Vol. XXXVI OCTOBER - DECEMBER 1961 No. 4

The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

PUBLISHED QUARTERLY

Editor:

DR. GEORGE KURIYAN.

The Indian Geographical Society

THE INDIAN GEOGRAPHICAL SOCIETY
UNIVERSITY CENTENARY BUILDINGS
CHEPAUK, MADRAS - 5
INDIA

CONTENTS

NOTICE

Members and Subscribers are informed that the subscription for the current year for the Indian Geographical Journal has fallen due on the 1st January 1962. They are requested to kindly send their remittances with arrears, if any, to the Treasurer, Indian Geographical Society, 17-c, ARAVAMUTHU GARDENS, MADRAS-8.

M. N. VASANTHA DEVI,
Hon. Secretary.

THE
INDIAN GEOGRAPHICAL JOURNAL

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

Vol. XXXVI	OCTOBER - DECEMBER 1961	No. 4

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

DIASTROPHIC FORCES AND THEIR GEOMORPHIC EXPRESSION IN RANCHI PLATEAU

By

DR. P. VERMA,
University of Saugar.

Ranchi[1] plateau is a part of a region commonly known as Chota Nagpur plateau. It attains an elevation of 3500′ near its western margin while the rest of the plateau is about 2260′ above sea-level. Its western part rises as a steep escarpment above the general level of the plateau. Thus the Ranchi plateau may be divided into two division viz. — the ' Western Highland ' and the ' Main Plateau '. (Fig. No. 1).

Northwards the plateau overlooks the valley of the Damodar down a steep escarpment which has been dissected by its tributaries. The descent towards east and south is not as steep as that on the north but is marked by water-falls made by rivers flowing down the plateau. However, the gentlest descent is towards south but even that is well-defined by deeply-dissected river valleys.

A major portion of Ranchi plateau is formed of Archaean rocks among which the important rock types are granite-gneisses. To the south of it lies the region of Dharwarian formations. The former has intrusive relation with the latter showing that granite-gneiss is a comparatively younger formation. At the foot of the northern escarpment lie the detached patches of Gondwana formations.

All these features are affected by later diastrophic forces and they are the guiding factors in the formation of the present relief.

THE OROGENIC MOVEMENTS:—

The orogenic movements are confined to the sedimentary deposits of Dharwars and Gondwanas. The movement which folded the Dharwarian formations is of the pre-cambrian age and is called Archean Orogenesis. Though the ranges have been eroded away altogether in their folded form as such, and generally form low lands in the landscape, the dip of the strata in the residual hills, reflects the character of their past form. In Gangpur and

1. Ranchi, a district in the State of Bihar, lies in the extreme south western part of it between 22°21′-23°43′ N. and 84°-85°54′ E.

adjoining parts of the southern Ranchi, the famous Gangpur anticlinorium is located. Between this anticlinorium and the granitic mass of Ranchi, there is a zone which has a synclinal structure. Further west, we meet with the alternate bands of granite-gneiss and mica-schist, the former of which forms part of an anticline and the latter that of a syncline. Further eastwards, to the north of Singhbhum anticlinorium, a syncline is located in which Dalma Traps have been deposited (Fig No. 1) The syncline is again succeeded by an anticline to the north. The last two features dominate south-eastern Ranchi.

A marked difference in topography is found in the regions of two major formations viz. — granite-gneisses and Dharwars. Being homogeneous in structure, we do not find in granite-gneiss, any structural guidance in the arrangement of hills and valleys. Here the watersheds are the highlands and their extent is decided by the size of the rivers, while in the regions of Dharwars, the hills and valleys normally run along the strike direction. Besides, being residual hills, their shape and extent is decided by the outcrops of comparatively hard formations.

As usual in other places, orogenic movements are accompanied by differential movements and igneous activity. The evidence of such faulting is provided by crushed conglomerates on both the sides of anticlinoriums. The crushed zone of the north enters into southern Ranchi.

The outcrops of Dalma Trap prove the occurrence of the volcanic activity during Archaean orogenesis. The rocks of this volcanic flow are found in an elongated belt extending in southern Ranchi, Manbhum and southern Singhbhum.

Folds are also evident in the Gondwana deposits to the north of Ranchi Plateau. But the formations are subject more to faulting than to folding. In the north and south Karanpura coal-fields, the folds extend from east to west; hence it is understood that the stress exerted on the strata was in a north south direction.

Two periods of movement have been recognised here, one which deformed pre-Mahadeva strata, that is after Panchets and the second which folded the later deposits. The direction of movement in both cases was the same.

EPEIROGENIC MOVEMENTS :—

The most prominent and vigorous movement to which this area has been subjected is epeirogenic, which is expressed by the occurrence of fractures and faults accompanied by uplift. None of the geological formations has escaped this force. These movements have occurred from the time of the Archaean orogenesis upto the Tertiary period.

As mentioned earlier faulting and displacement occurred in southern Ranchi during the Archaean orogenesis. But the structure there is so complicated and confusing that it is practically impossible to detect the amount of throw. Besides the zone of crushed conglomerates of Dharwar series, there are a number of other faults which have been traced in southern Ranchi. For example, a distinct fault has been traced along the boundary between granite mass and the Dharwars, particularly in Manbhum. Similarly, there is a well-marked fault north of Dalma Trap mainly extending in Manbhum but entering for some distance in Ranchi plateau area.

Coming to the north, along the northern margin of the Ranchi plateau runs the boundary-fault of Gondwana and that of the Damodar Valley. The fault is supposed to have been formed at the time of actual deposition. The fault runs along the whole upper Damodar valley but the region adjacent to Ranchi plateau is that of the north and south Karanpura and Rampur coal-fields.

Thus, some of these faults are definitely of early ages and epeirogenic activity recurred along such weak zones in latter periods also. But some of these faults might have been formed during the Cretaceous and the Tertiary block-movement which were probably the last to affect this region. About these movements Dr. Dunn says "subsequent to the out-pouring of the Deccan Trap, there was prolonged erosion and uplift to the extent of about 1,000′ in the western Chota Nagpur......... the remnants of the latter were left as a small plateau in the west. This peneplain was being formed throughout a great part of the Tertiary times".[1] This is the movement which made the 'Western highland' a distinct topographical feature of the region. It retains its prominence even now in the whole of Chota Nagur plateau.

The main plateau of Ranchi was rejuvenated subsequent to the 'Western highland'. "Next, in the latter part of the Tertiary period, uplift was renewed to the extent of about 1000′ in the western Chota Nagpur, but in the form of a block-movement with a warping along a north-south line which is now represented by the eastern edge of Chota Nagpur Plateau. At the same time a trough developed along the valley of the Damodar, presumably due to faulting, cutting off the small Hazaribagh plateau to the North".[1] Dr. Dunn has mentioned that later there was a third period of movement but probably Ranchi plateau and Damodar valley have taken their present form as a result of this block-movement.

The fact that Ranchi plateau has been subject to some recent epeirogenic movement is clearly expressed in its shape, present topography and drainage. Besides, there are geomorphic features to prove that rising was not continuous but there must have been at least two distinct periods of uplift with a long break of standstill, while the region was sculptured by exogenic forces.

Granitic mass of Ranchi came into existence in the first era of the geological history but its present elevation ranges from 2250′–3250′. The exogenic forces working on these formations throughout the later three eras could not have left it so high. Its history is of degradation, never alternated by aggradation. Moreover, the younger deposits of the area are for the most part Gondwanas, which have their base either on the granitic formation or on the Dharwars. The thickness of Gondwanas, as estimated by the geologists is considerable but still these deposits form the lowlands.

Moreover, similar granitic masses of the south in Manbhum, Singhbhum, Gangpur and Bonai, also do not attain such elevation as the Ranchi Plateau. They are only about 1000′ high on an average. But this fact does not lead to any significant, topographical difference. Thus it can be concluded that the land-mass of Ranchi must have been peneplained several times in its history and its present elevation is the product of a recent epeirogenic movement.

1. Dunn: The Economic Geology and Mineral Resources of Bihar Provinces M.G.S.I. Vol. 78, (1942) p. 12.

The ' Western Highland ' which was rejuvenated earlier, is even now much higher than the main plateau and there is a distinct escarpment which separates the two (Map. No, 2). But only the small table-lands comprising the ' Western Highland' attain the elevation of 3000'. The main river valleys *i.e.*, of the North Koel and the Sankh, have the same average elevation as that of the main plateau. It shows two facts, firstly the rivers are unable to change these tablelands into sharp-crested ridges which might have been possible in the period in which they had carved out their valleys into gorges. Naturally the surface rocks are more resistant to erosion than the lower ones. And secondly, this part of the plateau must have been elevated to its present elevation before the rise of Ranchi plateau proper, otherwise the rivers would have been flowing on a higher level and might have narrower and deeper valleys with overlapping spurs. The longitudinal profiles might have been steeper and more irregular than they are at present. Now the waterfalls, the most prominent features of the river valleys - are found either near their sources or across their tributaries. Only a few minor falls are found in the main rivers. Also, the common uplift must have been reflected in the watersheds of the rivers. Because here the rivers have to work more in order to extend their channels by headward erosion. Hence, the watersheds of the rivers must have been broader, higher and unaffected by river action. But actually the watershed between the North Koel and the Sankh is less than 250' wide and important tributaries forming these rivers rise at a few hundred yards distance from each other on two slopes of the narrow elongated tablelands.

In this connection it is necessary to mention that both the ' Western Highland ' and the main plateau have independent drainage systems and the watershed still runs along the escarpment overlooking the main plateau. There is not a single river of the main plateau which has extended its valley upto the interior of the ' Western Highland '. All of them either drain the scarp face or the narrow marginal zone along the escarpment.

All this discussion brings us to the conclusion that the river system of the ' Western Highland ' is of older date prior to the upliftment of the main plateau of Ranchi as they show most of the characteristics of old age, while the rivers of the main plateau developed lately after its upliftment.

THE GEOMORPHIC EXPRESSION OF THE UPLIFTMENT ON THE MARGINAL AREAS :—

The ' Western Highland ' :—The marginal escarpments overlooking the surrounding region were originally formed by the upliftment of Cretaceous period but they vary in their geomorphic characteristics and so they need detailed treatment. The escarpment to the east overlooking the main plateau and the one to the north overlooking the Auranga and Damodar river valleys are intersected by rivers which divide them into separate blocks, while the escarpment to the south is not so well-marked and distinct but is still steeper than the southern escarpment of the main plateau.

Escarpment to the East :—There can be two possibilities of the formation of this well-marked and steep escarpment. Firstly, the ' Western Highland ' was covered by the Deccan Trap which served as a resistant cap-rock for the under-lying granite. Thus, there was differential weathering of the ' Western Highland ' and that of the main plateau, giving rise to this escarpment. But such is not the case, as investigated by Dr. S. C. Chatterji,[1] in his field survey, basalt is found even on the main plateau.

1. Chatterji, S.C.: Some aspects of Geomorphology of the Ranchi plateau. Cal. Geo. Review. Vol. VII. 1945 Nos. 2 & 3, p. 33.

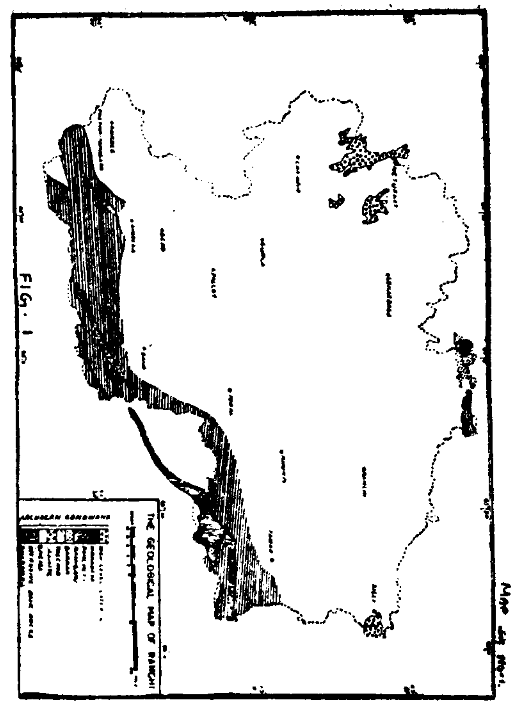


Fig. 1

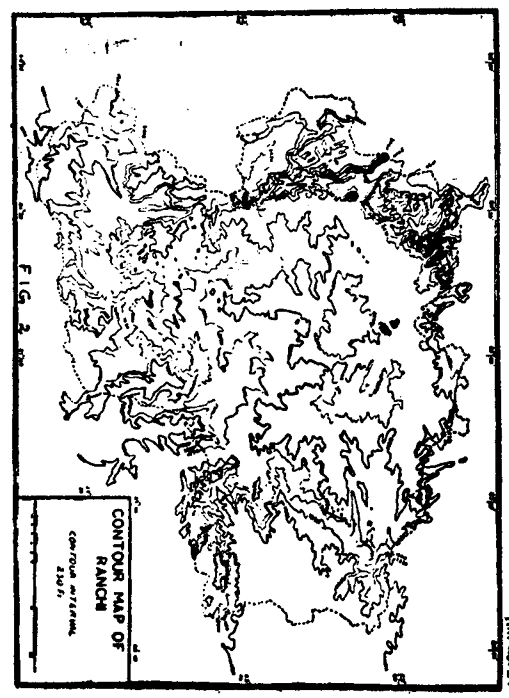


Fig. 2

Fig. 3

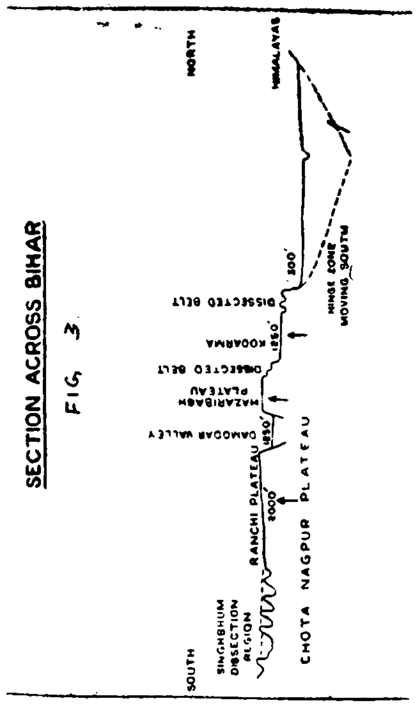
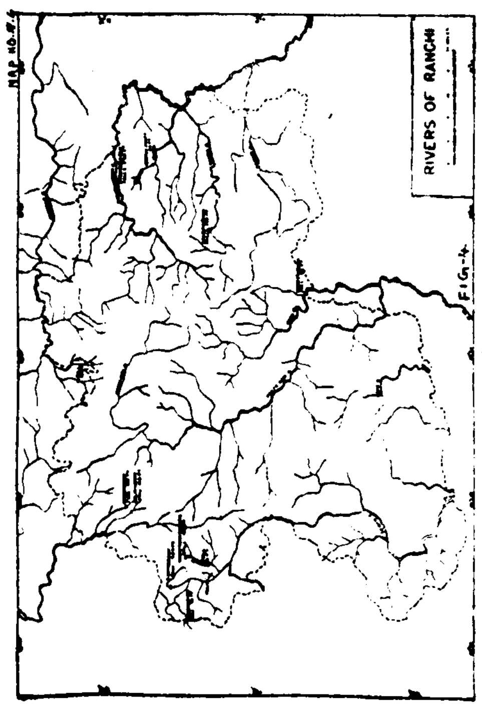


Fig. 4



Secondly, as mentioned earlier the escarpment marks the line of a previous uplift, prior to the rejuvenation of the main plateau. But such a fault-scarp, in course of time could not have remained so distinct and steep. Thus, the first factor also seems to have given its helping hand in making the escarpment a prominent topographical feature. It is therefore, considered that the upper part of the escarpment was formed by uplift and has become high and well-marked, in due course, by the differential erosion of granite and cap-rock basalt. So this is probably a composite scarp, the upper part being formed by uplift and the lower by erosion.

The escarpment to the North :—The escarpment to the North is of the same nature. Being part of the boundary fault of the Gondwanas it will be more convenient to discuss it with the northern escarpment of the main plateau. But it will not be out of place to mention that the escarpment in this section is highest in the whole of the Ranchi plateau. The descent on an average is between 1850'–1500', for example, from Khamarpat (3504') to the valley of Deonad river (1750') or from Bulbul (3349') to the valley of Auranga river (1750'). Probably it is due to the combination of two factors; first, the uplift of the 'Western Highland' in relation to the rift-valley of Damodar was larger as compared to the main plateau, and secondly the granite-gneiss was protected by a cap-rock of basalt on the 'Western Highland' while the Gondwanas of the Damodar valley suffered intensive erosion.

Escarpment to the South :—As mentioned in the previous paragraph, the southern escarpment of the 'Western Highland' is neither so prominent nor is so high. The area is highly dissected by the river Sankh and its tributaries. Instead of well-marked tablelands, there are only small buttes and elongated hills. At present, the rocks on both the sides of the escarpment are the same, so there is no difference in the topography, either on its top or at its bottom. It is possible that the basaltic cover was removed much earlier here than in the north. And subsequently the rivers have been actively engaged in brushing off the escarpment. Hence the amount and the line of uplift is not easy to detect.

The Main Plateau :—As mentioned earlier *the northern escarpment of the main* plateau runs along the southern boundary of the Damodar valley. This valley is one of the branches of the main Narbada-Son rift. Even between its two boundaries, the southern boundary fault is more marked. In case of Ranchi, only those portions of Damodar valley which include Ramgarh, North Karanpura coal-fields lie adjacent to it in the north. If we observe only the southern boundary of these fields it will be evident that they are abnormally straight and are practically in one straight line, extending westwards, one after another. (Map No. 1). The boundary of each is interrupted by the granitic out-crops. Naturally it may be assumed that this straight boundary was formed by faulting before the deposition of Gondwana beds. After the deposition the subsidence was renewed and the deposits sunk much deeper. In the case of Raniganj coal-field the sinking was about 9,000' in the vicinity of Panchet hill.[1] The evidence of faulting of Gondwanas along the southern boundary is found in all the coal-fields of the Damodar valley. About the Ramgarh coal-field, C. S. Fox writes "the southern boundary of the field is cut-off by a strong fault"[2]. A similar statement is made by him for the southern boundaries of North and South

1. Fox, C.S — Lower Gondwana coalfields in India, M.G.S.I. Vol. 59 (1934) p. 83.
2. Ibid p. 134.

Karanpura coal-fields. Describing the structure of the South Karanpura coal-field and pointing to where the southern boundary fault is exposed, Jowet Albert is of the opinion — "The southern boundary fault is exceedingly well-exposed in the river east of Huburwa Hill, at one point a section in the bank above 25 ft. high, shows grits dipping northwards at a high angle, faulted against hornblende schist."[1]

This statement proves that the southern boundary of these Gondwana deposits is a weak zone and persisted throughout the geological history of the region. Even at present the northern escarpment of Ranchi plateau runs along the southern boundary of these Gondwana deposits. As soon as this boundary is crossed, the highland is met with. But as we move from west to east, the escarpment is found more and more receding southwards away from the Gondwana deposits. Upto Rochap, a hill between Batuka and Nalkhari Nadi-two southern tributaries of Damodar, the escarpment runs adjacent to the southern boundary of Gondwana. Eastwards though it has receded southwards but two prominent spurs run upto the southern boundary of South Karanpura coal-field. Further east, the escarpment swings south-eastwards, terminating in Dondag pahar an eastwards extending spur of Ranchi plateau. (Maps 1 & 2). Below the escarpment, in this section, the land slopes gently up to Damodar. Probably because being lower in elevation and also being comparatively nearer to the sea, this part would have been attacked first by the rivers, and naturally levelled before the adjacent part in the west.

From the above, it is therefore concluded, that during the late Tertiary block-movement, the same line of weakness was utilised, and the Ranchi plateau was uplifted along the faulted zone, making the southern boundary of the Damodar valley, for it is the law of nature to utilize the same zones of weakness again and again, for the expression of any earth movement.

Here the faulting has taken place at the junction of the two geological formations, so there is no question of there being similar rocks on both sides of the fault, which is an important indication of faulting. As the rocks on the down-throw side are Gondwanas, which are more susceptible to erosion than granite-gneiss, they must have been eroded more easily, hence the lower part of this fault-scarp may have been formed by differential erosion. So this fault again can be classed as a composite scarp. Thornbury says that such scarps are common in nature.[2]

Being guided by the steep slopes, the rivers which descend from the escarpment have comparatively straight courses and are naturally parallel to each other. Such are the southern tributaries of the Damodar river which descend from the Ranchi plateau. Main rivers from west to east are the following — Dhudki nadi, Dhangarha nadi, Chirokhara nadi, Dainkata nadi, Saphi, Batuka nadi, Nalkhari nadi and Dhondhab nadi. In the extreme west, Gala nadi, which is a tributary of the westward flowing river Auranga, also drains the scarp-face. These rivers in their turn have developed innumerable tributaries, which are actively engaged in lowering this escarpment.

Along the zone where these rivers flow through the escarpment, their gradient is steep, hence their force is utilized in cutting their beds and thereby forming narrow and deep gorges. Such gorges are found in all the

1. Jowet Albert: on the Geological structure of Karanpura coalfield. M.G.S.I. Vol. 52 (1929) p. 39.
2. Thornbury: *Principles of Geomorphology*, p. 249.

above mentioned rivers and in some of their tributaries. These gorges are alternated by long, narrow and sharp-crested ridges, which present a topography somewhat similar to the mountains. The predominance of relief in this zone is a clear evidence of the work done by these rivers subsequent to the formation of the escarpment.

Another effect has been the existence of rocky outcrops in the river beds and on river banks through out this zone. Moreover, the deposits are found just above their confluence with the Domadar only, and not in the section where they flow through the escarpment or near their sources. By observing the sources of these rivers it becomes evident that all of them have encroached in to the flat tops of the plateau and are extending their shallow valleys, the flat tops of the plateau, however, continue to exist in between them. These must have been at one time part of the plateau, though they are now isolated by their headward erosion.

Another fact which is very striking is that the valleys of the above mentioned rivers must have been interrupted by a sudden drop at the fault-scarp thereby creating the waterfalls. But now we find only one fall of 70 ft. in the courses of Dhangarha river[1], preceded by by a gorge about 1½ miles long. (Map No. 4). All the other falls seem to have been eliminated by the active erosion and the rivers have comparatively smoothened their valleys in longitudinal profile. Existence of this single waterfall along the escarpment is a unique feature. It has persisted for a longer period probably because of two factors. First, the rocks may be more resistant than the rocks in the other river valleys to the east, and secondly, in comparison to the other tributaries of the Damodar, which drain the scarp face this river is situated near the source of the Damodar. Owing to its location in the interior, far from the sea, the waterfall has remained unaffected by the normal process of elimination while the irregularities of the rivers to the east have been brushed off.*

All these facts lead us to the conclusion that the escarpment is in a mature stage and a time will come when these rivers will extend their valleys by the headward erosion and river capture and ultimately by their active erosion, the conspicuous nature of the escarpment will vanish.

