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BY

M. NAZIR, B.A., Hons., (Lond.), P.E.S.,
Central Training College, Lahore

AND

V. S. MATHUR, M.A., (Lond.)
Govt. College, Lahore,
Vice-President, Indian Geographical Society.

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

The Physiognomy of the Ghaggar Plain¹

BY

SHAMSHUL ISLAM SIDDIQI, B.A., (HONS.), M.A.
Lecturer, Muslim University, Aligarh

The topography of the Ghaggar Plain is simple, for the two Siwalik and Aravalli hills in the region being insignificant in extent and magnitude, one is concerned with only one feature—the plains.

Aravalli Hills:—They are the hills intersecting the Indian continent from Gujrat in the South-West to Delhi in the North-East. They are but the depressed and degraded relics of the oldest mountain chain of India which at one time extended from the Deccan to beyond the northern limits of the Himalayas² and came into existence at the close of the Dharwar era, when the sediments that were deposited in the seas of that age were ridged up by an orogenic upheaval. Since then the Aravalli mountains remained the principal feature in the geography of India for many ages, performing all the functions of a great mountain chain and contributing their sediments to many deposits of later ages. They stood, in Palaeozoic times on the edge of the Rajputana sea and were rejuvenated³ in post-Vindhyan, or

1. Denomination of the region bounded by the Indus and Punjab on the North-West, the Sutlej on the North, the Siwaliks in the North-East, the Jumna on the East and more vaguely in other directions by a line running through Gurgaon, Bawal (Nabha State), Mohindergarh (Patiala state), Dadri (Jind state) and Bikaner and Bahawalpur states.

2. It has been variously derived from 'Arbali' a Hindi or Sanskrit word said to mean 'higgledy-piggledy', applied to any broken ground (Archaeological Survey Reports, Vol. XX), and from 'ara'—a saw, in allusion to the serrated nature of the range, a feature which is not conspicuous within the limits of the Ghaggar Plain.

3. Wadia, D. N. *Geology of India*, New edition, 1939, p. 72.

4. Rec. G. S. I., Vol. LXII, 1930, p. 404; *Cyclopaedia of India*, Vol. II, 1908, p. 46.

Vindhyan times. It is because the upheaval of this range was partly renewed in later times that the Aravallis still form a very distinct geographical feature; otherwise like their contemporary ranges, they too would have been effaced by ages of continuous denudation and lost all topographical individuality.

The Aravallis are a true tectonic mountain. The series of ridges and peaks, with breadth varying from 6 to 60 miles are generally from 1,000 to 3,000 feet in elevation, the highest point, Mount Abu (5,650 feet) being in the extreme South-West, outside the area under study. The Aravalli range may be said to terminate at Singhana in Jaipur State, for north of Singhana, within the region under study are only a few broken narrow ridges, rising abruptly from the plain, which appear to be mere spurs and offshoots of this extremity. The most northerly outliers on the line of the range occur near Hissar and Rohtak, touching the Jumna at Delhi.

The principal hills in the Ghaggar Plain, however, are the Shekhawati hills in Gurgaon, the Delhi Hills in the South-West of the district of the same name and the Kaliana Hills in Jind state. But the hills are a marked feature only in the Gurgaon District. Elsewhere they are too insignificant even to properly deserve the name.

From Noganwa (Alwar state) commences a range of the Aravalli hills, which runs northwards almost uninterrupted to about Bhundsi (Gurgaon District) and for a long distance constitutes the boundary between Gurgaon District and Alwar State. A little North-West of Firozpur Gurgaon District) the hills diverge but unite again near Tijara. The interval between them is due to the erosion of a zone of slates or other easily removed beds. On the east of this range near Santhawari (Gurgaon District) there is also an isolated quaquaversal dome-like structure.

A little South-West of Nub (Gurgaon District) the range bifurcates again. One branch proceeds North-Eastwards to Sohna, where it twists sharply a little to the South-West and then runs northwards to Bhundsi sending out an arc westwards to Kasan (Gurgaon District), with ridges North and South. At Kasan there is a pass, about 15 feet wide, formed by the removal by natural and human agencies, of thick micaceous pegmatite. At the North-East extremity of the range, near Bhundsi there is a projection from the main ridge in the form of an anticlinal dome and due west of this, on the other side of the ridge, is a larger and more irregular promontory. The other branch enters the Alwar State terminating only after a few miles. Northwards, beyond its termination are a number of scattered hills

which continue into Rewari also. These ranges, their vicinity being inhabited by the Meos, are popularly called the "Mewat Hills".

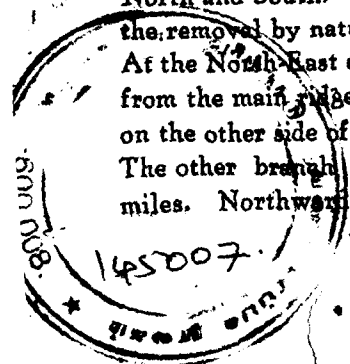
The top of the ridge is very even and only about 1,500 feet above sea level in the south, gradually falling northwards to about 1,200 feet. So flat is the top that a paved causeway ran along it for miles connecting the various strongholds of the Mewati chiefs during the Muslim rule.

From about 5 miles South-East of Sohna (Gurgaon District) to Delhi extends a large plateau, about 3 miles in width which is probably the vestiges of an isoclinal anticline. The maximum elevation of this plateau, 1,000—1,100 feet above sea level, or 400 feet above the alluvial plain of the Jumna, occurs near its southern limits; northwards its surface gradually falls till at the Mutiny Memorial on the Ridge, the height is only 794 feet above sea level, or 80 feet above the plain. As a matter of fact it is composed of numerous ridges and its continuity is broken by wide expanses of alluvium, strewn with the ruins of Tughlaqabad and the earlier of the "Seven Cities", but in a broad sense it can be considered as a plateau. These ridges of the plateau enter Delhi from Gurgaon on the southern border. Some of these extend eastwards towards the Jumna. One of the highest of these spurs supports the Fort of Tughlaqabad. The principal of the ridges extends from the Qutub and Mahrauli to the western side of New Delhi, where on one of its spurs is situated the Government of India's Secretariat and the Viceroy's House, and encircling Shahjahanabad almost reaches the edge of the Jumna waters at the small village of Wazirabad.

Though viewed from below it appears to be a flat tableland (perhaps an elevated plain of erosion), when ascended it proves to be in detail very uneven, trenched by ramifying ravines which trend mainly along the strike and are separated by low ridges (representing slightly harder beds) as stated above.

The more northern ribs of the Aravalli series disappear beneath alluvial cover in Delhi, but the rocks still underlie the plains to the West and North-West. "They are continued under the plain up to the Himalayas and thus form a divide between the subsoil water of the Gangetic and the Indus Plains". Their presence is revealed by the few small promontories that peep through the alluvium in Hissar, near Bhiwani and farther northwards.

1. The Agricultural Geog. of the Punjab, Kazi Saeeduddin Ahmad, p. 23.



All these hills, within the limit of our region, whether the ranges, the detached portions, or the table land are of insignificant height. Nowhere do they seem to attain an elevation of more than 500 feet above the level of the country at their base.

Siwalik¹ ('belonging to Siva'—a Hindu divinity) Hills:—It is the first rock-group (hill) met with in passing from the plains into the Himalayan foot-hills and is separated from the latter by an almost continuous reversed fault. In the few places that the fault is absent, it is pressed against the outer ranges of the Himalayas and is not easily identified. This low but very long range separates the Himalayan mountains from the Indian plains, and is, perhaps, the most recently formed range of similar magnitude on the earth². It is remarkably uniform in character throughout.

With the exception of a short distance of 50 miles, opposite the basins of Tista and Raidak, the range "has been shown by geologists to skirt the Himalayas throughout their length with remarkable uniformity for 1,600 miles, from Brahmaputra to the Indus and even to the West of the Punjab³." The average width of the range is 10 miles, though at places it is as wide as 25 miles. The elevation generally varies from 2,000 to 3,500 feet. Below Simla, the Siwaliks are 5,000 feet above sea-level. They are considered to be still rising.⁴

At the passage of the Sutlej there is a break—not a bend—in the alignment and the two lengths of the range appear to overlap. Within the Ghaggar plain the range nowhere penetrates to any distance into the interior but only skirts the Ambala and Ludhiana Districts, in the north-east of the Sutlej the hills run like a wall separating Ambala from the long narrow valley of the Sirsa river in Nalagarh State until they are cut through by the Ghaggar. Beyond it lies the Morni Ilaka, a hilly tract of about 93 square miles, chiefly made up of two main ridges, and culminating in the Karoh Peak (4,919 feet) on the Sirmur border.

"In many places, the strata may be observed, rising one above the other, the face of one stratum resting on the slope of another, while another

1. Hindu mythology considers it as the edge of the roof of Siva's dwelling in the Himalaya. The name 'Siwalik' was mentioned by the emperor Baber in his Memoirs, A. D. 1528.

2. Burrard, Col. S. G., and Hayden, H. H., A sketch of the geography and Geol. of the Himalaya mountains and Tibet, Pt. II, p. 96.

3. Burrard, Col. S. G., and Hayden, H. H., A sketch of the Geography and Geol. of the Himalaya Mountains and Tibet, Pt. II, 1933, p. 96; Hamilton, A. P. F. Himalayan Jour., Vol. VII, 1935, p. 91.

4. Burrard, Col. S. G., and Hayden, H. H., A sketch of the Geography and Geol. of the Himalayan mountains and Tibet, Pt. I, Vol. II., p. 60.

straight scarp rears itself on the slope of the first, and this frequently repeated, till on looking down on these abrupt ridges from a height, or viewing them from one of the numerous gorges which cut somewhat diagonally through the range, the appearance presented is that of the teeth of a huge saw."¹ Besides the Aravalli and the Siwalik hills, the only other rocky hills deserving the name are in the south, close to the Bikaner border of Jodhpur and Jaipur, the highest of which near Gopalpura is only 600 feet above the level of the plain or 1,651 feet above the sea.

Plains:—The Ghaggar Plain, however, is mostly formed of the plain that descends southwards from the Siwaliks and eastwards from the Aravallis. It belongs largely to the same level table land to which does the thirsty desert of Rajputana and the wild and dry country of Sind. Considered as a whole it presents the appearance of a gently sloping plain, leading from the North-Eastern hills to the sandy desert in the South-West. The slope is regular and gradual, seldom exceeding 2 feet in a mile, so that even the upper parts are of moderate elevation. Thus the cities of Ambala, Ludhiana and Delhi are respectively, 902, 812 and 715 feet above sea-level; the surface slopes regularly to the South-West and we find Bahawalpur at an elevation of only 375 feet. From the Aravallis, about a thousand feet above sea level, the plains slope imperceptibly eastwards to an average of 600 feet near the Jumna.

Except for a few, insignificant outliers of the Aravalli system, already mentioned, which traverse Gurgaon and Delhi Districts, there is no ridge of high ground between the Indus and the Jumna, and the Ghaggar Plain passes into that of the Gangetic valley without visible interruption. The ridge of the older rocks which runs up from the plateau of Rajputana, in the prolongation of the Aravallis, dies out at Delhi, and to the North of this city, the watershed² of the two great river systems is only the highest part of the plain, the right bank of the Jumna, with an elevation ranging from 800 to 1,000 feet above the sea.

The vast plain nowhere rises to a height of more than 1,000 feet above sea level³ in spite of the great distance from the sea.

1. Handbook of Economic Products of the Punjab, Vol. I, 1868 Baden H. Powell, p. 127.

2. Medlicott, H. B., Sketch of the Geology of the Punjab, 1883-84, P. 6.

3. Heights above sea-level of the towns of the Ghaggar Plains:—

Ambala	... 902 ft.	Ferozepur	... 645 ft.
Ludhiana	... 812 "	Bahawalpur	... 375 "
Hissar	... 689 "	Delhi	... 715 "
Karnal	... 809 "	Bikaner	... 736 "

The plain is not one flat level tract, but there are numerous rocky projections of low elevation in various parts of it, such as some hillock of gneiss near Tosham in Hissar; and of Nummulitic rock at Gajner and Koliat in Bikaner. Its surface is further diversified by the action of the prevailing winds, which have heaped up the sands in a well-marked series of ridges, dunes and hillocks. If we except the insignificant hills and petty ridges of wind-blown sand, the only eminences are "Thehs" or mounds which represent the accumulated debris of ancient village sites. These rocky prominences which stand up above the alluvium and sands are humble, time-worn outliers of the very ancient Aravalli system, presenting in their bare, bold and rounded outcrops, and in their curiously worn and sand-blasted topography, striking illustrations of the phenomena of desert erosion.

Sand Hills:—Bahawalpur, Bikaner, Hissar, and parts of the Phulkian States, Rontak and Gurgaon are dotted over with undulating sand-hills, and the aspect presented by them resembles that of a series of magnified wind-ripples. The hills in southern Bikaner and a wide tract near Charanwala in Bahawalpur are arranged in crescent shaped ridges, running nearly South-South-East to North-North-West. These parts of Bikaner and Bahawalpur are called Bagar and Rohi or Cholistan respectively. In Bagar the surface is mostly covered with undulating sand hills from 20 to over 100 feet high and in Cholistan the dunes at times rise to a height of 500 feet. Further North they are transverse and elsewhere not arranged in any definite order. These sand hills are sparsely clothed with stunted shrubs and tufts of coarse grass in the dry season, while the light rains cover them with vegetation.

Recent and Past Glaciation of Lahoul

BY

LUDWIG KRENEK, VIDYA BHAWAN, UDAIPUR

The heart of Lahoul is enclosed by the two sources of the Chenab, the Chandra and the Bhaḡa rivers. Only this central part (roughly 800 sq. miles) will be the object of this study, excluding the upper Chandra above Shigri. On the other hand, the glaciated valleys on both sides of the Chandra and Bhaḡa valleys will be included.

Lahoul is shown on map 52 H, 1 inch to 4 miles. It is reliable as far as the lower reaches are concerned. The glaciated region however is in many cases mere guess work, the "Snowfields" normally not being shown at all. Much better is map 52 H/S.W. 1 inch to 2 miles, but it depicts only a small Part of central Lahoul. The map presented here (see Fig. 1) is an attempt to show the real extent of glaciation in the Chandra Bhaḡa triangle.¹

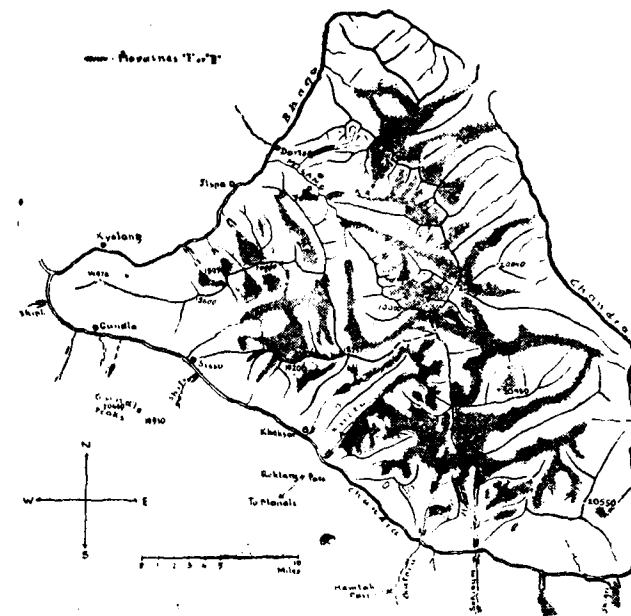


FIG. 1. Glaciation of Central Lahoul Area of present glaciation shaded.

¹ It is based on trigonometrically fixed points of the available maps. The details are compiled from levelled photographic panoramas taken during the "Lahoul expedition" of the National Union of Students in August—Sept. 1939 and from observations during a visit in May—June 1945.

Lahoul is a region of transition between the monsoon influenced countries of Chamba and Kulu, and the dry regions of Rupshu Spiti and Tibet proper. In spite of its nearness to the South Western border ranges, it is much more Tibetan in character. Khoksar in the Chandra valley, only 12 miles as the crow flies from Manali (Kulu), shows in nearly every respect climate, vegetation, buildings, population and customs closer relation to the Tibetan villages hundreds of miles away than to those nearby in Kulu. The view from the Rohtang Pass (13,000 ft) between Kulu and Lahoul depicts the most striking contrast especially during the monsoon. To the south, the whole valley is full with forests, fields and pastures. Soft colours are predominant. Mist is drifting between the ridges and dense clouds hide all the major peaks. To the north, tremendous rock slopes, tinted in brilliant colours arrest the eye. Only a few green patches interrupt this stony waste. No trees are visible. The air is so clear that the view extends to the most distant mountain ranges. A magnificent blue sky underlines the contrast to the cloudy south.

The glaciation of Lahoul however does not show so much difference from that of Kulu, for the following reason: Where the Chandra and Bhaḡa valleys are sheltered from the influence of the monsoon by the Pir Panjal ranges, the high mountains of Central Lahoul receive sufficient precipitation. The north eastern parts however show already a marked decrease in glaciation².

Present glaciation. Very little of Lahoul's glaciation is visible from the usual route following the Chandra and Bhaḡa valleys. Even the view from the Rohtang pass hardly gives any idea about the amount of glaciation. The great snow-collecting basins are well hidden from the outside world.

Types of glaciers. Most of the glaciers within the Chandra—Bhaḡa triangle belong to the "Alpine" type (snow collected in high basins, "snow fields"). A characteristic example is the Milanḡ glacier (length 9 miles, area 11 sq. miles, snout 12,300ft).—The "Mustaḡh" type (snow collected along the whole length of the deep valleys) is well represented in some of the glaciers coming down from the Gundla peaks. The best example of this type however is the Chatoru glacier, which has its origin in the tremendous 7,000 ft—icewall of Deo Tibba, easily visible from the Hamtah Pass.

A special feature of the above mentioned Gundla peaks is the "re-constructed" glaciers. The ice of the upper glacier is pushed over a precipice

2. In mid-June 1945, the snow line on slopes of similar exposition (all south) was at 14,000 ft. North of Sissu, 15,000 ft. North of Kyelang and nearly 16,000 ft. around Kanzam Pass (Spiti border).

and is collected again at the foot of the wall, forming a new glacier. Two glaciers of this type, both to the East of Gundla, are more impressive than any I have seen so far. The larger one of these falls over a rocky wall of about 1,700 ft; the second is interrupted for at least 2,000 ft.

Though most of the glaciers belong to the Alpine type, the ice walls of the higher peaks are definitely "Himalayan," showing hundreds of small "avalanche-gullies" characteristic of all the great peaks of the Himalayas.

The snow line lies at about 17,000 to 17,500 ft in Central Lahoul, probably higher in the eastern part and certainly lower in the Pir Panjal. No figures are available³.

The snouts of the bigger glaciers terminate between 12,000 and 14,000 ft.⁴ Only the Glaciers of the Gundla peaks though smaller, reach much lower altitudes (Shiti glacier 10,541 ft. and the above mentioned reconstructed glaciers 10,000 ft.). This is due to the extreme steepness of their long profile.

The measurement of the speed of the Milanḡ glacier, though proposed, could not be carried out, as our Lahoul expedition had to be shortened due to the outbreak of the war.

Fluctuations. All the glaciers visited are in retreat. Old terminal and lateral moraines and the extensive areas covered by ground moraines in front of the present snout, bear ample testimony to this. The whole appearance of the glacier tongues confirms this view. A cross section through the snout is concave. The surface is furrowed by many rivers, and in some cases parts of the ice thickly covered by debris, are completely cut off and remain in front, or to the sides of the glaciers as "dead ice." All these signs of decay are very conspicuous, giving the impression of a rather speedy retreat.

Now two questions have to be asked: (1) What is the amount of this retreat? (2) For how long have the glaciers been retreating?

The position of the snouts of two glaciers in Lahoul (Sonapani and Shigri glacier) was fixed in 1906 by H. Walker and E.H. Pascoe (see Rec. of the Geol. Survey of India, vol: 35.p.4) The Sonapani glacier at the time

3	Compare: Kumaon, Bhaḡat Kharak glacier	17,500 ft.
	" Tibetan frontier	18,500 ft.
	" Karakorum, N.W.	16,500, East up to 19,000 ft.
4	Compare	
	Gangotri glacier	12,770 ft
	Pindari "	11,720 ft.
	Milam "	11,600 ft.

of my visit in 1945 was still covered by snow. Therefore no comparison could be made. The Shigri glacier has retreated at least half a mile since 1906⁵. (See Fig. 4). The authors state that in 1906 all the glaciers visited were already retreating. Evidence is again provided by the Shigri glacier. Probably about 1880 this glacier advanced to the other side of the Chandra valley, thereby completely blocking the river (for how many years?). The lake so formed is mentioned in P. G. Egerton's book: "Journal of a tour through Spiti" and in Col. Tyacke's "Sportsman's manual in Kullu". If the Shigri glacier is not an exception, we can, therefore, assume that the maximum advance took place about 60 years ago, and that since then, or at least since 1900, the glaciers are retreating.

