op. cit., p 148.
29. Widtsoe, J. A , op. cit.

amount of rainfall lost as surface run-off is mainly due to undulating topography and the condition of the soil when the rains fall. The effects of the topography are minimised by bunding, the object of which is to allow every small portion of the land to receive, absorb and conserve its own quota of water that falls on it as rain. The land is divided and sub-divided into small units which should receive and absorb the whole of the rain, whenever it comes. The exact size of each division would depend on various factors such as the slope of the land, the nature of the soil, the depth of the soil and the usual intensity of rainfall.

A well-ploughed soil with loose spongy texture at the surface absorbs rain water more readily and thus most of the water escapes the desiccating influence of sun-shine and winds. The deeper the soil is ploughed the greater the depth of loose soil available for retaining a large quantity of water for the use of the crop. In order to effect the maximum absorption of rain water the land should be ploughed before the onset of the rains. The following table shows the beneficial effects of ploughing and bunding[30] :—

| *Treatment.* | | *Percentage of rainfall absorbed by the soil.* |
|---|---|---|
| Control (no bundling, no ploughing) | ... | 10% |
| Bunded only | ... | 28·6% |
| Ploughed and bunded | ... | 40·6% |

The usefulness of throwing the land into pockets is shown by the following figures for the run-off obtained in 1938-39[31] :—

| | *Control Plot.* | *Scooped Plot.* |
|---|---|---|
| Number of days when there was run-off ... | 13 | 10 |
| Total rainfall when there was run-off in either of the plots ... | 15·66″ | 15·66″ |
| Silt washed in tons per acre ... | 9·86 | 3·60 |
| Rainwater lost in inches ... | 7·52 | 3·29 |

In the control plot about 50% of the total rain water was lost as surface run-off. The pockets into which one of the run-off plots was thrown, effectively decreased the run-off water to less than half the value for the control plot, while the silt washed off, was nearly 1/3 of the value for the cropped plot.

In addition to these mechanical methods of control of surface run-off and erosion, cultivation of crops should be done in such a way that the maximum protection to the soil is offered for as long a period as possible during the rainy season. Strip cropping is one of the best examples among the methods of biological control of erosion. The principle of strip cropping is to alternate strips of erosion - permitting with erosion resisting crops. For example, wide spaced, clean-tilled crops like cotton offer the least resistance to erosion, while close growing crops like 'Setaria' or ground-nut offer the maximum resistance to erosion. Under the local conditions of Hagari, the mixtures of 'Setaria' and cotton are sown, which could easily be replaced by strips of 'Setaria' and cotton. Not only is this anti-erosive, but it was found that there was minimum of root competition in such an arrangement[32].

30. Subba Rao, op. cit., p. 246.
31. Ibid, p. 245
32. Madras Dry Farming Scheme, *Report*, 1939-40, p. 58.



Under the climatic conditions prevailing in the scarcity tracts it has been shown that a large quantity of the water absorbed by the soil is lost by evaporation. A soil compacted at the surface loses a larger quantity of water by evaporation than a soil kept loose at the surface by tillage. If the surface of the soil is kept in good mulch it arrests the movement of water to the surface where it could be positively lost by heavy evaporatian. A 3″ to 4″ thick layer of loose dry soil is most effective in minimising the loss of soil moisture. By the formation of soil mulch it was found that it was possible to save nearly 70% of the soil moisture lost by evaporation from a control plot[33]. This increase of moisture is useful for sowing *rabi* crops. Mulching is more effective on a heavy soil than on a light one. Some loamy soils are self-mulching *i.e.* under arid conditions they dry up quickly and thus form a natural nil mulch on the surface. For the formation of soil mulch it is necessary to plough the fields after each heavy shower of rain.

Besides soil mulch, artificial mulches have also been tried with significant success in the experiments conducted in Sholapur and Rohtak. An artificial mulch may be formed by covering the ground with any kind of vegetable, sand or paper debris. If the winds are intense there is a liability for the debris to be blown away before the onset of the monsoon, and therefore they are spread immediately after the first shower of rain. At Sholapur, it was found that artificial mulches were not as effective in controlling evaporation as soil mulch. On the other hand at Rohtak it was found that 60% of the soil moisture was lost before the soil was fit for cultivation and soil mulch could be formed[34]. It was found that artificial mulch conserved more water than the soil mulch as the former saved the water lost, during the period the soil was wet and unsuitable for the formation of soil mulch. Sand conserved water better than vegetable debris, and hence soils covered with a layer of sand give better yields, *e.g.* in Hissar district where medium loamy-soils have been covered with sand by the storms blowing over the area.

The amount of soil moisture lost by evaporation also depends on the moisture status of the soil when the rain falls. If the soil is dry, the downward movement of the water is much slower and the bulk of the water is then stored near the surface, where the loss due to evaporation goes on most rapidly. Thus it would seem that as the lower soil layers are moistered, the water is enabled to slide down. It is dangerous to allow the soil of a dry farm to become very dry, especially below the first root. Atkinson found at the Montana (U.S.A.) that soil which to a depth of 9′ contained 7·7% of moisture in the fall, contained 11.5% in the spring, and after carrying it through the summer by proper methods of cultivation 11%. Therefore, it may be concluded that it is possible to carry out soil moisture from season to season. Storing of water to relatively great soil depths, away from the direct action of the sunshine and winds is a fundamental principle in successful dry farming.

Since the soil moisture could be carried over from season to season, it follows that the rainfall of successive years could be stored in the soil for the use of one crop *i.e.* where the practice of clean following or resting the ground with proper cultivation for one season is followed the farmer is enabled to store in the soil the large portion of the rainfall of two years to be used for one crop.

33. Kanitkar, op. cit , p. 197.
34. Nijhwan, S D. *Conservation of soil moisture under Dry Farming*, Indian Forester, Vol. V, 1944.
35. Widtsoe, op. cit.

*Rainfall (in inches).*[36]

| 1937 | 1938 | 1939 | 1940 | 1941 |
|---|---|---|---|---|
| 18·44 | 8·64 | 9·30 | 16·96 | 16·83 |

| Intensity of cropping | Percentage on over dry soil | | | |
|---|---|---|---|---|
| | 1937 | 1938 | 1939 | 1941 |
| (1) One crop every year—100% intensity ... | 9·08 | 9·06 | 9·08 | 9·43 |
| (2) Two crops every three years—66% intensity ... | 13·85 | 11·41 | 10·32 | 14·09 |

Thus, there is always more moisture in fallow plots than in cropped plots and it was due to this deep-seated moisture reserve that a fair crop was raised from these plots during the famine years of 1938 and 1939 when not a blade could be raised from the plots cropped every year.

The following are the results of experiments conducted at Hagari[37].—

*Moisture absorption in plots having a crop after a fallow, and having a crop after the crop. Losses in moisture % between 15-10-40 and 16-1-41.*

| | 0·6″ | 6″–12″ | 12″–24″ | 24″–36″ | Over 36″ |
|---|---|---|---|---|---|
| Sorghum after cotton ... | 19·4 | 13·1 | 12·2 | 2·1 | 4·90 |
| Sorghum after fallow ... | 21·1 | 14·2 | 11·5 | 10·1 | 6·29 |

It will be seen from the above table that a crop after a year of fallow absorbs moisture from the third-foot-layer also, while in plots which are continuously cropped absorption of moisture from the third-foot-layer is negligible. The extra moisture in the plots after fallow is used in the production of extra dry matter. "In view of the uncertainty of the seasons, however, fallowing of a large area cannot be recommended to the cultivators. Fallowing of a small proportion of the holding as an insurance against famine is feasible."[38].