We have emphasized the view that Ranchi plateau has been formed by block-upliftment and the Damodar valley by sinking. The existence of three hills Batuka 2425', Aswa 2450' and the Lugu pahar 3200', in this valley might however, lead to a different conclusion that the valley has been formed by erosion and not by faulting. Support for the latter view is found by geomorphologists in the argument that in epeirogenic movements, uplift always does not take place in one direction, but the reverse movement is also evident. In the case of this rift valley, the second process, being localized to the valley, led to the upliftment of the valley, instead of its further sinking, and these hills were thrown up almost to the height of the upthrow blocks on either side of it. This becomes clear by the erosion which is going on vigorously on all the sides of the hills, causing steep slopes.

Another feature may also be mentioned here, that the southern block of the rift valley, namely Ranchi plateau which being uplifted more vertically than its northern counterpart, the Hazaribagh plateau, shows signs of tilting as well. About Hazaribagh plateau Dr. Dunn says that "Along the northern side of the plateau the movement was more of the

1. The river drains the western part of the escarpment.
***The logic of this argument is not quite clear (Editor).**

nature of a tilt, the surface sloping more gradually down towards Kodarma[1] " On Ranchi plateau the fact is confirmed by the shorter length of the rivers in the north as compared to those flowing to the south or to the east. Besides this, the highest parts of the plateau are found adjacent to the northern escarpment and southwards the height decreases slowly (Map No. 2). As described above, the valleys in the north are narrow and deep. Their youthfulness is further indicated by vertical corrasion and by headward extension of their channels. In constrast to them, the rivers flowing to the south and east, that is on the back side or on the gentle slope of the tilted block, have not only open and broader valleys (except where they descend from the plateau) but they have made their flood plains in which they meander from one side to the other. Sand deposits are also found in their valleys. However, it will be true to say that the tilt was not very acute as the rivers flowing towards the south and east do not rise from the edge of the tilted block, but take their rise from a central ridge (Map No. 4). South Koel adopts a circuitous route across this ridge. In this connection a doubt may arise owing to the non-existence of any evidence of tilting in the ' Western Highland ' where the peculiar drainage pattern is not found. Not only the Sankh and its tributaries extend far northwards but North Koel also rises from the extreme southern part of the ' Highland '. They have open and well-developed valleys, except in the upper sections where the youthful conditions are found and the waterfalls are met with. Also the highest point of the plateau is reached in Neturhat plateau which is located in its centre.

The Eastern Escarpment:—(Map No. 2) The topography of the eastern margin of the plateau indicates that formerly the plateau had extended more towards the east but it receded later to its present extent, mainly by the erosive action of Subarnarekha and its tributaries. At present Subarnarekha marks the eastern margin of the plateau and for a long distance the district boundary also runs along it. Beyond the valley of Subarnarekha in the east, large mesas are found which are separated from the main plateau. The northern mesa is very irregular in shape. Its prominent hills are Durgha pahar 1874 ft. in the north and Sangrampur pahar 1801 ft., Uparhanga 2037 ft., and Bhaski 2380 ft. in the south. The descent from the last one southwards is very steep and in places by precipitous escarpment. The southern mesa is called Baghmundi. It is flat topped and somewhat rounded in shape. From it rises the Chamtu hill 2390'. On the other side of the valley and analogous to these mesas, are spurs which extend from Ranchi plateau upto Subarnarekha. From north to south they are known as Dondag pahar 1804 ft., Barkibur pahar 1986 ft., and Chandgarhi pahar 2081 ft. In addition to these, there are very small rounded buttes on both the banks of Subarnarekha, ranging in height between 1500' and 2000'. This topography shows that at one time the plateau extended far eastwards and these mesas are merely its remnants. However, owing to the tilting of the plateau, these high and extensive mesas and buttes are found only in the northern part. Southwards not only the main plateau swings south-westwards but in place of mesas only small buttes are met with, and thus an extensive gently sloping plain is left on both the banks of the Subarnarekha. Its valley is bounded on the south by a high elongated ridge called Dalma to the east of Subarnarekha and Deshwar pahar to the west of it. (Map No. 2) The uplifit is also expressed by high waterfall not only in Subarnarekha, but in its main tributaries which descend from the plateau (Map No. 4.) All of them are preceded by deep and narrow gorges with deposits in their

1. Dunn: The economic Geology and Mineral resources of Bihar Province. M.G.S.I. Vol. 78, (1942) p. 12.

beds. This denotes that the line of uplift was much eastwards and Subarnarekha has carved out its valley through the plateau. The highland has receded much westwards due to the constant operation of exogenic forces, and the waterfalls have kept pace with the recession.

Moreover, contrary to the north or to the west, here the uplift took place in one type of rock — granite and gneiss. That may explain the absence of precipitous and steep escarpment. The descent from the plateau though well marked and considerable, is gentle and gradual, and for this the Subarnarekha and its tributaries are responsible. The presence of extensive stony wastes along this slope, give some idea of vigorous degradation which is going on along this escarpment.

Coming to the *southern escarpment* we find that the gentlest descent from the plateau is on this side (Map No. 2). It may be due to several factors. The gneisses and granites come into contact with Dharwars of the south, which while varying in resistance, form low-lands in general. However, the resistant rocks have formed hills and ridges, and they rise even higher than the level of the plateau proper. Naturally they obscure the prominence of movement. The obscurity has also been accentuated by the fact that here two movements have affected the area, the diastrophic in the plateau and orogenic in the south and not only Dharwars but the granitic mass has been degraded so vigorously that the land in a broad zone has lost the undulating nature of the plateau and has been converted into innumerable hills and valleys.

This southern descent though gradual is not uniform. Abrupt descents are alternated by gentle slopes. Roughly, there are three steep slopes which are well-marked on the spurs between the main rivers which are however, graded and also open. Nevertheless, the persence of these steps in the river is marked by the rocky outcrops in the water channel, or by the narrowness of the valley parallel to the steep descents on the spurs. Along each of these steep slopes three separate sets of rivers take their rise which accentuate the prominence of the alternate steep slopes. In between them on gentle slopes, the rivers do not flow along the general southern descent of the plateau but take an easterly or westerly turn. This is most probably beacause in this zone strike of the country rock becomes more important than the general slope. Further, the guidance of country rock can also be seen in the direction of the flow of the small rivers in the southern marginal areas where Dharwar out-crops are found. The tributaries join the master streams either from N. E. or S. W.

The presence of waterfalls also strengthens the statement. When river Sankh descends from the main plateau, it has a very narrow and straight valley. It is a perfect gorge and is headed by Pheruaghagh falls. Similarly, when Karo descends from the third steep slope forms the Pheruaghagh falls and runs through its narrow gorge. Granite being a homogeneous rock, these steps cannot be formed by erosion and most probably mark the intermittent uplifts to which this area was subjected.

The first steep descent is from the main watershed southwards that is from 2500 ft. to 2250 ft. on the spurs and to 2000 ft. in valleys. The second descent is from 2050 ft. to 1950 ft. on the spurs, that is from 2000 ft. to 1900 ft. It is sufficiently steep in the south-eastern section of the plateau.

Thus it may concluded that diastrophic forces working in the geological past have left their imprints on Ranchi plateau, and to some extent they are responsible for the present height of the plateau as well as for the present base-level of erosion for the rivers of the area.

GEOGRAPHICAL ZONES OF MURSHIDABAD

By

N. D. BHATTACHARYA, M.A.,

Varanasi.

INTRODUCTION :

Murshidabad-on-Bhagirathi, (24° 12'N 88° 17'E), one of the decayed historical cities of West Bengal, lies at a distance of 197 kilometers (122 miles) north of Calcutta and is truly "the mirror of its age and epitome of its region"[1] The city was a regional capital of Bengal, Bihar and Orissa in the mediaeval period. The present townscape is situated on the eastern bank of the river Bhagirathi, familiarly known as 'Bagri',[2] at an altitude of 61' above sea-level. One can curiously observe the social and cultural patterns of its landscape and the conspicuous 'role of geographical factors involved in shaping them! It is needless to say, the cultural imprints of different periods of its growth have been preserved in various parts of its urban habitats!

EARLIEST NAME :—

The earliest name of the city was 'Masumabazar'[3] and its early history is in obscurity. During the seventeenth century, it rose to the zenith of commercial activities and acquired a reputation for manufacturing silk fabrics.

EVOLUTION IN BRIEF :

The morphology of the city is the outcome of various stages of its development since ancient times. The main phases of evolution dealt with are[4]:

(i) Ancient Cities——Kiriteswari, Kusumkhula and Akbarpur ;

(ii) Evolution of the city in the early eighteenth century (1704— 1740 A.D.)——When Murshiduli Khan transferred the seat of Government from Dacca (now capital of East Pakistan) to 'Makhsusabad', and named the place after himself as 'Murshidabad'. This period witnessed an over-all change;

(iii) Evolution of the city during the mid-eighteenth century (1740—65)——the reign of Alivardi Khan, Siraj-ud-daula and Mir Jafar Khan——When the city experienced the highest cultural development ; and

(iv) Between 1765-1772 A.D.——When a conspicuous devastation in the townscape of Murshidabad set in. Later on, both, physical and political factors were responsible for the rapid decay.

1. Smailes, A.E., 'The Geography of Towns' Hutchinsons University Library, 1953 P. 70.
2. Mitra, A., Census 1951, W.B., District Handbooks, Murshidabad (1953) P-11.
3. Sarkar, Sir. J N., Krishna Nath College Centenary Commemoration, Vol. (1853—1953) Historical Memoirs, Old Murshidabad, P-131.
4. Bhattacharya. N.D. The Evolution of the City Morphology of Murshidabad; Thesis for M. A. degree. submitted in the Dept. of Geog., B.H.U., 1957 unpublished, pp.—26-27.

A well-marked change can only be visualised after the great partition (1947). The Census, 1951 returned 10,756 persons[5] and thus it is a Class IV Municipal Town. It is, now, a Sub-Divisional headquarters and covers 5·0 sq.miles. Evolution of the townscape of Murshidabad has already been discussed analytically elsewhere[6].

The object of the present paper is to focus attention on the 'Geographical Zones' of Murshidabad. The term 'Geographical Zones' distinctly differs from the 'Functional Zones'. Dr. Singh, pioneer in the field of Urban Morphology in India, carefully considers the following points to distinguish 'Geographical Zones' of Banaras[7] ; (i) type and density of houses, (ii) nature and character of roads, (iii) the general pattern of land-use. As regards the 'Functional Zones' of a city, Dr. Singh's considerations are ; "Business, industry and residence all play their own role in the differentiation of the urban habitat so that different zones may be distinguished on functional basis".[8] From the above definitions of the terms, — Geographical Zones and Functional Zones are, now, quite clear. The author has, elsewhere, discussed, in detail, regarding the 'Functional Zones' of Murshidabad.[9]

A. GEOGRAPHICAL ZONES :

The present town of Murshidabad represents different geographical personalities in its nature and character of roads, type and density of houses and general pattern of land-use. Keeping in view the above points, three 'Geographical Zones' of Murshidabad may thus be broadly distinguished : (1) The Inner Zone, (ii) The Middle Zone, and (iii) The Outer Zone.

Broadly speaking, the Inner Geographical Zone of Murshidabad consists of the Killa Nizamat which is still administered by the Nawab Bahadur of Murshidabad, under the guidance of the Board of Revenue, Government of West Bengal. This zone almost coincides with the Functional Zones of the town. It exhibits different aspects including the Palaces, the Imambara and the Nawab Bahadur's Institution. The Middle Geographical Zone shows a transitional character. The Outer Zone is characterised by numerous open spaces, almost uninhabited and covered with jungles. The mediaeval remnants are conspicuously scattered herein. In recent years, a transit camp was opened by the Government of West Bengal for the "Displaced persons"[10] of East Pakistan. Moreover, the suburban areas upto the Gobranala, now-a-days, are pervaded by jungles The river-sides present different aspects which deserve a separate treatment.

5. Census, 1951 (W.B.) Murshidabad, Table 1·1—A P.-1.
6. Bhattacharya. N. D., Murshidabad——A study in Urban Geography, The National Geographical Journal of India. Vol. V. Part—1, March, 1959. Pp-38-48.
7. Singh, R. L., Banaras : A study in Urban Geography, 1955. pp.—41-42.
8. Singh, R. L., Op. Cit., P.-73.
9. Bhattacharya. N. D. " Functional Zones of Murshidabad, Proceedings of 46th Session of Indian Science Congress Association (Delhi — 1959), Abstract Part III, pp.—259-260.
10. A 'Displaced person' was defined by the Registrar General of India as follows : "A displaced person means any person who has entered India having left or being compelled to leave his or her home in Western Pakistan on or after the 1st March. 1947 or his/her home in East Pakistan on or after the 15th October, 1946 on account of civil disturbances or the fear of such disturbances or on account of the setting up of the two Dominions of India and Pakistan."

THE INNER GEOGRAPHICAL ZONE :

An examination of the map (*vide* Fig. 1A), will reveal that this Geographical Zone consists of a narrow strip along the Bhagirathi, *i.e.*, from Urdubazar (J. L. No. 59) to the southern gate of the Killa Nizamat, a little north of the Panchraha Bazar which is the main collecting and distributing centre of the locality. This area is bounded on the east roughly by the Lalbag-Jiaganj road which was very recently abandoned by the Bus Service authority, owing to severe damage of this road caused by the river Bhagirathi near about the Mahimapur embankment (J. L. No. 71).

Geographically, the area occupies the higher ground of 81.57 acres, which has never been affected by floods. The Bench Mark near the 'New palace' familiarly known as the "Wasif Manjil" records 61 ft. and the entire area is situated above the flood level. The present Killa or fort was built up during the reign of Humayun Jah. The river Bhagirathi provided with a natural barrier and hence there is no outer rampart of the Fort. A large number of boulders, visible during the summer season, were deposited at the foot of the Killa to check the direct currents during the rainy season as the Killa and the Hazarduari (palace) stand on the concave side of the river. The inner wall of the Killa is constructed by bricks and stones within its campus which is locally known as 'Harem' where the relatives of Nawab Bahadur of Murshidabad reside. There are many palatial buildings mostly characterised by Muslim designs. The palace or Hazarduari, a three storied building, 424 ft. long, 200 ft. broad and 80 ft. high, is at present the chief object of attraction of Murshidabad. This building after the Italian pattern, designed by Col. Duncan MacLeod, was erected by Humayun Jah, the then Nawab Nazim of Bengal, in the year 1829 A.D. This palace and Imambara attract a number of visitors almost every day from within and outside the district. It is true that this entire zone represents the administrative core of the city since the early eighteenth century. Even today this area is looked after by the Nizamat as already stated hereinabove.

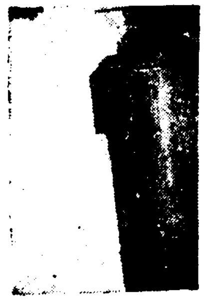
THE MIDDLE GEOGRAPHICAL ZONE :

This zone forms a transitional belt between the inner zone on the one hand and the outer zone on the other. The entire zone is to be considered in keeping with the view of 'street-lay-out, pattern of settlements and the types of houses.'[11] This zone is longitudinal in character and functions mainly as residential area. Its outer limit is now and then irregular and does not follow any definite road boundary. Starting from Lalbag (South) Mahimapur (North), this zone covers a considerable area with numerous remains which indicate that this area was fully built up and extremely congested in mediaeval times. The main interest of this zone is, at present, as the sub-Divisional administrative centre (court) which is located at Lalbag near the embankment.

The southern part of this middle zone is highly populated and the density of population per acre is moderately high. The Hindu settlements are predominant in this part, consisting mostly of pucca houses which are haphazardly located. To the north, on the other hand, the Muslim settlements consist of kachcha dwellings, mostly located along the Lalbag-Jiaganj Road. After partition (1947). there was sufficient inflow of people who have

11. Singh U. Geographical Zones of Allahabad. The National Geographical Journal of India Vol. II Part I, 1956, pp. 36-47.

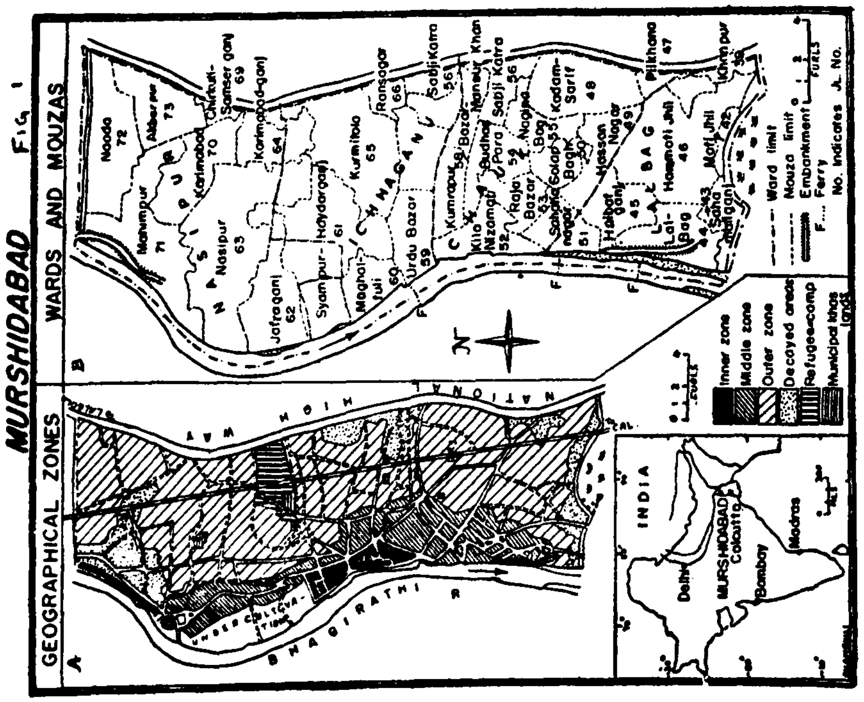
Ruins and Remnants of House of Jagat Seth, Murshidabad.



Stable Near Panchraha Bazar

Katra Masjid (under construction)

Kurmitola Transit Camps.



permanently settled over the area. In this part, two predominant Hindu settlements are observed, one at Nasipur (J. L. No. 63) and another at Mahimapur. One of the most conspicuous characteristics of the zone is the presence of numerous mosques and temples which stand almost side by side, reducing thereby the communal feelings of the people. Truly speaking, the influence of modernity can be found only in the immediate vicinity of the Lalbag court.

THE OUTER GEOGRAPHICAL ZONE

Apart from the middle zone, the outer zone covers a considerable area from Akbarpur (J. L. No.73) to Motijhil (J. L. No. 42). On the east, it is bounded by the National High-way where it coincides with the Municipal boundary. This is charactcrised by mango-groves, a few patches of cultivated lands, tanks and depressions. Besides, the area is conspicuously dominated by jungles. Most of the dwellings, within this zone, are kachcha, indicating poverty of their inhabitants.

Most of the vacant areas along the railway line which runs almost through the heart of this zone, are practically untouched even for cultivation. There are two railway stations, namely, the Murshidabad station and the Nasipur station. The cultural landscape of this zone is characterised mainly by the ruins of mediaeval structures and hamleted settlements mostly enveloped by the jungles. Aptly speaking, the function of this zone is, at present, rather rural than urban. Though this region has many things in common with the other zones, yet its nature and functions are at some places so variable that the following sub-regions may easily be distinguished; (i) The Kurmitola Transit Camp area, and (ii) The Decayed Residential areas.

(i) The Kurmitola Transit Camp area.

Formerly, a portion of this area was the trenching ground of the Murshidabad Municipality. This sub-region lies nearly one and a half miles north-east of the Palace and it covers an area of 195·43 acres of land. The railway line runs through the heart of the area and the National Highway also runs almost parallel to it touching the eastern boundary of the camp area. Just after the great partition of India, a number of camps have grown up owing to the human floods from East Pakistan. The Govt. of West Bengal has provided the displaced persons with temporary settlements here. The number of persons concentrated in this area, according to the Municipal report is approximately 10,000. In very recent years a good number of people are persuaded to settle down at Dandakaranya and the remaining are provided with Rs. 2,250 to permanently settle down within the Municipal jurisdiction or elsewhere suitable. A daily market (daily at 5 P.M.) has grown up to meet the increasing demand of the campers.

(ii) The Decayed Residential Areas :—This sub-region may further be sub-divided into the following: (a) Motijhil and the neighbouring areas, (b) Mubarah-Manjil, (c) Pilkhana, (d) Sabji-Katra, (e) Mahimapur, and (f) Kulhoria.

(a) Motijhil and the neighbouring areas:— About three quarters of a mile to the south-east of Lalbag Sub-divisional court is Motijhil which constitutes the J. L. No. 42 and covers an extensive area of 287.99 acres. The number of occupied houses is only two at present. Moti-Jhil or pearl-Lake (vide Photo plate) is a long horse-shoe-shaped lake. According to Major Rennell, it is one of the windings of the former channel of the Cossimbazar

river [12] " i.e. the Bhagirathi. A large number of beautiful buildings were erected by Nawazish Khan (1743). Ghaseti Begum resided until she was driven out by Siraj-ud-Daula. This is the place where Lord Clive-,the mighty man of the East India Company, held the first English *Punya* in May, 1766. The Motijhil was often described by the local people as a 'Bhukailash' or Earthly Paradise owing to its magnificient scenic beauty. Even today, Motijhil, undoubtedly an ox-bow lake, is one of the beautiful spots in the district, which attracts a large number of tourists during holidays.

(b) *Mubarak Manjil*:— Another decayed area stands on the east of the Moti-jhil on the Berhampore-Lalgola Road. The 19th century buildings are in ruins here.

(c) *Pilkhana*:— This area (J. L. No. 47) was populous during the 18th century and the elephants of the Nawabs of Murshidabad were kept here. Hence the name of this place 'Pilkhana'. The ruins of the Pilkhana still exist just by the right side of the National Highway leading to Berhampore. The area covers narrow patches of about 60·62 acres of land. It occupies only 10 houses with 38 persons.

(d) *Sabji-Katra*[13] :— This Katra (J. L. No. 56) lies on the both sides of the National Highway (Berhampore-Lalgola Road) and covers an extensive ground of about 244.94 acres with 98 persons. This area was the most populous part of the city and is, at present, regarded as the old core of Murshidabad. Murshid Quli Khan, founder of Murshidbad city, constructed here a mosque, popularly known as 'Katra Masjid' in 1725 A. D. It was made after the model of the 'Great Mosque of Mecca of Arabia' This mosque was severely damaged by the earthquake of 1897 [14] During recent years, this early 18th - Century mosque has been taken up by the Archaeological Department of India, Eastern Circle, for thorough repair. One of the domes (originally surmounted with five domes) has been completed by the said department.

It can now be safely said that the nucleus of the early city was the Katra, the market place as well as the religious centre. A 'Ganj' already developed on the bank of the Katra-jhil-the present 'Gobra Nala' the early trade route directly linked with the Padma (the Ganga). This channel is now almost silted up.

A quarter of a mile to the south-east of the Katra Masjid. is the 'Tope-Khana; the site of the Nawab's artillery park and east entrance of the old capital, protected on the east by the Gobra Nala. Here, still, lies the Great Gum called 'Jahan-Kosha' (destroyer of the world). It is interesting to note that this great gun is worshipped by the low income group[15].