Far more interesting and important than these recent fluctuations are the secular movements. There are clear indications of at least two advances far beyond the above mentioned maximum. In fact, it is these stages which can be traced easily on practically all the glaciers of Central Lahoul. They are far more clearly marked than the recent variations.

Secular movements. Just opposite the Rohtang Pass beyond the Chandra river, the Kulti valley leads straight into the heart of the Lahoul mountains. In its lowest part this valley is bounded on both sides by straight lines, looking like artificial dams. They are clearly visible from the height of the pass. Hundreds of travellers have seen them, dozens have described them. They are nothing but two enormous old side moraines of the Sonapani glacier, $4\frac{1}{2}$ miles from the present snout. As we follow the course of the Chandra river downstream we shall find many places where the glaciers formerly reached the main valley, where as in the Bhaḡa valley up to Dartse, only one advanced so far.

In many cases a second "set" of side moraines (the terminal moraines are normally destroyed) can be distinguished. They are less clearly defined, and indicate slightly farther advance in a more remote time. In future they will be marked as "I", the younger ones as "II"

Of all the valleys visited a few of the most interesting ones are selected for closer description.

(1) *Milanḡ Valley.*—The basin of the Milanḡ is the largest of all the tributaries in the Chandra-Bhaḡa triangle. Each of its branches provides interesting glaciological problems.

5. No exact figures can be given, as I could not take any camera or scientific instruments with me in 1945.

The second side valley to the North, just above Yotse (Koa Ronḡ coming down from a magnificent cirque of Dolomites—like mountains, would be the best example to demonstrate, even to a layman, the extension of former glaciation. The moraines of this glacier are of a definite red colour, whereas the rocks of the neighbouring mountains are greenish—a striking contrast. As shown on the sketch (see Fig. 2), parts on its side moraines have been eroded by the Koa Ronḡ river the end moraines by this river and the Milanḡ. Distance from the present snout 3 miles, retreat 35% of its former length.⁶ Reason for this large retreat: One of the main feeders no longer reaches the glacier.

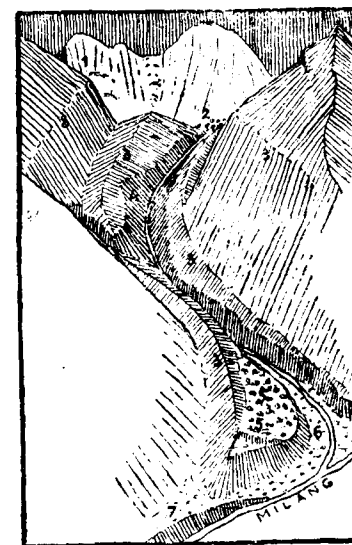


FIG. 2. Mouth of the Koa Ronḡ.

- 1.....Pt. 20500 (see Fig. 1).
- 2.....Ground moraines in front of the present snout,
- 3.....Side moraines of stage 'II'.
- 4.....Side moraines eroded by river,
- 5.....Ground moraine of stage 'II'.
- 6.....Deposits of Koa ronḡ River,
- 7.....Terrace of Milanḡ river, 50 ft. high,
- 8.....Approx. height of ice-age glacier.

The Milanḡ glacier itself is the only example where stage "I" is better preserved than "II". The terminal moraines of "I" are distributed over a rather large area, indicating either slow retreat, or fluctua-

6. The percentage of shrinkage in area and especially in volume would certainly be more valuable, but, for these figures, accurate maps are indispensable.

tations. Distance of the terminal moraines of "I" about 1.3 miles, of "II" 0.6 miles. Retreat 15%. The glacier of the southern Milanğ valley, shown on map 52 H as joining the main Milanğ glacier was even at the time of stage "I" more than two miles from the junction.

(2) *Shipting Valley*.—(Sheet 52D/NE and H/NW). Observations at the mouth of this valley convinced me that the advance in question must be dated rather far back for the following reasons :—(a) The old moraines are covered by full grown trees, (b) The Shipting river has eroded firm rock to a depth of 20 to 30 ft.

(3) *The side valleys of the Chandra above Khoksar*.—An excursion from Khoksar to the Shigri provides overwhelming evidence of a more extensive glaciation in former times. The signs increase in number and size as we go upstream.

The *Kulti valley* (Sonapani glacier) is the only example where an intermediate stage between "II" and the recent fluctuations is clearly marked, in the form of a huge red moraine mentioned by several authors and shown on map 52 H/S.W. This moraine has caused the formation of a lake two miles long, the traces of which are still visible. The lake was empty already in 1906. Of all the main glaciers visited, the Sonapani glacier shows the greatest variation, the retreat being 40%. Probable reason: Flatness of the valley floor. (See Fig. 3).

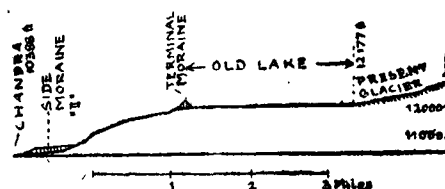


FIG. 3. Long-profile of the Kulti-valley. (From map. 52 H S/W). Heights to lengths two to one.)

The glacier from the *Sakchum valley* (to day three miles from the river and 250 ft. higher) as well as the glacier from the opposite valley have both reached the Chandra. They probably met. Still more impressive are the moraines of the glacier coming from the Sara Umğa Pass (Chota Shigri). They run like two mighty barriers, sometimes 400 ft. high

7. The present end is taken from map 52 H/S.W. Surveyed in 1921. It is most likely that the glacier has retreated further since.

across the whole valley. Several small moraines between "II" and the present moraines can be distinguished.

But everything seen so far is surpassed when we approach the *Bara Shigiris*. The Chandra valley opens out to a width of about half a mile and more. Two miles before reaching the glacier we have to cross the end moraine of stage "II", fortunately still easily traceable, though partly destroyed by river erosion. One and a half miles further, the surface layers of the north bank of the Chandra valley have been eroded for several hundred yards, exposing now, smooth and polished rock (see Fig. 4). The ground in front of the present snout is covered with fine sand gravel and numerous old moraines, cut by many water channels into isolated "mountains". In fact this area provides an excellent example for studying the phenomena connected with a retreating glacier in an open plain (drumlins, eskers). It is a kind of miniature edition of a European glacier at the end of the ice age.

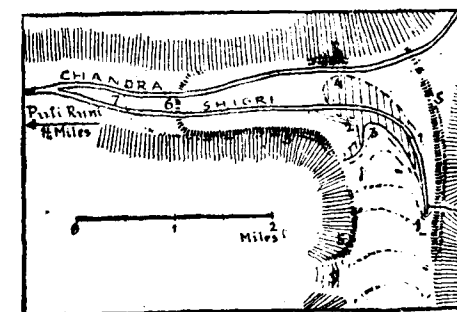


Fig. 4. Not to scale. Secular movements of Shigri glacier. (1) Ice cave 1945. (2) Ice cave and course of Shigri 1906. (3) Present snout (4) Snout 1906. (5) Side moraines of "II" and "I". (6) End moraines "II". (7) End moraines of stage "I". (8) Bank eroded by Shigri glacier.

The main stream emerges now on the right (eastern) side of the glacier. It is bounded by the huge side moraines of "II" and "I" (at an average 500 ft high) stretching right across the plain to the other side of the Chandra valley.

The terminal moraines "I" are, as in the Milanğ valley, distributed over a wide area, the limits being probably 500 yds. below "II". They are rather difficult to determine, because the whole valley is filled with

8. This glacier is not shown on the map at all, only the Shigri river. The whole area is incorrectly represented.

glacial and fluvial deposits. Most of the boulders originally brought down by the glacier have since been transported by the Chandra and Shigri rivers.

The Chandra valley at the time of "I" or "II" must indeed have been a grand sight, when so many ice streams reached the river bed and ice-dammed lakes enhanced the beauty of the landscape.

The question of determining the age of stage "II" and "I" is a very difficult one. In spite of the enormous Himalayan erosion, most of the moraines of "II" are well preserved, looking quite similar to the "1850" or "1820" moraines of the Alps. On the other hand the amount of erosion which has taken place since then, points to a much earlier date. The problem could probably be solved by questioning the villagers in the Chandra valley, who must have noticed the variations. No information could be obtained at Khoksar. Perhaps Sissu would be the best place, as the Shiti glacier, which formerly reached the Chandra, is only half a mile away.

The following is an attempt at comparing the glaciers of Lahoul (and probably of all the adjacent parts of the Himalaya⁹) with alpine glaciers: In both parts the glaciers are now retreating. In the Alps since 1850 (if we neglect the small advance between 1880 and 1890), whereas in Lahoul, judging from the Shigri glacier, the maximum at the end of the 19th century was well defined and the last retreat has taken place since then.¹⁰

Stage "II" and "I" might be compared with the maximum in the 17th century ("Fernau moraines"), though they are perhaps still older. The amount of variation however surpasses anything found in the Alps¹¹.

There are more problems to be solved in that connection: Was there a "minimum" between the recent maximum (1880—1900) and stage "II", or a more or less continuous retreat? Similarly: Do the stages "II" and "I" represent a definite advance after a more congenial period (as was the case in the Alps at that time when the glaciers were much shorter than to-day), or only a temporary halt in a general retreat? Then there remains the question of correlation of the many well defined river terraces with

9. I am quite certain that the huge side moraines of the Gangotri glacier described by J. B. Arden ("The snout of the Gangotri glacier" Rec. of the Geol. Survey of India, vol: 72 p. 135) and clearly shown on one of the photographs, belong to stage "II".

10. The great glaciers of the Karakorum however are on the average stationary,

11. Retreat of some alpine glaciers from 1850 to 1904:

Rhone glacier 1,400 yds.

Gepatsch ferner 800 "

Vernagt ferner 1½ miles:—From 1904 to 1935 the glaciers of Eastern Alps retreated 190 yds. on the average.

the movements of the glaciers. We have collected some material on all these questions but it is still insufficient to draw definite conclusions.

Lahoul during the ice-age. It is considerably more difficult to trace the history of the ice-age in the Himalayas than in Europe. The enormous erosion, due to the still proceeding uplift of the Himalayas, has changed greatly the form of the U-shaped valleys¹². It has removed side moraines along the valleys and covered glacier-worked rocks with new layers. Talus fans from both sides give the valleys a V-shaped appearance. Many parts of Lahoul consist of soft rocks which are especially susceptible to erosion. In these parts glacial forms have been completely obliterated.

Still, it was possible to trace the extent of the Chandra—and Bhaḡa glaciers during the ice age, especially by looking for "truncated spurs". The signs are most prominent in the Chandra valley between Khoksar and Purana Khoksar. There the valley is straight, all the spurs having been cut away. The rocks look smoothened and there is a marked steepening of the slopes in the lower parts. According to these signs, the height of the glacier was more than 1,500 ft. above the present river level at the confluence of the Chandra—and Shigri glacier. It nearly kept this height till below Sissu. Then it slowly decreased to hardly more than a thousand feet at the confluence with the Bhaḡa glacier. The latter had the same 1,500 ft. thickness between Dartse and Kyelang. Farther down, hardly any signs of the ice-age are left. It would be worth while following the Chandra-Bhaḡa glacier and ascertain its end during the ice age.

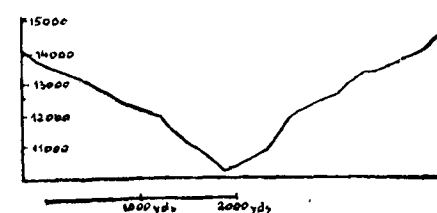


FIG. 5. Cross-section of the Chandra valley between Khoksar and Sissu, milestone 44. (From map 52 H S/W). Heights true to scale.

In some parts of the Chandra valley, a rather steep terrace can be discerned, above the upper limit of the ice age glacier, giving the valley a somewhat "alpine" appearance, with trough and trough shoulder. This terrace can be followed as far down as Gundla and upstream up to the

12. The trough is much better preserved in many of the side valleys: Shiti—and Sissu valley, Shigri—and especially the upper Milan valley are excellent example.

Sakchum, though often interrupted. In some places it can be seen even on map 52 H/S.W. (See Fig 5). It would be most interesting to find out whether this terrace has any connection with the former glacier, whether it can be explained in a similar way as the alpine trough shoulder. It may however be due to a soft layer between two more resistant ones. This is difficult to ascertain as the layers are roughly parallel to the river bed. A closer investigation was impossible as the terraces were, even in the beginning of June, still snow-covered.

Most of the tributary valleys are *hanging valleys*. The height of the "hang" differs greatly, from nearly zero to 1,200 ft. As a rule one can say: The bigger the side glacier, the lower and less steep the "hang". The steep part of those valleys, whose glaciers have not reached the main valley during "I" or "II", are cut by narrow gorges. Best example: First valley above the Kultu nalla.

The picture of Lahoul's recent and past glaciation, as it is here presented, clearly shows that the investigations were done on an extensive rather than intensive scale. Many detailed observations will be necessary to tackle some of the interesting problems mentioned above. Similar investigations in the adjacent parts of Chamba, eastern Lahoul and Kulu would be especially valuable.

Rainfall Regimes in Ceylon

A paper read before Section D. of the Ceylon Association of Science, Colombo, May 1945

BY

A. D. BAPTIST, B.A., *Dipl. Geog. (Lond.)*

This paper is an attempt at a division of Ceylon into regions on the basis of rainfall regime, or seasonal distribution of rainfall.

To understand the seasonal distribution of rainfall in Ceylon it is necessary to consider the types of air movement over the Island at different times of the year. The types of air movement fall into three broad classes:—

- (i) Monsoonal,
- (ii) Local, and
- (iii) Cyclonic.

Monsoonal air movements: The South-West Monsoon prevails over the Island from May to October, and the North-East Monsoon from December to March, while in between are two periods, each of a few weeks duration, in which there is no definite monsoonal current in either direction.

Local air movements: At such times, e. g., in April and November—though these periods are not necessarily confined to the limits of the calendar months—the air circulation over the Island is of a purely local type, and is not at all influenced by Ceylon's position as an Island off the continent of Asia. The atmospheric circulation now set up is due to local causes. i. e., with the heating of the land by day, a sea breeze sets in by about 10 a.m., and blows inland towards the hills. As this air current is too weak and shallow to surmount the obstacle of the central hill-country, the moist air collects at the foot of the hills, and, when it is heated sufficiently by contact with the ground and by radiation from it, convection currents are set up which by afternoon result in cloud formation and rain. By night the circulation is reversed and a land breeze blows out to sea. The clouds disperse and the sky becomes remarkably clear. Thus the inter-monsoonal periods are characterised by fine clear mornings and afternoon and evening thunderstorms which recur with almost mathematical regularity, unless some disturbing influence like the approach of a cyclonic depression upsets the daily rhythm.

Cyclonic air movements: While in the Bay of Bengal no month can be said to be entirely free from cyclonic depressions, in Ceylon they occur with the greatest frequency during the inter-monsoonal periods, March April and November-December, being most frequent in November. During these periods when the air is rather still, differential heating of the atmosphere over a sea studded with small Islands such as the Andamans or Nicobars may set up centres of low pressure which may serve as nuclei of depressions. Depressional activity may also be initiated by interaction of opposing air currents. Once they are formed these depressions generally move westwards across the Bay. They are responsible for a good deal of rain, and, as they originate in the Bay, appear to influence the Eastern and Northern parts of the Island more than the South and West. Very often they result in two or three days continuously unsettled weather, and if the paths of their centres happen to cross the Island a narrow belt of country may experience exceptionally heavy rain. The heavier rainfall of November (as compared with April) experienced in almost all parts of the Island is due to the greater frequency of depressions in this month, while the occurrence of some depressions in December tends to mask the effect of the North-East Monsoon and to increase the total rainfall.

The South-West Monsoon: The South-West low lands, particularly the coastal districts receive heavier rainfall at the beginning and end of the monsoon in May and in October, i.e., when the monsoon winds are relatively weak, rather than at the height of the monsoon. This is because the early or later monsoon winds are weak enough for the increased surface friction over the land as compared with the sea to cause a slight rise of the air currents as soon as they reach the coast with resulting expansion, condensation and rain. There is also a tendency at these times for the monsoon air to stagnate over the low land, and thus get heated and rise. Hence in May and in October there is more rain on the South-West coastal plain where the rain is convectional rather than orographic. In the interior, the ascent of the winds is more marked when the obstacle of the hills is encountered, and the rainfall is accordingly greater in the middle Kelani and Kalu Ganga basins than on the coast. But the ascent of the winds over the central Hill-Country is most marked somewhat later when the monsoon winds are at their maximum strength, and therefore the rainfall of exposed hill stations in June or July is greater than that in May or October, e.g. Hatton, Nanu-Oya, Luccombe. On the leeward side, the monsoon wind is warm and dry with a *chinook* effect. This warm and dry wind is known in the Eastern Province as the Kachchan, and the high temperatures experienced there in June are closely connected

The decrease in the rainfall in August when the monsoon gradient is almost as steep is probably due to the fact that when the monsoon is well established it runs in regular stream-lines, and its course is, therefore, not so readily disturbed as when it is more irregular. That is, it makes its way round the obstacle of the hills, and thus avoids rising over them and dropping its moisture.

The North-East Monsoon: Almost the same considerations apply to the North-East Monsoon with the windward and leeward sides reversed. But there are some important differences:

(i) The North-East Monsoon being merely the North-East trade wind is not so great a rain-bringer as the South-West Monsoon.

(ii) The winds, unlike those of the South-West Monsoon have crossed only a small stretch of sea, and therefore their moisture content is not as great.

(iii) The barometric gradient is not so steep; the maximum average pressure difference between Trincomalee and Colombo being not even as much as 1.0 m. b. for any month. (It is as much as 3.0 m. b. for the South-West Monsoon).

(iv) Perhaps for this reason it causes more widespread rain than the South-West Monsoon whose rainfall is somewhat confined to the South-West quadrant of the Island.

(v) It is of much shorter duration, lasting only four months, viz. December to March.

(vi) The average pressure charts show a diminution of pressure not in a North-East to South-West direction, but from North North West to South South-East, or from North to South.

(vii) It is neither particularly warm nor dry on the leeward side. In fact, the apparently leeward side—the South-West quadrant—is not strictly in the lee of the monsoon when the wind is North North West.

Having analysed the fundamental causes that contribute to the rainfall of Ceylon, we may now examine the seasonal distribution of rain in various parts and group together rainfall stations which show the same type of periodicity or regime. (See Table).