Experiments to determine the optimum plant population and spacing of plants have been carried out at all research stations. The results indicate that the seed rate should be kept at 4 lbs. per acre instead of 6 to 8 lbs. used by the cultivators and sowing should be done with a drill having coulters spaced 18″ apart. The 18″ wide sowing facilitates interculturing operations even at the later stages of the crop growth. The lower seed rate not only reduces the soil moisture lost by transpiration from the plants, but also secures a high grain yield, which is usually the most important objective of the cultivators in the scarcity tracts. It may however be pointed out that the straw yield as measured by weight suffers in no way and in fact the method ensures a proper balance between grain and straw.

36. Singh, D. and Dayal, S. *The role of fallowing under dry farming*, Ind. Far. Vol. V, 1944.
37. Subba Rao, op. cit., p. 51.



The water holding capacity of soil depends upon the humus content, but there are conflicting opinions as to the influence of humus upon the water holding capacity of the soil. Some believe that it is increased, and that it regulates soil aeration, favours root-development and hastens the activities of micro-organisms in the soil. But experiments have shown that it is not advisable to put in heavy doses of organic manure under dry farming. The application of manure enables the crop to draw water from the lower layers of the soil. "The crop in the manured plot takes 20% of its total water requirements from the third-foot layer while the crop in the untreated plot does not take any water from the third-foot layer[39]. Therefore the crop in the manured plot puts on luxurient vegetative growth at the expense of moisture in the soil. Hence in seasons of low rainfall the manured plots are depleted of their soil moisture and this results in a yield of grain lower than in the unmanured plots.

*Yield of Bajra (in lbs. per acre).*[40]

| | 1936 | | 1939 | |
|---|---|---|---|---|
| | Grain | Straw | Grain | Straw |
| Manured ... | 1942 | 4392 | 413 | 1238 |
| Un-manured ... | 912 | 4642 | 397 | 813 |

But manure when applied in moderate doses does have a beneficial effect. It has been pointed out that the soils, in these scarcity tracts, due to their high clay content are able to hold a large quantity of rain water, but a large part of this soil moisture is held firmly by the soil colloids. Manuring results in increasing the amount of available moisture, which is utilised in producing a greater quantity of dry matter.

Weeds also dessicate the soil of its moisture and reduce the moisture content to such a low extent, as to inhibit the growth of a crop. "The water requirement of some of the typical weeds was found to be higher than that of *jowar*[41]" By keeping a plot free of weeds, it is possible to save 300-500 tons of water in an acre of soil to 6′ depth *i.e.*, 3″ to 5″ of rain water[42]. Therefore, land should be kept free of weeds under dry-farming conditions. This does not involve additional labour, and weed eradication is incidental to mulch formation, as the cultivation done to form soil mulch could also keep down the weeds.

Rotation of crops has also been found to be distinctly beneficial under-dry farming conditions, as the different plants absorb moisture from different depths. For example, deep rooted plants like cotton, when rotated with plants with shallow roots, penetrate into the lower layers of the soil and utilise the entrapped moisture. Experiments conducted at Bijapur to determine the advantage of crop rotation over continuous *jowar* cropping, showed that *jowar* combined with cotton gave an increase in grain yields of 15% on deep black

38. Ibid. p. 52.
39. Nijwan, S. D., op. cit.
40. Ibid.
41. Karitkar, op. cit., p. 252.
42. Nijhawah, op. cit.

soils, and about 40% on loamy soils. In the Sholapur district the soils are comparatively shallow, and therefore cotton cannot be grown in rotation with *jowar* in a major part of the district. But if gram is grown as a rotation crop, the *jowar* yield was found to increase by 10%.

But the average low yields in these scarcity tracts is not only due to lack of adequate moisture, but also due to the low fertility of the soil, which has declined due to annual erosion and cropping. Manuring adds directly to the plant food in these soils, but the fertility could also be raised by fallowing and crop rotation. One of the chief values of fallowing lies in the liberation of plant feed during the fallow year, which reduces the quantity of water lost the next year for the growing crops. " The results of analysis show that fallow plots are more fertile and contain more available phosphorous, potash and nitrogen than cropped plots[43] ".

Rotation of crops increases the fertility of the soil; cotton as a rotation crop adds much organic matter to the soil by the leaf fall from the plants; leguminous crops like gram, ground-nut, etc., enrich the soil by the addition of nitrogen and some organic matter.

As a result of the experiments carried out in Sholapur and Bijapur, the Bombay Dry Farming Scheme (B.D.F.) was drawn up, which consists of the following operations[44].

(1) Ploughing at least once in three years, (2) bunding and terracing the land, (3) manuring (either farm-yard manure or green manure), (4) repeated harrowings during monsoon months before sowing, (5) sowing with a moderate seed-rate of 4—5 lbs. per acre with a wider drill, and (6) repeated stirring of the surface soil. The B.D.F. also advocates a rotation of crops and fallowing a part of the field and taking a crop in alternate years.

The dry-farming system is, however, intended only for lands having black cotton soils, and it is applicable to *rabi* crops. The system is not applicable to light or shallow soils or to the so called *mal* lands containing disintegrated rock. But experiments at Sholapur have shown that the B.D.F. system with more modifications is applicable even to such soils. The principal modifications are that ploughing should be carried out annually, only two borrowings need be given and sowing be in rows 12" apart, two inter-culturings with hoes should be given at intervals of one month. Contour cultivation and strip cropping appear to be of particular value in *mal* lands.

The B.D.F. system could be applied in the dry areas of Madras and Andhra also, with slight modifications; the main modification being that the land should be ploughed in alternate years.

Kanitkar has worked out the economies of Dry Farming method and Cultivators' Method, and shown that the dry farming method gives 50% more income after meeting the extra cash expenditure involved in the improved method[45]. Besides, by the adoption of the improved method a fairly good yield of grain could be got even in scarcity years, when the cultivators' crop fail to produce any ear heads; and it is in such years, which occur very frequently in these tracts that the value of the improved method is most apparent.

43. Widtsoe, J. A *Dry Farming* 1911.
44. Indian Forester. *Good crops with little rain.*, Vol. I, 1950, pp. 30-31.
45. Kanitkar, op. cit., p. 323.



But any farming does not offer a solution for all the famine tracts. There is a lower limit of rainfall, beyond which even dry-farming methods are not effective for the growth of crops. It has been found that the moisture condition of the soil at the sowing time is a determining factor. Where the moisture content of the top three feet of soil is below 20% at the time of sowing, which happens with a rainfall of 15", it results in a very bad year[46]. Hence we may take 15" annual isohyet as forming the lower limit beyond which, even dry farming fails as a solution in the scarcity tracts. Though many of the famine tracts in north India receive less than 15" and some even less than 5" of annual rainfall, in peninsular India there are no extensive tracts receiving less than 15". Hence all the famine tracts of South India could be benefitted by the practice of dry-farming *i.e.*, an area of nearly 39.5 m. acres (excluding about 5 m. acres which are protected by irrigation). This indicates the magnitude of the problem which could be tackled successfully, at least in part, by dry-farming.

Though dry-farming could never be a substitute for irrigation in the semiarid tracts, yet the conditions are such that it is the only practical solution for the scarcity tracts. As against irrigation which involves a large capital outlay, dry-farming requires a small initial investment, and therefore is within the reach of the poor cultivators of India.

This is what dry-farming could do for the famine areas of Peninsular India. The experimental stage is not yet over, but the basic principles have been established. It is for the cultivators now to apply the results of scientific research and reap the rewards of their labour undaunted by the vagaries of the monsoon.