(e) *Mahimapur*:— The ruins and remnants of the old houses of 'Jagat Seth', Banker of the world, are still visible at Mahimapur, a few yards from the present Nasipur palace. The vast area constitutes the J.L. No. 71 in the Nasipur Ward and covers an area of 287.02 acres. A close study of the map (vide Fig 1-A will reveal that this portion lies on the concave slope of the river Bhagirathi. The water of the river directly dashes on the left bank; hence bank-erosion is highly effective. The major portion of the old house

12. Census, 1951, W. B., Handbooks of Murshidabad, (1953), A. Mitra, Appendix I—P-LVI.
13. Sabji — Vegetable ; Katra — Market or Ganj.
14. Mazumdar, P. C., The Musnud of Murshidabad, Calcutta, 1904, pp. 171-173.
15. Personal observation (1960-61). What is the low income group? (Ed.)

Jagat Seth has already been eroded by the river. The 'Bund' or the embankment on which the Lalbag-Jiaganj road runs, has recently been cut away by the Bhagirathi as already stated. A few remains are now covered with impenetrable jungles and inhabited by wild animals.

(f) *Kulhoria or Colaria* :— To the east of the palace, outside the limit the Killa, is Kulhoria, the site of the palace of Murshid Quli Khan, which is still pointed out by the local people. Almost everywhere throughout the length and breadth of the city, ruins and remnants of the palaces are conspicuously scattered.

B. MUNICIPAL WARDS OF MURSHIDABAD:—

Apart from the geographical zones, from the administrative point of view, Murshidabad, the sub-divisional headquarters, covers an area of 5.00 sq. miles and is divided into four wards. Starting from the south in order, we have: (i) Lalbag, (ii) Chauk, (iii) Ichhaganj and (iv) Nasipur. According to the Municipal old records, there were, altogether, 41 Mohallas. The said ward, now-a-days, are further sub-divided in to 32 Mouzas.

The Municipality was established in the year 1869. The administration of the historic town is vested in the 'Town Municipal Council'-composed of nine councillors, one vice-chairman and one chairman. The chairman is the supreme authority of the Municipality. Recently the Govt. of West Bengal has deputed an executive officer to look after the administration. The revenues of the Municipality are mostly derived from taxation on buildings, shops and markets. The main items of expenditure are public works, street lighting, conservancy, sanitation etc.

C. RIVER SIDE ASPECTS OF MURSHIDABAD:—

Anyone who beholds the mediaeval city from Dahapara[16], on the opposite side of the river, is thrilled by the picturesque landscape of Murshidabad. He will immediately have a glimpse of the 'Nizamat-Killa' (Fort) which commands a delightful landscape and contains the 'Hazarduari', the 'Imambara', the 'Madina', a group of mosques and residential quarters, and other innumerable buildings. The river, in front of the 'Killa' is about a mile in length. The embankment is studded with sentry boxes, lamp posts and pillar. Along the entire river-side, from Mahimapur to Amaniganj, there are as many as 20 ghats, most of which are in ruins.

There are a few magnificient ghats within the Killa-Campus which have their own importance. Starting in order from the North Gate of the Killa near the Imambara, we have the 'Top-khana Ghat' (Artillery Ghat). In honour of the Nawab Bahadur of Murshidabad, a canon-shell is exploded every night just at 8 P. M. during the winter season.[17] It is really interesting to note the sound of this explosion which serves as a time-indicator to the citizen. A little south of the said 'Ghat', is Lat-Ghat, built in honour of a lord, probably Lord Curzon, who visited the city during the first decade of

16. Dahapara — Dacca Para. In the year 1704, when the great Dewan, Murshid-Quli Khan transferred the seat of Govt. from Dacca to Murshidabad, there was a considerable influx of population. These people were settled on the right bank of the Bhagirathi. The people named the place as 'Dacca-Para' in memory of the capital Dacca, wherefrom they came. Owing to local pronunciation, Dacca-Para, in course of time, was named as 'Daha-Para' - Personal enquiry.

17. During the summer, the gun is exploded at 9 P.M. daily.

the 20th century. Among the lot, the Chauk-Ghat (brick built) with an over-bridge, is the most important. It is used for bathing purposes by the inhabitants of Chauk.

Further down stream, in front of the New Palace, there is the 'Wasif Manjil' Ghat with a beautiful bungalow. The ghat is named in honour of the late Nawab Bahadur of Murshidabad. This stone-built ghat, with a water measuring scale, is not meant for public use.

Present condition of the Ghats:—A number of beautiful ghats were built either by the Nawabs or the Zamindars of Murshidabad during its palmy days. Unfortunately, negligence of the local authorities towards these ghats has been the root cause of their wretched condition. Almost all the ghats are seriously damaged by the direct currents or the heavy silting of the river. All the stone-built ghats are collapsing and are gradually being washed away by the river particularly during the rainy season.

Another point worth mentioning in connection with the ghats is the defilement of the river due to the discharge of sewage through a big drain (that runs through the heart of Chauk ward) beside the Chauk ghat. This is a definite menace to the public health. A necessary investigation for repairing, improving, or rebuilding the ghats, is urgently needed.

Summary and conclusion:—It is quite obvious now that in Murshidabad there are three distinct Geographical Zones. The inner consists of the Killa-Nizamat; the middle zone represents a transitional character; and, the outer zone is scattered with mediaevel ruins and remnants. Different phases of development of the urban landscape of Murshidabad, are conspicuously related to both natural and cultural forces of the site. At present, within the Municipal limit, there reside only 10,756 people (1951 census). This decayed town, however, is gradually developing after the partition of India.

After analysing the historical and geographical factors, the author suggests the following measures for the general improvement of the townscape of Murshidabad.

(i) that the pollution of river-water should be checked;
(ii) that the medical facilities are to be increased;
(iii) that a number of tube-wells, instead of wells, are to be constructed for drinking water;
(iv) that the decaying condition of the ghats needs immediate consideration;
(v) that the necessity of another market is keenly felt by the people of Nasipur and Ichhaganj wards;
(iv) that the small industries like silk manufacturing, mango processing and ivory carving, are to be encouraged by the State Government
(vii) that with the introduction and encouragement of tourism, the very face of the townscape could undoubtedly be improved; and,
(viii) that, last but not the least, with the execution of the Farakka Barrage, the inland navigation will improve and hence a conspicuous change on the cultural landscape of Murshidabad will be visualised.

With the introduction of electricity, in recent years, a phenomenal change has already been marked.

ACKNOWLEDGMENTS.

The author expresses his deep debt of gratitude to Dr. R. L. Singh, M.A., Ph. D (Lond.), Professor and Head of the Department of Geography, Banaras Hindu University, for his helpful suggestions in the preparation of this paper. He further extends his thanks to Shri S. K. Roy, M.A., B.T., W.B.E.S., Head Master, Nawab Bahadur's Institution, Murshidabad, Shri Sailajabhushan De, Commissioner, Murshidabad Municipality, Shri Kamakhyapada Sinha for certain local information and guidance.

SELECTED BIBLIOGRAPHY

1. Bhattacharya, N. D., Functional Zones of Murshidabad. Proc., Indian Science Congress Association, 46th Session (Delhi-1959), Part III (Abstract) pp. 259-260.
2. Bhattacharya, N. D., Murshidabad - A study in Urban Geography '. The National Geographical Journal of India, Vol. V, Part I, March, 1959, pp. 38-48.
3. Majumdar, P. C., ' Musnad of Murshidabad ' (1704-1904), pp. 171-173.
4. Mitra, A., · Handbooks of Murshidabad, Census 1951, W.B., Appendix—I,P—LV.
5. Sarkar, Sir Jadunath, Krishnath College centenary commemoration Vol. (1853-1953), Historical Memoirs, pp. 131-132.
6. Smailes, A. E., The Geography of Towns, Hutchinson's University Library, 1953, p. 70.
7. Singh, R. L., Banaras—A Study in Urban Geography 1955, pp 41-42.
8. Singh, R. L. and Mukherjee, B, (Mrs.), ' Functional Zones of Ranchi ', National Geographical Journal of India, Vol. III, Parts 3 and 4, Sept. and Dec., 1957, pp. 117-124.
9. Singh, U., Geographical Zones of Allahabad. N.G.J.I. Vol. II, Part I, 1956. pp. 36-47.

PERSISTENCE PROBABILITY OF COLD SPELLS IN UTTAR PRADESH

By

R. N. TIKKHA, M.A., B.Sc.,

Modi Sc. & Com. College, Modinagar, (U.P.)

INTRODUCTION :—

As commonly believed certain weather sequences have a tendency to persist. This persistence is of great importance from the agricultural and bio-climatological points of view. An attempt to study the Persistence Probability of the spells of cold days in U.P. (Uttar Pradesh) must, of necessity, contribute to the solution of many agricultural and bio-climatological problems[1]. An attempt is, therefore, made to study the Persistence Probability of these abnormal days on a quantitative basis.

Rambhadran[2] applied Logarithmic Series to the daily rainfall data of Poona to find out the spells of rain and rainless days but Srinivasan[3] proved that Logarithmic Series was applicable in the case of daily temperature. The purpose of these attempts was to forge new tools for weather forecasting. However, a none too mathematical approach to describe these spells is desirable from the point of view of Geography. Therefore, an effort is made to analyse the nature of this persistence. The treatment, to the extent possible, is disengaged from mathematical complexities and is given a simple but significant form.

NEED FOR THE SPECIFICATION OF COLD WAVES :—

In the India Meteorological Department the criterion for specifying a cold wave is that the minimum temperature should decrease by more than 13°F from the normal temperature of the month but for a moderate cold wave the decrease should be of the order of 9° to 12°F. These criteria have been fixed on an empirical basis for all areas and is not of much practical value because actual calculations on these bases have revealed that at Gorakhpur there was only one day out of 25 years (1931–55) when there was a cold wave in January. Thus there is a need for defining a hot or a cold wave in a practical way.

STANDARD DEVIATION THE PROPER CRITERION :—

The criterion should take into consideration the actual situation of the place in relation to the distribution and dispersion of temperature at that place. Standard Deviation, as we know, is a measure of the dispersion of the distribution and is widely used in mathematical statistics[4]. For defining a cold wave some knowledge of the distribution of temperature and characteristics of spell is necessary. Thus Standard Deviation can be employed as a suitable criterion for defining a cold day.

DEFINITION OF A COLD DAY :

A day is abormally cold if the minimum temperature of the day falls below the mean of the minimum temperature by an amount greater than the Standard Deviation of that month.

COMPUTATIONS OF STANDARD DEVIATIONS :

The Standard Deviations for the month of December, January and February (Winter Season) were computed from daily minimum temperatures for 25 years (1931–55) for the eight stations[5] scattered in the state of U.P. and are given in table I.

TABLE 1

MEAN MINIMUM TEMPERATURE IN °F (1931–55) AND STANDARD DEVIATION (S.D.)

Station	December		January		February	
	Min. Mean	S.D.	Mean Min.	S.D.	Mean Min.	S.D.
1. Mussoorie	39·7	4·5	36·5	5·0	38·5	5·6
2. Roorkee	43·9	4·2	43·4	4·4	47·7	5·1
3. Bareilly	48·0	4·0	47·2	4·4	51·7	4·9
4. Agra	45·4	4·9	44·6	5·8	49·8	6·0
5. Jhansi	48·5	5·1	48·1	6·0	53·3	5·9
6. Lucknow	48·3	5·3	47·7	4·7	52·7	5·1
7. Allahabad	48·8	4·6	48·4	5·4	53·3	5·0
8. Gorakhpur	51·0	3·7	49·7	4·3	54·1	4·5

It is clear that the S.D. increases with the passage of cold months, the exceptions being Jhansi, Lucknow, and Allahabad. These three exhibit a contrast. In the case of Jhansi and Allahabad the S D decreases in the month of February but in the case of Lucknow it first drops in the month of January and then again rises in the month of February.

PROBABILITY OF COLD DAYS

The S.D. by itself is not capable of giving a real picture of the probability of cold days. S.D. is an average of the variations and conceals 'extremes' in the process of calculations. It, therefore, presents us with a dim outline of variations. In fact, we want to find comparative coldness of days and their frequencies on a quantitative basis. For this purpose the actual number of cold days has to be determined and then graded into *cold days*, *very cold days* and *extremely cold days* and finally their probability of occurrence determined.

A day can be considered to be cold, very cold, and extremely cold if the minimum temperature (Tn) is reduced by the value of S.D. (σ), twice the value of S.D., (2σ) and thrice the value of S.D. (3σ) respectively. This gives us three formulae — (i) $Tn-\sigma$, (ii) $Tn-2\sigma$ and (iii) $Tn-3\sigma$ for calculating 'cold', 'very cold', and 'extremely cold' days respectively. In this way actual number of days were calculated from the daily record of temperature during the period 1931–55. For example there were 139 cold days out of 775 days in the month of January at Gorakhpur. This gives the probability of $\frac{139}{775} = 0.19$ for January for a day of abnormality on chance. In this way the probabilities were calculated for all these stations and shown in tables, 2, 3 and 4.

TABLE 2

THE PROBABILITY OF OCCURRENCE OF THE MINIMUM TEMPERATURE DURING THE PERIOD DECEMBER — FEBRUARY FOR *COLD DAYS* ($Tn \leq -\sigma$)

S. No.	Stations	December	January	February	Seasonal change of probability
1.	Mussoorie	0·15	0·15	0·19	0·04
2.	Roorkee	0·15	0·20	0·15	0·05
3.	Bareilly	0 22	0·20	0·23	0·03
4.	Agra	0·16	0·19	0·20	0·04
5.	Jhansi	0·14	0·18	0·23	0·09
6.	Lucknow	0·12	0·20	0·16	0·08
7.	Allahabad	0 17	0·20	0·17	0·03
8.	Gorakhpur	0 18	0·16	0·18	0·02

N.B. :—Tn is the minimum temperature and σ is the Standard Deviation.

TABLE 3

THE PROBABILITY OF OCCURRENCE OF THE MINIMUM TEMPERATURE DURING THE PERIOD DECEMBER — FEBRUARY FOR *VERY COLD DAYS i.e.*, ($\leq Tn-2\sigma$)

S. No.	Stations	December	January	February	Seasonal change of probability
1.	Mussoorie	0·04	0 01	0·01	0·03
2.	Roorkee	0·07	0·02	0 02	0·05
3.	Bareilly	0·02	0·02	0 04	0·02
4.	Agra	0·03	0·02	0 03	0 01
5.	Jhansi	0·01	0·00	0·03	0·02
6.	Lucknow	0·00	0·02	0·01	0·02
7.	Allahabad	0·00	0·01	0·04	0·04
8.	Gorakhpur	0·01	0·02	0·03	0·02

TABLE 4

THE PROBABILITY OF OCCURRENCE OF THE MINIMUM TEMPERATURE DURING THE PERIOD DECEMBER — FEBRUARY FOR *EXTREMELY COLD DAYS i.e.*, ($\leq Tn - 3\sigma$)

S. No.	Stations	December	January	February
1.	Mussoorie	0·00	0 00	0·00
2.	Roorkee	0·00	0·00	0·00
3.	Bareilly	0·00	0·00	0·00
4.	Agra	0·00	0·00	0·01
5.	Jhansi	0·00	0·00	0·00
6.	Lucknow	0·00	0·00	0·00
7.	Allahabad	0·00	0·00	0·00
8.	Gorakhpur	0·00	0·00	0·00

PROBABILITY OF COLD DAYS ($Tn - \sigma$)

(i) Mussoorie is a hill station. The probability of a Cold day is highest in the month of February which is not the coldest month. (January is the coldest month for the whole of U.P.). The probability of occurrence of a Cold day in the month of December and January is the same.

(ii) The probability of occurrence of a Cold day at Roorkee Lucknow and Allahabad is highest in the coldest month i.e. January. While this probability in the months of December and February are exactly the same in the case of Roorkee and Allahabad, Lucknow shows a minor difference of 4% (0·04).

(iii) At Jhansi and Agra the probability goes on increasing with the passage of months. It means that the onset of winter is least disturbed by the occurrence of cold days but the end of the winter is the most disturbed season when the probability rises to 0·23 and 0 20 respectively.

(iv) At Gorakhpur and Bareilly the probability of occurrence of cold days is lowest in the coldest month but high in the beginning and the end of the winter season.

(v) On the whole the probability of the occurrence of cold days throughout this season is highest in Bareilly.

THE PROBABILITY OF VERY COLD DAYS ($Tn-2\sigma$)

(i) Highest probability of Very Cold days occurs in the month of December at Mussoorie and Roorkee Roorkee has the highest probability of Very Cold days out of all stations of U. P. In the other two months the probability is very low.

(ii) Highest probability of Very Cold days in the month of February occurs at Bareilly, Jhansi, Allahabad and Gorakhpur. Thus it is a strange thing that Very Cold days are expected to occur in the end month of winter.

(iii) It is clear that the probability of occurrence of Very Cold days in the coldest month i. e. January is uniformly low throughout U. P. with the sole exception of Lucknow where it is the highest during the season.

(iv) The probability of occurrence of Very Cold days is very low every where. It does not go above 0.07.

THE PROBABILITY OF EXTREMELY COLD DAYS ($Tn-3\sigma$)

There is no probability at all of the occurrence of Extremely Cold days. Only at Agra, there is a probability of 0.01 of Extremely Cold days. This probability occurs in the last month of the winter season.

One thing clearly stands out. The month for expecting abnormal cold days is not the coldest month. It is the last month i. e. February in which a higher probability is generally expected.

VARIATION OF TEMPERATURE AND PROBABILITY OF COLD DAYS

Comparison of variation of S. D. and that of probability of the three months reveals that at Mussoorie, Bareilly and Agra the higher the S. D. the higher is the probability of occurrence of Cold Days in the month of February. At these stations the highest S. D. and the highest probability *go together*. Lucknow is the exception where the highest probability is associated with the lowest S. D. The S. D. for the month of December is lowest of all the months with the exception of Lucknow. The probability of Cold days is also the lowest in December with the exception of Bareilly and Gorakhpur. It means the correlation between these two factors-lowest S. D. and lowest probability is complete for Mussoorie, Roorkee, Agra, Jhansi and Allahabad.

The correlation between these two values for the month of January almost does not exist. This correlation is valid only for Agra and Allahabad. At Agra, the S. D. is midway between the preceding and the following months and so is the probability. At Allahabad the S. D. is highest in January; similar is the probability of occurrence of Cold days. For the stations Mussoorie, Roorkee, Bareilly, Agra and Gorakhpur the S. D. for January is in between those of December and February but the probability of occurrence of abnormal Cold days is lowest in the case of Bareilly and Gorakhpur but highest in the case of Roorkee. Thus S. D. is not a good index of the probability of occurrence of Cold days for the month of January.

NORMAL EXPECTION OF ABNORMALLY COLD DAYS.*

It is interesting to know in a definite manner the number of abnormally cold days expected in each month. It is obtained by dividing the number of abnormally Cold days by the total number of years and the results are shown in table 5.

TABLE 5

NUMBER OF AVERAGE ABNORMALLY COLD DAYS EXPECTED IN EACH MONTH AND SEASON. COLD DAYS $\leq$Tn$-\sigma$

S. No.	Stations	No. of average abnormal cold days expected $\angle$ Tn$-\sigma$			
		December	January	February	Total for the Season
1.	Mussoorie	4·6	4·7	5·4	14·7
2.	Roorkee	4·7	6·3	4·2	15·2
3.	Bareilly	6·8	6·3	6·4	19·5
4	Agra	5·1	5·9	5·6	16·6
5.	Jhansi	4·4	5·5	6·4	16·3
6.	Lucknow	3·7	6·2	4·6	14·5
7.	Allahabad	5·2	6·2	5·2	16·6
8.	Gorakhpur	5·6	5·2	5·1	15·9

* Those, which fall below the mean of the month by > σ but less then 2σ

TABLE 6

NUMBER OF AVERAGE ABNORMALLY VERY COLD DAYS EXPECTED IN EACH MONTH AND SEASON.

(VERY COLD DAYS $\leq$Tn-2σ)

S. No.	Stations	December	January	February	Total for the season
1.	Mussoorie	1·3	0·4	0·4	2 1
2.	Roorkee	0·4	0·6	0·7	1·7
3.	Bareilly	0·6	0·6	1·0	2·2
4.	Agra	0·5	0·5	0·7	1·7
5.	Jhansi	0·2	0·2	0·8	1·2
6.	Lucknow	0·2	0·5	0·4	1·1
7.	Allahabad	0·2	0·2	1·3	1·7
8.	Gorakhpur	0·5	0·9	1·0	2·4

TABLE 7

NUMBER OF AVERAGE ABNORMAL EXTREMELY COLD DAYS EXPECTED IN EACH MONTH AND SEASON (EXTREMELY COLD DAYS $\leq$Tn-3σ)

S. No.	Stations	December	January	February	Total for the Season
1.	Mussoorie	0·04	0·08	0·12	0·24
2.	Roorkee	0·04	0·08	0·08	0·20
3.	Bareilly	0·04	0·04	0·08	0·16
4.	Agra	0·00	0·04	0·36	0·40
5.	Jhansi	0·00	0·00	0·00	0·00
6.	Lucknow	0·00	0·00	0·00	0·00
7.	Allahabad	0·00	0·00	0·08	0·08
8.	Gorakhpur	0·00	0·04	0·00	0·04

In any month, the minimum number of abnormally Cold days is 3.7 and the maximum number of abnormally Cold days is 6.4. The corresponding figures for the whole of the season are 14.5 and 19.5 respectively. Bareilly gets the maximum number of abnormally cold days i. e. 19.5 while Mussoorie, Roorkee and Lucknow have the lowest number of such days in the cold season.*

* No where in U. P. more than three abnormally 'Very Cold' days are experienced. Gorakhpur has 2.4 the highest number and Lucknow 1.1 the lowest of all. (Table 6). The Probability of occurrence of 'Extremely Cold' days in U. P. is very low i.e. nowhere exceeding 0.40. which is at Agra, while the lowest (0.00) is at Jhansi and Lucknow. It means that these two stations do not experience any extremely Cold day in the cold season. (Table 7)

PERSISTENCE OF TEMPERATURE ABNORMALITY

A study of the probability of cold days strongly suggests that the nature of the spells of such abnormalities be investigated. As the length of a spell is really the number of continuous abnormal days occurring in a month the frequencies of cold spells were calculated from the record[6] with the criteria $Tn-\sigma$ for abnormalities. From such tables one could know the frequencies of a certain spell but cannot get any clue to their persistence.