The monthly march of rainfall in Ceylon shows the influence of the following factors:

(i) The proximity to the equator with a resulting all-year rainfall with two minima;

TABLE
AVERAGE MONTHLY RAINFALL IN INCHES

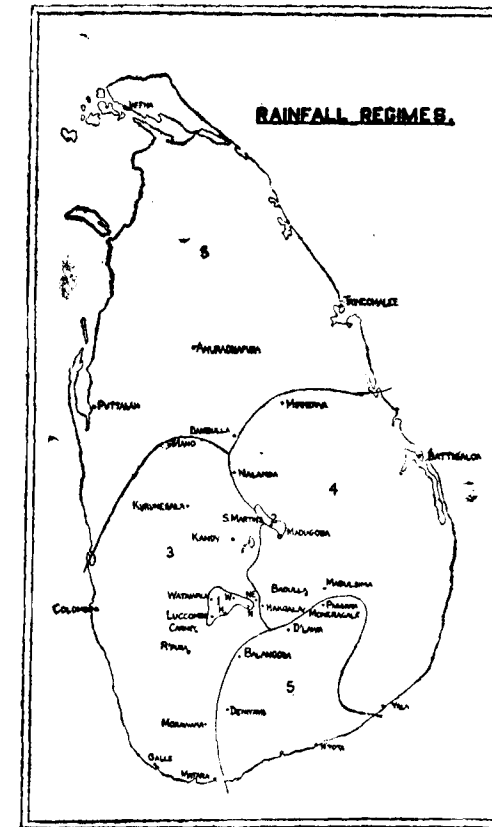
STATION	Alt. Feet	REGION (1)												S	O	N	D	Total
		J	F	M	A	M	J	J	A	S	O	N	D					
Hatton	4,140	4.6	2.2	6.7	9.4	12.2	22.0	21.4	15.9	14.1	14.0	11.0	6.0	139.5				
N'Oya	5,342	4.9	1.5	4.2	5.6	8.9	15.1	14.8	11.6	11.4	11.0	9.3	6.1	104.3				
Lucombe	3,600	3.6	1.6	6.7	9.0	16.0	26.3	24.3	19.6	17.4	16.4	11.6	6.3	158.6				
Watawala	3,260	5.6	2.9	7.3	11.0	21.9	40.7	29.8	26.7	27.0	24.0	15.1	7.3	219.5				
Watawala	4,402	5.2	1.5	5.8	7.8	9.6	16.9	17.3	13.0	12.9	13.1	10.1	7.2	120.9				
S. Martin's	3,600	40.7	9.1	9.8	9.6	5.7	4.8	4.5	3.4	5.8	18.9	23.6	38.3	174.3				
Madugoda	2,595	21.0	6.1	6.8	6.7	4.4	2.6	3.3	2.5	4.4	12.8	14.3	18.7	103.4				
Colombo	...	4.0	2.2	4.9	8.9	15.0	9.0	6.0	2.6	7.0	13.2	12.3	5.6	90.8				
Galle	...	3.6	3.0	6.2	8.8	12.5	8.7	6.7	5.2	10.4	11.6	11.1	8.2	96.0				
Kandy	1,611	6.7	1.8	5.8	6.2	6.0	9.6	7.6	5.5	6.6	10.9	11.2	9.1	86.9				
N'Eliya	6,170	6.7	1.7	4.3	4.7	6.9	10.9	11.8	7.7	8.9	10.6	9.5	8.0	91.8				
R'pura	...	6.5	4.5	11.0	11.2	20.1	19.0	13.3	10.6	16.3	17.8	15.0	9.2	154.5				
Carney	1,001	7.9	5.8	13.9	17.9	31.2	33.0	22.2	18.3	25.5	26.5	19.1	10.5	231.5				
Kurunegala	...	4.9	1.7	6.0	9.4	6.7	7.4	4.1	2.7	6.2	15.9	13.5	7.1	85.6				
Maho	...	5.3	3.7	3.9	5.8	4.0	3.3	2.6	1.0	3.8	11.4	10.4	5.3	58.4				
Baticalos	...	13.8	2.7	3.3	1.7	1.9	1.0	1.1	1.8	2.6	7.1	15.9	17.2	70.1				
Badulla	2,225	10.6	2.5	5.6	6.4	4.7	1.8	2.4	2.7	4.5	9.7	10.0	11.4	72.2				
Madulsima	4,500	17.4	4.3	8.5	2.5	5.4	1.8	2.4	4.0	5.3	13.7	15.0	17.6	104.7				
Minneriya	...	13.6	2.8	4.1	6.3	3.4	0.5	1.0	2.1	4.1	10.1	14.8	16.5	79.3				
Nalanda	...	12.8	2.9	5.4	5.6	3.5	3.8	2.5	1.8	3.4	2.8	14.1	15.2	83.8				
Hakgala	5,581	12.1	3.4	6.7	7.1	8.0	7.0	7.3	5.0	6.6	12.8	12.1	13.4	101.5				
Yala	...	5.2	1.2	4.2	2.6	2.1	0.4	1.3	0.3	1.3	4.5	6.5	6.6	35.7				
Jaffna	...	4.3	1.2	1.8	1.5	1.6	0.4	0.6	1.0	3.1	9.6	16.3	9.4	50.9				
Trincomalee	...	8.7	2.0	2.4	2.0	3.4	1.1	1.9	3.5	3.8	9.1	14.3	12.1	64.8				
A'pura	...	5.7	1.5	3.7	5.9	3.1	0.9	1.4	1.2	3.9	9.8	11.5	7.6	56.2				
Puttalam	...	3.6	1.1	3.3	4.9	3.7	1.7	1.3	0.2	1.8	8.1	10.0	6.2	45.9				
Dambulla	...	10.5	2.3	5.1	6.6	3.1	1.6	1.7	1.6	3.6	10.8	12.2	10.6	69.8				
Balangoda	1,732	6.8	3.8	9.9	11.3	6.6	5.7	5.3	3.2	5.2	11.8	12.2	10.7	92.9				
Passara	2,800	10.2	2.8	7.2	9.2	5.5	2.9	2.8	3.4	5.1	11.2	12.8	10.7	85.5				
D'Jawa	4,101	6.3	1.8	5.0	5.2	5.9	1.8	2.0	3.0	4.4	9.5	10.2	8.1	63.2				
Deniyaya	1,900	9.5	5.2	13.2	10.8	11.6	9.5	7.6	4.9	9.4	13.7	15.5	14.7	125.4				
Moneragala	...	9.8	2.7	6.2	7.4	4.4	1.5	2.4	3.6	4.3	11.7	12.5	10.0	76.3				
H'tota	...	3.7	1.1	3.8	3.3	3.4	2.2	2.4	1.1	3.1	4.8	7.8	5.6	42.3				

(ii) The South-Central position of the Hill-Country;

(iii) The South-West and North-East directions of the monsoon winds. These last two factors combine to place the driest parts of the Island in the North-West and South-East.

(iv) The position of the Island in the Bay of Bengal, and the influence of the cyclonic depressions originating therein.

The accompanying map shows a division of the Island into regions of differing rainfall regime. As in all cases of climatic divisions, the boundaries are only approximate. The following names are suggested for these:—



Region (1) South-West Monsoon Regime.

Region (2) North-East Monsoon Regime.

Region (3) Equatorial regime with predominant South-West Monsoon influence.

Region (4) Equatorial regime with predominant North-East Monsoon influence.

Region (5) Equatorial regime with cyclonic rather than Monsoon influence predominant.

The table gives the rainfall figures for the stations marked on the map.

(1) Only a small triangular area with apices roughly at Watawala, Adam's Peak and Nanu-Oya show a definite one-season rainfall with a single maximum, occurring at the height of the South-West Monsoon. Hatton and Lucombe lie within this triangle. This area is fully exposed to the South-West Monsoon and its rainfall regime may be described as a South-West Monsoon regime. This does not imply that convectional and cyclonic air movements make no contribution to the rainfall of this region, but that the rainfall due to the monsoon is great enough to mask the effects of the convection and depressions.

(2) Theoretical considerations would lead one to expect to find a corresponding area fully exposed to the North-East Monsoon and showing a North-East Monsoon regime. I have been able to find only two stations which might be said to answer to this requirement, viz., S. Martin's and Madugoda. Even in the case of these two, there seems to be a slight tendency to a secondary rise in the rainfall in March—April. Perhaps the North-Eastern slopes of the Knuckles Hills do have a clear cut single maximum, but absence of recording stations precludes confirmation of this at present.

All other stations in the Island show the equatorial regime with two maxima, characteristic of equatorial regions in other parts of the world. The two maxima are, however, not of the same size.

(3) In the South-Western part of the Island most rainfall is received from the South-West Monsoon and there is no real dry season. Typically, the May or October rainfall is greater than that of November e.g., Colombo Ratnapura, Galle. This may be described as an *Equatorial regime with South-West Monsoon influence predominating*.

Stations in the South, in the East and in the North of the Island also show two maxima, but the spring maximum which occurs in March or April is insignificant, and the total for the year is much less than in the previous regions. Besides, the two drier seasons combine to form one season of definite and prolonged drought lasting six months or more, e.g., Puttalam, Anuradhapura, Batticaloa. The second maximum occurs in November or December, and I think there is a good case for demarcating the area with a December maximum—Region 4 from those areas with a November maximum—Region 5.

(4) Stations with the December maximum are situated in the East Central part of the Island, e.g., Batticaloa and Badulla, and their regime

may be described as *Equatorial with North-East Monsoon influence predominating*.

(5) Stations with the November maximum are either in the North or South and from what we have noted about cyclonic activity in this month we may describe their regime as *Equatorial with cyclonic influence predominating over pure monsoon influences*, e.g., Jaffna, Trincomalee, Hambantota. It is not intended to imply that the monsoons are not responsible for any rain here, but that the rain due to depressions is greater. In fact, there are a number of border-line cases where it is difficult to decide which influence is predominant, e.g., Maho, Dambulla, Passara, Balanigoda. There seems to be also a small detached area round Rajawella and Milapitiya in the Mahaweli Ganga Valley to the South-East of Kandy in which this regime obtains.

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Rice in India

BY

GEORGE KURIYAN

Continued from Vol. XX, No. 2, page 84

The actual distribution of rice in India is brought out by the dot map and the major areas of concentration are in the river valleys and deltas. Map I shows the correlation between isohyets and rice cultivation. The 50" annual isohyet normally appears to be the lower limit of cultivation, except in parts of the United Provinces, Bihar, Madras, Sind and the Punjab. But in these regions, the crop is dependent more on irrigation than on rainfall and it is, therefore, true to conclude that without facilities for irrigation, the crop does not thrive where the annual rainfall is less than 50". Apparently, there is no upper isohyetal limit, it being successful even in those regions where the annual rainfall is 100", or more. But topographic factors would begin to play a more determinant role in such areas.

Map II shows the percentage of area under rice to net cultivated area. It is seen that Bengal stands supreme. Due to double and treble cropping, a large portion of the delta has more than 100% of the net cultivated area under rice. In the whole region south of Dinajpur, and the Garo and Khasi hills, more than 80% of the net cultivated area is devoted to this crop. The only other regions with similar concentrations are the Brahmaputra valley in Assam, the districts of Singhbhum, Cuttack, Puri and Sambalpur in Orissa, Raipur and Bilaspur in the Central Provinces, and West Godavari, Chingleput, Tanjore and South Kanara in Madras.

Map III* shows the percentage of the area under rice to the gross area. In Bengal the cultivation of the crop is well distributed, with the greatest concentration occurring in the south eastern part of the Province, in the districts of Bakkarajanj, Noakhali and Faridpur, where more than 80% of the gross area is under rice! The Ganges-Brahmaputra doab, together with the districts of Mymensingh, Dacca and Tippera form another very important rice producing tract where the crop occupies 60 to 70% of the gross area. Under these conditions, it is clear that the prospects of increasing the acreage are not rosy. As it is, there is no other region in India

* Maps II and III should be studied simultaneously to observe the importance of rice in comparison with other cultivated crops and with reference to the total area. Thus S. Kanara has more than 100% of the net cultivated area under rice but the crop occupies only 20 to 30% of the total area. Many other similar examples can be cited.

where rice occupies a higher proportion of the gross area. These facts make the recent Bengal famine all the more inexplicable.

Outside the Province of Bengal, it is only in the Balasore District and the Cauveri delta that more than 50% of the gross area is devoted to rice. Even in the Godavari delta, the crop occupies only 40 to 50% of the gross area.

Methods of rice Cultivation: Probably in no other crops are the methods so varied as in rice, but in the main, there are two types of cultivation, (i) dry & (ii) wet. The former is both in extent and output, of very little importance, but a passing mention of it may, however, be made.

Dry Cultivation of rice is found in the poor laterite and gravelly soils in many parts of India, particularly in S. Kanara, Malabar and in parts of the Agency tracts of Ganjam and Vizaapatam. They are mainly of three types, the first is the most primitive type known by different names in different parts as 'Kumeri' in S. Kanara, 'Punam' in Malabar and 'Podu' in the Vizaapatam Agency; the second is a slightly more advanced type known as 'Modan' in S. Malabar and the third is the *Budama* of Kistna & Godavari. In the first type the slopes of hills are first cleared of the jungle by cutting and burning, and the rice is grown on the cleared ground. After one or two crops are taken, the clearing is given up and the jungle allowed to develop again. The dry paddy may be sown mixed with pulses, or grams, (as in Vizaapatam), and may in some cases be followed by a gingelly crop, or more rarely, by a cotton crop (as in Vizaapatam). Most of the land available has been brought under cultivation and there are few possibilities of extending this destructive method of agriculture. In the 'Modan' cultivation, the land is terraced after deforestation and no jungle springs up again. But the land has to be left fallow for two, three, or more years, to recuperate between two or three crops of rice. The third type—the *Budama* of the Kistna and Godavari uplands—is grown on the deep heavy black soils, between lines of red gram.³¹

In parts of the Province of Madras, especially in Chingleput, Kurnool and Salem districts, rice is sown as a dry crop, in the hope that monsoon rains of adequate quantity will be available at the proper time to fill the rainfed tanks. Once the supply of water is assured, it becomes a wet crop. In the districts of North Arcot, South Arcot, Chingleput and Salem, rice is also sown as a garden crop with the help of lift irrigation from wells.

³¹ By the time the red gram grows up to cast its shadow, the rice gets matured.

Wet Cultivation : Nearly 98% of the world's rice crop is a wet crop and wet cultivation is practised wherever the supply of water is assured, as in the deltaic regions and river valleys of the Ganges, Godavari, Kistna, Cauveri, Pennar, Periyar, Tambraparni, etc. In this type of cultivation, rice is actually grown in a field of standing water.

The size of the rice fields under wet cultivation differs from tract to tract, varying from a few cents to a few acres. It depends primarily on the level of the land in the tract. In the terraced slopes of Malabar and S. Kanara, the individual fields are even as small as 5 cents, while in the delta of the Godavari, they may be very much larger. Fields watered from wells are necessarily small. On an average, they are 10 to 20 cents. While smaller fields result in waste of cultivable area by the numerous bunds, levelling of fields which is a condition precedent, can be more thorough there. Actual experiments in Australia suggest that the most economical unit is not the large holdings similar to those of wheat, but smaller units where the levelling can be perfected. No mechanical methods have yet been devised which could get over the need for these bunds. The space required for the bunds in the rice fields, is thus, a necessity. Apparently then, in the case of rice cultivation, the problem of small holdings in India is not so serious as it has been made out to be.

The culture of rice is one of the most laborious of all the agricultural occupations. Three different methods are adopted for sowing. They are (i) transplanting (ii) broadcast sowing and (iii) drilling.

Transplanting is the most usual method adopted. Generally the seeds are sown in well manured specially prepared seed beds. As soon as the seedlings have attained a height of a few inches, they are removed from the nursery and transplanted by hand into the field, already prepared and kept ready for the purpose. The period for which the seedling must be allowed to remain in the nursery depends upon the varieties, fertility of the seed beds and the manner of preparing them. It is generally the rule that for short duration varieties (50 or 60 days) the period should be short and for long duration ones, long. Roughly, for wet crops, a week should be allowed in the nursery for every month's duration of the crop, while the corresponding period must be longer in the case of dry crops. More important than age, however, is the commencement of the formation of the nodes in plants while in the seed bed, that make them unfit for planting. To get the seedlings established in the field as early in the season as possible, is one of the important desiderata for a successful crop.

Broadcasting : Rice is also sown broadcast in many parts of India, mainly in Bengal, where nearly 50% of the total area is so sown. The ideal conditions required for a broadcast crop are good early showers facilitating a thorough preparation of the land and timely rains to get the crop in, by the proper time. Generally broadcast sowing is practised in the case of dry crops, short duration crops and in poor lands. It is also confined to tracts where the availability of water is uncertain and the season undependable as in parts of Kurnool, Nellore, Chinglepet and S. Arcot districts, where the cultivation of the crop has to be started before irrigation water becomes available. In South Malabar, the first crop (*i.e.*, the main crop) is broadcast, as the crop has to be in the field when the S. W. Monsoon bursts. The land is already prepared in a dry condition and if transplanting is to be adopted, there would not be sufficient labour to get the whole work completed in time. The same question of labour arises, but obviously for a different reason, in the malarial tracts of Ganjam and Vizagapatam. Weeding expenses are very heavy in a broadcast crop, but there is not probably the same urgency about this work as there is in getting the crop in the field, in time.

Drilling : A special type of plough carrying a receptacle perforated at the bottom is used in drilling; as the ploughing is completed, the seeds are sown in a line. Drilling is to a certain extent replacing the practice of transplanting owing to labour difficulties³².

Transplanted rice has a higher yield but the why of it is not satisfactorily explained by experimental evidence. It is probable that physiological causes might account for it. When the crop is broadcast over the field, the seed is usually sown thick and consequently there is overcrowding of plants, resulting in competition among them, both for light and food. Such competition is likely to affect early tillering and number of ears, and will encourage shoot growth at the expense of root growth. Striking differences have been found in the relative development of the root system between the transplanted and broadcast crop. However, even when sufficient space is allowed by thinning out the broadcast crop, it does not develop a strong root system. The maximum lengths of the bigger roots are shorter and the finer roots are fewer in numbers. This probably leads to lodging being more frequent in the broadcast crop than in the transplanted one.

A scrutiny of the yield data shows that in spite of the larger number of ears in the broadcast crop, the greater length of ears and the larger

³² The Italians had been attempting to evolve a satisfactory transplanting machine, with what success is unknown.

number of grains per ear have contributed to a heavier output in the transplanted crop³³. For transplanting over broadcast sowing, in the case of *Kar* (a variety cultivated in the Cauveri delta), there was a profit of Rs. 8/8/- per acre, while in some others, it was as high as Rs. 18 per acre.

To a large extent, broadcasting is responsible for the comparatively low yields in India, due to the inadequate preparation of the soil, particularly where the seeds are sown with the first showers of rain, in land which suffers from want of moisture. The broadcast method accounts for nearly 50% of the rice area of Bengal and is also common in parts of C. P., U. P., Bihar and Orissa. It is the exception rather than the rule in the other rice growing countries of the world. In Burma, transplanted rice forms 95% of the total and the conditions in Indochina, Thailand, Japan and China, are almost identical. If, therefore, India is to increase her yield, a change in cultural practices is indicated. Particular stress must be laid on the fact that it is still possible to introduce transplanting with advantage in many cases, especially in large tracts of Bengal, C. P., U. P., and Bihar.

The seed rate per acre varies in different areas according to the nature of the soil and the type of sowing. For broadcast sowing, the seed rate is higher, because a larger portion of the seeds sown, fails to germinate. For transplantation, it may be as low as 10 lbs/acre as a minimum as in the Punjab, and as high as 120 lbs/acre as a maximum as in Chotanagpur. For broadcasting, the corresponding figures are 20 lbs/acre in the Punjab, and 160 lbs/acre in Coorg. In Madras and the United Provinces, transplanting requires about 40 lbs/acre, while broadcast sowing takes about 80 lbs/acre. In Mysore, the respective figures are 17 lbs/acre and 78 lbs/acre. It is only in Chotanagpur that broadcast sowing takes less seed (50 lbs to 80 lbs.) than transplanting, and probably this is due to the need to reject a considerable number of young seedlings which show insufficient vitality for transplanting in the field.

The cost of transplanting as judged from the amount of seed used is more or less an indication of the standard of cultivation attained, the seed rate being usually higher in the backward tracts. It can be anywhere from 20 lbs to 120 lbs of grain, sown on 5 to 7 cents of land to give enough seedlings to transplant one acre. It has however been found as a result of considerable research, that for any ordinary well-prepared wet seed bed, about 18 to 20 lbs of seed sown in about 7 to 8 cents of land should be

ample to transplant one acre. This is an optimum figure and may require modification when the grain is either small (e.g., *jeeragasamba* for which 8 lbs is enough), or very big (e.g., *Kar*, *basargi*, etc., for which 30 lbs may be required)³⁴. The average seed rate at present, for India as a whole, is about 70 lbs/acre. The total seed requirements of India is approximately 2.41 millions tons of paddy, i.e., not less than 1.61 million tons of rice. By carefully preparing the seed beds, it will be possible to save about 60% of what is now being used as seed, a saving of at least 1.4 million tons of paddy, or 1 million tons of rice! Is it not time that these improved methods are adopted?

Irrespective of how the seed bed is sown, the seed rate adopted affects the condition of the seedlings, thinner sowings giving rise to strong and sturdy seedlings and thicker sowings to poor and weak seedlings. Empirical results show that thinner sowing is always decidedly better, and it could be combined with wider planting of the seedlings in the fields. But by adopting economic planting, the yield of straw goes down. In tracts where the cattle are not dependent on the straw alone, this is not a serious matter and increased production of the grain should be the main consideration.

The ratio of the seed bed area to the transplant field may vary between 1:8 and 1:20. In parts of Malabar where the seed beds are raised on the precarious hot weather showers, the ratio may be as narrow as 1:4 or 1:5 since the bulk of the seed may fail to germinate. In the Kistna delta, however, the ratio is very much wider, showing that the weather is particularly suited and the ryots more enterprising.

Several experiments have been conducted on the optimum spacing between the plants and it has been found³⁵ that it is not possible to lay it down with any precision. It will have to vary according to the cultural standards, the variety and fertility of the soil. Wider spacing increases the yield by improving the number and length of ears, apparently to a greater degree than manuring.

Multiple Cropping: In Bengal, Assam and Orissa three crops of rice are raised in a year. They are named according to the season in which they are harvested and are generally known as *aus* or autumn crop, (sown in May to July and harvested in September,) *aman* or winter crop, (sown between June to August and harvested between November to February) and *boro*³⁶

33 Experiments in Ganjam have shown that in good years, broadcasting is as productive as transplanting. But generally, however, the broadcast crop suffers from precarious weather conditions and it is seldom that an ideal broadcast crop is met with. See Ramiah Op. Cit. p. 48.