46. Madras Dry Farming Scheme, *Report*, 1938-39, p. 4.

TABLE I

| Station | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | P.E. Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sholapur | 0·1227 | 0·2548 | 0·2794 | 0·6808 | 0·4763 | 4·463 | 4·826 | 4·695 | 7 818 | 3·668 | 2·197 | 0·2493 | 29·7303 |
| Bijapur | 0·3118 | 0·1043 | 0· 442 | 0 9482 | 0·9348 | 3·031 | 3·106 | 2 892 | 6·868 | 3·845 | 1·843 | 0·2251 | 24·3534 |
| Raichur | 0·1263 | 0·3738 | 0·1153 | 0·4063 | 0·8279 | 3·810 | 5·291 | 5·027 | 6·117 | 3·433 | 1·656 | 0·07017 | 27·2538 |
| Hagari | 0·0507 | 0·2200 | 0·1710 | 0·8678 | 1·3200 | 1·2230 | 1·546 | 3·106 | 5·077 | 5·876 | 1·972 | 0·2362 | 21·6657 |

TABLE II

NORMAL RAINFALL AT THE FOUR STATIONS

| Stations | Rainfall in inches | No. of years averaged | Rainfall below normal | | Rainfall above normal | | Rainfall nearly normal | |
|---|---|---|---|---|---|---|---|---|
| | | | No of years | % | No. of years | % | No. of years | % |
| Sholapur | 27·64 | 87 | 34 | 39 | 33 | 38 | 20 | 23 |
| Bijapur | 22·67 | 71 | 23 | 32 | 26 | 37 | 22 | 31 |
| Raichur | 25·15 | 65 | 25 | 38 | 20 | 31 | 20 | 31 |
| Bellary | 19·32 | 86 | 35 | 41 | 32 | 37 | 19 | 23 |

# SELF-SUFFICIENCY OF TAMILNAD IN FOODGRAINS*

*By*

MRS. V. KRISHNAN

" Our immediate task is to meet the basic needs of the people. Every national should have food to eat, clothes to wear and shelter to protect him from cold and heat. We, men and women of India, have to see that the nation attains self-sufficiency in food and stops all imports by 1951 ".[1]

The Government of India wanted to attain self-sufficiency in food by 1951. How far this has been possible, we are not going to enquire into here; but there were top ranking politicians and economists who believed that " India produces enough food to feed her millions and that the so-called food shortage is due to rationing and that if rationing is abolished everything will be alright ". Perhaps, these people in considering the question of food supply treat India as a composite unit and do not take into account the different sub-regions into which India could be divided. Perhaps, it would be better to aim at some degree of regional self-sufficiency for such an aim might not only bring the country nearer the goal of self sufficiency but is also likely to safeguard against possible interruption in the transport system of the country. The example of the Soviet Union with its three successful Five Year Plans (the main object of which-especially of the Third Five Year Plan-was to attain regional self-sufficiency) is before us and with efficient and wise planning we too can attain self-sufficiency in food. If such be our object then it is worthwhile enquiring into the potentialities of each sub-region in India and see to what extent it is self-sufficient with regard to its food requirements. One such sub-region is Tamilnad,[2] which forms one of the many politico-geographical regions into which India has been divided.

A well balanced diet as conceived by Dr. Aykroyd is given below[3] :—

| | | |
|---|---|---|
| Rice | ... | 10 ozs. |
| Cambu | .... | 5 ,, |
| Milk | ... | 8 ,, |
| Pulses | ... | 3 ,, |
| Non-leafy vegetables | ... | 6 ,, |
| Leafy vegetables | ... | 4 ,, |
| Gingelly oil | ... | 2 ,, |
| Fruit | ... | 2 ,, |

The composition of this well balanced diet is as follows :—

| | | |
|---|---|---|
| Carbohydrate | ... | 408 grams. |
| Protein | ... | 73 ,, |
| Fat | ... | 74 ,, |
| Calories | ... | 2590 ,, |
| Calcium | ... | 1·2 ,, |
| Phosphorous | ... | 1·47 ,, |

* Adapted from a Dissertation submitted for the B.Sc. (Hons.) Degree of the University of Madras.

1. Jawaharlal Nehru, Public Speech, Feb. 1951. Later on the target was fixed for 1952.
2. Tamilnad, in this essay, is taken to include those districts that go by the name of Tamil Districts viz. Chingleput, South Arcot, North Arcot, Salem, Coimbatore, Trichy, Tanjore, Madura, Ramnad and Tinnevelly.
3. After *Health Bulletin*, No. 23.

| | | |
|---|---|---|
| Iron | ... | 44·00 ,, |
| Vitamin "A" | ... | Over 7000 I.U. |
| Vitamin "B" | ... | ,, 400 I.U. |
| Vitamin "C" | ... | About 170 mgms. |

This diet is given for purposes of comparison with the existing south Indian diets.

Before proceeding further to analyse the principal diet groups of Tamilnad and see how far these come up to the standard as regards the protein, fat and vitamin requirements, it is better we look into some of the factors that determine the composition of the diet of the people and consequently its nutritive value. They are, in short, discussed below:

(1) *Religion*, bringing as it does taboos forbidding certain foodstuffs, may be expected to have a great influence on the composition of diet.

(2) The *geographical situation* of a region modifies to a great extent the composition of the diet. Different regions have different climatic conditions consequent on their geographical location. This results in different kinds of grains being produced in different regions and the one cereal which is produced most in a particular region forms the staple cereal in the peoples' diet. Thus the interior districts of Tamilnad, being dry and not having adequate facilities for irrigation to raise such a semi-aquatic crop as rice, produce large quantities of millets and hence, millets form the staple cereal in the diet of a large number of people there. Again, the geographical situation of Tanjore at the delta of the Cauvery, favours the construction of a net work of channels and so it produces abundant quantities of rice *and more than* 95% of its population consume rice.

(3) *Social factors* also play a role in determining the nutritive value of diet—especially in areas where rice forms the staple cereal in the diet. Generally, in urban areas milled rice, much less nutritive than un-pounded rice, is eaten and "amongst some classes of community the use of highly milled rice is associated with ideas of social superiority. In the same way raw rice which is preferred by the Brahmin community is considered to be most civilised than pre-boiled rice which is really more nutritive than milled rice".[4]

(4) Lastly, *economic status* is the limiting factor in determining the quantity and quality of food taken. This last mentioned factor is the most important one influencing the diet of the people not only in India but in the whole world.

Now we will discuss about the diet groups that prevail in Tamilnad. The diet given below could be taken as typical of that of the agricultural labourer of Madras[5]:—

| | | |
|---|---|---|
| Rice | ... | 15 ozs. |
| Millets | ... | 2 ,, |
| Pulses | ... | 0·5 ,, |
| Leafy vegetables | ... | 0·3 ,, |
| Non-leafy vegetables | ... | 0·9 ,, |
| Vegetable oils | ... | 0·1 ,, |
| Meat, fish and egg | ... | 0·8 ,, |

4. *Health Bulletin*, No. 28.
5. After Dr. Aykroyd - *Diet Surveys in India.*



Composition of the diet:

| | | |
|---|---|---|
| Proteins | ... | 37 gms. |
| Fats | ... | 10 ,, |
| Carbohydrates | .... | 438 ,, |
| Calories | .... | 1990 ,, |

(96% of calories are derived from cereals).

A glance at the diet given above reveals that cereals form the most important item in the diet. In addition to his staple cereal, the labourer consumes only small quantities of pulses, vegetables and meat. Consumption of milk and fruits is negligible. Judged by conventional standard it is seen that protein and fat intake is very low. There is an almost complete absence of protein and fat intake being dependent on the nature of the cereal consumed. If millet forms the staple cereal in the diet, the protein and fat intake will be a little higher, since the millet has a higher content of these food constituents than rice. The intake of mineral salts falls below conventional standards. Vitamin "A" is lacking completely. Even the total caloric value of the food taken is inadequate. Thus we find that the diet of the average South Indian peasant is dificient from the stand point of both quantity and quality.