In order to determine the persistence of the spells the frequencies were cumulated from below upwards and tabulated along with the actual frequencies of the spells. The results for cold season are tabulated in the following tables:

TABLE 8

ACTUAL (Ac.) & CUMULATIVE (Cu.)* FREQUENCIES OF SPELLS

MUSSOORIE

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	31	55	28	56	26	59
2	10	24	16	28	15	33
3	7	14	2	12	6	18
4	3	7	3	10	6	12
5	2	4	4	7	4	6
6	0	2	1	3	0	2
7	0	2	2	2	1	2
8	0	2			0	1
9	1	2			0	1
10	0	1			1	1
11	0	1				
12	1	1				

ROORKEE

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	25	50	18	52	23	48
2	9	25	12	34	10	25
3	7	16	5	22	8	15
4	4	9	4	17	2	7
5	0	5	4	13	1	5
6	1	5	5	9	3	4
7	2	4	2	4	0	1
8	1	2	0	2	1	1
9	1	1	0	2		
10			2	2		
11						
12						
13						

BAREILLY

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	37	75	32	63	25	61
2	11	38	9	31	11	36
3	13	27	7	22	8	25
4	7	14	3	15	9	17
5	2	7	6	12	3	8
6	2	5	1	6	0	5
7	3	3	3	5	4	5
8			0	2	0	1
9			2	2	1	1

ALLAHABAD

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	22	53	27	62	21	50
2	9	31	14	35	12	29
3	11	22	7	21	6	17
4	3	11	3	14	3	11
5	5	8	5	11	1	8
6	1	3	4	6	1	7
7	2	2	0	2	4	6
8			1	2	2	2
9			1	1		

* Cumulative frequencies (Cu.) have been obtained by adding the Actual frequencies (Ac.) cumulatively from below.

TABLE 8 (Continued)

AGRA

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	22	49	16	48	21	53
2	10	27	19	32	9	32
3	6	17	9	22	9	23
4	5	11	3	13	5	14
5	3	6	3	10	3	9
6	1	3	2	7	3	6
7	0	2	1	5	2	3
8	1	2	2	4	1	1
9	0		1	2		
10			0	1		
11			0	1		
12			0	1		
13			1	1		

LUCKNOW

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	26	52	20	60	21	47
2	15	26	17	40	9	26
3	9	11	12	23	4	17
4	1	2	2	11	8	13
5	0	1	4	9	2	5
6	1	1	3	5	0	3
7			0	2	2	3
8			1	2	1	1
9			0	1		
10			1	1		
11						
12						
13						

JHANSI

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	15	43	26	52	21	59
2	9	28	7	26	12	38
3	10	19	4	19	11	26
4	5	9	4	15	5	15
5	1	4	4	11	4	10
6	0	3	3	7	3	6
7	3	3	3	4	1	3
8			0	1	1	2
9			0	1	1	1
10			1	1		
11						
12						

GORAKHPUR

Length of spells (Days)	Dec. Ac.	Dec. Cu.	Jan. Ac.	Jan. Cu.	Feb. Ac.	Feb. Cu.
1	27	60	20	47	17	45
2	9	33	9	27	10	28
3	13	24	4	18	5	18
4	5	11	3	14	6	13
5	2	6	3	11	1	7
6	3	4	5	8	3	6
7	1	1	1	3	0	3
8			1	2	1	3
9			1	1	1	2
10					0	1
11					0	1
12					1	1

AVERAGE LENGTH OF COLD SPELLS

Frequencies and lengths of spells have been graphed and histograms prepared (Figs. 1 and 2). From their study it is clear that the longest spell of 12 days is found at Mussoorie. The maximum lengths of spells for other stations ranges from 6 to 9 days. In fact the average of the length of the spells is 8 days. In the month of January the longest spell of 13 days is found at Agra. This value for Roorkee, Jhansi, and Lucknow are 10 days each but for the other 8 stations it is 9 days each except for Mussoorie where the maximum length of the spell is only 7 days. The average length of the spell for the cold season is 8.0 days.

In this season it is the first month i.e. December in which the frequency of one day cold spell is highest with the exception of Jhansi and Allahabad where this month is the middle one i.e. January. There is no station where the frequency of one day cold spell is highest in the last

Fig. 1

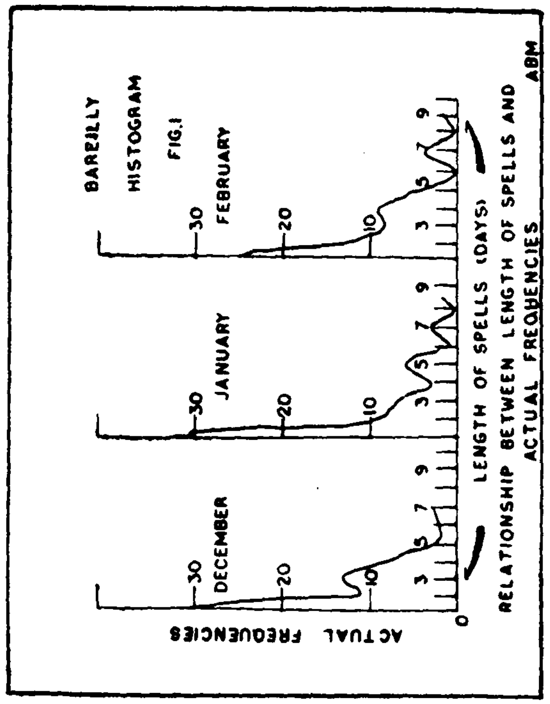
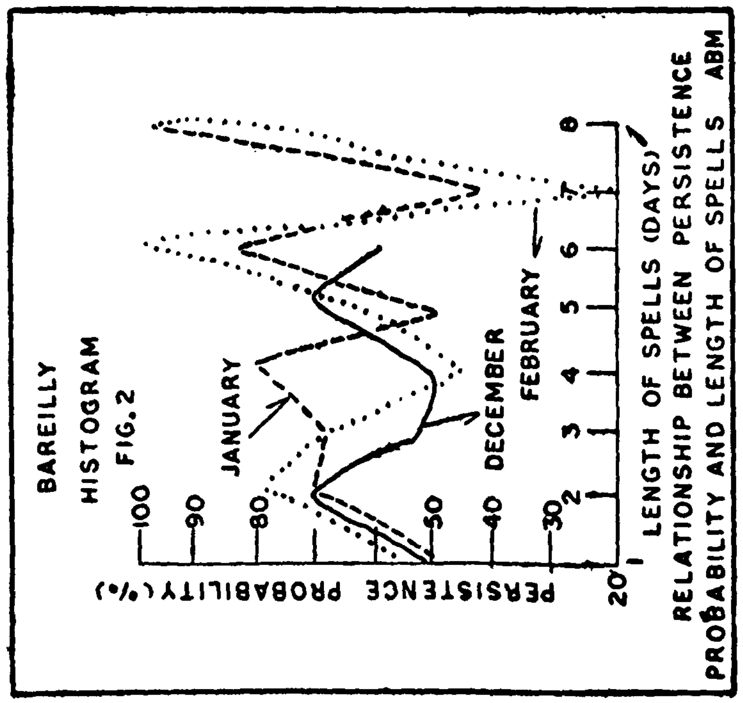


Fig. 2



month of the season i.e. February. Thus the individual abnormal cold days are most frequent in the first month of the cold season with few exceptions.

PERSISTENCE OF THE SPELLS

The above tables are the ready tools for calculating the persistence of the spells i. e. Persistence Probability which is really the chance of the abnormality on any day if it is preceded by a spell of X days' duration. This can be obtained by calculating the probability of a certain type of spell after a spell of X days.

For example, for a spell of 2 days in January at Gorakhpur the cumulated frequency is 47. It means that the possibility of a Cold day after a spell of one day is 27 divided by 47 which comes to 0.57. In this way the Persistence Probabilities were calculated for the months of the cold season and the results are tabulated as follows :

TABLE 9

PERSISTENCE PROBABILITY OF ABNORMAL DAYS FOLLOWING A SPELL OF X DAYS IN COLD MONTHS

(*Persistence Probability is expressed in percentage form.*)

Length of spells (Days)	Mussoorie			Roorkee			Bareilly			Agra		
	Dec.	Jan.	Feb.	Dec.	Jan.	Feb.	Dec.	Jan.	Feb.	Dec.	Jan.	Feb.
1 to 2	84	50	56	50	65	52	51	49	57	55	67	60
2 to 3	58	43	55	64	65	60	71	71	79	68	69	72
3 to 4	50	83	67	56	77	47	52	68	68	65	59	61
4 to 5	57	70	50	56	76	71	50	80	47	55	77	64
5 to 6	50	43	33	100	69	80	71	50	62	50	70	67
6 to 7	100	67	100	80	56	25	60	83	100	67	71	50
7 to 8	—	—	50	50	50	100	—	40	20	100	80	33
8 to 9	—	—	100	50	100	—	—	100	100	100	50	—
9 to 10	—	—	—	—	—	—	—	—	—	—	50	—
	Jhansi			**Lucknow**			**Allahabad**			**Gorakhpur**		
1 to 2	65	50	64	50	67	55	58	56	58	55	57	62
2 to 3	68	78	68	42	58	65	71	60	59	72	67	64
3 to 4	47	79	58	18	48	76	50	67	65	46	77	72
4 to 5	44	73	67	50	82	88	78	79	78	54	78	54
5 to 6	75	64	60	100	56	60	38	55	88	66	72	86
6 to 7	100	57	50	—	40	100	67	33	86	25	37	50
7 to 8	—	25	67	—	100	33	—	100	33	—	70	100
8 to 9	—	100	50	—	50	—	—	50	—	—	50	66
9 to 10	—	—	—	—	—	—	—	—	—	—	—	50

DECEMBER

With the single exception of Mussoorie, elsewhere, the Persistence Probability of one day spell to persist for the second day is above 50%. With the lone exception of Lucknow, the Persistence Probability of a two day spell to persist for the third day is higher than the persistence of one day spell to persist for the second day. The average persistence is 63.6%. At

Lucknow the Persistence Probabily of a two day spell to persist for the third day is as low as 42%.

Though the possibility of the occurrence of a 'three day spell' is very high at almost every station the same for a 'four day spell' is every where very low. With the exception of Agra (where the persistence of the 'four day spell' is higher than that of a three day spell) the persistence goes as low as 46% though on an average it is 50%. Thus there are only 50% chances for the persistence of a 'three day spell' into a 'four day spell'.

The persistence of a 'four day spell' to extend into a 'five day spell' is higher at Mussoorie, Lucknow, Allahabad and Gorakhpur while that at Agra, Jhansi and Bareilly is lower but equal at Roorkee. Thus east of the meridian of Bareilly the probability of a 'four day spell' to extend into a 'five day spell' is higher than that of the previous spell but it is lower to its west. Mussoorie, however, belongs to the eastern group.

The Persistence Probability of a 'five day spell' to extend into a 'six day spell' is very high at Roorkee where it is 100%. At Jhansi and Bareilly the persistence is of the order of 75% and 71% respectively. Thus the possibility of a 'five day spell' to extend into a 'six day spell' at these places is very high indeed. The corresponding value for Gorakhapur is 66%. The lowest value is found to be at Allahabad where it is only 40%. At Mussorrie and Agra the chances for the persistence of a 'five day spell' into a 'six day spell' are fifty-fifty.

The persistence of a 'six day spell' to extend to a 'seven day spell' is 100% at Jhansi and Mussoorie while it is 50% at Roorkee, 67% each at Allahabad and Agra and lowest 25% at Agra. No 'seven day spell' occurred at Lucknow.

JANUARY

The probability of a 'one day spell' to persist into a 'two day spell' is roughly the same as in December and is above 50%. The highest value at Agra, Lucknow, Allahabad and Roorkee is almost 67%.

The persistence of a 'two day spell' to extend to a 'three day spell' is higher than the previous one with the exception of Mussoorie and Lucknow where it is lower. On an average the persistence of a 'three day spell' is 64·2.

The persistence of a 'three day spell' to extend into a 'four day spell' is very high except at Lucknow where the persistence is almost 50%. Except at Agra where the persistence is 59% the persistence for this spell is everywhere above 66%.

The probability of a 'four day spell' to persist to a 'five day spell' is very high. It is above 75% everywhere. Thus whenever a 'four day spell' of abnormally cold day occurs in U.P. it is extended into a 'five day spell' 75 times out of 100.

FEBRUARY

The Persistence Probability of a 'one day spell' to extend to a 'two day spell' like other months is above 50% but less than 64%. Its value is highest at Jhansi where it is 64% and lowest at Roorkee where it is 52%.

The Persistence Probability for 'two day spells' to extend to 'three day spells' is higher than the persistence value of 'one day spells' to extend to 'two day spells' with the exception of Mussoorie where it is almost the same. Thus whenever a 'two day spell' of abnormally cold days occurs it is in 65% cases extended into a 'three day spell'.

The Persistence Probability for a 'three day spell' to extend to a 'four day spell' is higher than two and three day spells, at Mussoorie, Lucknow, Allahabad and Gorakhpur but lower at Roorkee, Bareilly, Agra and Jhansi. This is the Persistence Probability for the extension of 'three day spells' into 'four day spells' and it is lower in the western U.P. but higher in the eastern U.P. The average of this probability for the western and the eastern part of U.P. is 58·5% and 70·0% respectively.

The Persistence Probability for the occurrence of 'four day spells' to extend to 'five day spells' is lower than that of 'four day spells' at Mussoorie, Bareilly, Lucknow and Gorakhpur but higher at Roorkee, Agra, Jhansi and Allahabad. The values of persistence at Allahabad and Roorkee are 73% and 71% respectively while the value at Lucknow is the lowest *i.e.* 38%.

THE WINTER SEASON

From the figures and graphs it is clear that the monthly curves at any station do not show much parallelism. However some parallelism does exist. At Mussoorie, the January and February curves show rough parallelism upto the length of spell of six days. It means that the persistence patterns of these two months are identical but do differ in degree. Similar patterns are discernible at Agra and Allahabad but upto the length of spell of four days only.

December and February curves run almost parallel at Roorkee, Bareilly and Gorakhpur upto the length of six days. Thus at these stations the beginning and the end of cold seasons show similar persistence of the length of spells.

At Lucknow December and January show similar patterns with regard to persistence. The first two months exhibit similar variations but those of December are more pronounced than that of the next month. Thus the weather which is more predictable in December becomes less reliable in the middle of the cold season.

Jhansi does not show any similarity in the persistence pattern of abnormal days.

ACKNOWLEDGMENT

The writer acknowledges with gratitude the guidance that he received from Dr. A. B. Mukerji, Department of Geography, Osmania University under whose supervision this work was completed.

REFERENCES

1. Klages, K. H. W. (1942) ... *Ecological Crop. Geography*, Macmillan & Co., New York, pp. 243-244.
2. Rambhadran, V. K. (1954) ... Indian Journal of Meteorology and Geophysics, Vol. 5, No. 1, p. 48, Poona.
3. Srinivasan, T. R. (1956) ... Indian Journal of Meteorology and Geophysics, Vol. 7, No. 1, p. 43, Poona.
4. Bowley, A. L. (1948) ... *Elements of Statistics*, Staples Press, New York, p. 249.
5. India Meteorology Deptt. Monthly Meteorological Register., 1931-1955.

THE HISTORICAL FACTOR GOVERNING THE LAND USE PATTERN IN MORADABAD DISTRICT.

By

S. L. Duggal

INTRODUCTORY :

The district of Moradabad, properly spelt Muradabad, occupies a west-central position in the historically famous region named Rohilkhand which lies in the north-west of Uttar Pradesh. It lies between the Himalayan foot-hills on the north-east and the Ganga river on the south-west. On the north and south it is bounded by the districts of Bijnor and Budaun respectively; on its east lies the newly created district of Rampur, which runs like a wedge between it and the Bareilly district; on its west lie the districts of Bulandshahr and Meerut on the right side of the Ganga river. It is a fairly compact district lying between the parallels of 28° 20′ and 29° 16′ north latitude and between the meridians of 78° 4′ and 79° 0′ east longitude.*

The area of the district is apt to vary from time to time, owing to the action of the Ganga river. The present area of the district is about 2293.5 sq. miles. For the purpose of administration it is divided into six tahsils, namely, Thakurdwara, Moradabad, Bilari, Amroha, Sambhal and Hasanpur. The district got more or less its present boundaries in the year 1837 A. D. excepting the Kashipur Tahsil, which was not made over to Nainital till 1870 and a few villages which have been transferred to Rampur, recently. In 1844, the area was divided into seven parganas of which six have remained almost in tact in the present district, while the seventh, namely Kashipur now forms part of Nainital.@

Occupied by civilized people for many millennia, the land bears the indelible imprint of prolonged usage. Perhaps, the area was occupied in the pre-Aryan times, since when many races have come here one after the other so that the present people of the district are a mixture of several racial strains. Basically, they are of the Dravidian and Indo-Aryan stock. Superimposed upon this base was a later migration of people and culture from the north-west. Thus we have here various sects of people, generally akin to those found throughout northern India. The crowding of many on a little land is a dominant feature. Among the rural people the ways and the standards of living are not much different from those of their predecessors.

SAMBHAL IS AGE-OLD

Practically, nothing except some ancient sites, yet unexplored, has been preserved of the early history of the district beyond the vaguest tradition, the most prominent among the ancient sites being the town of Sambhal known as Sambhaleshwar (or Sabrit) in the Satyuga, Mahadgiri in the Tretayuga and Pingala in the Dwapara-yuga. A brief reference to the history** of occupation seems necessary to have an understanding of the background of the present day land-use in the district.

* Nevill, H. R., Moradabad, A Gazetteer (1911), p. 1.

@ Ibid, p. 112.

** Ibid, pp. 141–169.

THE MUSLIM CAMPAIGNS

About the eleventh century A. D. there seems to have been an extensive colonisation of the area by various tribes of Rajputs, among which the most important were the Katehrias. In 1196 A. D., Qutub-ud-Din Aibak captured the city of Budaun since when, by degrees, Muhammadan settlements have extended over the area pushing back the Katehrias to the east of the Ramganga river. It is note-worthy that it was at this time that roads were cut through the jungles, here, for they served as an impenetrable refuge for the Katehrias. Expedition after expedition was sent against them by the Sultans of Delhi and, many times, the whole countryside was laid waste. The area remained important in the annals of medieval and Moghul history, too.

THE MOGHUL RULE

Under Akbar, the district was included in the province of Delhi, in the Sarkar of Sambhal. It was divided into a number of zamindaris or Mahals, which paid revenue and provided cavalry and infantry to the Emperor.

FOUNDATION OF MURADABAD

In 1624 A. D., Raja Ramsukh, the head of the Katehrias of Chaupala raised a disturbance to quell which Rustam Khan Dakhni, Governor of Sambhal, was commissioned by Emperor Shahjahan. Rustam seized the fort of Chaupala and built a new fort there naming it as Rustamnagar. This annoyed Shahjahan, who questioned Rustam about it. But, with a great presence of mind, Rustam replied that he had called it Muradabad in honour of the young prince Murad. It was in this way that the present name of the Moradabad town, which gives its name to the district also, was given.

ROHILLA UPRISINGS

Again, the district was disturbed in the latter part of the 18th century, when the Rohilla Afghans, who had settled in large numbers as mercenaries in the service of the local chieftains, became very much organised under one Ali Muhammad. They seized, in 1742, Sambhal, Amroha, Moradabad and Bareilly and, eventually. Ali Muhammad was recognised as the governor of the area. In 1746, however, when he came into conflict with Safdar Jang, Nawab Wazir of Oudh and with the Emperor at Delhi, he had to quit. During the invasions of Ahmad Shah Abdali, the Rohillas recovered their lost possession again. Later on they came into conflict with the Marathas and the British so that, in 1774, with the help of English troops, the Nawab Wazir of Oudh extended his dominions on Rohilkhand, leaving Rampur as a Jagir to Hafiz-Ullah Khan, the Rohilla chief.

OUDH ADMINISTRATION & THE CREATION OF ZAMINDARIS

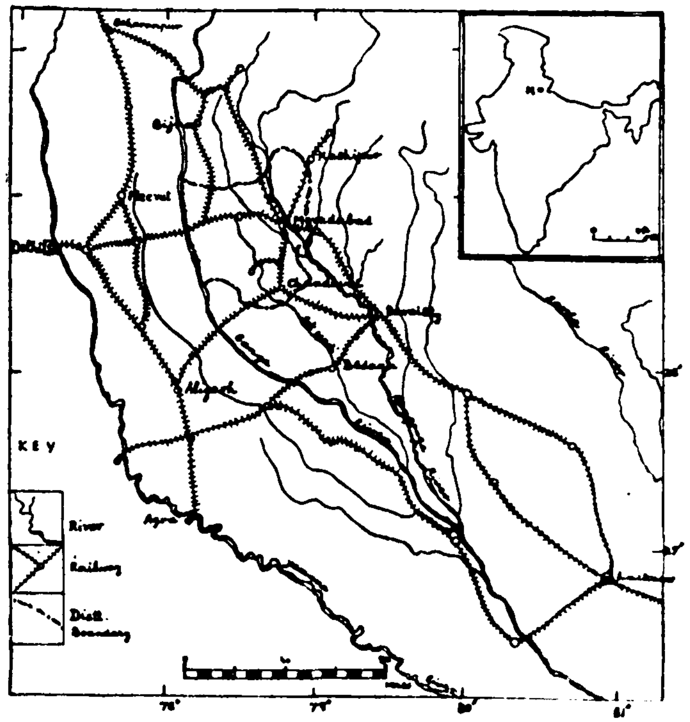
During the days of Oudh administration the area was assigned to Chaudhri Mahatab Singh Bishnoi and others, whose sole object was to collect as much revenue as possible in the short period of their uncertain tenure of office. They sublet the country to the highest bidders, who exacted the utmost that could be wrung from the poor cultivators of the soil. The condition of the peasants was so deplorable that thousands of them had to migrate to other parts of the country, leaving large areas out of tillage. In 1801, the Nawab Wazir ceded Rohilkhand to the East India Company, who made Moradabad as the headquarters of their collectorate. But the country was disturbed owing to the Maratha war and constant fear of invasion.

UPRISING OF AMIRKHAN PINDARI

The early assessments of the land revenue were much too severe and the famines of 1803–04 further added to the disquiet found among the people of the area in 1805, when Holkar, being besieged by the English forces at Bharatpur, directed Amir Khan Pindari, who was born at Sambhal and was serving under the Marathas, to create a diversion in Rohilkhand. Amir Khan and his cavalry over-ran Moradabad and other neighbouring districts many times. In the course of 29 days, he plundered almost every village in the district and the disturbance caused by his loot was reflected for years in the prevalence of armed bands of dacoits, consisting for the most part of Jats, Ahirs and Mewatis. Their chiefs were later on offered land and money by the collectors and, gradually, they settled down.

MORADABAD DISTT.

Situation and Accessibility.



THE MUTINY OR THE WAR OF INDEPENDENCE 1857-58 AND THE REDISTRIBUTION OF ZAMINDARIS AFTER THAT

The district was once again, seriously disturbed in 1857 and 1858, when the so-called mutiny or war of Independence spread into it from Meerut. Much time elapsed before things settled down again. It was as a reward for loyalties during the mutiny days that a redistribution of Zamindaris was made by the British rulers. Thus Gur Sahai Jat of Amroha became a Raja with a grant of eleven villages; Rai Parduman Kishan of Sahaspur got fifteen villages; Willayat Hussain Khan of Hasanpur got twenty villages; Thakori Thakur got the estate of Pipli; Chaube Jai Kishan Das of Moradabad got seventeen villages; and many more got similar rewards.