34 Ramiah Op. Cit. p. 26.

35 Ramiah Op. Cit. p. 37.

36 The *boro*, however, is sometimes called the spring crop from the time of sowing.

or *dalna* or summer crop (sown from the end of January to March and harvested in May and June.) The three crops do not necessarily occupy the same land, although double cropping does take place to a limited extent in some areas.

The main rice area of Bengal comprises the delta of the Ganges—Brahmaputra and the fundamental problem of the delta is to get the water off the fields. A considerable area is subject to heavy floods. There are two groups of aus, one that is grown on the highlands in April—May and the other grown in lowlands in February—March. The latter grows in 5 to 6 feet of water and the harvest is generally done in 3 to 4 feet of standing water. The aman is also of two types (i) the transplant aman which is the most important and (ii) the aman broadcast in lowlying areas during March to May and harvested in December to January, when the flood waters have dried up. Some of these lowland amans can grow up even in 20 to 30 feet of water! The boro is sown in seed beds where water does not dry up, even during the cold weather. In Bengal, Bihar and Orissa, winter rice is lowland rice with a period of about 5½ to 6 months of growth, the autumn crop is highland rice with a growth of 90 to 115 days.

Area in millions of acres under rice for 1937—38

Crop	Aus or Autumn.	Aman or Winter.	Boro or Summer.	Total
Harvest months.	August— September	November— January	February— May	
Bengal	5·86	15·92	0·41	22·19
Assam	1·02	3·83	0·20	5·05
Bihar	2·31	7·19	0·01	9·51
Orissa	0·94	4·18	0·03	5·15
United Provinces }	4·43	2·70	0·02	7·15

The relative importance of each of these crops is well indicated by the above statistics of acreage for the year 1937—38 which was a normal year of rice production in India. It is obvious that the aman crop is the most important.

In Madras, the times of sowing and harvesting vary considerably in the different parts of the Province, mainly because of the different seasons of the year when the rainfall is received. Almost all the cultivation is confined to the two monsoon periods, June to January. The crop either gets the benefit of the rains directly as in Malabar and South Kanara, or gets its

water supply from rivers which depend upon the monsoon for their freshes as in Trichinopoly, Tanjore and Godavari. There are rice areas on the East coast which do not get the benefit of the south-west monsoon, either directly or indirectly and are exclusively dependent on the north-east monsoon. Usually these areas have a large number of irrigation tanks which get filled during this monsoon and the rice season extends from October to January. In special isolated tracts as in the Godavari where water facilities extend beyond February, a hot weather crop may also be grown between February and May. In the districts of Godavari and the Circars, the autumn crop is harvested in October and November, the winter crop in December and January and the summer crop in April and May. In the central districts, the first crop (autumn) ripens in October, the second about December and the third in April. In the Nellore area the harvest timings are approximately January and March for the two crops and May if there is a third crop. In the southern districts, the first crop is harvested in September, the second in February and the third a few weeks later. On the west-coast only two croppings are normal, the first in September and the second in January and February. Thus the bulk of the rice harvests in the Province of Madras comes between the period December to February while some small quantities may be expected in September—October and later in April—May.

In the rest of India as in the Central Provinces, Central Indian States, Sind, Punjab and North West Frontier Province, only one crop of rice is usually grown which is harvested between the end of August and early in November.

Manuring: Rice land is generally prepared by a system of puddling in water, which affects the physical conditions of the soil and produces a finer and more clayey texture. In course of time this process would make the soils heavier, which must be counteracted by proper manuring. Organic manures have been found to be beneficial. Again, as the land is kept flooded in a swampy condition during the greater part of the growing season, there is no free oxygen present in the soil. The nitrogen of the manure, instead of forming nitric acid as is usually the case, forms ammonia which is readily absorbed by the plant. Fermentation in rice soils being anaerobic, nitrates are decomposed and the nitrogen is liberated as a free gas, which the plant cannot use. Hence the popular conception that nitrates need not be applied to rice. But certain physiological experiments with rice conducted in Bombay appear to point out that the plant can take nitrogen both in the ammoniacal and nitrate forms, and the absorption is more in the ammoniacal form in the early stages which gradually decreases

as the plant gets older with increasing absorption of the nitrates. The application of nitrogen in the form of ammonium salts, or amides improves both growth and yield, while the application of nitrates is expedient only in the later stages of the life of the plant³⁷. This leads to the suggestion that a mixture of nitrate and ammonium sulphate should prove a better source of nitrogen than the latter alone.

A rice crop giving 3,000 lbs of grain and an equal amount of straw from an acre, removes from the soil roughly 48 lbs of nitrogen, 23 lbs of phosphoric acid and 41 lbs of potash and these will have to be replaced if the soil is not to be depleted of its fertility. Artificial manuring will considerably improve the rice lands. Nitrogenous and mineral manures are more or less beneficial but they are most economical when applied in conjunction with bulky organic manures. Generally speaking the soils are deficient in phosphorus and nitrogen. For continuous rice cultivation, it pays to use phosphatic fertilisers freely; the addition of nitrogenous manures liberally is also profitable and very often the addition of potassium sulphate would give excellent results. The best type of manure would be a combination of bonemeal, superphosphates, etc., together with ammonium and cyanide compounds. These do not, however, have any indirect effect of increasing root aeration and hence could be applied with greater advantage in conjunction with green manures. Empirical results at Coimbatore have shown that the supply of nitrogen in the form $\frac{2}{5}$ artificial and $\frac{3}{5}$ organic is the best.

The value of green manure is most apparent in soils of average fertility where the increased yields are about 20-25%, while fertile lands under similar treatment have shown increases of only 8 to 10%. The good effects of green manuring are striking during bad seasons. It should, however, be pointed out that the practice of growing a green manure crop on the soil itself for ploughing in, particularly a non-leguminous type, is far from being as profitable as bringing leaf from outside to be ploughed in. 4,000 to 5,000 lbs of leaf per acre will be an optimum dose. Poor soils have shown a depression in yield under increased dosage unless supplemented by phosphatic manures. Many green manure crops can be cultivated, the pulses, sun hemp (*Crotalaria juncea*), wild indigo, kolinji (*Tephrosia purpurea*), daincha (*Sesbania aculeata*), pillipesara (*Phaseolus trilobus*), cowpea (only in Malabar) and the field bund should be utilised for some such crop, as is done in Godavari and Malabar.³⁸

³⁷ Copeland Op. Cit. p. 21. Nagaoaka has shown that upland rice which grows normally in aerated soil shows less need for amoniacal compounds than the lowland variety.

³⁸ Tanjore will do well to copy this.

Cattle manure is one of the best but it is always inadequate. e.g. In Tanjore, where it is the only form of manure used, it is just sufficient for about a tenth of the area. There is a pernicious habit of using cattle dung as fuel. And the cattle manure available in the country is very poor stuff due to the very bad ways adopted in making and preserving it. S. Kanara is unique in the care that is bestowed upon it. Greater attention must be paid to convert all vegetable wastes into manure by composting them. Municipal rubbish also should be used carefully. Rice thrives best with an almost unlimited amount of humus. While chemical manures may have a definite value, what rice wants is a large quantity of additional soil forming material. To this end, the Japanese employ every conceivable substance to enrich their rice fields, from leaves and even the lighter branches of trees, grasses, clover and other leguminous refuse, to burnt out native bricks suitably ground down, ashes and other refuse. The Japs also make full use of the large amount of night soil. This valuable material is not wasted, but is conserved in large brick receptacles where it is added to other accumulations of material collected for manurial purposes including the mud recovered by dredging the irrigation canals³⁹. As compared with these, our record in India is hopelessly unsatisfactory.

Among bulky organic manures may be included the different oil seed cakes⁴⁰ available and the fish manure. They are complete manures and there is generally little necessity to use anything else in conjunction with them. Bonemeal also is included among the bulky organic manures. Exceedingly rich in phosphoric acid and with a fair amount of nitrogen, it undergoes rapid decomposition in the rice soils and makes the manurial ingredients available as plant food, although it is best used in conjunction with green manure.

The results of manurial experiments in Madras show that :—(i) green leaf definitely increases the yield, (ii) organic manures like cakes serve the same purpose as green leaf, (iii) ammonium sulphate, ammophos, niciphos, etc. are as good as green leaves in increasing the yield, (iv) the above fertilisers when used in conjunction with leaves gives increases over plots receiving leaf only, (v) phosphatic manure gives no response over the application of green leaf, (vi) the increase in yield is generally 10 to 15%,

³⁹ Douglas Rice p. 30.

⁴⁰ The total quantity of oil cake manufactured in India is about 1.45 million tons. Half of this is required for feeding the cattle and the remaining half is insufficient for manuring the intensively cultivated crops such as tea, sugarcane, potatoes, green vegetables, etc. Very little cattle manure is now available for application to the cereal crops. India is one of the greatest producers of oil seeds and if the export of the seeds is banned and the cake converted into oil in India, it would make available a large quantity of cake manure and thus improve the agricultural yield of all crops.

(vii) green manures alone, act beneficially in poor soils only, and that perhaps, for the first few years only, (viii) lands beyond a certain fertility, indicated by an average yield of about 3,000 lbs./acre, do not respond to manures, and (ix) it is always best to apply phosphates in combination with other manures as they have generally no value alone.

Rotations: In wet land rice, in a large proportion of the area available for cultivation, there is practically no rotation practised, except the growing of Jute alternating with rice in east Bengal. But in some places, although rice may be grown year after year, with sometimes even two crops a year, it is the custom to take a catch crop of some pulse, blackgram, green gram, cow gram, horse gram, or gingelly. Often, this is sown in the standing rice crop a fortnight before the harvest, when water is drained off. Sometimes, sun hemp may be grown for fodder, as in Kistna. In a few places where facilities exist, instead of sowing these catch crops in standing rice, the land is ploughed after the harvest and then the pulse is grown. The other important crops grown in actual rotation with wet land rice are sugarcane, betel wine, plantain and turmeric. In South Kanara, tobacco sometimes follows the main rice crop in coastal areas. In a few places west of the United Provinces, rice may be sown after winter wheat. All these crops, however, are confined to places where the soil is not too heavy and where facilities exist for irrigation and drainage.

Pests: It is a general principle that the more extensively and continuously any crop is planted, the more it is likely to be the prey of epidemic diseases and pests. Rice is perhaps the most widespread of crops and is certainly the crop which has been the most continuously planted over single great areas. It is, therefore, remarkable that it has never been destroyed as an industry of any country (as coffee has been) and is not even known to be generally subject to any such serious damage from an enemy, as wheat for example, has suffered from its rust. The explanation is probably not that rice is any more immune than wheat, though this is possible, but is rather to be found in the different methods of culture. Commonly transplanted and always harvested by hand where its culture is old and intense, rice has been comparatively easily and naturally guarded against epidemics, by reasonable care and without recourse to any scientific methods such as disinfection, or the use of enemies of the pests.

It is however, estimated that about 1% of the average production of India (worth about 3 crores of rupees) is wasted through weevil infestation⁴¹, damp and vermin attack. More than half the loss is due to

⁴¹ Report on the marketing of Rice in India Op. Cit. p. 19. The chief rice pest is the stem-borer, but the ryots in Godavari have dodged this problem by using early duration varieties for the first crop and by delaying the planting for the second crop.

weevils, vermin being the next in importance. It is noteworthy that hand-pounded rice undergoes deterioration more quickly than milled rice and both more than paddy.

Harvesting: The crop should be harvested when it is slightly under ripe. If the heads are allowed to mature fully, there is considerable loss by shedding and such paddy tends to yield a rice with more broken grain. On the other hand, premature reaping is also undesirable as the quality of the rice is lowered by the larger proportion of imperfectly developed kernels. Generally the right time for reaping is indicated when the rice kernels in the lower part of the head have not hardened completely and the upper part of the leaf blades have not turned completely dry.

After reaping, the primary concern of the producer is to get the sheaves dry as rapidly as possible, regardless of the effect which that may have on the ultimate quality of the rice. It is very desirable that some research is conducted on the existing method of handling the crop prior to threshing, to diminish the high proportion of broken grains.

Threshing may be done, either manually by treading, or by beating the sheaves against a block of wood, or by bullock treading. The manual process is not only more economical but also gives cleaner paddy. The cost of harvesting including threshing and winnowing varies from Rs. 3-8-0 to Rs. 6-0-0 an acre. There are no machines used for harvesting or threshing. With the most intensive method of rice growing under swampy conditions in small irregular shaped fields, frequently terraced with bunds all around to conserve the water supply, and with agricultural labour being still cheap, there is very little scope for introducing machinery for harvesting. However, there appears to be room for the development of cheap mechanical rotary threshers similar to those used in Japan.

Varieties: Of the 7,000 botanical varieties of rice, more than 4,000 have been identified in India suitable for the different soils and climates. In spite of their multiplicity the Indian peasant knows the various kinds and the right places to grow them. Experienced Botanists find difficulty in distinguishing them in the early stages, while the Indian peasant does so with a marvellous degree of certainty. "And yet we have good earnest souls, out fresh from Europe endeavouring to teach the ryot how to select the seeds."⁴² It is not surprising, therefore, that there are considerable physical variations in the different types and qualities of rice cultivated in this country. They may, however, be classified depending

⁴² Kenny intensive farming in India page 250.

upon their physical characteristics into (i) fine or slender, (ii) medium and (iii) bold or coarse. Fineness, or slenderness is indicated by a fairly high, length to breadth ratio. In the fine rice, the ratio of length to breadth is more than 3, while it is less than 2 in the bold or coarse type, and the medium type has an intermediate value⁴³. The smaller the size of the grain, the better is the quality. Fine rice is the costliest and is normally consumed by the well to do. Medium rice is the most important commercially as it constitutes nearly half the quantity that reaches the market. Bold rice is consumed by the cultivators, artisans and manual labourers. The taste of rice is very conservative and consumers seem to think that the variety of rice to which they have been accustomed is the best and that any other kind of rice is unsuitable. The markets are highly localised and the degree of importance attached to each quality varies widely, e.g., the *basmati* of the U. P. and the Punjab is not appreciated in South India. Natural translucency is almost everywhere accepted as a desirable characteristic. As a rule, the whiter the colour, the better is the price fetched. Other qualities which are appreciated are, uniformity of size and shape, and freedom from foreign matter and impurities. Invariably, rice which has been stored for a year or more, commands a premium.

Rice is also classified into raw, or par-boiled "depending upon the way paddy has been treated, the latter by first steeping the paddy and subsequently applying heat by steam or other means to toughen the rice kernel, to enable it to withstand hulling or milling, without excessive breakage.

As a rule, par-boiled rice is cheaper than raw rice of the same quality because par-boiling hardens the grain and enables a higher percentage of extraction of 'head rice', or whole grains to be obtained on milling. Par-boiling also results in an increased total output of rice. It stores better and retains its freshness for a longer period. Thanks to its cheapness, the consumption of par-boiled rice has increased considerably in the last 20 years.⁴⁴

A third method, of classification of rice is dependent upon whether it is machine milled (27%) or hand pounded (73%). There are at least 10,000 rice mills of varying capacity scattered throughout the country and in all probability, there are more. They handle annually about 62% of the marketable surplus (i.e., 27% of the total production) which, however, has

43. The total production of fine rice in India is 3.39 million tons. i.e., 13%.
do. medium do. 8.79 do. i.e., 32%.
do. bold do. 15.11 do. i.e., 55%.

44. Raw rice constitutes 43% of the total production and parboiled rice, the remainder, viz., 57%.

45. It is said that parboiled rice has a higher nutritive value than raw rice.

remained stationary during the last 2 or 3 years. The public are beginning to realise the better nutritional qualities of hand-pounded rice. It is mainly the City dweller who eats the milled rice; the irony of it is rather poignant the more educated and civilised man of the towns eats the less nutritious product!

Yield:—The yield depends on a host of factors like the nature of the soil, the climatic conditions, manurial practices, pests, diseases, etc. The yield of any crop as published in the official books is obtained by multiplying the area under the crop by the standard yield. The standard yield is the average yield on average soil in an year of average character and this is derived from the information based upon crop cutting experiments conducted over a period. These experiments, however, are not carried out on a sufficiently large scale and the methods employed lack uniformity. The accuracy of most of the standard yields given in these official publications would in any event be questionable. Again, the fact that paddy (the form in which the grain is harvested) is converted into terms of rice, interposes another factor, which if based on defective, or inconsistent formulae, is liable to seriously affect the total output; and this in its turn, will considerably viciate the average yield computed. Thus the conversion figure is 62% in the Central Provinces while it is 70% in the Bombay Province and the official publications of the Government of India are based on the reports from the Provinces and States among which such wide disparity is found⁴⁶. Further more, the important fact that as much as $\frac{2}{3}$ the rice produced in India is the result of hand-pounding a method which usually gives a larger output of rice than machine milling⁴⁷ does not appear to be taken into consideration. The published estimates of rice production cannot, therefore be regarded as representing the true position. It is, therefore, true to conclude that the average reported annual production of 29 million tons falls short by about 2 to 3 million tons, when corrections are made for the conversion factor and the greater output in the hand-pounded rice.

The published standard yield of rice for the last five quinquennia is given below.

Standard yields of rice in lbs. per acre.

Province.	Quinquennium ending.				
	1911-12.	1916-17.	1921-22.	1926-27.	1931-32.
Bengal.					
Winter.	983.	1,036.	1,029.	1,022.	1,111.
Summer.	1,104.	1,179.	1,156.	1,142.	1,238.
Autumn.	807.	871.	888.	892.	1,023.
			Average for 1906-32 — 1,090.		

46. The average conversion figure for India as a whole is about 65%.

47. Hand-pounding usually gives 72% rice including edible brokens 3% bran, and 25% husk, while machine milling gives 68% rice including edible brokens, 8% bran and 24% husk.

Bihar & Orissa.

Winter.	1,234.	1,234.	987.	987.	987.
Summer.	800.	800.	800.	800.	800.
Autumn.	800.	800.	800.	741.	741.
Average for 1906-32 — 919.					

Assam.

Winter.	1,008.	952.	896.	896.	896.
Summer.	...	1,008.	1,008.	1,008.	1,064.
Autumn.	672.	706.	706.	706.	717.
Average for 1906-32 — 870.					

Madras.⁴⁸

...	1,047.	1,065.	1,057.	1,055.
Average for 1916-32 — 1,056				

U. P.

900.	900.	900.	900.	900.
Average for 1906-32 — 900.				

C. P.

624.	624.	624.	647.	648.
Average for 1906-32 — 633.				

Bombay.

1,230.	1,230.	1,230.	1,230.	1,230.
Average for 1906-32 — 1230.				

It is significant that, in some instances, no corrections or revisions have been made for the last 25 years! After making the corrections for the conversion factor, the probable yields for the Provinces will be,⁴⁹ Bengal 1171, Bihar and Orissa 1043, Assam 1,000, Madras 1088, U. P. 968, C.P. 747, and Bombay 1218.

Probably, the most difficult factor in computing the output is the seasonal factor. Water has, perhaps, the most important influence on the yield. Where rice is mainly a rainfed crop as in Bombay, good yields depend on the timely onset of the monsoon and a well-distributed rainfall during the growing period. Based on actual crop cutting experiments it has been found that the yields on irrigated lands are much better than on unirrigated lands⁵⁰. The yield varies according to the crop and the varieties grown. Summer rice generally gives the largest yields and autumn the lowest. Bold, or large grained rices, under similar conditions of soil, weather and cultural treatment, generally yield about 15 to 60% more abundantly than the small fine slender varieties⁵¹. To meet the present emergency there is ample scope for improving the yield by the cultivation of these

48. The acre yields are different in different districts, they being particularly low in Ganjam and Malabar.

49. Vide Report on the marketing of Rice in India Op. Cit.

50. The corresponding figures of average out-turn of paddy expressed in lbs./acre are:

	Irrigated	Unirrigated
Madras	1,694	1,138
Central Provinces	1,200	900
United Provinces	1,100	850
Punjab	1,269	587

51. Report on the marketing of rice in India Op. Cit p. 19.

bolder varieties. This is likely to be much more successful than any attempt to augment the output by an increase of acreage.

The time of planting is a very important criterion for the success of the crop; the earlier the planting, the better is the yield. Both for short duration and long duration crops, the sowing should be done early in the season with the first supply of water. The adjustment of cultural practices like fertilizing the crop, closer planting of the seedlings, etc., might to a certain extent obviate the harmful effects of late sowing, but they can never replace the good effects of early sowing.