Middle class diets differ from those of the poorer classes chiefly in containing more vegetables, fruits and milk products and smaller proportion of cereals. So there is a greater amount of protein and fat intake and cereals supply a lesser percentage of the total caloric intake. The following diet will illustrate this point[6]:—

| | | |
|---|---|---|
| Raw milled rice | ... | 11·31 ozs. |
| Par boiled rice | ... | 2·56 ,, |
| Pulses | ... | 1·63 ,, |
| Vegetables | ... | 1·64 ,, |
| Fruits | ... | ·43 ,, |
| Nuts | ... | ·74 ,, |
| Gingelly oil | ... | ·85 ,, |
| Milk | ... | 10·49 ,, |
| Jaggery | ... | ·35 ,, |
| White sugar | .... | ·90 ,, |

Composition of the diet:

| | | |
|---|---|---|
| Proteins | ... | 49·7 gms. |
| Fats | .... | 72·5 ,, |
| Carbohydrates | ... | 416·0 ,, |
| Calories | ... | 2464 |

(55% of calories are derived from cereals).

So we find that in South India, as elsewhere, an increase in incom leads to an improvement in the diet not only in quantity but also in qualit —an improvement in the right direction.

6. For more details see Dr. Aykroyd and Krishnan B. G. - *Diet Surveys in Sou Indian Villages*. Ind. Journal of Medical Research, Vol. 23.

Cereals form the most important item in the diet of the agricultural labourers of Madras. This is because they are the cheapest, while protective foods like milk and milk products, green vegetable, fruits, fish and meat which are rich in first class protein and vitamins, are on the whole dearer. Certain foods are dearer than others. The price of common foods is influenced naturally by labour and distribution costs. There are a number of other factors influencing food prices *e.g.* the storage and preservation costs. Of more fundamental importance in determining the relative prices of different food stuffs is the food energy per unit of land relationship. To produce 1000 calories in the form of milk, meat and most vegetables more land is required than to produce 1000 calories in the form of cereals or root crops. So prospective foods give a smaller caloric return per unit of land than the energy yielding cereals and root crops. "From this it follows that if the amount of land available per capita is small it must, if the population it supports is to obtain enough to eat, be devoted to the production of foods which give a high caloric return, *i.e.*, energy yielding foods. So the density of agricultural population has a direct bearing on the potential production of certain kinds of protective foods[7].

Since the per capita acre of cultivated land in Tamilnad is small, cereals (rice and millets) form the most important item in the diet of the people; and the term food grains becomes synonymous with food. Hence it is obvions that, taking the existing conditions as they are, the self sufficiency of Tamilnad in food is greately dependent on the self-sufficiency of the region in food grains.

The next problem is to fix a standard by which self-sufficiency of Tamilnad in food grains is to be determined. By the term food grains we usually mean the cereals (rice and millets), and hence in the following paragraphs the self-sufficiency of Tamilnad in these two cereals has been dealt with.

C. R. Srinivasan in his report on 'Rice Production and Trade in the Madras Presidency', has determined the rates of consumption of rice and millets in the different districts of the area. Before arriving at his figures he refers to the numerous other figures of per capita needs proposed by other persons and the difficulties which one experiences in proposing a figure representing the proper capita needs. He says, "At the Crop Planning Conference held...at Simla mention was made that an adult took 1·25 lbs. of rice in Madras and that there has been a growing tendency for many people to take rice diet. Col. McCarrison mentions the quality of polished rice taken per head per day of the population as 21 ozs. for a poor Hindu family and 23 ozs. for a well-to-do family besides other food stuffs in the way of pulses, milk and vegetables etc. Dr. Slater in his studies of South Indian Economics estimates the daily ration of raw rice at 27 ozs. and *ragi* at 25 ozs." So, in the absence of any recorded statistical data on this point he has arrived at the actual ration by taking into consideration, in the case of each district, the total quantities of cereals produced, the quantities of imports and exports of cereals and the adult population of each district and also making allowance for a probable higher rate of consumption in the producing districts and a lower rate in the importing districts. Thus the daily ration required per head of the population is calculated by him as follows :—

7. Family Enquiry Commission—*Report*.



| *District* | | *Rice in ozs.* | *Millet in ozs.* |
|---|---|---|---|
| Tanjore, Chingleput, Coimbatore and S. Arcot | ... | 24½ | 26 |
| Madras | ... | 22 | × |
| Trichinopoly, N. Arcot, Salem, Ramnad, Tirunelveli and Madura | ... | 19½ | 26 |

S. Y. Krishsnaswamy while commenting on the above says that there is not much justification for verifying the per capita consumption, with reference to the administrative divisions of the state. He thinks that it is desirable and more in accordance with the probable actual conditions to assume a fairly steady per capita consumption and that for purposes of a fair average 24 ozs. of rice per day or 28 ozs. of millets per day would seem a suitable figure.[8]

By taking the existing conditions as they are, it would be improper to fix the standard in consonance with the above estimates. The proper standard seem to be one pound (or 16 ozs.) of cereals per adult per day—one which has been recommended by the Food Grains Policy Committee[9]; and one on which the rationing schemes where based when they were introduced in the country during the war. This standard nearly falls in line with the amount of cereal intake of an ordinary South Indian Agricultural Labourer as evidenced by the the diet surveys conducted by Dr. Aykroyd and his followers. There seems to be no justification in reducing the standard still further, for even in a well balanced diet as conceived by Dr. Aykroyd, where the intake of protective foods is adequate the quantity of cereals to be taken is fixed at 15 ozs. (10 ozs. of rice and 5 ozs. of cambu). Again the balanced diet drawn up by the Nutrition Advisory Committee which provides the various nutrients in quantities sufficient for the daily needs of an adult man, contains 14 ozs. of cereals. So in view of these facts it is neither proper nor justifiable to fix the standard below one lb. per adult per day especially when cereals form the most important item in the existing diet of the people. The same amount of 1 lb. per adult is adopted both for rice and millets since they have more or less the same caloric value.[10]

Having fixed the standard, we should now look into some details about the production of food grains in Tamilnad and see to what extent they satisfy the requirements of the people.

Rice is the largest single crop of Tamilnad occupying an area of 4·76 million acres. Tanjore has the largest area and is aptly described as the "granary of the South". As the crop requires an almost continuous supply of water it is not cultivated in dry areas where there is little rainfall and where there is no scope for irrigation. The principal rice growing areas in Tamilnad are: [11]

8. Krishnaswamy, S. V. *Rural Problems in Madras Presidency*.
9. Food Grains Policy Committee, *Report*.
10. Caloric value of millets per 100 gms. caloric value of rice.

| | |
|---|---|
| Cholam<br>Cambu<br>Ragi | Rice raw home pounded — 350·2<br>Rice par boiled ,, — 348·0<br>Rice raw milled ,, — 348·9<br>Rice par boiled milled — 347·0 |

11. Ramamurthy, K. *Some Aspects of the Regional Geography of Tamilnad*, I.G.J. Vol, 24.

1. The Cauvery Valley and delta.
2. Chingleput and eastern half of North Arcot and northern margins of South Arcot.
3. The Pennaiyar Valley.
4. The Periyar tract and Vaigai Valley.
5. The Tambraparni Valley.