CONCLUSION

This brief reference to the history of the area makes it sufficiently clear that normal course of the evolution of landuse patterns in the district has been disturbed for many centuries before the present era of settled political conditions started under the British Crown. Thus politics, besides other factors, must have counted a lot in the development of early land-use patterns. The present pattern, however, started from the time when the British had sufficiently established themselves as the administrators of law and order in this area. It continued until the time when Independent India started the execution of its Five Year Plans. Thus it can serve as a commentary on the conditions during the rule of the British Crown and also as the basis for the working out of our new plans in the area.

Further, the district is representative of Rohilkhand. It benefits by the drainage of both the Ganga and the Ramganga, a left bank tributary to that great river. It is also traversed by the 'Bhur' ridges so characteristic of this part of the Gangetic lowlands. Both the Ramganga drainage and the bhur ridges of fine sand have played a very important role in the geographical development of Rohilkhand, e. g, while the Ganga-Yamuna Doab was brought under canal irrigation long ago, owing to the gentle slope of its land, Rohilkhand could not be, because of its undulating character. In the Moradabad district, the only canal irrigation scheme which has, so far, been put into effect, after long deliberations and a number of failures, is that of the Ramganga water-lifting scheme.

Its situation on the wrong side of the Ganga has played an important part in its historical evolution. The natural protection provided by the deep channel of the Ganga river, which is not easy to be bridged, was sufficient, in the medieval times, to shelter the freedom loving Katehrias, Rohillas and others, who have left their indelible impressions on the bhangar uplands of this region, the former having given the name to the bhangar and the latter to the whole region.

Moradabad town, the district headquarters, is just one hundred miles from Delhi and by going only sixty miles almost due east from there, we are in the district of that name. Had it not been for the natural protection provided by the Ganga river, the district would have been under a greater influence and control of Delhi like the Meerut district, its neighbour on the right side of that river. But contrary to that, owing to an easy access from Lucknow through the lowlands to the north of the Ganga, the Nawab of Oudh could hold it under his sway for a considerable period of time. The same physical factor, however, rendered this area a cockpit for many centuries and the series of battles which were fought, here, to bring it under the rule of Delhi, caused a thorough devastation of it. In the pre-muslim times, it had rich forests and agricultural areas.

Thus, we have, in the Moradabad district ,an area representative not only of the physical conditions available in a large part of the Ramganga Valley but also of the cultural and historical factors which have contributed a great deal towards the development of the present day land-use patterns in most parts of these lowlands. By a study of the conditions available here, one can, it is hoped, have a glimpse of the various factors affecting the geographical evolution of this valley.

Reviews.

CROSSROADS—Land & Life in South West Asia George B. CRESSEY, *Maxwell Professor of Geography*, Syracuse University, New york, U.S A. 1960, 593 pp, illustrated with maps, charts, pictures - The Lippincott Geography Series-Editor-Clarence F. Jones.

As claimed by him, Professor Cressey has in this book, brought home, the three principal ideas-" The Crossroads character of S. W Asia, the role of water in its economy and the way in which man is changing its landscape " and in the opinion of the reviewer, he has done this in an inimitable fashion.

Written, as it is, in a very pleasing style, and lavishly illustrated with a very large number of excellent photographs, each one of which speaks volumes for itself, the book becomes extremely readable; and throughout, the conclusions arrived at are always fortified by a wealth of statistical material, almost unparalleled. As far as the reviewer knows, there is no other book on Arab Asia or South Western Asia which is more beautifully illustrated.

The author deserves the thanks of all students of climate for the excellent manner in which he has displayed in the climatic graph of each of the several stations he has chosen, a host of factors like the monthly averages for temperature and rainfall, the daily temperature range together with the extreme recorded temperatures, as well as the monthly potential evapo-transpiration; and all these in a small single composite diagram for each station.

The book is divided into two parts-Part I consisting of 9 chapters dealing with the region as a whole and Part II consisting of 8 chapters, giving a Regional Analysis describing each country in detail, Turkey, Arabia, Egypt, Iraq, Iran, Israel, etc. Every chapter heading in the list of contents gives the key to the pages that follow and even at the cost of making this review a bit too long, one feels fully justified in quoting from some of them. For example, Chapter 6 Land Use " Man's welfare depends on his skill in converting soil, water, and sunshine into food. Many social and political problems have grown out of man-land relations ". Chapters 7 & 8 Mineral and Oil Resources—" Minerals provide the basis for modern industrialization but South West Asia appears to be poorly supplied, except for oil ". " Two thirds of the world's petroleum lies beneath the surface of Southwest Asia; its spectacular development is a modern economic miracle ".

After a study of the geological features and the economical problems of the region which have been so dexterously inter woven by the author, no one will fail to realise the extremely close association between Geography and the manifold political problems which now loom so large.

From beginning to end, is furnished the information obtained by the author personally through his extensive travels and enquiries, and they undoubtedly enliven the text. " This volume is a product of 7 visits and 2 years of residence. To fully understand the land and life of S. W. Asia would require a life time in each area ". It looks as though within two years, Professor Cressey has been able to assimilate what it normally would take several life-times for others.

This book will for many years remain the most authoritative text both for study and reference. The abundant references cited by the author at the end of each Chapter would certainly assist a really serious student to obtain fuller information.

GEORGE KURIYAN.

Vol. XXXVII JANUARY - MARCH 1962 No

The Indian Geographical Journal

Formerly

THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATI

PUBLISHED QUARTERLY

1962

Editor:

DR. GEORGE KURIYAN.

THE INDIAN GEOGRAPHICAL SOCIETY
UNIVERSITY CENTENARY BUILDINGS,
CHEPAUK, MADRAS-5
INDIA

CONTENTS

NOTICE

Members and Subscribers are informed that the subscription for the current year for the Indian Geographical Journal has fallen due on the 1st January 1962. They are requested to kindly send their remittances with arrears, if any, to the Treasurer, Indian Geographical Society, 17-C, ARAVAMUTHU GARDENS, MADRAS-8.

M. N. VASANTHA DEVI,
Hon. Secretary.

THE
INDIAN GEOGRAPHICAL JOURNAL
Formerly
THE JOURNAL OF THE MADRAS GEOGRAPHICAL ASSOCIATION

Vol. XXXVII | JANUARY – MARCH 1962 | No. 1

AN ANALYSIS OF THE SPATIAL DISTRIBUTION OF INDUSTRY IN INDIA WITH SPECIAL REFERENCE TO POPULATION.*

By

GEORGE KURIYAN

Industrial activity in India is distributed rather unevenly with nearly three quarters of factory workers being employed in the four states of W. Bengal, Bihar, Maharashtra, and Gujarat. It is well known that the economy of India is heavily unbalanced, partly as a result of its excessive dependence on agriculture. and partly because of this uneven distribution of industry. Even as late as 1951, there were only 2·4 million factory workers in India-less than 2% of the working population-and when 75% of these get agglomerated in four States, the share of the other States becomes unduly minimised and creates in them extreme conditions of poverty and lowering in the standards of life. It would definitely be a desideratum if there is a more even distribution of industry throughout the different parts of India, to secure the balanced development of the country as a whole.

As early as 1883, the Famine Commission grasped the fundamental issues at stake when it pointed out that the only remedy for the recurring disasters of famine in India was the rapid industrialization of the country, providing thereby diversified employment to large groups of population. But unfortunately, this is still no more than a vision and a dream. Progressive countries as they rose up in the ladder of civilisation have consistently reduced the number of persons employed in agriculture. In the U. S. A. 70% of the working population was employed in agriculture in 1850, and now it is less than 15%, but at the same time, the volume of agricultural production has increased by more than 250%. During the same period, 1850 to 1950, on the other hand, in India the number of people directly dependent on agriculture has shown no appreciable diminution when expressed as a percentage of the population, which may lead one to the erroneous conclusion that conditions today are not much worse than what they were in the beginning of this century. This is, however, far from being true. A more accurate appraisal would be to determine the actual number of persons dependent on agriculture, approximately 210 millions in 1901 and

* A paper presented to the General Assembly of the International Social Sciences Council at Paris in September 1961.

atleast 330 millions in 1961, and today we have, therefore, not less than 160% of the numbers that we had in the beginning of the century, indicating thereby that practically the bulk of the increase in population has consistently gravitated back again into the sole occupation of agriculture. And, there has been no corresponding increase in the area of cultivated land, creating a serious problem of poverty and lack of employment. Besides the problem of disguised unemployment and under-employment among the cultivators-which probably runs into a few millions-about 3.4 million people are wholly unemployed and there is a volume of underemployment equivalent to 4.9 millions of man years. These were the figures for 1951 as accepted by the Planning Commission and no similar figures have yet been published for 1961, but when it is remembered that the growth of population during the decade has been of the order of 21.5%, at an approximate rate of 7½ millions per annum, then it must be confessed that even on the most conservative estimate, there is an annual addition of not less than 1.8 millions to the labour force. With no corresponding increase in employment opportunities, obviously then, the problem of unemployment in 1961 must be infinitely worse than what it was in 1951. The growth and development of industries under these circumstances, is of very great value, not merely because it is creating opportunities for employment as well as wealth, but also because it keeps the hands and minds of educated youths free from drifting into undesirable political activity, as a result of unemployment and discontentment.

It would be very advantageous to secure a diversity of occupation in areas which are now exclusively dependent on agriculture; a widespread dispersal of industry should, therefore, be an immediate objective and this can only be achieved, if and only if, there is a large scale development of power resources all over the country. Besides solar power and atomic energy, in both of which India is certainly well-endowed, she has immense potentialities for water power development, at least 30 to 40 million k. W. widely distributed all over the country. But her resources in coal are much less significant, and in oil, perhaps, even more so,*[1] nor are these evenly distributed. Remarkable progress has now been made in the generation and distribution of water power. The major river valley projects like the Bhakra Nangal, Damodar Valley, Hirakud, Tungabhadra, Machkund, Kosi valley and a host of smaller ones, all put together now generate more than 2½ million k. W., approximately 5 times the hydro-power generation and 2½ times the entire power generation of India in 1947, indeed, a significant spurt, and an achievement which gives room for optimism. Needless to say that in a land like India with 550,000 villages, through a planned distribution of electrical energy, industries could be decentralised and the workers allowed to remain in their rural homes without creating any of the ugly faces of the steam-coal civilisation. For all practical purposes, in the immediate future, the growth and development of hydropower, perhaps here and there coupled with thermal power, with interconnecting grids, will determine the possibilities for dispersal of industry.

It has been suggested and that rightly too, that if India's industrialisation is to be accompanied by a further concentration of population in the already overgrown cities like Bombay, Calcutta, Delhi etc., then it is not impossible that much of the benefits of industrialisation may be nullified by the social problems of slums, disease, squalor etc. It must also be

---

Recent exploratory work in Baroda and Assam seem to suggest that within the bowels of Mother India, is stored up significant quantities of this magical fluid, but no estimates of resources are available as yet.

remembered that both Calcutta and Delhi, two of the larger industrial cities, are from the defence and strategic points of view unsuitable centres because of their proximity to Pakistan, and if strategic considerations should throw their weight in the siting of an industry, then obviously the interior towns will have to be preferred in future.

While in the aggregate India's industrial output may seem massive, per head of population it is extremely poor and much less than what it is in many other advanced countries. India, which at one time was so highly skilled in the crafts and industries and a great emporium of trade, so great that the European powers like the Portuguese, the Dutch, the French and the English, all founded East India Companies and came in quest of India's products and waged many a battle among themselves for the supremacy and maintenance of that trade route to India, it is that country which is now apparently condemned to a perpetual holiday!

Prior to the first World War, the only major industries in India were cotton and jute for both of which there were exceptional facilities in the form of raw material. Since 1920, there was a more progressive industrial policy which resulted in the birth of several new industries like iron and steel, sugar, cement etc. The second World War created conditions for the maximum utilization of the then existing industrial plants and because of high prices and constant demand as a result of war scarcities and shortages, long term factors like advantageous location were not given the due attention they deserved. The developmental emphasis was mainly on consumer goods at the expense of basic capital goods industries, and as a result of this, in the second Five Year Plan 1956-61, industries, mining and transport were given considerable financial assistance, about 5,700 million dollars, approximately 57% of the investment in the public sector.

In the space of this short paper, it would be impossible even to catalogue all the industries that are now in operation, and I have therefore, been forced to restrict my comments to the two major industries (i) textiles and (ii) iron and steel.

TEXTILES:

The cotton textile industry is the largest industry in India and ranks third in the world as a yarn and cloth producer. (12·7 million spindles and 210,000 looms in 1961). From the point of view of spatial distribution there is a tremendously heavy concentration of the industry in the States of Maharashtra and Gujarat. About half the mills are located in these States, but they have between them, more than half the spindlage and nearly two thirds the loomage. It must be remembered that all the world over, cotton industry has a tendency to be attracted towards the market rather than to the raw material, and since cloth is one of the basic necessities of life, the demand for cloth in any area can be approximately measured by the total population of that area. A much wider dispersal of the industry, therefore, especially in States like Madhya Pradesh, Bihar and Kerala would be of considerable assistance in removing regional disparities. It is anticipated that this will be borne in mind when the present spindlage of 12.7 millions will be augmented to 16.5 millions by 1966 and provision made for the addition of 25,000 automatic looms.

On the whole, the cotton industry is still finding the shortage of raw material the basic problem to contend against, one of the after-effects of partition-and even today, substantial quantities of quality-cottons have to be imported from Egypt and U. S. A., although it is hoped that by 1966, the country may become self-sufficient in such quality-cottons.

The next important textile industry, Jute, has been hard hit as a result of partition, even more so than cotton; since practically all the mills are in India, while the raw material is almost exclusively of East Pakistan origin, especially so of good-quality jute. Since Pakistan has a practical monopoly in the cultivation of jute, the problem of India to find raw material is, in this case, even more difficult than in the case of cotton.

Experiments conducted during the last ten years to obtain indigenous jute have not yielded satisfactory results and it looks as though we will have to remain dependent on Pakistan for the raw material. It should also be borne in mind that there is nothing which would render it impossible for Pakistan becoming a manufacturer of jute, and with the long term loans and technical assistance now offered by the U. S., it would only be a matter of a few years before this is achieved and Pakistan may then prevent the export of good quality jute abroad. The prosperity of this industry, epecially from the long term point of view, is bleak and it would be a suggession that from now on, efforts should be made to change over these mills from jute to cotton, silk, or rayon.

IRON AND STEEL:

During the last ten years, there has been a remarkable effort in augmenting the production of iron and steel within the country. With only two centres of production in 1951*[2], Tatas at Jamshedpur (1 million tons steel) and Indian Irons at Kulti and Asansol (½ million tons steel), efforts have been made during the last ten years, not merely to double the output of these two, but also to start three new plants at Rourkela, Bhilai and Durgapur in the public sector, each capable of producing a million tons of steel.*[3]

The general principles regarding the factors of localisation and the regional distribution of any industry may be summed up as follows: It is not merely a matter of comparative transport costs; and in some cases, an industry has to deviate from the point of minimum transport costs to take advantage of a favourable labour location, or an industry may be deliberately located in a depressed area for the sole purpose of making such region economically viable. In so far as the larger industries like iron and steel are concerned, economic and technical considerations are always important and in practice, marginal deviations alone are feasible. "The siting of the three new steel plants at Bhilai, Rourkela and Durgapur, the heavy machinery plant at Ranchi, the heavy electrical project at Bhopal and the exploitation of the lignite deposits at Neyveli in Madras, justified as these all were on purely economic grounds, have also had the effect of creating new centres of industry in parts of the country hitherto untouched by industrialisation. During the second plan 1956-61, and in the proposed third plan 1961-66, preference has been and will be given to the location of public sector projects in relatively backward tracts, so long as this could be done

2. Besides these two, the only other centre of production then was at Bhadravathi in Mysore State, producing 80,000 tons of pig iron.

3. A fourth plant is under contemplation to be erected at Bokaro.

without significant prejudice to technical and economic considerations. Likewise, in the licensing of private sector projects also, the claims of underdeveloped areas have been generally kept in view." The above quotation from the Report of the Planning Commission conclusively shows that, as far as possible, the present policy is to foster regional patterns of development with new industries being started of either consumer goods, or of processing agricultural raw materials in different parts of the country. For e. g., in the third plan period 1961-66, attempts will be made to start cotton mills in Assam, Rajasthan, Orissa and Panjab, sugar mills and distilleries in Andhra, Mysore, Madras and Maharashtra; steel rolling mills in Assam, Madhya Pradesh, Kerala and North Bihar; and a tyre and tube factory and an electrical lamp factory in Kerala. New paper mills based on the raw material of bagasse is to be started in the sugarcane growing areas of Uttar Pradesh and a synthetic rubber plant is to be opened at Uttar Pradesh on the basis of the local supply of power alcohol. Many new small 100,000 tons pig iron plants are to be commissioned wherever non-metallurgical coals are locally available. Several industrial estates have already been opened up in all the States and scores of them are in the offing, and increasingly they will be located in the smaller towns. The general approach appears to be to avoid further concentration in cities where considerable development has already taken place.

Other examples of a deliberate attempt at dispersal of industries which have come to the forefront are, the new fertiliser factory at Rourkela, and the exploitation of the iron ore resources in Orissa; the Nunmati oil refinery, and a fertilizer plant in Assam; a phyto-chemical plant, expansion in fertilizer factory, and the construction of a ship-yard in Kerala; the synthetic drugs factory, the Visakapatanam port, the Andhra paper mills etc. in Andhra Pradesh; the security paper mills, and the basic refractory project in Madhya Pradesh; anti-biotic drugs factory, fertilizer factory, refractories' plants, expansion of precision instruments factory etc., at Uttar Pradesh; the development of copper, lead and zinc deposits in Rajasthan; machine tool factory in the Panjab; surgical instruments plant, raw film project, pilot irons and steel plant, Neyveli lignite high temperature carbonisation plant, teleprinter factory, a steel rolling mill and the exploitation of the Salem bauxite, all in Madras; an oil refinery in Gujarat; and a cement factory in Jammu and Kashmir. These are the larger public sector projects for the Third Plan.In the private sector, the following developments have also been envisaged; an aluminium and cellulose plant in Uttar Pradesh, a fertilizer factory, a nylon factory, a caustic soda factory and a zinc smelter in Rajasthan; synthetic rubber, polythelene and a paper pulp factory in Assam; an automobile rubber factory in Kerala; etc. Besides these, it is also quite likely that there would be local development around new irrigation projects and it is hoped that some sort of industrial development, at least the processing of agricultural commodities, will originate in the Dandakarinya, and in the canal areas served by the Tungabhadra, Nagarjunasagar, Koyna, Chambal, Rajasthan canals, etc.

In conclusion, it would only be appropriate to survey the entire industrial arena, particularly to take stock of our failure to achieve the projected targets. It will be found that production has fallen short of anticipation in some important cases,

PRODUCTION TARGETS FOR 1960–61 AND ACTUAL PERFORMANCE

—	Unit	Production targets	Actual production
Steel finished	million tons	4·8	2·2
Nitrogenous fertilizers (in terms of nitrogen)	000 tons	290·0	110·0
Phosphatic fertilizers (in terms of P_2O_5)	000 tons	120·0	55·0
Textile machinery	Rs. Crores	17·0	9·0
Cement machinery	Rs. Crores	2·0	0·6
Paper machinery	Rs. Crores	4·0	...
Aluminium	000 tons	25·0	18·5
Newsprint	000 tons	60·0	25·0
Chemical pulp	tons	30000·0	...
Soda ash	000 tons	230·0	145·0
Caustic soda	000 tons	135·0	100·0
Dyestuffs	million lbs.	22·0	11·5
Cement	million tons	18·0*	8·5

* Revised to 10–11 million tons in May, 1958.

The combined output of the three new steel plants in 1960–61 was only 0.6 million tons as against a target of 2 million tons. The actual production of all these industries mentioned in the table above, is approximately only 50% of the target, but in most others, the objectives have been attained.

Mention must also be made of the occasional problem that has sprung up between capital and labour in some of the industries, which in its wake has resulted in an impoverished output.

One of the customary yard sticks of production is the aggregate amount of production divided by the number of workers employed; judged in terms of this measure, the industrial productivity of India has gone down substantially since 1939 by about 20 to 30%, atleast in the iron and steel industry in which there was a proper unit of measurment. The productivity of labour has fallen low; the annual average production at the Jamshedpur plant has diminished from 28.9 tons of steel per worker in 1939 to 23.2 tons of steel in 1954. Similarly in the factories of the Steel Corporation of Bengal the average annul output per worker has diminished by more than 30%*4. This means that the cost of production in terms of real resources has substantially increased. The strain on machinery and equipment during the war, the irregular supplies as well as inferior and non-uniform quality of the raw material have certainly contributed to the diminished output to some extent; but the managements have thrown the responsibility on labour and stated that labour is working below capacity, while labour has protested that the plants are antiquated, that they have not been properly

*4. ECAFE Economic Survey of Asia and the Far East, 1949 page 88.
See also TISCO 48th Annual Report 1954–55 pp. 18 to 30. Figures of production for later years have not been made available.

reconditioned, and that managerial efficiency is at a low ebb. It must be confessed that the number of workers employed in this industry appears to be excessive, especially on a comparison with foreign producers, but the industry, because of the threat of labour strike has not been able to reduce the numbers to a reasonable level. A curtailment of the present complement of labour appears to be *a sine qua non* before prices can come down. In any case, this is a matter which requires careful study and investigation, much more than what has been spent upon it, till now.

There can be no doubt that in the industrial field, far reaching gains have been secured, but it must also be admitted that so far, it has been insufficient to make an impact on the general condition of the mass of the population, or radically to alter the structure of the economy. Poverty, unemployment and under-employment in 1961 are much greater than what they were in 1951, in spite of the fillip given by the two Five Year Plans, and it cannot be said that we have safely rounded the corner yet, but given peace and good will, the corner does not appear to be far beyond our reach say, by the fifth Five year plan in 1976.

VEGETATION OF THE UPPER DOAB

By

A. B. MUKERJI, Ph. D. (Louisiana)

Osmania University

In the Indo-Gangetic Plain, in general, and in the Upper Doab, in particular, the original natural vegetation is characterised by its sparseness, open savannah appearance, and limited number of species. Associations of species are found only in few areas. Some of the species are found in all the ecological habitats. Climatically, the region is suitable for the development of deciduous forests throughout. Man's intervention, however, has prevented the development of the true climatic climax vagetation in the Upper Doab (Varma, 1936, p. 266).

PAST VEGETATION

The traditional historical evidence of the existence of the forests and cultural fires in widely distributed areas of India and in the Upper Doab are recurrent (Stebbing 1921, p. 30). The Vedas and the Later Epics such as the Ramayana and the Mahabharata constantly refer to the existence of various kinds of forests in this area. The existence of a regular department of forests during the Epic Period (1,000 to 600 B.C.) is also referred to in the Epics (Bose, 1942, p. 84).

Archaeological evidence based on the study of sculptures and literary evidence based on the study of the Epics conclusively show, that until the 7th century A.D. a major part of the Upper Doab was covered with wet, tropical forests (Randhawa, 1952, p. 497). During this period a conscious attempt through legislation was made to protect the forests (Bose 1942, p. 84).