The method of sowing also influences the yield, transplanted rice being a better yielder than rice which is either broadcast, or drilled. The difference is about 10% in N. & S. Kanara and about 20% in the Balaghat district of the Central Provinces. Experiments at the Cawnpore research farm have shown that transplanted rice may yield 70% more than broadcast, or drilled rice. In transplanting, there is much greater control over the mixing of the strains and this is a distinct advantage which is often lost sight of. There are, however, some practical limitations to the universal adoption of transplantation. Where the crop is dependent on rainfall, it is only possible on low lying tracts capable of retaining moisture. It is also slow and laborious, making enormous seasonal demands on labour, which may either be scarce, or too expensive for the poor ryot.

The improvement of cultural practices can increase the present yield by about 20 to 25% and if improved strains are used (even bolder varieties seem adequate to tide over the present emergency, although there is a deterioration in quality) the yield should be still better, e.g., the yield in the central farm at Coimbatore during the last 15 years has increased from 2,000 lbs./acre to 4,000 lbs./acre.

The official estimate of the yield in India is about 825 to 850 lbs./acre, although it has fallen to 728 lbs./acre in 1938-39 for reasons which are unknown⁵². The average figure for Burma is about the same or slightly better than that for India, while for Indo-China it is 650 and for Thailand 900 to 950 lbs./acre. For Japan, it is about 2,150 lbs./acre⁵³, Egypt more than 2,000, Spain about 3,500⁵⁴, Italy about 3,000 and U.S.A about 1,500.

52. Ibid.

53. In a competition in Japan, the yield was as much as 7,000 lbs./acre.

54. It is said that the yield in Spain is better than that of Italy due to the prevalence of transplanting in Spain (Vide Imperial Institute, Indian trade enquiry, Report on Rice p. 105). Spain also introduces exotic varieties (notably Japanese) with a view to check the deterioration of races cultivated too long in the locality.

Hence the yield in India does not compare unfavourably with the other adjoining countries of S. E. Asia, except China for which no statistics are available. The average yield in China must be greater than that of India since China's share of world production is greater than that of India, in spite of the fact that the area is smaller. The Indian yield, however, falls far short of that of Japan, U. S. A., or the Mediterranean countries. In all these countries, apart from the high fertility of the soil, artificial manures are used in plenty—60 to 80 lbs. of nitrogen and 50 to 60 lbs. of phosphoric acid per acre. These cost on an average more than Rs. 50 per acre. The Indian ryot cannot be expected to spend more than Rs. 15 per acre for manures and one of the urgent problems which requires an immediate answer is to find suitable manures at reasonable cost. More attention than has been done in the past should be devoted to this aspect of the problem.

It is said that the yield of all crops⁵⁵ increases polewards and, this apparently seems true when we notice the disparity between the Mediterranean countries and India⁵⁶.

By improving the seeds, the yield could be augmented. The cultivator generally retains the paddy needed for the seed, but when he is short of it, he buys it at a prohibitive price, or borrows it to be returned in kind at an exorbitant interest. Seed is also obtained from the several agencies of the Agricultural Department in some places. The role played by co-operative agencies is negligible. About 10,000 tons of pedigreed seed have been distributed by the government departmental agencies and if account is taken also of the natural spread which has occurred, still on a liberal estimate, only about 4½ million acres i.e. 6 per cent of the total area is under improved varieties! This is far from being satisfactory when it is realised that the Agricultural Research Institute has spent more money on rice research than anything else for the last ten years. Efforts are necessary to ensure that large quantities of improved seed are made readily available and that the multiplication and distribution of such seed is properly organised. The agricultural authorities must also take steps to control and maintain the purity of the seed.

(To be continued)

⁵⁵ Proceedings of the Indian Science Congress Association, 31st Session 1944. Discussion in the section of Agriculture on "the method of improving the yield of rice"

⁵⁶ Or, is it because the water from the fields is drained off completely now and then in Italy and Spain? This as has been noted, promotes a vigorous growth of the plants and incidentally of the weeds too?

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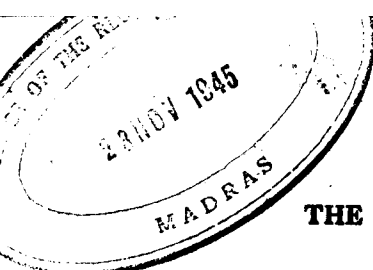
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Central Training College, Lahore

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V. S. MATHUR, M.A., (Lond.)
Govt. College, Lahore,
Vice-President, Indian Geographical Society.

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Location of the Original Aryan Home and other Early Aryan Settlements

A Historico-Geographical Solution of the Problem

BY

PROFESSOR MANECK B. PITHAWALLA, D.Sc., F.G.S.
Bombay University Teacher in Geography for Postgraduate
Research, N. E. D. Engineering College, Karachi.

SUMMARY OF THE ARGUMENTS ADVANCED IN CHAPTER I

(1) The Syr Darya has fortunately retained the relic of the name Syr or Sur, originally found in the mythical Avestan river Ardui Sura, so highly praised in the Zoroastrian scriptures and remembered even in certain prayers of the Avesta. It was supposed to have flowed from the Hukere mountain into the Sea of Vourukasha, identified by such great scholars and pioneer geographical researchers as Sir Jivanji Modi, as the Elburz and the Caspian respectively. This is most probably the Original Aryan Home.

(2) This valley is so close to the second best Land mentioned in the first Farvard of the *Vendidad*, viz. Sughdha, Sozdiana or the Amu Darya valley and the valley of the Zarafshan, also emerging from the same continuations of the mountains and falling into the same sea. The geographical conditions in both these valleys are similar.

(3) Culture is generally born of the environment and these geographical conditions resemble, to some extent, the conditions mentioned in the *Vendidad*, the *Bundahishn* and other sacred books of the Parsees, sufficiently

quoted in the body of the thesis viz., good agricultural land, good water supply, good pasture, glaciers in the neighbouring mountains, glaciated condition of the rocks, dangers of floods, excessive silting up of the valley, hydrographical changes, peculiar plant and animal life, both wild and tamed, settlements protected from the onslaughts of un-Aryan tribes, and, above all, the splendid landscape and appearance of the heavenly bodies in the clear sky which must have been greatly instrumental in developing the earliest religious notions of the Aryan race. So the environment was suitable for producing such a high civilisation.

(4) Though this God—chosen Land now falls within the Steppe—Desert belt of Afrasia, it has played its part in producing such a high civilization many milleniums ago, when the climatic conditions were better. Today both the Atlantic storms and the S. W. monsoon belt do not reach this region as they used to do before. Even now there are excellent oases found within the region, harbouring fortified towns as of old.

(5) This valley of the Syr Darya is on the high caravan route even at present and it was quite central for all the offshoots from it. The Russian Railway now passes also through the valley.

(6) Some Orientalists have identified the Aryan Home not very far from this valley. e.g., the Pamir by Max Muller, some spot between the Syr and the Amu Darya by Baron Bunsen, and the lake Balkhash by Sirdesai; in fact it is the general opinion of several Orientalists that the original Aryan Home was somewhere in Central Asia.

(7) It is near Iran, which has still retained the ancient name Airyana in a slightly modified form, and which has proved to be such a great power of civilization in the ancient and medieval times that the whole of the then—known world was once brought under its sway. This country has retained its ancient traditions admirably, though it has seen many political upheavals and subsidences in later periods. Many of the cities, rivers, mountains, etc., mentioned the Zend-Avesta can be identified with those lying on the Iran plateau to-day.

CHAPTER II

It has been already shown that the early Aryans could not always remain in the first chosen land of *Airyana vaejo*, but had to migrate to other localities for certain geographical and other reasons. I shall now deal with some of these early Aryan Settlements and their historical geography. It is likely that streams of Aryan migration flowed from the original Aryan

Home in as many directions as possible, according to the facilities offered by the countries involved. This must have gone on for many milleniums, say from 5,000 B.C. onwards. These Aryan settlers succeeded in replacing or absorbing the primitive aborigines, their languages and cultures, as they went farther and farther.

Let us now consider those early Aryan settlements, which were more or less in touch with, or in the neighbourhood of the Original Aryan Home, especially in Middle Asia.

Earliest Iranian Geographers

The chief authorities on this subject are the same Avestan geographers as have been quoted before. In fact, the information which can be gathered from the *Vendidad*, the *Yashts*, etc., and their Pahlavi translations and commentaries, notably the *Bundahishn*, is the oldest authentic geography of the world. Modern geographers should be grateful to them for these valuable records.

I shall, first of all, deal with the 16 Chosen Lands of Ahura Mazda mentioned in the 1st Chapter of the *Vendidad*.¹ Rhetorically, at the very outset the author says that King Jamshed extended the earth and made it "habitable in such a way that those places, which were not joy-giving, became joy-giving, good and comfortable; otherwise, all the corporeal world would have rushed into *Aryana vaejo* and it would have been impossible to cross over to other places." Thus the civilised world grew first at the instance of King Jamshed (Yima) and, one by one, the settlements were established.



Identification of the 16 Chosen Lands

I. *Airyana vaejo*.—The Original Aryan Home, already dealt with fully in the first chapter of this thesis. All the migrations and extensions from it were towards the south.

II. *Sughdha*.—Soḡdiana. The name is derived from Avesta *such* = to burn; so it is possible that a Fire-temple was established here after the first batch of the Aryans left the original Home. It is also identified with modern Samarkand, higher up in the Amu Darya valley, although in Pahlavi books it is fixed in the valley of the Zarafshan river, a tributary of the Amu. The distance between this and Land No. 1 is about 200 miles, which is reasonable for such an early migration.

As Ahriman (the Evil Genius) created severe winter and the 'serpent' (noxious animals) in the Syr Darya valley (Land No. I), so he caused a plague of locusts in this Land which destroyed crops, etc.

III. *Mouru*.—Merv. It lies in the valley of the Murghab, naturally the third river valley occupied by the Aryans, going towards the south. This town is still in existence, as it was called 'pure' and 'strong'. Ahriman here created the calamity of an evil intercourse of horsemen, thieves, robbers and heretics, and it is natural that this settlement was harassed by non-Aryan nomads from the plains below, under their king Afrasiab.

IV. *Bakhdhi*.—Balkh. Evidently the fourth Aryan settlement possible in the neighbourhood. Balkh stands even today in the upper valley of the Amu Darya (Oxus), though some miles away from the river in its present course. Safe in its higher reaches from the onslaughts of the Turanians, it was subsequently made the capital city by the Kyanian King Gushtasp, who accepted the religion of Zoroaster (Zarathushtra) the prophet of Ancient Aryana. As the capital of Bactria, too, it is described in the Avesta as a city "with high-lifted banners." Ahriman could only create ants and ant-hills, which have not destroyed this great citadel in spite of the passage of time.

V. *Nisaya*.—Nisaya. It seems to have been lost due to some hydrographical changes. The river on which it must have stood is dried up, though Justi and Harley placed it in the Murghab valley. It is said in the *Vendidad* to have been lying between Lands No. III and No. IV. Speiḡel, Burnouf, Bunsen and Hauḡ thought it wrongly to be Nishapur in Khorassan.

Nisaya is shown in the map given in the *Census of India Report*, Vol. I Part I 1931 P. 467. Lat. $38\frac{1}{2}^{\circ}$ N Long. $56\frac{3}{4}^{\circ}$ E. No authority, however, is quoted. Besides, it is too far from Localities III and IV and may be a second Nisaya. This is the only doubtful settlement so far. On account of Ahriman it suffered from the sin of unbelief, having been previously occupied by some unbelievers and destroyed by them.

VI. *Haroyu*.—Hari Rud Valley. It can be taken as Herat, but it was really the next river valley that could be found by the emigrants, a very fertile granary of Asia. Ahriman created tears and a wailing only for this very reason, as a confession of his defeat.

VII. *Vaekeret*.—Seistan. It is also known as Saḡestan and lies again to the south of the Hari Rud. Dr. Hauḡ was keen on identifying this locality with Seistan, the home of great Iranian heroes, Keshasp, Nariman, Zal, Rustom and others. Darmesteter, Harley, Justi and Sykes thought it to be Kabul according to the Pahlavi commentators. But Speiḡel and Ritter agree with Hauḡ, who is more correct when we examine the relief map of the region. Several small rivers fall into the Lake Seistan today and it is possible that a river, named Vaekeret (meaning, divided into two), was one of them. Lake Seistan certainly occupied a wider area in the past ages, but it has very much shrunk in size. Ahriman caused the evil geni of Pairikas and other idolators to settle here and we are told that there was Daevayasnism (polytheism) prevailing here before the advent of Zoroastrianism.

VIII. *Urva*.—Kabul valley. It is described in the *Vendidad* as having rich pasture and much fertility. Evidently it is another river valley, occupied by the Aryan pilgrims and is really wide in extent. Dr. J. J. Modi identified it as Kabul. It is not really to the south of Land No. VII, as there were no such fertile valley in that direction, but towards the east the settlers found other good rivers. Ahriman created the sin of haughtiness, as this settlement was really so wide, fertile and prosperous.

IX. *Khenta*.—Kandahar. Dr. Hauḡ explains its identity etymologically as *Khand* = blooming and *har* = spring. So *Khent*—*har* became Kandahar, which is feasible. Harley and Darmesteter take it to be Hircania, far away to the south of the Caspian sea, from its capital, called Veherkan=Gorḡan. This is impossible, as it would not have the juxta-position of the next locality. Ahriman had an unnatural sin brought in here, from which there was no escape and there was the decay of the settlement.

X. *Harahvaiti*.—River Sarasvati or Arghandab. It is quite the next best logical settlement, identified by Sir Aurel Stein, many decades ago, as the *Western Sarasvati*. In the Cuneiform inscriptions it is styled *Harau-wates*, and the Greeks called it *Arachosia*. Naturally it must have been occupied by the Vedic Aryans on their way to the *Eastern Sarasvati in Sapta Sindhu*, occupied by them later on. Ahriman is said to have caused another unattonable sin of burying the dead, which is against the precept of Zoroastrian Aryans.

XI. *Hautumant*.—The Helmand. There is no doubt about the identification of Haetument with the Helmand river, as the name signifies. It is on the east of Vaekeret but naturally next to the Harahvaiti available for settlement, still towards the south of the other localities. Although it now flows into the salt lake, Hamun-i-Helmand, due to desiccation and other catastrophes, it was once a bright and prosperous region. Stein has discovered a tribe called Kianian, even now living on the river banks.

XII. *Ragha*.—Raghae, ancient Rae. It was at one time the capital of Media, called Raghae by Greek writers. It is also the traditional home of Zoroaster. Now lying in ruins to the south-east of Teheran, it must have had a good water supply from the Elburz water-shed, but again the streams appear to have dried up beside a salt lake, called *Daria-i-Namak*. It lies on the great highway from eastern to western Iran. So holy a place, in which the Prophet exercised both the temporal and the spiritual powers, would surely induce Ahriman to cause unbelief in the hearts of the people; but after all, truth prevails and this first Aryan settlement on the tableland of Iran proper can be easily traced to the ruins of Rae.

N.B.—The question naturally arises as to why this 12th Land happens to be so far removed from the 11th locality of the Helmand in modern Afghanistan. The answer is that after the last-named settlement, in which both the Persian Aryans and the Vedic Aryans lived together for the last time and the schism occurred due to the geographical as well as religious causes, the former chose to move eastwards towards the Iranian tableland while the latter travelled through the Kheiber Pass and arrived for the first time at the Indus, as there were hardly any habitable localities left towards the south and also there were no good rivers in Baluchistan due to inland drainage, for their settlement. This great event of separation took place about 1,500 B.C.

XIII. *Chakhra*.—Kakhra or Kura valley. The next settlement suitable for the Persian Aryans was in Azerbaijan in this Kura valley, which is even now fertile and prosperous, making the provinces of Azerbaijan and Georgia so famous in history. Haug thought it to be some place in Khorassan and Darmesteter supported his theory. But if there were a suitable locality here for an Aryan settlement in that age, it would have been

occupied by the people even before Ragha and soon after the schism among the Aryans in the Helmand basin. There is no place like Charkh or Chakhra found any where in Khorassan.

As the Kura valley is perhaps the farthest to the south-west from the original Aryan Home, there are chances of its having a strong non-Aryan element in it and Ahriman is said to have "counter-created a sin for which there is no atonement,—the cooking (burning) of corpses", which the Persian Aryans never tolerated.

XIV. *Varena*.—Gilan. Some kinds of anti-Aryan antagonism seems to have driven the faithful back to the only other available Iranian locality, named Varena, the popular parts of Gilan, "having four corners or cross-roads". A small river, the Safid Rud even now flows northwards into the Caspian sea and the Elburz mountain stands giant-like around it. With Mazandaran, it shares the reputation of possessing some human "daevas", as Ahriman in all his vindictiveness created disbelief and barbarian and other tendencies, which stopped the stream of Aryan migration at least for the time being, on this side of the country.

XV. *Hapta Hindava*.—Sapta Sindha. While the Persian Aryans, were thus struggling for their existence on the plateau of Iran, the Vedic Aryans thought it wise to descend from the mountainous region and to pass through the Khaiber, which was luckily available, into the rich valleys of the Indus system, formerly seven in number but now only five (the Punjab) due to some hydrographical changes. They were, according to Prof. Max Muller² 1. Sindhu (Hindus) 2. Vitasta (Hydapes, Jhelum) 3. Asikani (Akesines, Chenab) 4. Airavathi (Hydraotes, Ravi) 5. Vipas (Hyphasis, Beas) 6. Satudhru (Hesydrus, Sutlej) 7. Sarasvati (lost in the desert). According to the *Vendidad*, this region suffers from summer heat in the lower latitudes and alluvial plains, due to Ahriman's revenge. Some of the Vedic hymns were actually composed on the banks of the Sarasvati, now lost among the Ambala streams and the Hakra-Gaggar depression.

XVI. *Rangha*.—Ram-Ganga. There is much difference of opinion about the identification of this last locality, blessed by Ahura Mazda according to the *Vendidad* geographer. No other suitable locality beyond the Sapta Sindhu can be traced for an early Aryan settlement except the Ganges, so sacred to the Hindus, which I consider definitely to be Rangha. It cannot be anywhere else in Iran or Iraq, as some Orientalists imagined without any sound reason.

East. From here the Aryan civilisation spread as far as the Nile in the west and the East Indies in the east. The very language Pushtu belongs to the Iranian stock. There are numerous ruins here which are identified with place-names in the Zend-Avests (Avan, Meher, Jamyed and Tir Yashts), e.g., *Khanvant*=Bamian mountain, *Pouruta*=Paroponessus mountain, *Ushidarena*=Seistan mountain, *Bost*=a principality in Seistan, *Zabulistan*=district round Ghizni etc. Every one of these places is "bathed in the ancient spirit of Zoroastrianism." Seistan, particularly, is a burning cauldron in summer today, but it was one of the most prosperous in pre-historic times. "At first Ram Seheristan on the banks of the Helmand was the capital of Seistan but the river having changed its course from there, later on, Zaranj or Dooshaka on the Helmand was made the capital. The fire-temple of Karkoe was situated in this city." Side by side with physical catastrophes, political causes, too, ruined this country in many ways. "The actual area of the Gaud-i-Zirreh (Hollow of Zirreh), over which there seems to have been once a permanent, if variable water-surface, measures fully 100 miles in length and 30 in breadth; and the Seistan lake once covered the whole of the present delta of the Helmand. To-day, even in spring, the Zirreh marsh does not measure 10 miles by 3, as a rule, and the Helmand valley, below Rudbar, is a series of dead cities, including the famous Shahtistan and Zabidan; but the cause lies in the neglect to replace the famous dam, Band-i-Rutam, which Timor destroyed and which had made the lakeland for centuries an exporter of grain." To-day Afghanistan contains many relics of human races, human tongues, native and foreign, without any coherence or unity whatsoever. A strong political control over the population and a kind of Tennessee Valley Authority would bring the land again into the limelight, as in the past.

Old Iran

The tableland of Old Iran was not as favoured by nature as Afghanistan and so there were only three of the Chosen Lands established on it, although parts of it were nearer the Original Home and lay on the high way between the east and the west. There are practically no good rivers in Iran. Luckily, however, northern Iran lies to a certain extent, within the influence of the Atlantic Storm Belt, and also the heights of the Zagros Range are affected by the Mediterranean climate. They have proved more favourable and defensible than the midland plains and the Khorassan Divide, and what is lost here in latitudes is gained in altitudes. Very healthy hill stations are found in the midst of these mountain fastness in such provinces as Farsistan, Khuzistan, the valley of the Karun, etc. In

later centuries great kings established their dynasties here e.g. Achaemenian, Parthian and Sassanian. Perhaps the Aryan civilisation, born of the river valley civilisation, was not able to conquer these heights easily and to provide the necessities of life for the people living in them.