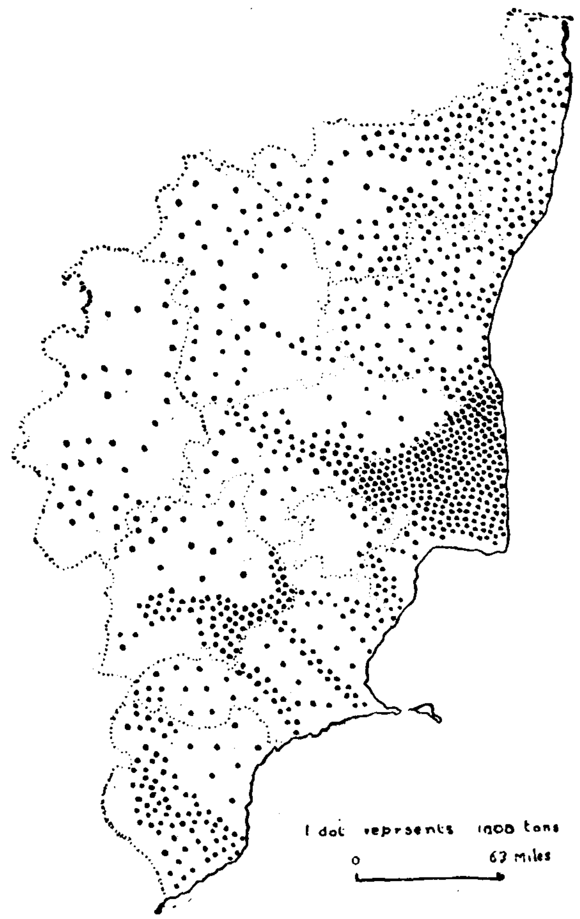



Fig. 1

The rice growing season in Tamilnad synchronises with the monsoons. The majority of the area consists of single crop lands where a variety of five to six months' duration is grown. Places with better water facilities grow two or three crops a year. Fluctuations in area and production of rice from year to year are a common feature of this region because of the wide range of seasonal conditions under which the crop is grown in this unit. The rice area is divided into two broad groups:—(1) irrigated and (2) un-irrigated. Out of a total of 4·76 million acres 4·40 million acres are irrigated in Tamilnad. The crop in the districts of Chingleput and Ramnad is rainfed in its



initial stages of growth and is irrigated after the receipt of the north-east monsoon which helps in filling the tanks. Even the irrigated areas are not absolutely free from the vicissitudes of the season. "The actual quantity of the rice produced is mainly dependent on the strength and distribution of the two monsoons since a greater portion of the irrigated area is from wells and tanks whose regular and timely supplies are to a large extent dependent on the two monsoons which are generally inadequate in the interior districts and untimely and excessive in the coastal districts.[12]

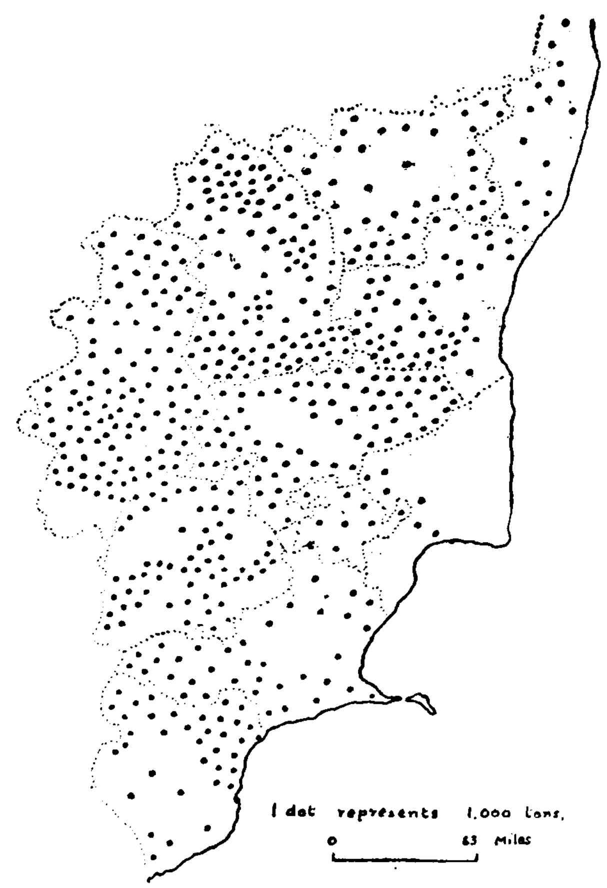



Fig. 2

The next largest area in Tamilnad is cropped with millets, total area being 4·68 million acres. In the millets group Cholam occupies the largest area (1.59 m. acres). "The cultivation of cholam is chiefly confined to the west central region which receives only slight rainfall. In the coastal plains where there is the danger of pollen from the flowers being washed away by heavy rains, very little cholam is grown."[13] Since the crop is mostly rainfed the yields are dependent on the vicissitudes of the monsoon. The average

12. Srinivasan, C. R. *Rice Production and Trade in Madras Presidency.*
13. Ramamurthy, K. op. cit, Vol. 24.

yield may be anything from 100 to 700 lbs. for the dry crops while the irrigated yields may very from 1200 to 1500 lbs.''[14]

**Next to** Cholam, Cambu occupies a large area under millets (1·17 million acres). "There are two chief areas of production: The first includes the northern and eastern portion of Coimbatore plains, the Karur taluk and south eastern taluks of Salem district. The second includes the black cotton soil region of Koilpatti and Sattur and the red soil of Srivilliputtur.''[15] This crop too is mostly rainfed.

The other millets grown are ragi, korra, varagu, samai and maize and in all they occupy an area of 1·93 million acres*.

When paddy is converted into rice there is loss of 33% in the weight of the grain by husking. So only 67% of the paddy produced is available for consumption. Some deductions have to be made from this figure for seed purposes and conversion into rice products. It is very difficult to estimate the allowance that should be made for seed purposes; for the seed rates vary not only in different districts, but also for different kinds of paddy-transplanted paddy requiring less seed rate per acre than broadcast paddy.[16]

The loss by husking for different millets is given below:—[17]

| | | | | | |
|---|---|---|---|---|---|
| Cholam | ... | 15% | Varagu | ... | 40% |
| Cambu | .... | 20% | Samai | ... | 45% |
| Ragi | ... | 10% | Maize | ... | 40% |
| Korra | ... | 20% | | | |

Making allowance for this loss by husking, the net quantity of cleaned millets produced in Tamilnad has been found. In the official statistics[18] the 'Acreage under crops' contains also a column to indicate 'other cereals' but this is not understandable when figures of production for these 'other cereals' are not given. A rough estimate of these could be obtained as the figures for the average yield of millets are available. "A comparison of the total acreage and total production of millets shows that on the average one acre under millet crop produces roughly ¼ ton of cleaned grain."[19] This ratio is being adopted to calculate the production of the 'other cereals', and this is added to the figures for other millets. "A deduction of 20% is made from these figures for seed purposes"[20]

A word is now necessary about the population figures that have to be adopted. "For extrapolation of population statistics two methods are generally adopted. One is the statistical method which consists in fitting a methematical function to the observations and the other the bio-statistical method based on the excess of births over deaths"[21]. The population of each district estimated by the second method is given in Appendix. The figures here indicate persons of all ages. The per capita consumption depends on

14. Krishnaswamy, S. Y. op. cit.
15. Ramamurthy, K. op. cit.
16. For more details see Krishnaswamy, S. Y. op. cit.
* The figures of production of various food grains are taken from the 'Season and Crop Report'. These figures represent unhusked grains and so loss by husking has to be taken into account.
17. Season and Crop Report.
18. Ibid.
19. Krishnaswamy, S. Y. op. cit.
20. Ibid.
21. Krishnaswamy, G. V. *Indian Journal of Economics*, 1930.