The wet, tropical forests of the Upper Doab containted evergreen trees of the Indo-Malayan affinities which flourish at present in Assam, Bengal, Burma, and the West Coast of India (Randhawa, 1952, p. 497). Mention of four Indo-Malayan tropical trees: the leguminous, pinnate-leaved *ashoka* (*Saraca indica* Linn., *Caesalpiniaceae*); the large, madder tree with orange sized fruit and spreading branches the *kadamb* (*Anthocephalus indicus* Rich., *Rubiaceae*); the rather tall, pale yellow, fragrant flower champak (*Michleia champaka*, Linn., *Magnoliaceae*); and *nagasura*, St. John's wort (*Mesua ferrea*, Linn., *Guttiferae*) with slender twigs and middle height; constantly recurs in the sculptures of the period 100 B.C. to 800 A.D. and suggests the existence of wet, tropical forests in the Upper Doab (Randhawa, 1952, p. 499).

The forests however, changed to a great extent by felling and burning, persisted until recent historical periods. The nature of the forests also changed from the wet, tropical to dry, deciduous forests dominated by a very large, resinous tree *sal* (*Shorea robusta, Dipterocarpaceae*). The *sal* had actually displaced evergreen forests from the Upper Doab (Champion, 1939, p. 10). The *sal* forests covered the area until the beginning of the British colonization (Misa and Puri, 1954, p. 27). The North Indian Copper-plate Grants inscriptions repeatedly mention the existence of forests and forest lands in each village (Gupta, 1933, p. 39). The original, natural vegetation of the Upper Doab before the movements of the Jats in the 17th and 18th centuries in the area was a dry, deciduous forest (Haig, 1958,

p. 107), composed, predominantly, of *sal* (Calder, 1937, p. 71; and Spate, 1954, page 63). Mogul emperors hunted tigers, wild water buffaloes, and wild elephants in the forests of this region until the sixteenth and seventeenth centuries A.D. (Spate, 1954, p. 79). Today these patches of the leguminous tree *dhak* (*Butea frondosa* Roxb., *Papilionaceae*) in the vicinity of the villages are the vestigial remains of the old forests, which have been cut down and cultivated (Mukerji, 1940, p. 91).

Both cultural and natural factors have been resorted to for the explanation of the disappearance of the original vegetation and the development of the present savannah type of vegetation. Although detailed data on the problem is scattered through numerous memoirs, records of travel, and revenue records, no systematic study has as yet been made.

As for the physical cause, increasing desiccation beginning around the 8th century A.D. and continuing upto the present time has been suggested by Randhawa (1952, p. 503), and by Login (1872, p. 186), as the cause of the disappearance of the forests. Randhawa (1952, p. 503) bases his arguments on the present coterminus distribution of the four Indo-Malayan trees mentioned earlier in the evergreen trees of India and adjacent countries to the east.

These evergreen forests receive an annual rainfall of over 80 inches. From the present natural distribution of these four trees Randhawa (1952, p. 500) infers that until about the 7th century A.D. the southern part of the Upper Doab had a rainfall of 80 inches or more. Today the rainfall of the southern part of the Upper Doab is less than 25 inches. Thus, increasing aridity is a definite conclusion (Randhawa, 1952, p. 501).

Randhawa's circuitous arguments are, however, most confusing. Whether it was the increasing aridity that caused the disappearance of the forest, or the disappearance of the forests as a result of their being burnt and felled by man, which in turn caused the aridity of the region, are problems that are not discussed by Randhawa. Aridity might have been the effect, rather than the cause of the disappearance of the original forest vegetation.

Cultural activities of man have been far stronger and effective in the removal of the original vegetation cover. Three millennia of clearing for agriculture and of unregulated grazing (both often promoted by burning the forest) have stripped the forest from nearly all of the plains (Spate, 1954, p. 63). Activities of man including the felling of the trees and the burning of the forests have been recognized by other scholars (Misra, 1959, page 3; Baden-Powell, 1896, p. 275; Varma, 1936, page 266; and Chaturvedi, 1956, p. 455).

The forests were cut and burnt for both cultivation and grazing right from the Vedic Age (circa 1500 B.C.) (Gupta, 1933, p, 246; Chaturvedi, 1956, p. 450; Wheeler, 1959, p, 126). Definite evidence of slash-burn agriculture are not available but the possibility of the practice cannot be ruled out. The forests were not only cut to clear lands for agriculture but also for wood to be used as fuel, building materials, chariots, and a large number of sacrificial implements (Gupta, 1933, p. 246). While the forests were depleted for economic uses, their preservation was not ignored. Religious injunctions preserved the forests during the Brahmanic and Buddhist periods (Chaturvedi, 1956, p. 455). *Dhak* (*Butea frondosa* Roxb.) and *pipal* (*Ficus religiosa*) were never cut down as both were and still are regarded as sacred. Later, during the Mogul Period the forests suffered the worst than in any earlier period. Unlike the Hindus and the Buddhists, the Moslems had little compunction about felling trees (Chaturvedi, 1956, p. 455; and Sen, 1955, p. 146).

The role of the Jats in removing the forest cover in the Upper Doab has also been of some consequence. During the reign of Akbar (1555–1605 A.D.) the Jats cleared the forests by felling the trees and thus settled the cleared lands (Baden-Powell, 1896, p, 275). Such clearing was most extensive in the central parts of the Upper Doab where the Jats had settled permanently. The natural vegetation of the edges of the Pleistocene Terrace and of the Recent Floodplains was relatively little modified by the Jats as their settlements here were of very short duration.

PRESENT VEGETATION

The present vegetation of the Upper Doab is wholly different from that of the past and displays an open, savannah appearance (Mukerji, 1938, p. 99). The activities of man have disturbed the soil : water : vegetation equilibria producing sharp environmental gradients. As a rule we get all stages of temporal and spatial community organization from the almost open ground and water to the relict forests (Misra, p. 3). The vegetation of the Upper Doab is composed of three broad types : the forest, the woodland, and the grass communities.

FOREST

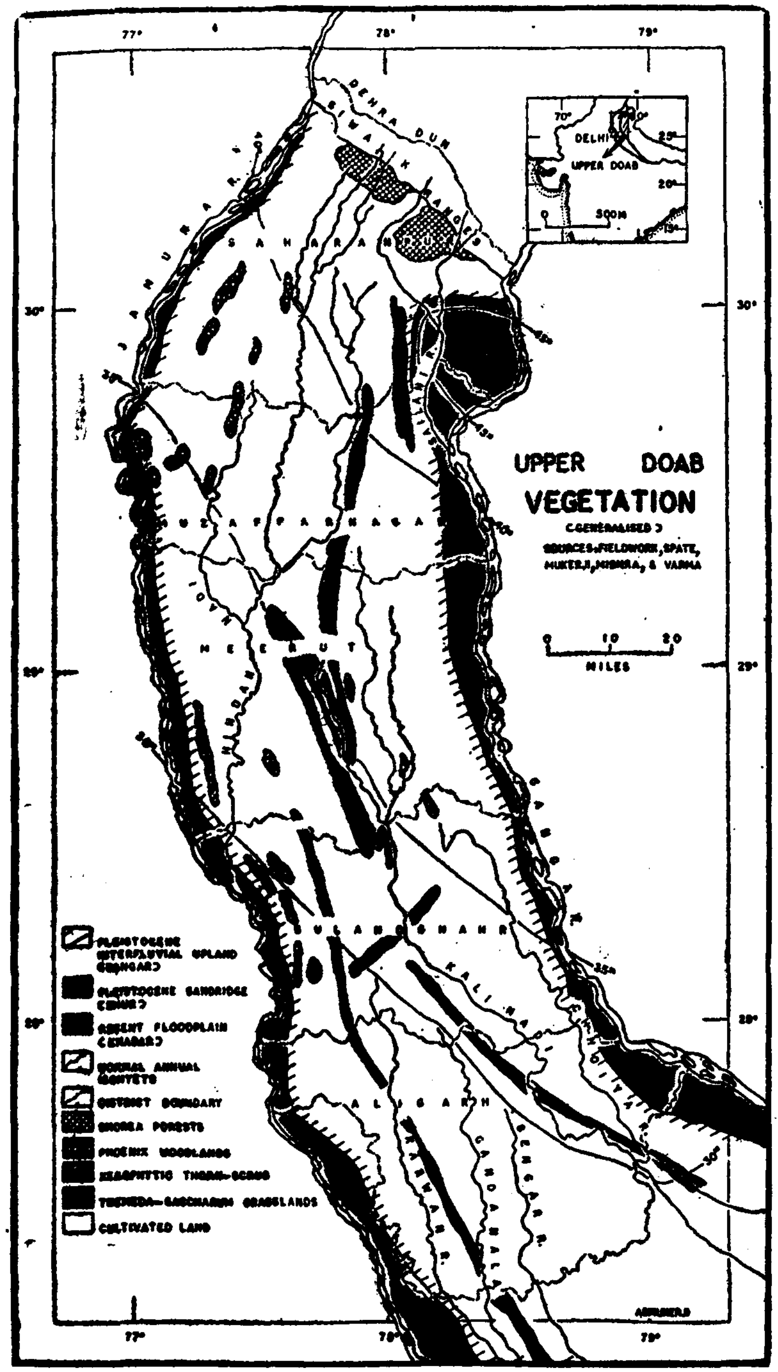
The true forest is found in the Saharanpur District on the Interfluvial Upland (Refer Map). This forest community is dominated by pure stands of *sal* (*Shorea robusta*). The *sal* grows specially well on the well-drained loam soils resting on a gravelly sand layer. The *sal* forests are low, moderately dense, and ordinarily closed. The *sal* tree has a great range of adaptability to different habitats. Its' wood is very hard and is widley used for house building.

WOODLANDS

There are six woodland associations in the Upper Doab. Most of these are found both on the Interfluvial Upland and the Recent Floodplains.

1. Woodlands composed predominantly of the leguminous tamarinds (*Tamarindus indica* Linn., *Caesalpiniaceae*) are found on the riverine strips on both the Pleistocene Interfluvial Upland and the Recent Floodplains. The tamarind is native to Tropical Africa but is now grown all over India The name tamarind (*Imli* in Hindi) has been derived from the Persian word tamai hind which means Indian date. This is an indication of its recent introduction in India. The tamarind grows to a large size and great age. It has a canopy of billowing foliage. It reaches a height of about 50 feet. Its fruit is a pod with three to twelve seeds. The pods are green at first but when ripe they are buff and brittle. Apart from its natural occurrence in the riverine strips, it is found as a planted tree along the road and around villages. Tamarind groves in forests mark the sites of deserted cultivation and abandoned villages (McCann, 1955, p. 65). The seeds are a rich source of pectin from which jams and pickles are made. Bark is used as tanning raw material.

2. Woodlands composed of tamarinds and mangoes (*Mangifera indica*, Linn., *Anacardiaceae*) are found in both the Pleistocene Interfluvial Upland and the Recent Floodplains around the villages in small, compact, groves. The mango is a large, spreading, evergrown tree with dark green



leathery foliage; and small, yellow, odorous flowers. The tree is grown extensively all over India for its fruits. It is an ancient tree in India and very sacred to the Hindus. Its leaves are used as spoons for the pouring of libations, the wood is used in the funeral pyres, and the marriage alter is decorated with its twigs and leaves. The flowers are dedicated to the Moon and Madan (the Indian Cupid). The bark gives a gum used in medicine.

3. The woodlands having drought-resisting trees are found in the sandy floodplains (Spate, 1954, p. 63). The typical community is composed of two low leguminous; the thorny, gum exuding *babul* tree (*Acacia arabica* Willd., *Mimosaceae*) with stiff, leathery pods and pinnate leaves; and *Prosopis spicigera*, *Mimosaceae*, a low tree with slender, grey branches and edible pods with ten to fifteen seeds. Along with these two trees are found a fair mixture of thorny, dense, slender-branched shrubs *Capparis decidua* and *Capparis aphylla* (*Capparidaceae*) and a spinous tree *Diospyros cordifolia* (*Ebeneceae*) (Randhawa, 1958, p. 57). Several species of tamarix with reduced scaly leaves are also found. The community is sufficiently distinctive to have been named as *rakh* vegetation (Bor. 1953, p. 150). Since this community grows in an area with less than twenty inches of rainfall, in the Upper Doab, its distribution is determined by edaphic rather than climatic aridity. Hence, the species are found mostly in the sandy floodplains.

The economic use of the community is quite considerable. The pods and branches are fed to goats and sheep. Unripe pod and bark are rich in tannin and are used in tanning. The bark of the *babul* exudes a gum which is used in place of Gum Arabic and its wood is an excellent fuel.

Continuous disturbance by the biotic factors, such as grazing, cutting of the trees, and intensive climatic droughts have forced some of the trees of the *rakh* vegetation to become xerophytic (Haig, 1958, p. 107). At places they are less luxuriant, floristically less complex, and have a simple structure with a low (20 to 30 feet maximum) single-tree storey. They are open and stunted (Spate, 1954, p. 69), with the trees widely scattered and thus, displaying a savannah appearance (Haig, 1958, p. 107).

4. Thorn scrub vegetation is found in the drier parts of the Upper Doab. This vegetation type has two sub-types: (1) thorn scrub found in climatically dry areas and (2) thorn scrub found in the edaphically dry areas.

(1) Thorn scrub predominates in the climatically dry areas of the Pleistocene Interfluvial Upland. Mukerji (1938, p. 103) considers this to be the degraded stage of the original Monsoon deciduous forest, the change effected by biotic factors. The thorn scrub vegetation reaches its maximum development in the ravines at the edges of the Pleistocene Interfluvial Upland. According to Mukerji (1938. p. 112) it is in a stage of transition, and appears like savannah with trees interspersed in the thorn scrub woodlands.

Two small, deciduous, leguminous trees; *shisham* (*Dalbergia sissoo*, *Papilionaceae*) with rachis zigzag leaves and thin, strap-shapen pods; and *khair* (*Acacia catechu* Willd., *Mimosaceae*) with brown bark, dark yellow flowers and dark brown pods; form a characteristic association on sandy escarpments overlooking the banks (Bor. 1953, page 83). Other members of the thorn scrub community include *Terminalia tomentosa* (*Combretaceae*), a tall tree reaching a height of 80 to 100 feet, with small spicate leaves and a pod with a solitary seed; *ber* (*Zyzyphus jujuba*, *Rhamnaecae*) a tall tree reaching upto 30 to 50 feet, with solitary straight thorns, and a fleshy fruit with a woody pod; and several species of *Euphorbia*.

The wood of the *shisham* is used for furniture and house construction. Its wood is very hard and is not eaten by white ants. Its wood is also used for carving. The wood of the *khair* is boiled and *katha* made from it. *Katha* is used as an ingredient in betel leaf for chewing. The *ber* branches are lopped for fodder and the leaves are fed to the *tassar* silkworm. Its thorny branches make good fences.

(2) Thorn scrub woods found on the edaphically dry *bhur* sand ridges (Mukerji, 1961, pp. 53–57) on the Pleistocene Interfluvial Upland are composed of xerophytic species. This vegetation includes leafless *karila* (*Capparis aphylla* Roth., *Capparidaceae*); *kilu* (*Salvadora oleoides* Done., *Salvadoraceae*) with tough leathery leaves and small flowers; *babul*; *hingot* (*Balanites aegyptica* Delile., *Simarubaceae*), a low 20 feet high tree with green flowers and large, woody fruit; *pilkham* (*Ficus cordifolia* Roxb., *Moraceae*), a strangling fig; thorn bush (*Zizyphus* spp.) and several species of tamarisk with reduced scaly leaves. *Karil*, *pilu* and *babul* form the *rakh* vegetation as described earlier. *Hingot* thrives well in open country on stiff clay soil, and is found with other thorny scrubs and xerophytes (Bor. 1953 P. 247).

5. The elevated, well drained, and dry sites on the Pleistocene Interfluvial Upland have a vegetation composed of the leguminous tree *dhak*: the berry tree *mahua* (*Madhuka longifolia* Linn., *Sapotaceae*); and the berry tree *neem* (*Azadirachata indica* Linn., *Meliaceae*).

The *dhak* is a small tree, deciduous in nature, with crooked trunk and black branches. It is typical of the open grasslands and is often found in pure stands. It is particularly noted for its profusion of orange and vermilion flowers that cover the tree from January through March. Hence, it is also known as "The Flame of the Forest". The pale, green, young pod becomes pale yellow when ripe. A red, astringent gum is exuded by the bark.

The wood is used by the Jats of the Upper Doab to line up the wells. Leaves serve as dinner plates on festive occasions. The bark produces a tanning material while the flowers are used in making a dye for cloth. The gum is used to cure diarrhoea.

Dhak is one of the very few trees of the original vegetation that has survived the destructive effects of man's cultural activities. That is why, it is found, in more or less, pure stands. The explanation is to be found in its antiquity and its sacred nature. Its sacredness is associated with that of the Moon. It is said to have sprung from the feather of a falcon imbued with *soma*, the beverage of the Gods. *Dhak* leaves are used in the Hindu ceremonies connected with the blessings of calves to ensure their development as good milch animals. The dry twigs are fed to the sacred fire. The wood is sacrificial and is often mentioned in the Vedas (Blatter and Millard, 1954, p. 16). A Brahmin has to eat a *dhak* leaf at the initiation ceremony. In the trifoliate leaf of the *dhak*, the middle leaflet represents Vishnu (the preserver), the left leaflet Brahma (the creator), and the right Siva (the destroyer). Eating the *dhak* leaf is thus, symbolic of attaining the godly powers. *Dhak*, therefore, because of its immense religious significance has been protected to the present day.

The *mahua* tree is noted for its delicious and nutritive flowers. It grows up to a height of 50 feet. It is a large, evergreen tree with thick, spreading crown and lanceolate leaves that crowd at the ends of the branches. The bark is yellowish green, and the red wood is hard. The fruits are fleshy, green berries and contain from one to four shiny, brown seeds.

The oil from the seeds is used for lighting, to adulterate clarified butter (*ghee*) for cooking, and for the manufacture of soap. An intoxicant liquor is distilled from the flowers. Low caste people cook the unripe fruit as a vegetable.

The *neem* tree is a large, evergreen, tree, growing up to a height of 40 to 50 feet. The long leaves are alternate and pinnate. The flowers appear during March through May as tiny stars on long, drooping stems which spring from the axles of the leaves. The olive sized fruit is yellow or purple.

The *neem* tree has many uses. The margosa oil extracted from the seeds is effective in the treatment of leprosy and skin diseases. Leaves and fruits are both vermifugal and the fruit is used as a purgative. Bank and gum yield valuable indigenous medicines. It is a general belief in India that the mere presence of the *neem* tree keeps an area free from malaria. The Jat villages have *neem* trees, mostly wild and protected, scattered at various places, both in the habitation and the cultivated fields. The Jats cook the tender green leaves with egg plants (brinjals) and eat it considering that this will give them immunity against skin diseases.

6. Characteristic associations of *Butea monosperma* and *Tamarisk articulata* Vahl., are found on saline lands on the Pleistocene Interfluvial Upland. These two are considered as the most salt resistant trees in the entire region of the Upper Doab (Bor, 1953, p. 152; and Randhawa, 1957, p. 144). The Jats use its wood for making ploughs and Persian Wheels.

7. Pure stands of the Indian wild date palm (*Phoenix sylvestris* Roxb.) are found in many wet depressions (*dahar*) on the Pleistocene Interfluvial Upland. The saline soils of these wet depressions can support no other crop except paddy which was not grown in the past to any extent by the Jats or other culture groups who preceded the former in the sequent occupance of the Upper Doab. At present also, the acreage of paddy grown by the Jats, the principal inhabitants of the Upper Doab is almost negligible. This has resulted in the preservation of the pure stands of the Indian wild date. Furthermore, the little use of the wood also assures its survival. This is a graceful palm reaching a height of 30 to 50 feet. The trunk is rough and the crown hemispherical. It has thick, pinnate leaves about ten feet long. The fruit is golden orange in colour. Valuable fibre is obtained from the leaves and the leaf stalks. The wood gives a durable post or beam but used to a limited extent.

GRASS COMMUNITIES

Two grass communities occur in the Upper Doab. The first is found in moist sites on the Recent Floodplains, and the second is found as meadow vegetation on the Pleistocene Interfluvial Upland.

1. Tall, rank grasses are found on the moist sites of the Pleistocene Interfluvial Upland. The community is formed by *sara* (*Themeda arundinaceae* Rid.), a six feet tall grass, with rigid, sharp-edged leaves; and *munja* (*Saccharum munja* Roxb.). These grasses form a thick, impenetrable, and continuous cover. They have deep, strong-roots and are ineradicable.

2. Meadow vegetation open to grazing is found in the waste lands and the level grounds between the cultivated fields. Thorny bushes are also prominent on such sites. Patches of *Zizyphus nummularia* are quite common (Randhawa, 1958, p. 57). Annual and perennial grasses give a strong, seasonal aspect to the communities. From July through October

the moist meadow is a closed community of the grass *Bothriochloa pertusa* A. Camus.; *Indigofera ennaephylla*, a leguminous annual shrub with trailing stems and many branches, and a thin cylindrical pod; the grass *Rungia repens* Nees.; and the *doob* (*Cynodon dactylon* Pers.), a perennial grass with prostrate stem and widely creeping, forming matted tufts with short ascending branches (Misra, 1959, p. 4).

In the dry season the community on such meadows becomes open, but the total strength of the flora is not much depleted on account of the replacements of the winter annuals. Among the herbaceous xerophytic vegetation growing in the dry season are *Leptaderia spartium* wtih erect cylindrical, almost leafless branches; the spiny *Aliagi camlorum*; the deep rooted *Arnebia hispidissima*; and *Euphorbia thymifolia* with tough penetrating root-stocks (Randhawa, 1958, p. 57).

The dry meadow is typical of the arid areas, not subjected to the retrogressive influence of more intense human factors. In general, they form a continuous cover but under severe grazing conditions the meadows assume a tufted character (Mukerji, 1958, p. 111). In the later stages of succession induced by overgrazing a seasonal grass *Aristida adescenscionis* Linn. becomes dominant.

SUMMARY AND CONCLUSIONS

The original climatic climax vegetation of the Upper Doab before the Christian era was of wet, tropical forests. Later, the dry, deciduous *sal* displaced the early wet forests. Several centuries of cultural activities of man gradually destroyed the original forest from all except the small area in the Saharanpur district. One significant conclusion is the fact that the present vegetation of the Upper Doab has been largely produced by human activities.

The natural vegetation of the Upper Doab consists of three types: the forest, the woodlands, and the grass communities.

1. Forest dominated by *sal* is found on the Pleistocene Interfluvial Upland in the Saharanpur District.
2. Woodlands are found on the following sites:
   (*a*) Riverine strips on both the Recent Floodplains and the Pleistocene Interfluvial Uplands dominated by the *tamarind*.
   (*b*) On both the Recent Floodplains and the Pleistocene Interfluvial Upland village groves composed of the tamarind and mangoes.
   (*c*) *Rakh* vegetation, found on the sandy floodplains formed of *babul*, *Prosopis spicigera*, and *Diospyros cordifolia*.
   (*d*) Thorn scrubs are found on climatically dry and edaphically dry areas. *Shisham* and *khair* form a characteristic association.