Historical Glimpses of the Settlements

True history of Iran begins with the reign of Cyrus the Great, who established the Achaemenian dynasty of Persian rulers in Farsistan in 558 B. C. Through these Great Kings the Aryan culture and civilisation were re-established in Old Iran and thence spread to the whole of the then known world. They conquered and ruled over some 23 large satrapies, including the Indus region, and left some splendid monuments in Persepolis, Pasardadae, Susa, Behistun etc. They also attempted the conquest of Europe by Asiatics for the first time in history and carried the lamp of learning and good government throughout the length and breadth of the world. In fact, they were the first empire builders in the world.

So there is a distinct historic connection between the earliest Aryan settlements, built by the original settlers, and these later Aryan settlements in Iran.

Cultural Aspects

The term 'Aryan' means noble and is still retained in the name Iran, which the great king Raza Shah Pahlavi revived lately after the dark ages which set in soon after the downfall of the Sassanian empire 651 A.D. Iran, shrunk today abnormally to modern Persia, swayed the destiny of the Aryan world for thousand of years. The cultural boundaries between the Aryan and non-Aryan territories were definite. At first, the whole extent of the country of Asia, occupied by the ancient Aryans before the schism, was supposed to be Aryan and the land outside its limits un-Aryan or Turanian. References to the great crusades made by the Aryans against the Turanian King Afrasiab, are found in the *Shah Nameh* of Firdousi. The Greek historians¹⁰ also spoke about "all the country between the Indian ocean in the south, the Caspian Gates, Kermania and the mouth of the Persian Gulf in the west" to be the Aryan land of later days. As the Aryan culture and civilisation spread more and more westwards, the whole of Persia, Media, Armenia and Asia Minor claimed the title. Even some of the new localities were named after the old Aryan settlements in these parts. Towards the north in the Siberian plains, however, the Aryans and the non-Aryans came constantly into clash with one another and bloody feuds ensued. Similarly, "all traces of Aryan as a geographical term vanished beyond Transoxiana." Not only wild migratory tribes but also wild

animals were the enemies of the 'noble race,' beyond the fair limits of the Aryan lands. Withal, Ancient Persia and Vedic India have played a unique part in Aryanising the non-Aryan world in the west and the east respectively. Even to-day the east and the west meet in Iran through the accident of geography and the sparks of Aryan civilisation are kept alive in the world. In the new scheme of the 'global atlas' of the world, however, this critical position of modern Persia must be reconsidered.

Aryan Institutions

An idea of the institutions of the early Aryans can be obtained from the pre-history of the Peshdadyans, their fore-fathers, who actually established a dynasty of rulers, which concluded about 2,000 B. C.¹¹ During this long period and for about 500 years later still, as we have seen above, the Persian Aryans and the Vedic Aryans lived together in these settlements. Names of their kings as well as deities are found commonly in these scriptures of both these peoples,¹² e.g. Av. Atar Sk. Aghni, Av. Vata Sk. Vayu, Av. Mithra Sk. Mitra, Av. Ahura Sk. Asura, Av. Anghra Sk. Indra, Av. Verethraghna Sk. Varuna, Av. Yima Sk. Yama and so on.

Peshdadyan clans have continued to live in the mountain fastnesses of the lands once occupied by these ancient Aryans. Fire temples in ruined conditions have been discovered all over this region, e.g. Bokhara. The Tajiks, Beloochees, Uzbeks, Galchas and other tribes have been found living in these northern river valleys and speaking a language akin to that of the Iranians and the Hindus. Dr. Geiger, one of the greatest Avesta scholars, has said: "I must not pass over the report of Mushketoff upon the Galchas dwelling in the vicinity of the glaciers of Zarafshan. Their culture, customs, manners, etc., resemble those of the Aryans and the Fire-worshippers."¹³

Nature of Settlements

The Aryans, according to Geiger, had fixed settlements in those river terraces where good arable land, good water supply and good pasture were available. Grass was the foundation of the economic life of the people living in these settlements. This was the chief difference between the unsettled life of the incoherent, wandering and unprincipled un-Aryans in the low-lying plains of bad lands, bad water supply and insufficient pasture and the well-organised, civilised and settled life of the Aryans with kindred ties, controlled by lovable patriarchs. The latter had pride of possession, disciplined administration and united strength in their settlements as a contrast to the looseness and irresponsibility of life of their opponents.

They developed a national life and sowed the seeds of wise kingship in the world for the first time. There was division of labour in their economic life and the people were classed as 1. priests, 2. warriors, 3. cultivators and 4. labourers. The geographical divisions of the land were 1. the house (*nmana*) 2. the street (*visa*) 3. tribal area (*zantu*) 4. province (*dakhyu*). All dwelling places and offices were confined to mountain fastnesses and located on the banks of rivers or streams. They were more like fortified villages harbouring a race of cultivators of arable land and breeders of cattle, each valley having a separate social unit, with a separate set of traditions and customs peculiar to its environment.

Role of Animals

Domestic animals were their best friends. The horse, which has played a valuable part in human civilisation and advancement in the world, was a native of this region. It was trained and utilised by man for the first time in this age. Its very name has gone into the surnames of great Iranian heroes and kings, e.g., Kershasp, Arjasp, Gushtasp, etc. In fact, the idea of kingdom originated here with the idea of the horse. Other useful animals were also trained and domesticated, while wild and injurious animals were destroyed. Sheep and goats were the principal wealth and the pecuniary (*L. pecus*=sheep) circumstances of lords and overlords were gauged by their numbers. Later on, even the camel, the 'sheep of the desert,' came into the picture, as the Aryans occupied drier areas of Iran and travelling across them became a necessity. The name of the prophet of ancient Persia, Zarathushtra, is derived from *ushtra*=camel, which can be considered to have given a most valuable share in the establishment and acculturation of more and more settlements on the Iran plateau. "The Iranians differed little from the race of whose customs the Rig-Veda gives,—not a full picture,—but a faithful outline. Pastoral folk, devoted to their flocks and herds, but not unlearned in the cultivation of the earth and the sowing of grain, they had reached what may be called the highest stage of primitive civilisation. Though milk, butter and cooked corn formed their principal food, on feast days they also ate meat, chiefly the flesh of oxen and buffaloes, which they were careful to cook thoroughly. The progressive Aryans denounced the more savage peoples who consumed it as 'wild men' or 'demons.' They kept horses, asses and mules; even horses were sacrificed occasionally. The wild boar was hunted, if not in the earliest, at least in very early times. The dog was prized for its fidelity as the guardian of the house and flocks."¹⁴ There is a good bit of canine literature recorded in Avesta in the *Vendidad*, the same Book of Laws, which the Parsees possess to-day as one of their most precious religious books.

The forms of the settlements of the early Aryans differed according to the land-forms available, and the conditions of life were adjusted and adapted to the natural environment, the river valleys particularly serving as lines of communication.¹⁵ "Mountainous parts, which themselves render the free movement of larger masses of men and animals difficult, are usually the first cause of permanent dwellings. Even wild and rugged mountain districts appear at a very early period to have been habited by these settlers to as great a height as the climate would allow, the higher parts still being available for pasture." Thus hill-stations, agglomerated villages and small fortified towns were created, their protection being largely left to nature.

Geography and Religion

Both the landscape and the skyline were superb. They were most important as the chief sources of inspiration for the great Mazdayanian (monotheistic) teachers of the Peshdadyan days. It was not at all a mere material civilisation. No doubt, the settlers could build solid houses, erect fortresses, cultivate fields, carve out caves, use metals, cut canals and even navigate rivers. But they also turned their attention to the moral and spiritual aspects of human life. Natural phenomena, like the eternal fire, the sun, the moon, the planets, the stars, the rivers etc., were deified and beliefs in angelology mythology and life after death were hinted¹⁶. A tremendous literature containing the hymns in praise of these deified objects was actually composed and the religion was tinged with polytheistic ideas at first. There was, however, no god of Ice suggested, which would have been the case if the Home was in the arctic region. Plants and animals belonging to the temperate zone were praised and spiritually associated with the working of the angels and archangels, who dominated Aryan theology, e.g. Beheram Yazad (Verethraghna), the angel of victory is depicted in the *Beheram Yasht*¹⁷ to appear before his devotees in no less than ten different forms. 1. Of wind, very furious and fair and overcoming many evil doers and demons, 2. Of a bull, strong and fair with yellow ears and golden horns, 3. Of a horse, white and fair, and so sharp-eyed that he could see even a hair in the darkest night, 4. Of a camel, majestically moving, intelligent in finding paths, of an adorable hump and a lofty head, throwing white foam and smiting enemies like Afrasiab, 5. Of a bore, sharp-toothed, young and of quick gallop, 6. Of a 15-year old youth, white-orbed and thin-heeled (handsomest), 7. Of a bird, swiftest and lightest and living in the declivities of villages, 8. Of a ram, white-bodied and of small horns, 9. Of a buck, all pure, beautiful and of sharp horns and 10. Of a man, full-grown, of brilliant body and a bearer of sharp

sword. This hymn itself gives us, by the way, an excellent picture of organic life as it was found in old Aryan centres. Other gods called *ahuras*, arising out of the environment of the settlements, were also instituted and worshipped, viz. Behman (animal world), Ardihahesht or Adar (fire), Avan or Ardui Sura (water), Khorshed (sun), Tir (Sirius), Mithra or Meher (Light), Govad (wind), Asman (sky), Aneran (cosmic rays) etc.

Men and women, again, held seasonal feasts, gave sacrifices to their gods and goddesses and even endeavoured to contact invisible powers of nature. The idea of the vernal equinox (Jamshedi (Naoroze) was King Jamshed's own, from early Peshdadyan time. Benevolent gods were adored and styled Asuras against evil spirits or Daevas, communal deities were invoked and sports with wild animals were organised and enjoyed. Just as there was a constant fight for man against his tormentors and oppressors, so in the invisible world there was a regular warfare between good natural powers such as wind, rain, light etc. and their counterparts, calm, dearth and darkness; even idleness was thought to be a sin.

The Coming of Prophet Zoroaster

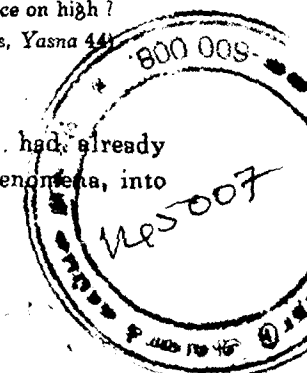
Not until Zarathushtra Spitama came at an opportune time and proclaimed his first *monotheistic* doctrine and faith, milleniums later in Iranvej, and still at the court of King Kae Gushtasp at Balkh (Chosen Land No. 3) announced it as the state religion of Iran that the world saw the light of Mazdayasnm, the religion of One God, for the first time in the history of mankind. "*Sruto Airyane vaejahi*, (he) the famous in Iran" is recited by Zoroastrians even now. He gave the title of *Mazda* to the only one Ahura (God), who became the God of the universe and the Gathas.

Zoroaster's spiritual influence on the land of old Iran was tremendous. He learnt much of his philosophy by holding communion with nature and understanding nature's laws.¹⁸ Nature was his text-book. Every pebble, every leaf and every drop of water taught him lessons. Investigations were made about the causes of natural phenomena and their effects noted. In a beautiful strophe of his, he makes an inquiry :

"This Thee I ask, speak forth aright, O Great Lord,
Who holds up this globe of the earth and that sky from falling down?
Who gave waters and trees? Who winds and clouds set so space on high?
And who framed, Mazda, the working of Good Mind?" (*Gathas, Yasna 44*)

Relation of Creed to the Locality

Prior to the birth of Zoroaster, the Aryan peoples had already developed an angelology and cosmogony from the natural phenomena, into



which they could not easily penetrate. Zoroaster analysed them and came to the conclusion that there must be *unity in nature*; otherwise the whole universe would be in a chaos. He saw order everywhere and styled it *Asha* (Sk. Rita) and discovered the facts that there was a constant war between good and evil with the ultimate triumph of the former over the latter and that there was nothing good that could be destroyed in nature. He embodied into his system as much of the philosophy and theology of the Aryans as was acceptable according to this law of *Asha*. Amazed by the process of volcanic eruption and the burning oil wells, he even accepted the method of 'fire-worship' only as a step to the Creator, Ahura Mazda. Bright sunshine was badly needed amidst dullness, and so Ahura Mazda the Deity represented light and lustre. The effect of this light on the people was psychological. The great struggle that mankind has to put up against nature as a hard task-master in the Aryan settlements, with their barrenness and fertility, drier parts and wetter parts, great heights and hollows, dangers and safety of life, annoyances from the unsettled nomads given to the settled and honest tillers of the soil, mischiefs of the false sages and wise words of the learned,—all this enabled the Prophet to establish the law of Polarity, *Spenta maniyu* and *Anghra maniyu*. The hope and optimism of his religious system followed suit,—resurrection, life after death and the reward of heaven or hell. Nature, again, is a great moral teacher, and Zoroaster learnt from her the virtues of family life, love of home, purity of mind and body, benevolence and protection of the weak and needy, all embodied in his religious system as its substantial parts.

Local Differences

Such an original Thinker and a World Seer and Teacher would naturally differ from other Aryan Rishis and Sages with pantheistic ideas. And so Zoroaster's fundamental conception of God is different from that depicted in the *Rig Veda*. He saw through the conflicting elements and solved the great mysteries of the world, depicted in his own hymns, the Gathas. He found that there is only One God, the wise Lord Ahura Mazda, in place of the *changing gods* of the early Aryans, e.g. Dyeus (sky god), Agni (fire god), Indra (rain god) etc., whom the Vedic Aryans recognised as the deities according to the *changing environment*, they found in the different lands through which they passed.¹⁹ Even the temperate *h* was changed to the tropical *s*. So the Asuras and the Daevas came into clash with one another and the schism started. Both the parties tried to tolerate these ideologies as long as they could, until the situation became unbearable and the separation took place, as we have seen above, very probably in their residence in Locality No. XI. While the Persian Aryans

marched back towards the land of Iranvej, the Vedic Aryans sought the valley of the Indus. Here they installed Indra, the god of rain, as the Deity in the *monsoon land* of Sapta Sindhu, displacing the old god Dyeus, the sky god, whom they worshipped in the drier parts of Central Asia. But having found unity in diversity once for all in Iran, Zoroaster stuck to the new and all-powerful God, Ahura Mazda, upto the last. From myriads of divine creations in the world, which he saw around him, rivers, valleys, hills, heavenly bodies, even plants, animals and human beings,—a medley of organic and inorganic bodies,—this Prophet conceived, upon the heights of the Demavend, the idea of the fatherhood of God. Increasing aridity in the drying plains below must have resulted in filthiness and filthy habits among the people and the growing menace of the wandering nomads to the national settlements of the Faithful must have caused restlessness, faithlessness, untruth and impurity in their minds. For all of them Zoroaster prescribed the antidote of *Ashoi* (purity) of mind and body. Good mind was the basis of good words and works. Such a Teacher was badly needed in a country having many classes and sects of people, in order to cement the bonds of true brotherhood. "When we put the Sage of Iran as far back as the 11th or 12th century before Christ, we have given him the proud place of the earliest religious thinker of the first rank in the Indo-European family."²⁰

Summary and Conclusion

Applying the principles of regional geography, with the help of a relief map, to a search for the most suitable locality for the Original Aryan Home or the cradle of Aryan civilisation in Asia and judging from the old Oriental literature available, especially the Zend-Avesta, I have come to the conclusion that there cannot be a better region for it than the Syr Darya valley. Geographical environment and prehistoric background are the keys to the solution. I have found that while some European Orientalists tried to advance *a priori* arguments and showed their predilection for their own homelands, other Indian scholars, notably B. G. Tilak, attempted an almost impossible task of identifying the North Polar region with the Aryan Home, where all the forefathers of the Aryan race lived together before they separated owing to certain reasons and then migrated to distant parts of the then known world. It was to deny the very existence of geographical control. Tilak depended too much upon doubtful translations of certain obscure passages especially in the *Vendidad* and also upon the premature and unacceptable theories of the Ice Age. He suggested such a radical change in the climate of the North Polar region that he thought where there was the polar ice, there were tropical and sub-tropical

water could be got and captured in the gravel before it is lost in the desert, human life flourished well.

When circumstances forced them even to migrate still further towards the south-west, less suitable from the points of view of climate and water supply, they chose some congenial heights within uncongenial latitudes e.g., the Elburz and Zagros chains, which became powerful nerve-centres of world operations in later times. Where the tribes did not agree with one another, e.g., the Vedic Aryans, they actually left the plateau for a region more congenial to their temperaments and requirements and went to the Indus valley. Only for the sturdy Persian Aryans parts of the plateau, including modern Afghanistan, remained sacred and they established many more settlements in this part of Central Asia.

The picture of the Aryan Home is more or less complete. Nothing substantial has been left out for discussion. It harboured a pastoral people in a congenial locality with the first spark of civilisation born of the geographical conditions in it. They were eager to follow nature and her laws, to make the best use of the environment in a land with good loess deposits, a grass cover and with the help of domestic animals such as sheep, goats, dogs, cattle, horses, camels, etc. Even the wild animals were involved in the struggle against nature, as they must be got rid of for an effective progress. Steadily the people passed from the food-gathering stage to the food-producing stage, under instructions from their leaders. Business obligations steadily involved moral obligations. Natural powers were invoked for help and a host of gods suitable to the temperament of the clans, were created,—Mithra, Indra, Varuna, Atar, Asura, etc., according to their needs and their longings. The march of the Aryan race from one river valley to another was magnificent and logical,—the Syr, the Amu, the Murghab, the Hari Rud, the Ferrah Rud, the Kabul, the Arghandab, the Helmand, the Kura, the Safid Rud and lastly the Indus and the Ganges. When the necessity arose and the escape on the Iranian highlands was inevitable, luck helped them to make their first contact with the prophet Zoroaster, who discovered unity in nature and directed the Persian Aryans to a life of utility, honesty and hard labour, of good thought, good word and good deed. Zoroaster was an idealist as well as a practical prophet. In a land with scarcity of water his religious system lay great stress on purity and a sixth sense of purity, so to say was developed among the Iranians.

In the second part of my thesis, an effective working of the geographical factor has been shown, so that whatever new localities the people choose

for their settlement, the natural physical conditions made or marred their fortune, mostly nature and not man becoming the victor. At the same time, the cultural boundary between the Aryan settlements and the lands of the nomadic peoples was sharp. In fact, the nomads of northern parts were the bitterest enemies of Aryan civilisation²³. This region of our study, covering the ancient provinces of Ferghana and Bactria, is indeed "a sort of microcosm in which we may be able to study the rhythm of Asiatic history." It is the region in which there was the earliest impact of the nomadic people on the original settled communities of Aryan stock without doubt.

Thus, whatever might be the trend of these early Aryan migrations, the whole pattern was after nature and wherever their new homes were made, they were specialised according to the special natural conditions and needs. Hence the differences between the various branches of the Aryan family, their language, literature, mode of daily life and even their moral and religious laws. Fundamentally, the human race, though divided into separate nations owing to unnatural political barriers and segregated by different languages and ideals, is One Family. There was, no doubt, a certain amount of mingling of their specialised cultures again in special regions and also an interchange of these between different regions. Thus four branches of the original Aryan family, that escaped from the Home through natural gateways into the outside world, may be mentioned here: (1) The European branch, which unfortunately is more materialistic than spiritual, as the climate, soil, mineral wealth, and other geographical factors existing in the region, have made them so. (2) The Chinese branch, which has still preserved its pristine purity, on the banks of its great rivers, and to which the characteristic Buddhistic element from the dry Tibetan plateau has greatly contributed. (3) The Persian branch, which has produced an excellent mixture of the eastern and the western elements, due to its peculiar geographical position between the two continents and (4) the Indian branch, which due to the large number of physiographic sub-regions found in India itself a definite geographical unit, is a veritable cauldron of cultures. This branch has suffered much due to the clashes between the specialised cultures, but there is still a great possibility of further acculturation and unification by a process of spiritual irrigation and canalisation of the waters of the various cultural cases. (For further discussion on this subject, vide my paper on "Correlations between the cultural Regions and the Physiographic Divisions of India, Burma and Ceylon" *Science and Culture*, May 1944.)

Now that the old flat map of the world is gradually changing into a real globe without the trammels of the uncertain limits of the east and of

the west, now that from the clash of human cultures, in all parts of the modern world, a new spirit of mutual help and good neighbourliness is being generated and now that the young science of Geography is being recognised as a powerful cultural science seeking to cure the neurosis from which the nations are suffering to-day, it is hoped that the above discussion will help as an eloquent pointer to the inherent unity of the human race and to the ultimate brotherhood of man and fatherhood of God.