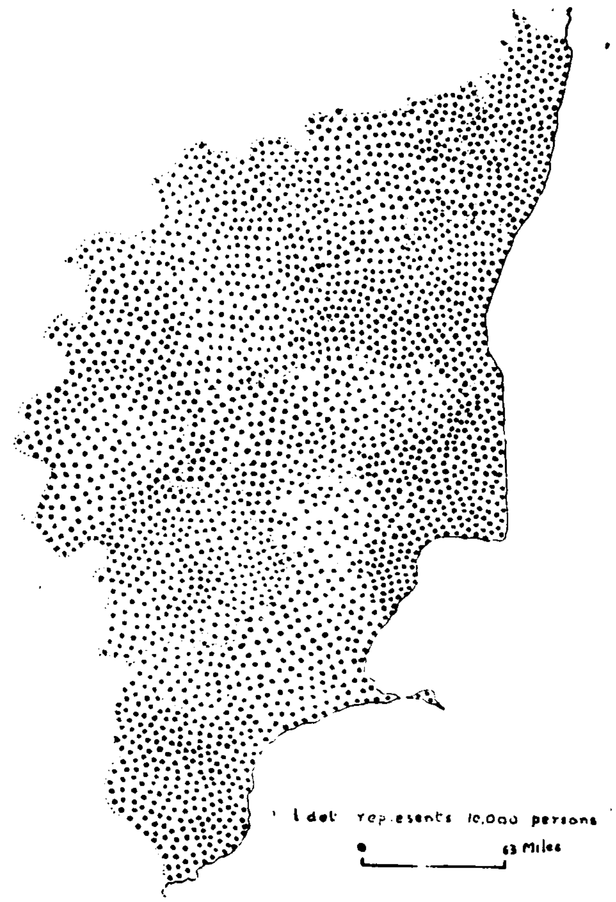



Fig. 3

the age of the person. Babies do not consume any cereal food and young children and old persons do not consume quite as much food as an adult. It, therefore, becomes necessary to adopt different rates of consumption for different age groups. For the sake of convenience it is desirable to equate the total population of Tamilnad in terms of adults so that a uniform per capita consumption may be applied in determining the requirements. Having regard to the different consumption capacity of the age-groups, Srinivasan has found that the population in terms of adults is equivalent to 75% of the total population.[22] On this basis it is seen that the present adult population of Tamilnad is 20, 766,384.

Now knowing the quantity of cereals that are available for consumption and the popolation numbers that have to be provided for, we could work out the self-sufficiency of the region in food grains. The question of self-sufficiency may be considered under three different aspects,

22. Srinivasan. op. cit.

(1) Estimating the deficiency of the region in the matters of different cereals.

(2) Calculating the number of people that Tamilnad could support according to the standard fixed with the present production.

(3) Calculating the daily ration of cereals that each adult would get with the present production.

For estimating the deficiency of the different cereals in Tamilnad we should know the percentage of population in each district which depends on millets or rice as their staple cereal. This is given in Appendix. The deficiency of the region in millets and rice works out to the extent of 289,382 tons and 63,924 tons respectively. In view of the huge deficit in millets, they should be imported to meet the requirements. " But figures of production and net imports of jowar and bajra show that there is no export or import of millets on any scale comparable with local production. This is true not merely for the whole of Tamilnad but for each district within the region itself as it is understood that there is not even inter-district movement of millets on any scale worth notice."[24] So the other alternative is that the per capita requirements of millets consumed should be less than one pound i.e., less than that of rice. But this could not be since actually the quantity of cereal intake is greater in the case of millets than rice. So this leads us to the conclusion that the percentage of population depending on millets does not represent the correct position. In all probability the percentage would have altered and this is suggested by the slow change over from millets to rice which is understood to be taking place. " Moreover millets are used as a substitute for and not as a supplementary to rice in the dietary the needs of the one depending to a large extent on the availability of the other, and in respect of which, therefore, an independent demand is difficult to estimate."[25] In view of this uncertainty it is better we adopt another method for estimating the deficiency of Tamilnad in cereals and this is to determine what part of the population can subsist on the millets now available and to assume that the rest for whom millets are not available eat rice, and deficiency of the region in the matter of cereals is thus calculated in terms of rice. A detailed working gives a deficit of 357,307 tons of rice annually.

Taking the second aspect, the total quantity of cereals available for consumption is 3,030,457 tons annually and according to the standard fixed this will be enough only for 18,597,873 adults. So Tamilnad could support only 89% of her population with the present production.

Taking the third aspect it has been found that the net quantity of cereals available for consumption will permit a daily ration of 14 ozs. per adult per day if there were to be no import of cereals into the country.

Hitherto in examining the self-sufficiency, Tamilnad has been taken as one unit and it has been found that the whole area is deficient to the extent of nearly 353,000 tons of in the matter of cereals. Except Tanjore all the other districts are deficit areas the extent of their deficit depending upon their regions.[26]

23. From the *Statistical Atlas of the Madras Presidency.*
24. Krishnaswamy, S. Y. *Rural Problems of the Madras Presidency.*
25. Krisnnaswamy, S. Y. op. cit.
26. The deficit % works out as—Chingleput 13·7, Madras 100, South Arcot 6·6, North Arcot 28·9, Salem 22 4, Coimbatore 39·4, Trichy 5·1, Madura 8·4, Ramnad 23·9, Tinnevelly 25·7.