Ber and *Terminalia tomentosa* are other species found in the climatically dry areas of the Pleistocene Interfluvial Upland. Thorn scrubs found on the edaphically dry *bhur* sand ridges on the Pleistocene Interfluvial Upland are formed by xerophytic species, as *karil*, *pilu*, and *hingot*; *pilkhan* and several species of tamarisk.

(*e*) *Dhak*, *mahua*, and *neem* form an association on elevated, well drained, dry sites on the Pleistocene Interfluvial Upland.

(*f*) Distinctive association of *Butea monosperma* and *Tamarisk articulata* are found on saline lands in the Pleistocene Interfluvial Upland.

(g) Pure stands of the Indian wild date palm are found in wet depressions on the Pleistocene Interfluvial Upland.

3. Tall rank grasses, *sara* and *munja* are found on the moist sites on the Recent Floodplains. A meadow vegetation formed of *Zizyphus, nummularia, Bothriochloa pertusa, Indigofera ennaephylla, Rungia repens* and *doob* is found between the cultivated lands of the Pleistocene Interfluvial Upland.

BIBLIOGRAPHIC REFERENCES

1. Baden-Powell, B. H. (1892) ... *The Land System of British India.* Oxford Clarendon Press.
2. Baden-Powell, B. H. (1896) ... *The Indian Village Community*. London : Longmans; Green & Co.
3. Blatter, E. A. H. and Millard, W. S. (1931) ... *Some Beautiful Indian Trees.* Bombay; Oxford University Press.
4. Bor. N. L. (1953) ... *Manual of Indian Forest Botany.* London: Oxford University Press.
5. Bose, A. N. Vol. I, (1942) Vol. 2 (1945) ... *Social and Rural Economy of Northern India Cir. 600 B.C.-200 A.D.* Calcutta : University of Calcutta Press.
6. Calder, C.C (1937) ... *An Outline of the Vegetation of India.* Calcutta, Indian Science Congress
7. Champion, H. H. (1936) Vol. 1 ... *A Preliminary Survey of Forest Types of India and Burma.* Dehra Dun: Forest Research Institute.
8. Chaturvedi, M. D. (1956) ... "India", *A World Geography of Forest Resources*, Ed. Hadon-Guest, S. New York; Ronald Press, pp. 455–483.
9. Gupta, K. M. (1933) ... *The Land System in South India between c. 800 A. D. and 1200 A. D.* Lahore: Motilal and Banarsi Das.
10. Haig, I. T. (1958), Vol. 1 ... et. al. *Tropical Silviculture* Rome.
11. Login, T. (1872) Vol. 28 ... "Memoranda on the most Recent Geological Changes of the Rivers and Plains of Northern India," *Quar. Jour. Geol. Soc. of London*, pp. 186-200.
12. McCann. C. (1955) ... *Trees of India.* Bombay: D. B. Tharaporewala Sons & Co.
13. Misra, R. (1959) ... "The Status of the Plant Communities in the Upper Gangetic Plain," *The Journal of the Indian Botanical Society*, Vol. 38 No. 1, pp. 1-7
14. Misra, R. and Puri, G. S. (1954) ... *Indian Manual of Plant Ecology* Poona: English Book Dept.
15. Mukerji, A. B. (1961) ... "Morphogenetic Nature of the Bhur," *The Indian Geographical Journal*, Vol. 36, No. 2, Apr.-June pp. 53-57.
16. Mukerji, R. K. (1938) ... *The Regional Balance of Man.* Madras: Madras University Press.
17. Mukerji, R. K. (1940) ... *Man and His Habitation* London: Allen and Unwin Ltd.
18. Randhawa, M. S. (1957) ... *Flowering Trees in India.* Delhi: Indian Council of Agricultural Research.
19. Randhawa, M. S. (1958) ... *Agriculture and Animal Husbandry in India.* New Delhi: Indian Council of Agricultural Research.
20. Sen, S. R. (1955) "India" *International Journal of Agrarian Affairs* Vol. 2, June, pp. 140-158.
21. Spate, O. H. K. (1951) ... *India and Pakistan.* London: Methuen & Co.
22. Stebbing, E. P. (1921) ... *The Forests of India.* Vol. 1, London: Bodley Head.

ACKNOWLEDGMENTS

The author acknowledges with thanks the constant encouragement to research and provision of funds given to him by Dr. D. S. Reddy, D. Litt., the Vice-Chancellor, Prof. S. A. Qadir, Dean of the Faculty of Arts, and Prof. N. V. Subba Rao, D. Sc., Dean of the Faculty of Science, all of Osmania University.

GEOGRAPHERS IN THE BATTLE AGAINST NATURE

By

ACADEMICIAN INNOKENTI GERASIMOV

Director of the Geographical Institute of the USSR Academy of Sciences

One of the most important problems facing Soviet geographers is to maintain the level of the Caspian Sea, which is growing shallower due to the tremendous evaporation of water from its great surface. The fluctuation in the level of the Caspian Sea affects the work of ports, oil fields, and the fishing industry. The evaporation of water from the Caspian Sea can be reduced by some fairly simple hydrotechnical construction, first of all construction of dams to separate the Kara-Bogaz-Gol, Komsomolets and Kochak bays from the sea. This will save 30 to 35 cu. km. of water annually.

A second aspect of the problem is to transfer to the Caspian Sea some of the discharge of Northern rivers. Soon, three dams and reservoirs will be built on the Pechora, Vychegda and Kama rivers Some 40,000 million cubic metres of water will flow through the Kama from the Pechora and Vychegda. This mighty flow of water will reach the dry zones of the trans-Volga country and the semi-desert area around the Caspian Sea, making it possible to irrigate them.

This is an immense job, and earth-removal work alone is estimated at 700 million cubic metres.

RECLAIMING DESERTS OF CENTRAL ASIA

It is not only around the Caspian Sea that the job of transforming desert or semi-desert areas is to be tackled. The deserts of Central Asia have to be reclaimed as well. In fact the irrigation of Central Asia is a very important problem facing the workers of our institute. At present irrigated lands there constitute less than two per cent of total arable land.

All the rivers of Central Asia watering its desert plains flow from high mountains, where they are fed mainly from glaciers, eternal snows and rain, and discharge their waters into the Aral Sea.

We think it will be possible to increase atmospheric precipitation in the mountain regions. A project is currently being considered at the Institute under which the discharge will be regulated through regulation of the melting of glaciers and the erection of big water reservoirs in mountain valleys. In this way the Amu-Darya and Syr-Darya rivers will be used completely for irrigation.

The utilisation of the wealth of West Siberia is another major problem facing the Institute. The West Siberian lowland is a huge territory, extremely moist in the centre. The annual excess of water is approximately 135 cu. km. The plan is to direct part of the river discharge to the arid regions of West Siberia and Kozakhstan. Soviet scientists are currently working on a project for turning the flow of Siberian rivers, in particular diverting the Ob and Yenisei to Central Asia. It has been estimated that these two Siberian rivers can supply no less than 300,000 million cu.m. of water annually. And, indeed, draining of the West Siberian lowland would create favourable conditions for a large-scale lumber industry in the very centre of the country, in an area with extensive inland waterways.

CONTROLLING SNOW AND FROST

Of the many plans for the transformation of nature in our country, the most interesting in my opinion are those of "reconstructing" East Siberia. These plans are closely linked with the control of eternal frost and surface ice.

The control of the snow layer is also an extensive geographic problem. It is extremely important because the total moisture accumulated in the form of snow comes to about one-half the annual atmospheric precipitation. If you can control the snow, you can control also the discharge of rivers, the reserves of soil and sub-soil moisture and other natural processes of extreme importance to the economy.

There are several ways of controlling the snow layer, some of which are simple and well-known measures such as snow-fencing, tree and shrubbery strips, stubbled fields, etc. Among more complicated are, the acceleration of thawing by darkening the surface of snow or altering its structure and other properties by physical and chemical methods.

I should also like to mention another immense task, a task of principle, in my view. I am speaking of the artificial liquidation of the Arctic icecap. Put into a nutshell, this problem is as follows : Geographic research of recent years carried out at drifting stations makes it possible to assert that the existence of the Arctic icecap is due mainly to the fact that the large expanse of icebound water possesses tremendous reflective power. It has been found that the surface of the earth, even in the extreme North, would be much warmer if it were not for this "mirror" of unmelting ice. Estimates indicate that the average annual temperature in the Arctic, if there were no icecap, would correspond to that of Syktyvkar and Arkhangelsk and would be only four degrees below that of many places in the central area of the European part of the Soviet Union.

If we were able by modern technical means to melt the icecap covering the Arctic Ocean it would probably never form again. This radical transformation of the Arctic would lead to a number of geographic changes, such as increasing the warmth of the extreme North and providing freedom of the seaways from ice. True, this would give rise to other problems. Disruption of the existing general heat and moisture balance would lead to climatic changes in vast areas of Eurasia and North America. Nevertheless this big task has to be tackled.

PROBING THE EARTH'S INSIDE

By

V. Belousov

Corresponding Member, USSR Academy of Sciences

Today we know much less about the deeper layers of the crust and the underlying upper mantle of the globe than about the outer space near the Earth. The deepest bore-hole extends only 7,800 metres down, while commercial drilling depths do not exceed 5,000 metres, or 1/1270th of the Earth's radius. On a sphere two metres in diameter, the layer known to us through bore-holes will be less than one millimetre thick.

The rock coming out of volcanoes or exposed at the bottom of gorges in highly elevated areas of the Earth's crust gives us an idea of the structure and composition of deeper layers. However, this is but a rough idea. Geophysical methods reach deeper, but, while yielding information about some physical properties of deep-lying structures, they tell us nothing about their chemical composition, not to speak of the fact that geophysical methods have so far been used on a limited scale.

Thus, we leave a solid basis of factual knowledge and venture into the realm of hypotheses and speculations at a depth of less than ten kilometres. For we lack the scientific data essential to a theory which would explain the geological processes conditioned by the factors originating deep in the planet's body. These are the motion of the crust, earthquakes, rises of magma, volcanic activity, a multitude of physical and chemical phenomena in rocks, etc. When we speak of these processes, we base ourselves on hypotheses, and everyone believes that his is the only hypothesis which is true, as we have no sufficiently objective criteria to assess them at their real value.

All this affects not only theoretical geology but also limits appreciably our potentialities in tackling practical problems. The formation of minerals in the crust is always related in one way or another to the motion of the crust, the rise of deep-lying materials in the form of ore-bearing solutions, etc. However, we shall not be able to formulate a plausible theory of mineral distribution until we have learned the nature and causes of these processes.

PROMISES OF SUPER-DEEP DRILLING

This was not too bad, when there were many rich deposits on the surface. But today the necessity of expanding the supplies of minerals and raw materials for communist construction imperatively calls for the extension of our knowledge of the Earth's inside. The time has come for us to launch a large-scale scientific offensive on the deep layers of the crust and the underlying mantle. For, it is in these areas that the fundamental geological processes, such as the formation of magma or ore-bearing solutions, take place.

Today the following lines of attack seem evident ; super-deep drilling ; observations in super deep bore-holes ; composite geological, geophysical and geochemical investigations into the deepest layers ; and laboratory studies into the properties of rocks under the temperatures and pressures prevailing in the Earth's inside.

The only direct method is drilling. This method alone can yield specimens of deep-lying materials for direct study. As will be recalled, American engineers have already started their Mohole project — an attempt to drill a hole through the crust and into the upper layers of the underlying mantle. As the crust under the oceans is thinner than under the continents, about 6 kilometres against 20 or 70 kilometres, it has been decided to drill the hole into the ocean floor from aboard a ship. At the "site" off South California, the ocean is 3,600 metres deep. Drilled in the water, the test hole went 200 metres through the hard rocks of the ocean floor, traversing a sandwich of loose sedimentary rocks and solidified flows of basalt lava.

In the light of the latest progress made in drilling techniques it is safe to say that bore-holes 15 to 18 kilometres deep are quite feasible to drill. Although there is no drilling equipment available for this purpose at the moment, it could be easily developed by the joint effort of engineers in the various sectors of technology.

At a depth of 15 kilometres the temperature may be as high as 400 degrees Centigrade and the rock pressure may rise to 4,500 atmospheres. The drilling tools would have to be made in metals capable of standing up well to such an environment; new flushing fluids would have to be devised, suitable for these depths; and new grouting compounds would have to be found. Other difficulties would certainly arise, but they could be tackled successfully, given proper coordination and teamwork.

What does super deep drilling promise to science?

A bore-hole drilled in the ocean floor would cut through the Earth's crust, traverse the Mohorovicic discontinuity and open up the upper layers of the mantle, thus settling the traditional controversy of geologists, geophysicists and geochemists as to the nature of, and the processes in, the mantle. This would at the same time answer quite a number of fundamental problems of geology, above all that of the origin of the Earth's crust.

A similar bore-hole 15 to 18 kilometres drilled on a continent will not reach the mantle, as the crust is too thick. But, as will be recalled the crust consists of two distinct layers. The upper layer, arbitrarily called the granite layer by geophysicists, is made up of sedimentary and metamorphic rocks. The bottom one is called the basalt layer, but this has not yet been proved or disproved. The two layers are separated by what is known as the Conrad discontinuity identified by changes in the velocity of propagation of seismic waves. There is some ground for believing that very important events take place near the Conrad discontinuity: formation of granites, separation of ore-bearing solutions, shifts of plastic material resulting in tectonic movements on the Earth's surface, and the like.

The depth at which the Conrad discontinuity can be reached varies from place to place. There are places where a bore-hole 15 to 18 kilometres deep would traverse it. According to the data gleaned by geophysical prospecting, this is true of a locality in Karelia, where the Conrad discontinuity comes within 8 or 10 kilometres of the surface or in the Trans-Caucasian area where the basalt layer occurs at a depth of 6 to 8 kilometres. In this way, super-deep bore-holes drilled in these areas could tell us much about the composition and structure of the lower sections of the granite layer and the upper sections of the basalt layer.

It is interesting to note that there is a locality within Soviet territory, where a bore-hole drilled on land to a depth of 15 to 18 kilometres would probably cut through the entire crust, traverse the Mohorovicic discontinuity below it, and enter the upper mantle. This locality is an island in the Kuriles, where, according to geophysical observations, the crust totals not more than 12 kilometres in thickness.

OCEAN VS. CONTINENT

One may ask where it would be better to drill a hole—in ocean floor as the Americans are doing so as to open up the mantle, or in a continent so as to glean more facts about the lower section of the granite layer and the upper section of the basalt layer.

Naturally, the primary task to be achieved through super-deep bore-holes is to obtain fundamental facts for a theory which would explain the geological phenomena occurring, well, deep in the Earth. It can hardly be expected that such bore-holes would at once strike at deep-lying ore bodies. What is equally evident, however, is that the closer a theory to practical needs, the better.

If we cut the mantle open through the basalt layer, this would hardly have any direct effect on geological practice. For, it is a fact that minerals are being chiefly mined on the continents and that the ocean floor differs markedly from the continental crust. On the other hand, drilling through the lower sections of the granite layer and the basalt layer on a continent would yield data which could be better used in formulating a theory to explain the deep-occurring processes with the results of which we have to deal in geological practice.

It should also be added that a super-deep bore-hole drilled through an extremely heavy mass of sedimentary rocks could strike at major deposits of oil and gas at very low depths. This may happen in the Caspian Depression, where sedimentary rocks seem to go down to a depth of 12 to 14 kilometres and where it is safe to suppose the presence of oil and gas bearing strata, deep in the crust.

One result of super-deep drilling is evident—super-deep holes would give access to new natural sources of energy taking origin in the elevated temperatures which exist in the Earth's inside. Of course, this energy would be easier to utilize, if the bore hole were drilled in a continent rather than in the ocean floor. Summing up, a continental bore-hole appears more attractive.

NEED FOR ALL-ROUND INVESTIGATIONS

Although drilling is an important tool of research into the Earth's inside, it should be stressed that this must not be isolated from broader geological, geophysical and laboratory investigation. A deep hole drilled in the Earth's crust may well be a technical record. But the hole as such will not augment our knowledge of the crust if drilling is not accompained by a wide range of many other investigations.

Apart from examination of the cores taken out of the hole, the rocks and environmental conditions should be studied *in situ* by means of instruments lowered into the hole. There already exist such instruments for normal depth. They can read the density, elasticity, temperature, electrical conductivity, magnetic and other properties of the surrounding rocks. But we shall yet have to device similar instruments for super-deep holes, instruments suitable for elevated temperatures and pressures.

If we are to foresee the behaviour of the rocks at a depth of 15 kilometrès, laboratory tests are essential, in which specimens of rocks would be subjected to temperature running into many hundred degrees and pressures of several thousand atmospheres. But a full idea of the states of matter deep in the Earth's inside, where all magmatic and tectonic processes are in the making, can only be obtained if laboratory equipment is capable of producing temperatures of several thousand degrees and pressures of several ten thousand atmospheres.

It is hard to overestimate composite regional geological and geophysical investigations. The Earth's crust consists of areas with different history : ancient shields and platforms, mountain ridges varying in age, sea and ocean basins, etc. There are reasons to suspect that the Earth's crust under different tectonic zones, areas with different history, also differs in structure. However, the differences have not yet been studied fully. A comparative geological and geophysical study into the various tectonic zones would add much to our knowledge of the processes taking place in the Earth's inside and bearing on the development of the crust. The results of such a study would be especially valuable, if it were related to super-deep drilling, for a super-deep hole could serve as a reference for the adequate interpretation of geophysical data. In fact, individual super-deep holes could throw much light on the structure of vast areas.

Super-deep drilling coupled with geological, geophysical and laboratory investigations would lift the veil of mystery over the structure of the globe's inside and over the forces governing the development of crust. Then geology would rise to a basically new level. Instead of being a discipline tracing the surface echos of deep-lying processes, it would become a genuine science of the Earth's crust as a whole. Simultaneously, we should obtain new possibilities for expanding our supplies of raw materials and power.

It should be borne in mind, however, that such a range of all-round investigations and technical projects is a task extremely difficult to accomplish and that its realisation would call for the joint efforts of a large team of scientists and engineers. The nation-wide importance of this problem was stressed at a recent joint conference of the Presidium of the USSR Academy of Sciences and the Board of the USSR Ministry of Geology and Conservancy of Minerals. The conference has mapped out some practical measures with a view to augmenting our knowledge of the Earth's inside so that the reserves of raw materials and power still remaining untapped in the globe could be utilized to a fuller degree.

The Programme of the Soviet Communist Party places much emphasis on the development of the country's reserves of minerals and raw materials. It is beyond any doubt that Soviet scientists and engineers, employing the novel methods and techniques described above, will find unprecedented possibilities for using the huge natural resources hidden inside the Earth.

A RE-CONSIDERATION OF THE CONCEPT OF THE PRIMATE CITY*

By

DR. SHYAM S. BHATIA

University of Delhi

The concept of the primate city[1] was formulated by Mark Jefferson in 1939. It is the purpose of this paper, first, to reconsider the concept two decades after its formulation in the light of new data and, second, to study the nature and pattern of change in the relationship of the leading city to the next city in different countries of the world over a period of time.

Jefferson studied the characteristics of leading cities in various countries of the world and was struck by the size and character of the leading city of each country relative to its second city. He noticed that the leading city of a country was disproportionately large compared to the second city and it was there that specialized services, the rarest goods from other parts of the globe, and maximum opportunities for talent and prestige were to be found.

The extent of the size of the leading city relative to the second city became apparent when he found that in 28 leading countries of the world, the largest city was more than twice the size of the second city while in 18 countries, the largest city was more than three times the size of the next city. The recurrence of the disproportionately large size of the leading city in relation to the next city in widely different countries led him to formulate the concept of primacy. He observed that throughout the world " the largest city shall be super-eminent, and not merely in size, but in national influence ".[2] He further stated that " once a city is larger than any other in its country, this mere fact gives it an impetus to grow that cannot affect any other city, and it draws away from all of them in character as well as in size. It is the best market for all exceptional products. It becomes the *primate* city".[3]

INDEX FOR MEASUREMENT

Though Jefferson emphasized that the leading city in a country " shall be super-eminent " and " always disproportionately large " [4], he did not state in clear terms as to how large the leading city had to be relative to the second city, in order to qualify as the primate city of a country. He, however, referred to certain cities as " triple primates " and "double primates" [5]. When we study the largeness of these double and triple primates relative to their second cities, primacy is implied in cases where the second city is less than half the size of the leading city [6]. This view is confirmed by reference to

* The analysis presented in this paper was made in fall 1956. The writer is thankful to Professors Thomas R. Smith and Duane S. Knos of the University of Kansas for help in this analysis.

1. Mark Jefferson, " The Law of the Primate City ", *Geographical Review*, Vol. XXIX (1939), pp. 226-232. Also see, Geoffrey J. Martin, " The Law of Primate Cities " Reexamined ", *Journal of Geography*, Vol. LX (1961), pp. 165-173.
2. Jefferson, *Ibid.*, p. 227
3. *Ibid.*
4. *Ibid.*, p. 231
5. *Ibid.*, p. 229
6. *Ibid.*, p. 228 See Table I.

his exceptions which invariably are cases where the second city is more than half the *size of* the leading city.

In order to compare the relative size of the second cities over the world, Jefferson devised an index which gives the population of the second city as a percentage of the population of the leading city in each country. In terms of this index, the leading city qualifies as a primate city when the second city has a value of less than 50. Since Jefferson termed his concept as the law of primate city, one may call the countries where his law is applicable as "conforming" countries and those where the law is not applicable as "non-conforming" countries. It may be pointed out that Jefferson did not use the terms "conforming" and "non-conforming", but these terms seem useful in a reconsideration of his law and are used in this paper in the above context. Thus, the conforming countries are those where the second city has an index value of less than 50 and *vice versa*.

SOURCES OF DATA

Index values of the second city as computed by Jefferson were based on data for early 1930s and are referred to as Jefferson's data in this paper. New data for various countries for early 1950s were taken from *Statesman Yearbook 1956*, *Demographic Yearbook 1955*, *The World Almanac 1956* and *Foreign Commerce Yearbook 1953* (issued by the United States Department of Commerce, Washington, D.C.). New data have been analysed for the 43 countries included in Jefferson's list[7] and also for an additional 28 countries not considered by Jefferson in his study.

APPLICATION OF THE LAW

The index values of Second cities for various countries included in Jefferson's list are given in Table I below. According to the law of primate city, Jefferson's values show 25 conforming and 18 non-conforming countries. The average index value of conforming countries is 28 while that of non-conforming countries is 67.

Applying the law to new data, we find that there are 29 conforming countries and 14 non-conforming countries. Comparing the conforming status of countries in the two sets of data, we find that conforming countries show a gain of four in new data. A change in conforming status has, however, been involved in more than four cases. Seven countries moved from non-conforming to conforming group while three countries moved in the reverse direction. The ten countries involved in a change of status from conforming to non-conforming and vice versa are shown in Figure I.