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APPENDIX

MODERN GEOGRAPHY OF THE SYR-AMU DARYA DOAB

N.B.—The following valuable notes were drawn by me at the Birkbeck College University of London, from a series of lectures delivered by Dr. J. F. Unstead, D.Sc. F.R.G.S., Emeritus Professor of Geography, on the Method of Regional Geographical Research, with the Caspian-Aral-Balkhash Depression as the region for study, during the session of 1932-33. The data were mainly obtained from Russian geographers. I am greatly indebted to the Professor for them. They are appended herein as they are worth comparing with the conditions of the region given in the body of the thesis as probably prevailing in the Aryan name.

Physiography and Geomorphology

Asia as a whole is a land of raised areas and of depressions, consisting chiefly of Tertiary rocks except in a few old blocks, e.g. Arabia, Siberia and Peninsular India. It has suffered from relative desiccation and dryness besides and consequently isolations, both internal and external, are great. In fact, it is a country of remarkable isolations, which have greatly affected its pre-history and history. It has also suffered from an Alpine set of disturbances in folding and faulting and from subsidences, with the result that the Caspian basin is some 3,500 feet deep and actually 85 feet below sea level, the depth reducing as one goes eastward. The Pamir acts as a hinge between the Himalayas and the Hindu Kush and the rivers flow through the fault fissures. They have few tributaries and there is partial or total disappearance of the streams in the blown-sand area, which is another characteristic of the region. Aridity is the greatest in the centre of the depression. Like other rivers in the Northern Hemisphere, they have their right banks cut up at about 3 miles per century and so settlements are washed away and tributaries are left far back. Thus they have made huge and deep ravines in the rocks as powerful denuding agents for thousands of years.

The Amu-Syr Doab is the Mesopotamia of Turkestan. The rocks are Tertiary and almost horizontally laid with the exceptional height in the middle. River changes are very great here, the valleys being covered with much silt derived from the soft Tertiary rocks and also blown sand. In the Ice Age, the Amu (Old Oxus) received the waters of the Zarafshan and went up to the Caspian direct, and the Syr took the waters of the tributary Talas into the Aral sea. The level of the Aral sea is the highest in June and the lowest in December. This level is about the same now as at the end of the Tertiary age, but in the glacial period it received larger deposits. The deposits in the lakes are marl, clay, sand and sandstone, and the

wind deposits are recent sand and loess. The Balkhash lake is very shallow and as it is being filled up considerably, its outline changes. The depression of Kara Kum is lower than the Balkhash lake but it has no water. The courses of the rivers particularly in the lower reaches change considerably on these accounts, inspite of their perennial sources on the high mountains. To-day the Amu Darya carries more water than any European river except the Volga.

Climate

The fundamentals of its climate are :

1. Position—Extreme type subject to monsoonish climate.
2. Altitude—High and low pressures developed—Storms expected
3. Latitude—Mediterranean climate.

In summer the prevailing wind is northerly with western and eastern deflections and in winter it is also northerly but with a southern deflection. Consequently, the accumulation of sand and loess is less in the north and more in the south. Heated lowlands in summer produce convection currents and there are cyclonic storms received in winter.

There are also local winds e.g., mountain and valley winds, the latter being very hot, sandy and destructive. During the night, the mountain winds start blowing, descending and cooling the valleys. Snow storms from the Hungarian Gate to the Steppe Desert area reach the region during the winter season. Lastly, the Caspian winds are local and affect only the coastal parts.

The Winter isotherms are more or less east—west from 0° F to 32° F and the Summer isotherms are much more spreading out, the heights of the mountains causing a difference of 5° to 6° F. There is a great variability of rainfall from year to year, 4: 1 for arid regions in general. In the mountainous area, it is of a desert type with short violent storms received at times. In spring and autumn also there are showers of a cyclonic type. Generally the rainfall increases from west to east in both the seasons. A combination of low temperatures with rainfall in winter results in heavy snowfall for a period of 50 to 100 days till March, when with the coming of the heat current, there is a sudden appearance of spring. There are cloud bursts of spring rains and sudden floods are common, so much so that at times huge boulders as big as 20 lbs. come down the heights.

It can be seen from the following tables that even now the temperatures are bearable and the rainfall satisfactory at some of the stations in this region :

Temperature Table

Station	Ht. Metres	Actual				Extremes				Absolute	
		Jan.	April	July	Oct.	Mean	Max	Mean	Min	Max	Min
1. Merv	230	-29.3	62.5	86.7	58.8	108.7	—00	130.0	—14.0		
2. Turkestan	215	20.2	56.2	83.5	50.8	106.3	—9.3	109.2	—21.3		
3. Samarkand	720	31.0	56.2	78.0	53.8	99.7	—2.2	103.2	—5.7		
4. Tashkent	470	29.0	56.8	81.3	53.2	103.3	—3.5	107.8	—18.5		

(14 years' observations)

Rainfall Table

Station	Jan. Feb. Mar. Apr. May Jn. Jl. Aug. Sept. Oct. Nov. Dec. Annual											
	(spring rain)						(summer draught)					
1. Merv	.6	.5	1.5	.6	.5	0	0	0	0	.2	.4	.4
2. Turkestan	1.0	.5	1.1	.8	.8	.3	.1	.1	.1	.3	.8	1.1
3. Samarkand	1.7	1.2	2.4	2.6	2.0	.4	.2	.0	.1	.8	1.1	1.2
4. Tashkent	2.2	1.1	2.6	2.8	1.5	.6	.2	.1	.2	1.0	1.5	1.6

(14 years' observations)

Soils

There is a close relation of climate to soil conditions in the region. Due to the northerly winds, most accumulations of windborne sand and dust take place in the S.E. corner and loess deposits take place at the foot of the mountains in it. Due to the great cold in winter with snowfall and the high temperature in summer, this growth is enormous upto a considerable height. Dust is carried much higher than sand and mist and clouds accompany the precipitation of dust, as the temperature falls.

Vegetation

The result is the loess Steppe bordering the steppe-desert parts, and grasses grow to a height of some 20 feet. The real grass thrives between the sands of Karakum and the Afghan mountain borders. Lower down is the meadow steppe, where poppies, tulips, forget-me-nots etc., grow. In fact, there is no real desert here, as there is some vegetation.

N.B.—Man has interfered with nature in the matter of natural vegetation. Great destruction was caused by the Arabs in the 8th century A.D. especially in the Farghana region where thick woods were found, and since their time there has been a systematic destruction of tree growth. The Russian settlers since 1815 destroyed forests, as their caravans needed wood. There is also removal of grass by nomads and animals. As the S.E. corner is well watered, there are attempts made to replant trees on a large scale and there is widespread growth of vegetation along irrigation canals.

Animal life

The distribution of animals is more independent of soil and surface condition than plants. There is throughout the area almost the same type

that has survived due to adaptation. The wild ass, antelope, sheep, deer, tiger, jackal, reptile, lizard, camel, horse and locust are found. Bird life, especially migratory, is splendid. Even arctic birds migrate to this region in winter. This is very strange, as it is generally such an arid one.

Human Geography

This region is unique from the point of view of the struggle between man and nature. It presents a marked contrast between the conditions in the lower basins of the rivers and those in the upper. These have acted as great stimulants to make man's life more or less perfect.

Irrigation.—Along and close to the rivers, higher forms develop. Irrigation is in vogue from the earliest times and settlements are limited to certain patches and close to the canals. Thus they had to be scattered and decentralised. Irrigation needed control of water over large areas from a distance and therefore associations and autocratic governments had to be established. In small areas, an intensive form of economic organisation was necessary. Population needed a system and the system needed population and so certain areas were highly populated. The result was a number of city states or small states, governed by despots. As no boundaries could be easily made, the lands were indefinite and between such indefinite states, the struggle for possession was constant. The mountains in the neighbourhood were both a kind of shelter as well as a danger of assaults from different tribes. In higher parts of the valleys, the people could find safety to a certain extent and so they remained there. The result was that they could maintain their traditions, their language and even their religion. These settlements could, therefore, develop a higher civilisation. They differed from the heterogeneous settlements along fertile strips of land lower down, called oases, which formed convenient routes for the wandering tribes to attack and plunder settled people. There was thus a constant influx of people into the region from times immemorial.

The first and foremost were the Aryans, who were the earliest to settle on the banks of the rivers. They were known well for their agricultural settlements in the upper reaches. Bokhara, Khiva, Samarkand, Tashkant and Khokand are still the relics of the past. Then came the nomads from the parching plains, then the Greeks, the Turks, the White Huns, the Arabs, the Mongols and lastly the Uzbeks. So century after century saw the inroads of foreign peoples, whose cultures have got conveniently mingled here. Climatic causes, bad years, growth of population, and then the rise of geniuses and great conquerors are some of the chief causes of disturbances ever since the dawn of civilisation in these valleys. But all

throughout, steady irrigation and settled and comfortable life have been the chief merits of these parts of Asia. They developed virile qualities, encouraged mingling of cultures and a mixed population, which in its turn had its attendant evils, e.g., human parasites, unstable masters, uncertain invasions, usuries etc. Even to-day there are half a dozen different kinds of people living in this area. Struggle for possession is constant and it is probable that the first breach between the various sections of the Aryan people, residing in the valleys, was due to this trouble. The Russians seem to have solved this problem, after this lapse of milleniums, by starting autonomous republics, all under Moscow.

Density of population :—Tashkant 100,000. Samarkand 110,000. Khokand 70,000.

The economic condition of the inhabitants has a bearing on the physical factor. Agriculture is the best on the loess region. The chemical composition of the soil is lime and magnesium sulphate, and the harvest is good without artificial manuring, provided there is enough water. The soil is impermeable and therefore good for canal construction. There is also good building material for manufacturing tiles, pottery and mosaic work. All these physical factors were enough for a real foundation of Turkish civilisation here. The region, however, suffers from bad communications all round. But the relieving feature is the great possibility of irrigation, practised here from very ancient times. In summer, the water down the mountains is allowed to run off unutilised, but in spring and autumn, much irrigation is done. Within the irrigated areas, the people are frugal, tough, enduring and conservative. They need proper direction and handling. There are different methods of using water e.g. (1) sluices made parallel to the main stream with a little gradient with water ultimately disappearing on level ground, (2) a fan kind of canal system within a certain radius, (3) Oasis system and (4) Karez or underground channel system. Nowadays even dams are also constructed by Russian government and good drinking water is provided.

Products :—Among cereals they have wheat, millet and oats. Rice is the second important crop, needing good amount of heat and much water. There are excellent vegetable gardens even in the poorest houses. Fruits grow wild in mountain valleys e.g., apricots, apples, pears and grapes. There is home-grown cotton imported from India. In fact this area is fast becoming a great cotton-growing centre for U.S.S.R. even upto a height of 2,500 feet, especially the Farghana district and also in Bokhara and Khiva oases.

The type of the people still found in this region is pastoral, both on the mountain side and in lower levels. People follow the northward march of spring, going in groups of families according to definite routes. There is a rivalry among them of trying to go up as quickly as they can. They return home in winter by November and the rhythm of life is complete with the temperature, moisture, vegetation, etc. At a time some 50,000 sheep are available; also herds of horses, camels, goats, etc.

The tribal system is still followed and there is a very rigid social organisation, bound up with the particular kinds of duties to be performed. In short, there is a very economic and carefully framed system of human organisation for the whole area.

Rice in India

BY

GEORGE KURIYAN

(Continued from Vol. XX, No. 3, page 126)

The average output of rice in the main producing areas for the period 1927-28 to 1936-37 in millions of tons is as follows:—

Province.	Output.	Percentage of All-India production.
Bengal.	8.64	29.79
Madras.	5.15	17.76
(Madras States)	0.50 } 5.65	1.73 } 19.49
Bihar.	3.64	12.55
Feudatory States in Bihar and Orissa.	1.47 } 5.11	5.07 } 17.62
U. P.	1.76	6.07
C. P. and Berar.	1.63	5.62
Central Provinces States.	0.34 } 1.97	1.17 } 6.79
Assam.	1.54	5.31
Orissa.	1.29	4.45
Hyderabad.	0.32	1.10
Mysore.	0.21	0.72
Others (including Bombay, Punjab, Sind and other States.)	2.51	8.66
	29.00	100.00
Burma.	4.85	16.75

Storage:—The paddy that is produced is stored in a large variety of receptacles, of which home-made structures of straw and bamboo splits are by far the most common. Masonry structures (*e.g.* *Kotha* in North-India and *Kanaj* in the Mysore State) are owned by the big land lords only, while the poor have mud bins (*e.g.* *Kothi* of North-India). In the Circars there are specially built granaries called *Gathis*, which are elevated structures built on pillars and provided with thickly plastered walls of bamboo mats on all sides and a *pukka* roof with projecting eaves, having an average capacity between 50,000 lbs. to 150,000 lbs. In Tanjore, there are the circular *Puris* with walls made of straw twists, temporarily erected on either masonry platforms, or elevated ground. They are much smaller and hold about 30,000 lbs. of grain. In parts of Orissa, Ganjam and Nellore, grain is stored for short periods in shallow underground pits. Other receptacles commonly

used are those made of wooden planks as in Assam, Bombay, Kashmir, Mysore and Malabar, the straw bundles—*Muras*—in South Kanara, and the common sundried bins of the Tamil districts.

Husked rice is invariably stored in gunny bags. But it is best to store the seeds in metallic bins rather than in gunnies, since seeds stored in gunny bags are found to lose their vitality after five months. Bulk storage is, however, much cheaper and better than storage in gunny bags, especially as the bags get damaged.

Stored rice always fetches a higher price than fresh rice. The normal period of storage varies in different parts of India; it is one, to one and a half years in South India, while it is as much as 3 years in the Punjab. The premium obtainable for age is about one rupee per maund.

Sale:—As is the case with most other agricultural commodities, the supplies of paddy and rice show a marked seasonality, the heaviest arrivals taking place between January and May. The seasonality is much more pronounced in the case of paddy than rice, large quantities of the former being hurried forward for sale as soon as the threshing has been completed. This is responsible for a greater harvest depression in the price of paddy than of rice. There is ample scope for producers to co-operate in the marketing of their produce with a view to bringing about a more even flow on the markets, and thereby minimise the harvest depression in prices. That the ryots can share this profit is evidenced by the work of the Dehra Dun *basmati* rice producers' co-operative society. Further, co-operative marketing will eliminate the middle-men who now pocket no mean share of the sale price.

Exports:—More than 90% of the Indian export trade in rice is maritime, passing through the British Indian Ports. Calcutta, (46%), Madras (37%), Karachi (12%), and to a much smaller extent, Bombay (5%), are the main centres from which exports are made. A considerable portion of the exports sent to Ceylon from Madras is *via* Dhanuskodi. The total annual Indian exports is about 250,000 tons of rice, and 2,500 tons of paddy,⁵⁷ and it has been diminishing steadily, partly because of an increasing population at home and partly also because of an expansion of production in Burma, Indochina and Siam with a consequent increased competition. Ceylon is the largest importer⁵⁸ taking 37% of the Indian exports, Mauritius and South Africa together account for 21% in equal proportions.

57. The average annual imports into India are 1.5 million tons of rice and 250,000 tons of paddy.

58. mainly the Madras *Sirumani* variety of parboiled rice.

Aden takes about 7%, Bahrein islands 5%, Strait Settlements 3%, United Kingdom 3%, and the remainder is split up very widely in still smaller proportions. The Indian rice maintains itself in international trade primarily because of the existence of large numbers of Indians who have settled in Ceylon, Mauritius and South Africa, who have a strong preference for the types and varieties of rice to which they have been long accustomed. More than 80% of the exports is parboiled rice and in recent years (since 1931), this proportion has shown a tendency to rise.

About 24,000 tons of rice, which constitutes less than 10% of the total exports, is sent out by land, and 50% of this is from Bengal to Sikkim, Bhutan and Tibet. 12% of the land exports is from Bihar and 8% from the United Provinces, both to Nepal. Some rice is also exported by land to Afghanistan and Baluchistan.

Imports:—Apparently there is no very close or consistent relationship between Indian domestic production (as officially estimated) and her imports, although in occasional years, as in 1933-34, a small crop may be followed by increased imports, or a bumper crop as in 1937-38, may result in a reduction of imports. The great bulk of the imports, about 1.5 million tons of rice and 0.25 million tons of paddy, annually worth about Rs. 13 Crores, is effected through the ports of Calcutta, Vizagapatam, Madras, Cochin and Bombay. There is a small quantity of imports, worth less than Rs. 1 crore, effected through land in North Bihar and Bengal. The imports have shown a steady tendency to increase. In the decade 1920-30, the import by sea amounted to 143,000 tons of paddy and 795,000 tons of rice, while the corresponding figures for the decade 1930-40 were 189,000 tons of paddy and 1,436,000 tons of rice. The great bulk of the imports (more than 92%) comes from Burma, and the rest from Indo-China and Siam.

The ports of Madras (including Cochin) handle the largest proportion of imports of both paddy and rice. In the case of paddy, about 70% of the imports from Burma and practically the entire imports from other countries are through the ports of Madras. Bengal ports account only for 30% of the imports from Burma. With regard to the imports of Burma rice, however, the ports of Bengal and Bombay each account for a quarter, while Madras ports have a half to their credit. Of the imports of rice from other countries, 70% is through Madras ports and the rest through Bombay. The quota for Bengal is insignificant. These facts clearly suggest that in pre-war years, Madras was the greatest importer and hence the largest deficit Province. It certainly goes to the credit of the administrators of this Province that they tided over the entire war period without any serious famine, similar to what Bengal experienced in 1943.

In recent years, it is found that the proportion of parboiled rice imported from Burma has increased, and in 1939 amounted to half the total imports, (raw 40%, broken 10%), while in the previous decade it was only 36% (raw 50% and broken 14%).

Deducting exports from imports, it is clear that India is a net importer to the tune of 1.25 million tons of rice and 250,000 tons of paddy, roughly 1.5 million tons of rice.

Consumption of rice:—With a population of omnivorous dietary habits, the agriculture of a country tends to determine in a very large measure the diet of the population. This is true of particular regions of India, for there is a strong tendency for the population of a region to subsist on the products of that region rather than to specialise in production and develop a more or less uniform diet by means of internal trade. In some regions, rice is the staple cereal, in others, it is almost unknown. And this is true of wheat also. For India as a whole, the dietary habits of the population determine the agriculture, or at least modify it profoundly. The Hindus, constituting more than $\frac{2}{3}$ the total population are generally vegetarians owing to certain religious scruples⁵⁹ and vegetarianism is the prevailing institution. Not only is butcher-meat not consumed by the great bulk of the population, but comparatively little use is made of fish, eggs and dairy products. In certain rural districts agriculturists use moderate amounts of fluid milk, but much greater use is made of curds and clarified butter (ghee). The cattle industry chiefly serves the purpose of producing work-animals.

The fat requirements of the Indian diet are chiefly supplied by vegetable oils of various kinds, coconut, rape seed, sesamum, peanut, cotton seeds, etc. Where the consumption of animal products (including fish) is so small, the protein requirements are furnished by legumes and cereals. Consequently legumes rich in protein are extensively used as they are of particular importance in the diet. Of the cereals, the three most prominent are millet, rice and wheat. In relation to food values, millet is generally the cheapest; of wheat and rice, one or the other may be the dearer according to the locality. The cereal diet varies from region to region, rice being consumed especially in the coastal areas, wheat in the interior and in the cities of Bombay, Calcutta and Karachi, and millet, more or less, throughout the country.

It is estimated that about 17.4 million tons which constitute about 60% of the total crop are retained in the villages, having a marketable surplus

59. Both Muslims and Christians are non-vegetarians. It must also be mentioned that amongst the Hindus, it is only the members of the higher castes who are strict vegetarians, but even amongst them, differences are noticeable, as for e.g., the Bengalee and Saraswat Brahmins who eat fish.

of about 11.6 million tons. Of the 17.4 million tons retained, 12 million tons (42% of the total crop) are for domestic consumption, 2.9 million tons (10% of the total crop) are given to hired labour as wages in kind, a part of which is consumed, and 1.61 million tons (5.7% of the total crop) are used for seed purposes, while 0.56 million tons (2% of the total crop) change hands in barter transactions.

Several factors have a bearing on the extent of domestic consumption and village retention. The retention is found to be greater where the size of the holding is small, i.e., where subsistence farming is practised. Again, the financial position of the ryot becomes important, those heavily indebted being obliged to part with a larger part of their produce immediately after the harvest to satisfy their creditors. Further, the nature of the crop is also significant; the coarser varieties are invariably retained in the villages while the finer ones are marketed. If rice is the staple crop, the proportion retained is greater, and that naturally so. Lastly, perhaps, it would also be governed by the general wealth of the community and the comparative prices at which other cereals are sold.