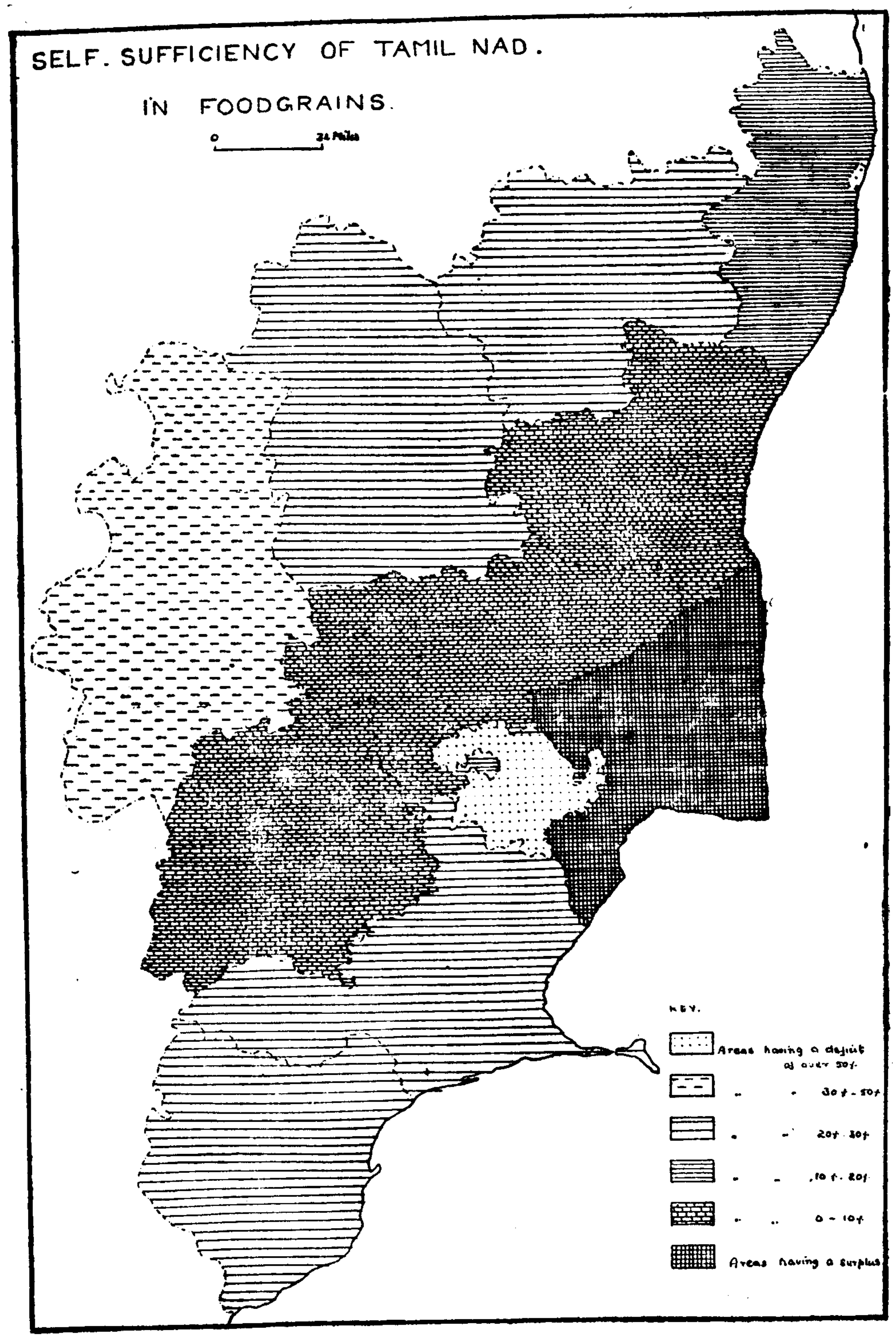



Fig. 4

This deficiency is not a new problem but prior to war it was made good by imports from Japan, whose entry into war has upset the balance and made the government realise that ere long the country would have to rely on its own resources. The only possibilities of extending cultivation lie in current fallows (5·16 m.ac.).[27] These fallows are comprised of :—(1) lands of the poorest classes which might produce something in a favourable year but which in bad years would hardly repay the cost of cultivation; (2) uncultivated lands—rocks, wells, pools, clumps of trees; (3) Pasture lands particularly in cattle breeding areas; (4) lands left waste in years of deficient rainfall; (5) lands purposely kept fallow by the ryots as annual cropping would not yield sufficient return to them; (6) low-lying parts of the delta where the soil is saline and presents certain difficulties to cultivation.

It is not certain whether it is possible to bring under cultivation the lands belonging to the first group since these lands are kept fallow due to the poor soil there. It is neither possible to bring under cultivation the pasture lands since, as it is, the quality of cattle is already very poor. The lands of the fifth category could be brought to bear crops by the application of manure and adequate water supply. Some lands belonging to the second category, which had till now remained as uncultivatable, have been reclaimed by tractors. This tractor cultivation is one of the important schemes of the Agriculture Department.

Those lands that are left fallow in years of deficient rainfall could be reclaimed if there is an assured supply of water. This means an extention of the irrigation schemes in the country. Firstly, the existing irrigation systems are being developed to their maximum capacity. For example, the scheme to bring under irrigation a large extent of un-irrigated land in the Cauvery Mettur Project and connected work completed in 1944. It was a complete success and about 60,000 acres were reclaimed. In Tanjore, the premier rice growing district, the government provided irrigation water from rivers and channels by about three weeks earlier to enable the cultivator to begin paddy cultivation early and take two crops of paddy from single cropped paddy lands. On account of this, 20,000 more acres of the single cropped area were put under two crops. In addition to this the early supply of water enabled a large area, so far considered as dry, to be brought under single crop paddy cultivation. Secondly, new irrigation projects like the Lower Bhavani and Malampuza have been started and these will bring many more acres of land under irrigation, when completed. But these will take some time to be completed and hence the construction of small irrigation works has assumed a new urgency now. Every effort is therefore being made by the government to sanction, execute and complete small irrigation schemes which are capable of producing quick results. One such measure which has proved highly successful is the 'New Well Subsidy Scheme' according to which a subsidy of half the cost of construction subject to a maximum of Rs. 750/- in rocky areas and Rs. 500/- in ordinary localities is paid for the construction of new well. Only paddy and millets are allowed to be cultivated under the subsidised wells for three years after their completion, failing which subsidies advanced are ordered to be summarily recovered. The additional items of work under this head are concerned with repairs to channels, tanks, etc.

27. The relevent data are—Area sown 12·81 m.ac., Forests 4·81 m.ac. Not available for cultivation 5·85 m.aç. Other uncultivated land (excluding fallows) 3·62 m.aç.



These methods are those that were adopted under the 'Grow More Food Campaign' (G.M.F.) to step up production by extensive cultivation. The other method to increase agricultural production is by improving the out-put per acre. The scope for increasing production by intesive cultivation is apparent when the rice yields of Madras are compared with those of other countries.[28] While the rice yield in Madras State may be the highest in India excepting Coorg, yet when compared to the European countries and China it is poor. It may be that the higher yields in Japan are made possible on account of the limited area under rice in that country. But in China where conditions appear to be more or less similar to those obtaining in India, there is 50% more yield than Madras. It will thus appear that if proper measures are taken considerable increases in the yield per acre can be effected.

Intensive cultivation envisages.—(1) the introduction of improved varieties of crops; (2) the adequate manuring of the crops; (3) the development of irrigation and supplying the crop with required quantities of water; (4) better cultivation with improved implements and (5) proper and timely control of pests and diseases.

The results of various comparative trials with improved paddy strains go to show that they yield from 10% to 25% more than the local types which they are intended to replace. The introduction of these improved strains so as to cover all parts of Tamilnad are likely to increase the production, at least by 10% to 15% (or on an average 12½%). Under the G.M.F. Campaign seed farms are being run all over Tamilnad for multiplying seeds of improved strains of paddy and millets. In spite of these efforts, still the areas under improved strains is only a small proportion of the total acreage (less than 5%) and there is a large scope for increasing agricultural production by this method.

Increased production from improved varieties has, however, its own limitations. Unless the standard of cultivation is simultaneously improved the increased yield from a better strain may not be permanently maintained. In many parts of the region fertility of the soil is establishsd at a low level, under such conditions improved varieties may give higher yields in the initial stages but, due to their higher uptake of nutrients, may depress the low fertility still lower resulting in low yields from subsequent crops. So the plant nutrients removed by improved seeds should be replaced annually by adequate manuring. Better manuring results in better crops and larger yields. "In the Central Agricultural Station at Coimbatore by judicious green manuring and application of small supplementary dozes of bone-meal and amonium sulphate, the fertility of the soil has been considerably improved, and the average yield of paddy has gradually risen from 2000 lbs. in 1937 to nearly 4000 lbs. in 1935. At the Pattambi Agricultural Research Station, the application of neem-cake and the ammonium sulphate, together 45 lbs. of nitrogen per acre immediately increased the yield by 22%. There are only two examples from a long record and other manurial experiments, conducted in many parts to show that rice yields can be augmented by 20% to 25% by a combination of organic and artificial fertilisers".[30] But in

28. The yields (in lbs. per acre) for other countries (and places) are :—Spain 3709, Italy 2963, Japan 2053, Egypt 1799, China 1554, Siam 961, Burma 845, Indo-China 637, Madras 1050, Bombay 967, Sind 861, Coorg 1369, Bengal 921, M.P. 655, Bihar and Orissa 701, Assam 757, Andhra 689 and Mysore 699, India (average) 829.

29. Krishnaswamy. op. cit.

30. Ibid.

Tamilnad the farmers very rarely apply any kind of artificial fertilisers to the field. In order to popularise the application of phosphatic fertilisers to paddy crops the Government have been selling them at half the cost price and ammonium sulphate at cost price.

Another scheme aims at utilising all the waste material of villages and towns as manure. There is the rural Composting scheme by which the villagers are persuaded to collect all their waste matter, especially those which can be easily decomposed, in pits and they get a subsidy of one rupee per cu. ft. of composted material. The Urban Composit Scheme is another scheme where the Municipalities of the urban centres are responsible for collecting the waste material of the cities and send it to other places to be used as manure. But it appears that no good has come out of this scheme.