In India, not only the quality but also the quantity of the diet depend to a large measure on the purchasing power of the several classes and castes, and more or less, subnutrition is present in large groups of the population. In a sense, therefore, India has never any genuine surplus of cereals for export, although large quantities of wheat and much smaller quantities of barley and gram are being exported.

Rice is the most important single article of food in this country and about 27 million tons⁶⁰ are consumed annually in India, almost entirely as plain boiled rice. Throughout the main producing areas of Bengal, Bihar, Orissa and Assam, in many districts of Madras, Mysore, Travancore and Cochin, in the eastern districts of the United Provinces, the Chhattisgarh plain of the Central Provinces and in scattered parts of Bombay and Sind, rice constitutes the staple food of the great majority of the rural population throughout the year. A very large proportion of the urban dwellers in these areas also use rice as their staple diet. In other parts of India, the consumption of rice is more seasonal in character with a tendency to increase in summer and decrease in winter. The consumption of rice in India is practically inelastic and is unaffected by price changes in other cereals.⁶¹

60. About 5.7% of the production is devoted for seed and another 4.75% is devoted for the preparation of *murmura* (parched rice), *Kheel* (parched paddy), and *chura* (beaten rice.)

61. Contra wheat for which there are substitutes like the millets, gram and barley.

An analysis of the per capita consumption in each of the Provinces shows that Assam and Bengal are pre-eminently the rice eating regions of India. The people of Bihar and Orissa are mostly rice eaters, but the tracts of heaviest consumption lie along the coastal districts of Orissa and North Bihar. Although rice may be regarded as the staple food of the greater number of the inhabitants of Madras, large quantities of millets are also produced and consumed, especially in Salem and the Ceded Districts, while the maximum consumption of rice is found in the deltas and coastal tracts. Rice is the staple food in the Chhattisgarh plain of the Central Provinces and the riverine tracts of Sind. Elsewhere in India, it is only consumed by a section of the population, or as subsidiary to another main food crop. Clearly, therefore, it is not possible to appraise accurately the total rice eating population of India. Although man is extremely conservative with regard to his diet, yet the present conditions, particularly in the West Coast have shown that he would be prepared to make drastic changes if confronted with starvation. In considering about famine conditions and the food requirements of each Province, it would be necessary, even if it were entirely rice-eating, to appraise the availability of not merely rice, but also of all the other cereals⁶².

There is at present no available substitute for cereals in the Indian diet. For a very large part of the population, the cereals represent the sole intake of food and there is very little room, taking the country as a whole, for the process of tightening the belt. Nutrition experts like Dr. Aykroyd are of opinion that "there is at all times serious under-nourishment, both as regards quantity and quality of some third of the population." Under these conditions he has suggested that every adult should be able to obtain a minimum amount of one lb. of cereals per day.

It is unfortunate that the 1941 Census does not classify the population according to age groups, but based upon the 1931 statistics, it is approximately correct to suggest that the adult population is $\frac{2}{3}$ the gross population. In addition the food requirements of the children have also to be taken into consideration. For the purpose of these calculations, therefore, 80% of the gross population could be considered as adults. If an attempt is made to ration the cereal foods at one lb. per day per adult, an estimate of the actual food requirements of each Province can be determined, and it could be compared with the available quantity to assess the exact nature of surplus, or deficit. Statistical information regarding British India is

62. In this connection, the Food Policy Committee report includes grams along with wheat, barley, maize, jowar, and bajra as food grains. This is not unobjectionable. It is suggested that grams should be deleted from this list when the question of cereal food grains is being considered.

available in the Statistical Abstract, Agricultural Statistics of India, the report of the Food Policy Committee and the various Trade Returns, but there is a considerable dearth of information as regards the Indian States, which consequently have been left outside the scope of this enquiry. The conditions in each one of them, however, approximate to the neighbouring Provinces of British India. The following tabular statement has been prepared based upon the available information.

NAME OF THE PROVINCE.	(1) Average rice production + imports - exports (in millions of tons).	(2) Average of other cereals (including gram) production + imports - exports in millions of tons.	(3) Average of Total Cereal Food available (including Gram) in millions of tons. $3=1+2$	(4) Average of Total Cereal Food available (excluding Gram) in millions of tons.	(5) Population in Millions, in 1941.	(6) Total annual cereal food requirement at 1 lb. per adult per day in millions of tons (calculated at 350 lb. per head of population).	(7) Surplus (+) or Deficit (-) including Gram in millions of tons. $7=3-6$.	(8) Surplus (+) Deficit (-) excluding gram in millions of tons. $8=4-5$.
Assam ...	1.734	0.022	1.756	1.753	10.205	1.590	+ 0.166	+ 0.163
Bengal ...	8.679	0.478	9.157	9.037	60.307	9.665	- 0.508	- 0.628
Bihar ...	3.381	1.847	5.228	4.782	36.340	5.678	- 0.450	- 0.896
Bombay ...	1.101	1.573	2.674	2.459	20.850	3.258	- 0.574	- 0.799
C. P. & Berar.	1.279	2.027	3.306	3.145	16.813	2.626	+ 0.680	+ 0.519
Madras ...	5.191	2.354	7.545	7.394	49.342	7.709	- 0.164	- 0.315
N. W. F. P. ...	0.006	0.615	0.621	0.594	3.038	0.475	+ 0.146	+ 0.119
Orissa ...	1.191	0.021	1.212	1.209	8.729	1.363	- 0.151	- 0.154
Punjab ...	0.270	5.200	5.470	4.978	28.419	4.440	+ 1.030	+ 0.538
Sind ...	0.293	0.337	0.630	0.581	4.535	0.709	- 0.079	- 0.128
U. P. ...	2.588	7.662	10.250	8.678	55.021	8.598	+ 1.652	+ 0.080
Total British India (includes Delhi, Coor, Ajmer, Merwara) ...	24.550	22.644	47.194	44.620	295.808	46.220	+ 0.974	- 1.600

Note:—The Imports and Exports are not from abroad and give the average for the period 1937-1940. The production of rice and other cereals are also based on the averages of the same period.

The deficit in food grains (excluding gram) on the basis of these calculations is 1.6 million tons. That these conclusions are approximately

correct is to some extent evidenced by the fact that the actual quantity of cereals (which almost entirely consists of rice) imported into India in recent years has generally been in the neighbourhood of 1.5 million tons. The Gregory Committee themselves admit that certain specific areas apart, the food crisis in India does not derive from an absolute decline in the volume of internal physical production. With an average annual production of nearly 30 million tons, it is difficult to understand why there should be such a remarkable dearth of rice in India.

Bengal has just emerged from a terrific famine. During the years 1935-40, the net annual imports of Bengal, was on an average, only about 350,000 tons, which was approximately 4% of the home production. The maps of rice distribution show very clearly the tremendous concentration of rice culture in Bengal, far in excess of every other Province of India. The Gregory Committee opine that the Bengal famine has been due to several causes, the most important of which are the following:—

- (1) the fall of Burma and the consequent loss of imports;
- (2) the fear of invasion and the apprehension that communication might be seriously interfered with, led to the accumulation of stock;
- (3) the military authorities practised a denial policy, the amount involved being not more than 40,000 tons, a negligible figure;
- (4) the devastating effect of the October Cyclone of 1942 in Midnapur, 24 Parañanas, Barisal and Dinajpur.⁶³

If these are the most significant causes, why is it that the subsequent aus crop could not rectify these conditions. The Gregory Report makes a passing mention, without assigning any reasons, that it is not possible to make the aus crop available to any large extent for the relief of distress in the cities. The aman crop of 43-44 has also been very satisfactory, but still we hear of a threat of famine in Bengal. The Gregory report admits that the bulk of India's imports consisted of rice to meet the requirements of certain well defined areas such as Malabar, Cochin, Travancore and Bombay and in the light of this, the Bengal famine is all the more difficult to account for. There is not much change in the absolute supply, the fact that there is a famine is due to the available supply having gone down for a variety of causes. Could not a strong administration prevent some of these abuses like withholding from sale, at least a part of the available stocks

63. Or is it also due to the consumption of rice having increased, because the poorer people who were hitherto content with a cheaper cereal, have now with an enhanced income, changed their diet to rice? No statistical information on this point is available.

meant for black market and investment reasons? Or is it possible that all the available statistical information about this crop is thoroughly undependable? Otherwise, it becomes difficult to comprehend how there could arise a famine of such magnitude in an area which is so nearly self-sufficient. Time will perhaps unravel the mystery behind this tragedy of so colossal a magnitude.

The conditions in Travancore, Cochin and Malabar as regards demand and available supply have been much worse than those of Bengal. It certainly goes to the credit of these Governments that they have been able to keep a famine of like magnitude, well outside their portals. The deficit in Bihar is of similar proportions to that of Bengal, in Bombay it is even greater (whether the calculations be based on deficit per capita, or the total quantity) and yet these Provinces certainly faced the crisis in a much more commendable manner and have come out with flying colours.

To tide over the famine, the Grow More Food Campaign was started. Most of the propaganda was based upon the myth of vast areas of land lying as culturable waste. When it is remembered that the Indian ryot has the experience of nearly 40 centuries of agriculture and the pressure of population has been always great, is it likely that he would allow cultivable lands to lie waste? Many things will have to be done before these so called culturable waste lands could be brought under the plough. Even then, it is very doubtful if they could yield any rice at all; because, rice wants a smooth mellow land.⁶⁴ The maps of rice cultivation indicate the difficulty of increasing the acreage as far as Bengal is concerned. The more practicable method would be to try and increase the yield per acre rather than increase the acreage. Some suggestions have already been made to achieve this end. In addition to this, direct assistance must be given to the ryot by supplying him with better seeds, manures, implements, irrigation facilities, etc. The manifold recommendations of the Gregory Committee should be accepted and implemented immediately. Further, a long term policy of subsidising agriculture should also be taken on hand. The ryot, especially the well-to-do ryot, must be assured of the price of his crop for a few years to come, in order to tempt him to invest more money on the land in improving it in several ways. It may at first sight appear to be an expensive policy, but in the long run, when the average income of the ryot has mounted up, would it not bring in its wake, very many desirable improvements to the whole of India?

64. It has been suggested to me that land has to be cultivated for at least ten years before it becomes sufficiently smooth and mellow for a permanent rice culture.

The Food value of rice:—The inner husk called the bran layer is firmly attached to the grain. Polishing of rice consists in the removal of this layer, either partly or wholly. The removal is never complete in hand pounded rice, while it is much more so when rice is subjected to machine milling. The bran obtained by polishing is a highly nutritive substance containing vitamin B, most of the protein, and practically all the fats, minerals and phosphorus compounds, and is of great value as a feeding material for livestock and poultry. During the polishing process, a large amount of "germs" get removed from the grain along with the bran, and it is these, namely the bran and the "germs" that contain the most nourishing parts of the grain. The thickness of the bran layer varies in different varieties, it being generally greater in the red rices. The high food value of red rice is appreciated in the rural tracts of the West Coast, Tinnevely and parts of Ceylon and Madagascar.

Thus, the produce as obtained from the field, freed from the husk only, is nutritious, easily digested, quickly cooked, and relatively cheap in the regions of production. The grain contains a large amount of starch, protein, fat, mineral and fibrous matter and vitamin B. Some consider the protein of rice from the nutrition point of view to be superior to that of wheat or maize, resembling more that of animal tissues. But the food value of the grain is very much lowered by subjecting it to machine milling and fine polishing; and it is generally true to say that the better the polish and appearance, the less nutritive the grain is. What is required now is a vigorous campaign, particularly among the educated middle classes to eschew polished rice.

Equally well, there are losses in cooking. The bulk of the rice consumed is eaten directly after boiling, and a thorough rinsing of the rice twice or thrice in clear water before boiling, removes all traces of bran. Again, the rice is boiled with more water than what the grain could absorb, so that the thick supernatant liquid with mineral matter, proteins and starches dissolved in it, is finally drained away. In this connection, it is, however, worth mentioning that although the Japanese eat polished rice, yet they do not waste the bran, but use it by adding it to the green pickles they prepare with cabbage leaves; and further, they consume fish in large quantities.

The occurrence of beri beri, a disease considered to be a consequence of sub-nutrition, is noticed among the people who eat finely polished rice and was first found in Madras in the Telugu districts. The disease is conspicuous by its absence among the people who consume parboiled rice.

Parboiled rice is thus more nutritive than raw rice and is generally so recognised, but the why of it is not clearly understood. Probably, some of the valuable elements in the bran layers which diffuse into the endosperm during the process of parboiling do not get removed in the subsequent milling and polishing.⁶⁵ Food reformers may, therefore, carry on a propaganda recommending the use of parboiled to raw rice.

Dr. McCarrison's experiments have also shown that rices grown under dry or semi dry conditions are more nutritious than those under typical swamp conditions.⁶⁶ Progress in this direction of growing dry or semi dry rices is also to be welcomed.

Before concluding this paper, it will perhaps be advantageous to make a comparison of the conditions of rice culture in the neighbouring monsoon lands of Burma, Japan and China.

Burma:—The development of rice cultivation in Burma for export is of recent date. Almost the whole of the area in lower Burma has been brought under cultivation during the last sixty years by small cultivators producing for an export market, the work having been financed mostly by the Madras Chettiyars. In upper Burma, the extension has been due to irrigation works carried out by government. More than 80 per cent of the crop of Burma, is from the stiff alluvial clays of lower Burma where the crop is entirely rain fed, and it is from here that the whole exportable surplus comes. 71 per cent of the total cultivated area of Burma is under rice, but it is mainly concentrated in the delta region of the Irrawaddy. Although only 11 per cent of the total rice area is irrigated yet it constitutes almost the entire area under irrigation. The acreage has tended to remain fairly constant, but since 1937 there is a tendency for a slight increase. The winter crop constitutes the great bulk of Burma's rice production occupying about 98% of the total rice area. The average yield is less than 1,000 lbs. per acre. As a rule, no rotation of crops is practised, and little or no manures are applied, cattledung alone, being sometimes applied to the nurseries. The total annual production is approximately 4.85 million tons (i.e., only 17% of the total Indian production) but only 0.85 million tons are reserved for domestic consumption, seed etc., leaving a balance of 4 million tons for export.

65. McCarrison 'Food' P. 51. When rice is parboiled before milling, the outer layers stick and are not so easily removed, and parboiling is, therefore, a good thing in some ways. But it is bad in other ways; it destroys any Vitamin A the rice contains, and since parboiled rice is always drier than white rice, it has to be washed in many changes of water before it can be used as food. As vitamin B is highly soluble in water, the washing of the parboiled, or any other rice, dissolves the vitamin B out of it and this very important constituent of the food is lost when this washed water is thrown away.

66. *Ibid* P. 81.

Japan :—Rice cultivation is very intensive; the coastal low lands and the river valleys are the most important rice lands. Hill rice occupies less than 2% of the total area, ordinary swamp rice 90%, glutinous rice 8%. More than 85% of the rice crop is irrigated from rivers and reservoirs and the use of paddle wheels is a common appliance to lift the water from the rivers to the fields. Both the small size of the rice fields and the steepness of the terraced hill sides on which rice is grown, are features which are noteworthy. Only $\frac{1}{3}$ the total area is double cropped. What scientific agriculture can do is well exemplified in the case of Japan. The average yield in 1938-39 was 3,000 lbs. per acre, 2 to 2½ times what it was 50 years ago. This improvement in yield is a consequence of intensive methods, use of improved types and the liberal application of fertilisers and manures.

Japanese rices are all short, being never more than 3 feet in height and they possess stiff straws so that they do not lodge even with heavy manuring. All waste material is composted, human excreta is liberally used and a green manure crop is grown. An acre of rice crop gets about 70 to 80 lbs. of nitrogen in the shape of sulphate of ammonia and about 50 to 60 lbs. of phosphoric acid in the shape of phosphates. Co-operative Societies play no mean part in the sale and distribution of chemical fertilisers. Breeding of superior types has long been practised and it is stated that nearly $\frac{2}{3}$ the rice area is now cultivated with seeds of known parentage, there being a very effective control over the distribution of the seed.

The rice crop is generally planted in June and harvested in October. It is grown in rotation with cereals like barley and leguminous crops. The application of phosphates is often done to the barley crop which precedes the rice. Weeding and harvesting are done by manual labour. Threshing and husking are done by small machines which are worked either by hand, foot, or electricity. The average yield is now 3,000 lbs. per acre and phenomenal acre yields of even 7,000 lbs. of grain have been recorded.

China :—The conditions in China resemble those of India more closely. Characteristically, the labour employed is entirely manual. But, the outstanding feature is the use of manures. All waste of man and beast from city and country is collected, stored without loss, allowed to ferment and decay and then applied in liquid form to the land in small quantities, so that nothing may be lost. It is applied intensively to the seed beds and to the field as a whole. What garbage there is, is similarly rotted and used with all other organic matter. The sluggish streams and canals are often dredged and the ooze carried to the fields.

It is high time India tries to emulate China and Japan in the use of manure and intensive methods.

Rice Civilisation :—The investment of effort required to develop paddy land immobilizes the population itself. Now whatever its past, any people tied down by immovable investment, soon becomes peaceable and peaceful. With peace, the population increases and multiplies, and a philosophy of peace and conservatism develops. The ancestors rest on the soil and both are revered. Rice growing peoples are typically not aggressive; they cannot afford to be, they have little inducement to be, until the pressure of population becomes insupportable, and by that time they are likely to have no spirit for aggression and to have adopted a code which prohibits it. With the loss of fighting spirit, they become easy victims of warlike peoples. But the latter in the nature of the case are not rice growers and therefore govern and exploit rather than displace the settled race. India and China have been conquered over and over again but they have simply absorbed their conquerors.

Thus the nature of rice culture underlies and explains the density of population as well as the stability of the human cultural systems of India and China. Man multiplies with the passage of time wherever war does not check the process. But no other human activity has held man fixed and made him as peaceful and conservative as rice culture has done. Industrial development may enable a people to levy on the produce of other lands and develop a denser population than any agriculture will support, but there is no warrant in history for the expectation that any other means of livelihood will lead to the evolution of a human cultural system as permanent as that associated with the culture of rice has proved to be.

LETTERS TO THE EDITOR

Geography and the Indian Science Congress

The Baroda session of the Indian Science Congress in January 1942, saw the last of the separate Geography section and thus we have lost the only existing body that could bring Indian Geographers together. Now it struggles as a mere annexure to Geology. We are, however, thankful for sparing us this short spell of individual honourable existence.

This step-motherly treatment with such an important Human Science as Geography merely shows the narrowness of the outlook of those who are responsible for it. This unwise step is a clear illustration that we in this country have not yet fully understood the great importance and practical utility of geography—a subject which has been defined as a 'Pivotal subject' by eminent educators of modern times. I only hope and pray that we may soon realise what an unjustified 'butchery' has been committed by a body that claims within its fold the cream of Indian scientists and educationists. We have not yet forgotten at what an unearthly hour and under what circumstances, the Geography section was voted to be closed down at Benares in 1941.

It was perhaps simply a gesture of good-will to the British Geographers who visited the Calcutta session of the Congress in 1938 that a temporary Geography section was so triumphantly started. The British visitors took a wise step in passing a resolution for the permanency of the section and it was somehow, decided to make the section a permanent feature. The section had hardly begun to settle down when in 1940 a proposal for its re-amalgamation with Geology was put forward at Madras. Then in 1941 the work was done and it was voted to be closed down. This 'mortal' anxiety on the part of some, lays bare their insincerity and narrow mindedness. Window dressing against the visitor is perhaps inherent in us. I wish I could know what are the reactions of the British geographers to this.

Geography needs no charity or patronage for its existence. I, or any of my fellow 'students of geography' have no intention of begging the delegates to the next sessions to graciously reconsider the whole situation. I, on the other hand challenge those who are responsible for it, to justify their action. To me and to all sensible and progress-loving persons, Geography is a subject of utility and great promise—and it is only the shrouded imagination of the foggy-headed conservative that may refuse to believe it. Its importance and great popularity is already established in our schools and intermediate colleges and it has also made a triumphant entry into some of our Universities. Much useful research work has already been effected and much is in progress. As such, Geography deserves all encouragement and due nourishment to grow to a grand maturity. Such unwise and uncalled for actions may only hinder its useful progress.

Geography is not envious of Geology or Anthropology—subjects that are as yet so uncommon in our colleges and yet nobody ever thinks of amalgamating them with something else. It only hopes that people in this country will some day wake up to its great importance as a 'human science' and restore it to its proper place in the realm of Indian Education.

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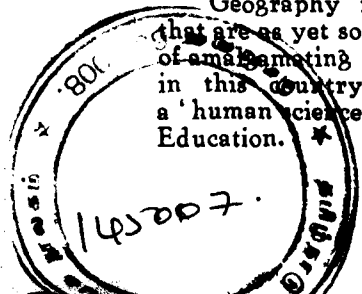
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