The Government are also attaching great importance to the production and utilisation of green manures. The Agricultural Department is providing green manure seeds from seed farms by paying ryots a premium of Rs. 6·50 per bag and selling them on a subsidised basis recovering through the sale price only half of the premium paid to the seed farm ryots.

The G.M.F. plan of the Government includes another important scheme for the control of pests and other diseases. Under this scheme fungicides and sprayers are made available to the ryots at 50% of the cost price. They are also loaned out.

If the introduction of improved varieties and application of manures should increase agricultural production adequately, they must be accompanied by efficient cultural practices. This is possible only by the use of right implements and the government is supplying iron implements to the ryots at controlled rates within the limited quota allotted by the Government of India. They also supply oil engines and electric motor pumps at concessional rates to the ryots for purposes of lift-irrigation.

Also, it is obviously essential that spoilage of rice and other food grains by rodents and insects should be kept down to the minimum. The prevention of this spoilage would help substantially in closing the present gap between supplies and requirements. "The problem of satisfactory storage has been brought into prominence during recent years since the procurement and retiring programmes introduced involve the bulk storage of cereals prior to distribution."[31] The Central Govertment are now paying greater attention to the problem of storage and improved methods of pest control are being followed in grain depots under the control of the Central Government.

The deficiency of food grains in the country could also be made good partly by the use of subsidiary foods. This, of course, is a thing to be greatly wished for, since the use of subsidiary foods are likely to solve not only the problem of quantitative self-sufficiency but also that of qualitative self-sufficiency, and the aspect should be clearly borne in mind when planning for a ready adjustment of the cropping of the country. Many advocate the increased use of vegetables but they perhaps fail to realise that the low economic status of a large majority of the people, which as mentioned previously, has resulted in cereals forming the predominant item in the diet, would prevent them from taking the much costlier vegetables as substitutes for cereals. Even when vegetables are produced in large quantities the

31. *Rice and Rice Diets—A Nutritional Survey*, F.A.O.





Government would find it perhaps difficult to persuade the people to take vegetables and other subsidiary foods as substitutes since the people are likely to be very reluctant to change their dietary habits. The importance of groundnuts as a substitute for cereal has been emphasised time and again but it is uncertain whether this will make the people less dependent on cereals.

As the standard of living of the common man improves, the amount of cereal intake is likely to become lesser and hence the demands may equal supplies; but this rise in the standard of living depends upon a number of factors. The industrialisation of the country could, to some extent, contribute towards this, but this does not seem likely in a very near future and it could not, always, help in achieving the target of self-sufficiency in a short period. Thus, as things stand today, intensive cultivation and to some extent extensive cultivation seem to be the only possible means of bridging the gap between supplies and requirements.

These are the Governments measures. But unless the public particularly the cultivators, too co-operate with the Government the success of the schme is not assured. The cultivator must be prompt in giving off his surpluses to the Government; and the people will do well to raise vegetables and other such things as much as they can in the back-yards of their houses, many of which are now lying idle.

But as said above, the production of food grains in Tamilnad depends on the vagaries of the monsoon over which man has no control. So the facilities for irrigation remain the fundamental need—a work which needs considerable prospecting and perspiration.

## APPENDIX

### POPULATION OF TAMILNAD IN 1950.

| District. | Estimated population. | Adult population. | % of rice eaters. | % of millet eaters. | Rice eating population. | Millet eating population. |
|---|---|---|---|---|---|---|
| Chinglepet ... | 1,963,477 | 1,472,608 | 87 | 13 | 1,281,469 | 191,139 |
| Madras ... | 856,666 | 642,499 | 100 | — | 642,499 | — |
| South Arcot ... | 2,796,377 | 2,097,283 | 63 | 37 | 1,321,288 | 775,995 |
| North Arcot ... | 2,857,150 | 2,142,863 | 65 | 35 | 1,492,861 | 650,002 |
| Salem ... | 3,185,451 | 2,389,088 | 35 | 65 | 836,181 | 1,552,907 |
| Coimbatore ... | 3,182,256 | 2,386,687 | 33 | 67 | 787,607 | 1,599,080 |
| Trichy ... | 2,366,140 | 1,774,605 | 47 | 53 | 834,064 | 940,541 |
| Tanjore ... | 2,658,058 | 1,993,544 | 97 | 3 | 1,933,738 | 59,806 |
| Madura ... | 2,709,956 | 2,032,534 | 52 | 48 | 1,056,830 | 975,572 |
| Ramnad ... | 2,170,046 | 1,627,534 | 55 | 45 | 895,144 | 732,390 |
| Tinnevelly ... | 2,471,301 | 1,853,486 | 63 | 37 | 1,167,696 | 685,790 |
| Pudukottah ... | 471,300 | 353,745 | 47 | 53 | 166,260 | 187,485 |
| Total ... | 27,688,178 | 20,766,384 | — | — | 12,415,677 | 8,350,707 |

# END OF SANNIKOV ISLAND LEGEND

Research by V. KUPETSKY, Soviet Scientist.

*By*

A. ALEXANDROV

For a long time people have been interested in the mysterious Sannikov Island in the Arctic Ocean. Many books and magazine and newspaper articles have been written about it. This year marks the 150th anniversary of the "high rocky mountains" being sighted to the north of Kotelny Island by Yakov Sannikov, a Siberian explorer. Soon after Sannikov's discovery, a strange new haze was again observed at the horizon (this time to the north-east of Kotelny Island) by M. Gedenstrom, the leader of a Russian expedition which prepared a geographical description of the New Siberian Islands.

Traces remained of the supposition of Sannikov, the Siberian merchant who discovered a number of big islands. Some maps showed the outlines of unknown "Lands seen by Sannikov." Polar expeditions were fitted out to look for the mysterious lands. An expedition, led by Pyotr Anzhu, a lieutenant of the Russian Navy, searched for them in 1820–1824. Participants in another expedition, led by Eduard Toll, a Russian Arctic explorer, tried to discover the legendary lands. The third Soviet high-latitude expedition made the same effort in 1937. Seven years later, at the request of Academician Vladimir Obruchev, the last "white spots" on the map of this section of the Arctic were studied in detail by a Soviet Air Expedition. No lands of islands were found to the north of the New Siberians Islands.

Some scientists, however, still had their doubts. Professors Vladimir Vize and Nikolai Zubov, well-known Soviet polar scientists, for instance, believed that Sannikov and Toll had not seen land, but simply an ice-hummock ridge. Other explorers were of the opinion that this land did exist at one time, but was subjected to complete destruction not so far back. There was the case of the Vasilyevsky Islands in the Laptev Sea composed of century-old ice, which literally melted away in the 30s of the present century. Still other versions were advanced including one alleging that Sannikov Land was floating island of ice.

Special research dedicated to Sannikov Island, has been completed by Valery Kupetsky, M.Sc. (Geography) an explorer and staff researcher of the Leningrad branch of the State Institute of Oceanography. After a thorough analysis of all the data he obtained, Valery Kupetsky, who has sailed in the Arctic waters, contributed fresh ideas concerning the Sannikov Island secret.

"The clue to this secret," Kupetsky told our correspondent, "lies in my opinion, in the existence of large expanses of clear water, of almost constantly unfrozen patches of water in the midst of ice to the north of the New Siberian Islands. A thick Arctic fog always hangs over ice-free water in frosty weather. Wreaths of this fog rise up and form a low cloud of odd pattern, which from afar may be mistaken for the outline of distant mountains, which, as it is claimed, Sannikov and other people saw.

"As regards the views of some explorers on the existence of organic life in the area of this mythical land, then it should be remembered," Kupetsky stressed, "that the unfrozen patches of water in the midst of ice serve as a 'window' in the polar seas through which light and oxygen, needed for organisms, flow into the Arctic waters."