The average index value of conforming countries according to new data for Jefferson's list is 30 while that of non-conforming countries is 76. A comparison with Jefferson's data shows that the average index value has increased both for conforming as well as non-conforming countries but it has increased more in the case of non-conforming countries.

The index values of second cities according to new data for 28 additional countries (not included in Jefferson's list) are shown in Table II below. Of these, 16 are conforming and 12 are non-conforming. Considering

7. Jefferson's list contains 51 countries of which six reduplications, Austria-Hungary Germany are excluded from this study.

TABLE I

INDEX VALUES FOR VARIOUS COUNTRIES IN JEFFERSON'S LIST

(In Parenthesis: First City — Second City)

Country	Jefferson's Data	New Data
1. Austria	8 (Vienna - Graz)	13 (Vienna - Graz)
2. Denmark	11 (Copenhagon - Aarhus)	15 (Copenhagan - Aarhus)
3. Hungary	13 (Budapest - Szeged)	12 (Budapest - Szeged)
4. United Kingdom	14 (London - Liverpool)	33 (London - Birmingham)
5. Mexico	18 (Mexico - Guadalajara)	17 (Mexico - Guadalajara)
6. Rumania	18 (Bucharest - Chisinan)	13 (Bucharest - Cluj)
7. Peru	20 (Lima - Callo)	11 (Lima - Ariqueppa)
8. Argentine	22 (Buenos - Aires·Rosario)	16 (Buenos Aires - Rosario)
9. Turkey	23 (Istanbul - Izmer)	29 (Istanbul - Ankara)
10. Cuba	25 (Habana - Halguin)	34 (Habana - Halguin)
11. Bolivia	26 (La Paz - Cochabamba)	25 (La Paz - Cochabamba)
12. Finland	26 (Helsinki - Viipuri)	28 (Helsinki - Viipuri)
13. Chile	30 (Santiago - Valparaiso)	32 (Santiago - Valparaiso)
14. Belgium	30 (Brussels - Antwerp)	72 (Antwerp - Brussels)
15. Czechoslovakia	31 (Pragne - Brno)	30 (Prague - Brno)
16. Philippines	31 (Manila - Cebu)	17 (Manilla - Cebu)
17. France	32 (Paris - Marseilles)	23 (Paris - Marseilles)
18. Bulgaria	35 (Sofia - Plovdiv)	29 (Sofia - Plovdiv)
19. Brazil	66 (Rio de Janiero - Sao Paulo)	87 (Rio de Janiero- Sao Paulo)
20. Norway	39 (Oslo - Bergen)	51 (Oslo - Nordland)
21. Greece	40 (Athens - Thessalonika)	38 (Athens - Thessalonika)
22. Portugal	40 (Lisbon - Oporto)	36 (Lisbon - Oporto)
23. United States	43 (New York - Chicago)	46 (New York - Chicago)
24. Colombia	43 (Bogata - Barranquilla)	55 (Bogota - Modollin)
25. China	44 (Shanghai - Peiping)	45 (Shanghai - Peiping)
26. Sweden	48 (Stockholm - Goteborg)	47 (Stockholm - Goteborg)
27. Japan	51 (Japan - Osaka)	31 (Tokyo - Osaka)
28. Egypt	52 (Cairo - Alexandria)	44 (Cairo - Alexandria)
29. Poland	53 (Warsaw - Lodz)	96 (Lodz - Warsaw)
30. Venezuela	55 (Caracas - Maracaibo)	48 (Caracas - Maracaibo)
31. Switzerland	59 (Zurich - Basel)	47 (Zurich - Basel)
32. Iran	61 (Tehran - Tabriz)	21 (Tehran - Abadan)
33. Yugoslavia	70 (Belgrade - Zagreb)	74 (Belgrade - Zagreb)
34. New Zealand	70 (Auckland - Wellington)	97 (Auckland - Christchurch)
35. Afghanistan	75 (Kabul - Kandahar)	37 (Kabul - Kandahar)
36. Netherlands	76 (Amsterdam - Rotterdam)	80 (Amsterdam - Rotterdam)
37. Soviet Union	76 (Moscow - Leningrad)	77 (Moscow - Leningrad)
38. Canada	77 (Montreal - Toronto)	66 (Montreal - Toronto)
39. India	79 (Calcutta - Bombay)	90 (Bombay - Calcutta)
40. Union of South Africa	80 (Johannesburg - Capetown)	70 (Johannesburg - Capetown)
41. Australia	80 (Sydney - Melbourne)	48 (Sydney - Melbourne)
42. Spain	91 (Barcelona - Madrid)	79 (Madrid - Barcelona)
43. Italy	96 (Rome - Milan)	81 (Rome - Milan)

all 71 countries together on the basis of new data, we find that 45 are conforming countries while 26 are non-conforming. The average index value for the forty-five conforming countries is 28 while that for the twenty-six non-conforming countries is 78.

TABLE II

INDEX VALUES FOR ADDITIONAL COUNTRIES (NEW DATA)

Conforming		*Nonconforming*	
Country	Index	Country	Index
French Morocco	32	Algeria	92
Burma	26	Pakistan	84
Iraq	38	Malaya	93
South Korea	33	Ecuador	81
Thailand	30	Nepal	96
Belgian Congo	47	El Salvador	57
Ceylon	17	Kenya	77
Costa Rica	13	Gold Coast	58
Ethiopia	7	Indonesia	80
Guatemala	12	Nigeria	69
Honduras	21	Southern Rhodesia	71
Indo-China	22	Syria	99
Lebanon	27		
Paraguay	20		
Tanganyika	31		
Tunisia	15		

VARIATIONS IN THE RELATIONSHIP OF SECOND CITY TO THE LEADING CITY

In Jefferson's data, index values range from 8 to 96, the average being 46·0 with a standard deviation of 23·6. In the new data with Jefferson's list of countries (see Table I), index values range from 12 to 97, the average being 45·1 with a standard deviation of 25·2. Considering the new data for all countries, index values range from 7 to 99, the average being 46·9 with a standard deviation of 27·0. Not only are the average values pretty close to one another, the standard deviation values also are not different. (The coefficient of variation shows a range of only seven percent).

From the above it follows that the second cities, as a group, have maintained the average index value over a period of time and this value is not much affected either by the changes in index values of individual second cities or when additional countries are considered. The little variation in average values also suggests that the growth of second cities in relation to the growth of leading cities in various countries has been such that the second cities on an average bear almost the same relationship to the leading cities today as they did two decades earlier.

But, do the variations in index values in new data have any relationship to variations in index values in Jefferson's data? Are Jefferson's index values in any way associated with index values in new data? In other words, is there any similarity between the variations in index values of Jefferson's data and new data when the same countries are considered? The Pearsonian coefficient of correlation between the two sets of index values comes to 0·778 and it is highly significant ($P = \cdot 01$). The coefficient of determination equals 0·6052 which means that 60·52 percent of the variations in index values of new data are explained by variations in Jefferson's data.

The magnitude of change in the index value of second city in each of the individual countries in Jefferson's list is shown in Figure 2 where the

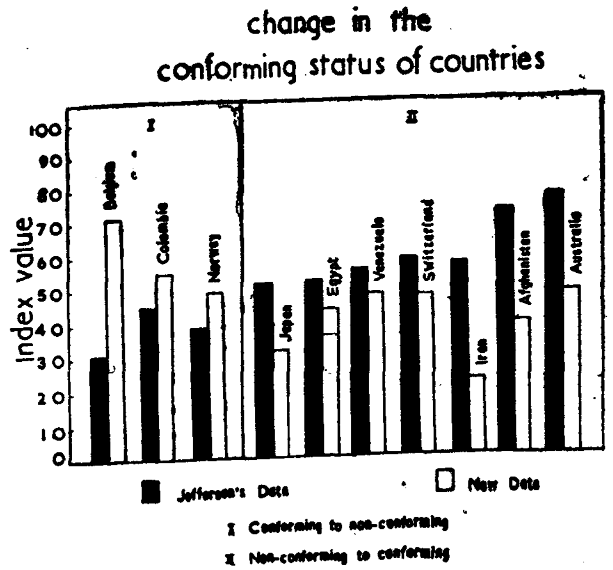


Figure 1

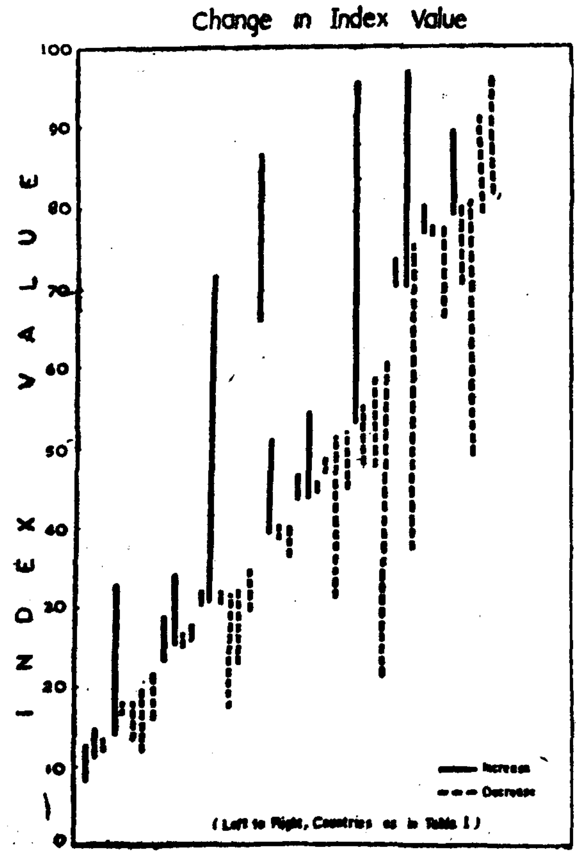


Figure 2

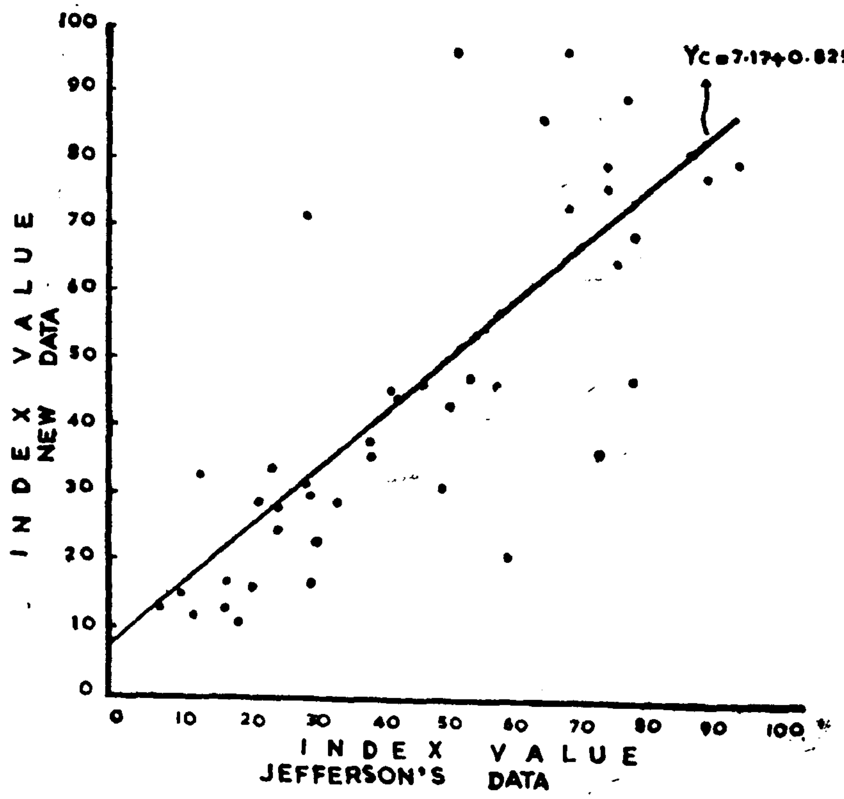


Figure 3. Regression Diagram

countries are arranged from left to right in the same order as in Table I. Of the 43 countries analysed, 19 countries show an increase in index value i.e. they move generally towards nonconformality, while 24 countries show a decrease in index value i.e. they move generally towards conformality. The magnitude of change in index values varies from as little as one to as high as 43. The maximum decrease in index value is 40 in the case of Iran while the maximum increase in index value is 43 in the case of Poland(cf. Table I)

The nature of change in index values of second cities over a period of two decades can be expressed by means of a regression equation. The regression of index values in new data (Y) on the index values in Jefferson's data (X) is shown in Figure 3. Assuming a linear relationship, the average index value for new data (based on the index values in Jefferson's data) is given by

the equation $Yc = 7{\cdot}17 + 0{\cdot}825X$.

A comparison of Y computed from actual index values of new data is given in Table III. The standard error of estimate which gives a measure of average dispersion and a basis for delimiting more than-the-average change, comes to 15·9. Countries that show a high departure from the average difference between Jefferson's data and new data are shown in Table IV.

TABLE III

DEVIATION OF Y COMPUTED FROM ACTUAL INDEX VALUES

(Y = NEW DATA)

No.	Country	Y	Yc	Y—Yc
1	Austria	18	13·8	— 0·8
2	Denmark	15	16·2	— 1·2
3	Hungary	12	17·9	— 5·9
4	U. K.	33	18·7	—14·3
5	Mexico	17	22·0	— 5·0
6	Rumania	13	22·0	— 9·0
7	Peru	12	23·7	—11·7
8	Argentina	16	25·3	— 9·3
9	Turkey	29	26·1	2·9
10	Cuba	34	27·8	6·2
11	Bolivia	25	28·6	— 3·6
12	Finland	28	28·6	— ·6
13	Chile	32	31·9	— ·1
14	Belgium	72	31·9	40·1
15	Czechoslovakia	30	32·7	— 2·7
16	Philippine Isles	17	32·7	—15·7
17	France	23	33·6	—10·6
18	Bulgaria	29	36·0	— 7·0
19	Brazil	87	61·6	25·4
20	Norway	51	39·3	11·7
21	Greece	38	40·2	— 2·2
22	Portugal	36	40·2	— 4·2
23	United States	46	42·6	3·4
24	Colombia	55	42·6	12·4
25	China	45	43·5	1·5
26	Sweden	47	46·8	·2
27	Japan	31	49·2	—18·2
28	Egypt	44	50·1	— 6·1
29	Poland	96	50·9	45·1
30	Venezuela	48	52·5	— 4·5
31	Switzerland	47	55·8	— 8·8
32	Iran	21	57·5	—36·5
33	Yugoslavia	74	64·9	9·1
34	New Zealand	97	64·9	32·1
35	Afghanistan	37	69·0	—32·0
36	Netherlands	80	69·9	10·1
37	U.S.S.R.	77	69·9	7·1
38	Canada	66	70·2	— 4·7
39	India	90	72·3	17·7
40	Union of South Africa	70	73·2	— 3·2
41	Australia	48	73·2	—25·2
42	Spain	79	82·2	— 3·2
43	Italy	81	86·4	— 5·4

TABLE IV

COUNTRIES WHERE THE INDEX VALUE VARIES GREATLY FROM THE AVERAGE DIFFERENCE BETWEEN JEFFERSON'S DATA AND NEW DATA

(*S.E.E. stands for Standard Error of Estimate*)

Over Predicted			
½ to 1 S.E.E.	(8-15·9)	Rumania, Peru, Argentina, Philippines, France, Switzerland.	
1 to 2 S.E.E.	(15·9-31·8)	Japan, Australia	Outstanding change
2 to 3 S.E.E.	(31·8-47·7)	Iran, Afghanistan	
Under Predicted			
½ to 1 S.E.E.	(8-15·9)	U.K., Norway, Colombia, Yugoslavia, Netherlands.	
1 to 2 S.E.E.	(15·9-31·8)	Brazil, India	Outstanding change
2 to 3 S.E.E.	(31·8-47·7)	Belgium, Poland, New Zealand	

Countries that have a departure of more than ± I standard error of estimate are taken as showing outstanding change. The countries with outstanding decrease in index value of second city are Japan, Australia, Iran and Afghanistan. The countries of outstanding increase in index value of second city are Brazil, India, Belgium, Poland and New Zealand.

Conclusion

The foregoing analysis shows that after an interval of two decades, the average index value of second cities as well as their conforming character remain almost the same as when Jefferson made his study. The individual index values nave undergone changes. The average degree of similarity in variations in the index values in Jefferson's data and new data as expressed by the Pearsonian Coefficient of Correlation is 0·778 which is highly significant at P = ·01. The nature of association in index values is given by the equation $Yc = 7 \cdot 17 + 0 \cdot 825X$. The standard error of estimate is 15.9 and taking this as a measure of change, countries showing outstanding change in index value of their second cities have been indicated. The concept of the primate city seems to be as valid to day as it was at the time of Jefferson's writing.

Annual Report

THE INDIAN GEOGRAPHICAL SOCIETY

THE TWENTIETH ANNUAL REPORT OF THE INDIAN GEOGRAPHICAL SOCIETY FOR THE YEAR 1961 (JANUARY TO DECEMBER)

THE COUNCIL OF THE INDIAN GEOGRAPHICAL SOCIETY has the honour to present the following report for the period January 1, 1961 to December 31, 1961.

MEMBERSHIP

The strength of the Society is shown below :—

	1956	1957	1958	1959	1960	1961	
Life Members ...	26	28	29	32	38	38	
Honorary Members ...	7	7	7	7	7	4	
Ordinary Members ...	68	79	96	109	121	95	(7 new)
Institutions ...	242	242	255	213	204	205	(20 new)

Members and Institutions are particularly reminded that they will be helping the Society if they will remit the current dues and the arrears of subscription, if any, as early as possible.

EXECUTIVE COMMITTEE

The results of the election held in January 1961 is given below :—

President	...	Dr. George Kuriyan.
Vice-Presidents	...	Dr. Miss. A. R. Irawathy. Prof. P. G. Dowie. Dr. S. M. Ali. Dr. P. Dayal. Dr. O. P. Bharadwaj.
Secretary	...	Shri. S. D. Misra (till 10th April 1961 when he resigned).
Asst. Secretary	...	Miss. M. N. Vasantha Devi (Secretary since 10th April, 1961).
Treasurer	...	Miss. M. Meenakshi.
Executive Committee	...	Mr. M. P. Rajagopal. Mrs. R. Radha (From the Council).
Members of the Council	...	Dr. H. P. Das. Dr. A. B. Mukerjee. Mr. R. Ramachandran. Mrs. R. Radha. Miss. C. Nirmala. Miss. M. Seethalakshmi.

GENERAL

Shri. S. D. Misra, who was elected Secretary, at the last Annual Meeting of the Society, tendered his resignation on 10th April, 1961 and Kumari. M. N. Vasantha Devi, till then Asst. Secretary was temporarily asked to shoulder the responsibilities of the office of Secretary till the next meeting of the Executive Committee. At the meeting of the Executive Committee held on 5th July, 1961 this temporary arrangement was confirmed.

FINANCE

The Financial Statement for the year ending 31st December, 1961 is set fourth in the Auditor's Report.

Receipts for the year under various heads amount to Rs. 3027-20nP. and together with the previous year's balance of Rs. 178-38nP., gives a gross amount of Rs. 3205-58nP. The expenditure has been Rs. 2947-13nP. leaving a balance of Rs. 258-45nP., Rs. 12-92nP. with the Treasurer, Rs. 20-47nP. with the Secretary and Rs. 225-06nP. in the Bank.

The Society is particularly grateful to the authorities of the University of Madras for the annual grant of Rs. 150/-. Further, the Vice-Chancellor, has been pleased to allow the effects of the Society to be accommodated in one of the rooms of the University Department of Geography; this has given the Society a permanent habitation and the Society takes this opportunity to place on record its gratitude to the Vice Chancellor. The Society also expresses its gratitude to the Ministry of Sciêntific Research and Cultural affairs for donating an amount of Rs. 500/- for the year, towards publication expenses of the Journal. During the last 36 years, ever since the Society was inaugurated, the quarterly journal of the Society has been published at an annual subscription rate, as low as Rs. 8/- per annum, and when it is remembered that even today the rate of subscription has not been enhanced, while the cost of paper, printing and other services have multiplied themselves several fold, the need of financial assistance to the Society from the Ministry of Scientific and cultural affairs becomes obvious.

Unfortunately during the year the usual grant of Rs. 500/- from the National Institute of Sciences was not received but it is hoped that it will be received before the beginning of April 1962.

In spite of all these financial hurdles, the Society has managed to survive and it is with legitimate pride that it looks back upon 1961 as the year in which it started reviving publication of 4 independent numbers as in the past.

ACTIVITIES

Under the auspices of the Society, Prof. Robert. S. Platt, Emeritus Professor of Geography, University of Chicago, gave two lectures one on "Field study, theory and method" and the other on "Comparative Regional Geography", on the 15th and 17th November, 1961 respectively, and another lecture was also given on 17th November by Mrs. Platt on the "Urban landscape of Chicago".

The recognition of the value of the Society's earlier contributions in the development and diffusion of Geographic Knowledge is really an inspiration and strength for further work. The Society pledges to work for the advancement of the subject, as it did all these years, and looks forward with full optimism, despite its poverty, to another year of useful work.

UNIVERSITY CENTENARY BUILDINGS, MADRAS, January 20th, 1962.

M. N. Vasantha Devi, (*Hon. Secretary*).

THE INDIAN GEOGRAPHICAL SOCIETY

UNIVERSITY CENTENARY BUILDINGS, MADRAS-5

Receipts and Payments Statement for the year 1-1-61 — 31-12-61.

RECEIPTS

RECEIPTS	Rs. nP.	Rs. nP.
Balance as on 1-1-61		
Cash on hand ...	11 79	
Cash at Madras State Co-operative Bank Ltd. Current account ...	148 79	
Postage-Imprest ...	6 20	
Prudential Deposit A/c ...	11 60	
		178 38
Subscriptions:		
1960 ...	213 00	
1961 ...	1,025 00	
1962 ...	38 00	
		1,276 00
Government of India grant from Ministry of Scientific and Cultural affairs 5-1-61 ...		500 00
University of Madras grant ...		150 00
Sale of Back number journals and other receipts ...		651 20
Recovery from old staff ...		450 00
		3,205 58

PAYMENTS

PAYMENTS	Rs. nP.	Rs. nP.
By Printing and Stationery (includes cost of publishing the Society's journal) ...		2,236 96
Postage		403 96
Conveyance ...		30 05
Salary and Bonus ...		245 84
Bank charges ...	34 22	
Less interest receipt from Banks ...	3 90	
		30 32
		2,947 13
Balance at close 31-12-61		
Cash with Treasurer ...	12 92	
Cash in current account with Madras State Co-operative Bank Ltd....	225 06	
Postage imprest with Secretary ...	20 47	
		258 45
		3,205 58

Examined and found correct.
For C. S. HARIHARAN & CO.

292, Esplanade, Madras-1, 19-1-1962.

G. Kuriyan, *President.* — M. Meenakshi, *Treasurer.* — M. N. Vasantha, *Secretary.* — C. S. Hariharan, *Partner, Chartered Accountants.*

JL

THE INDIAN GEOGRAPHICAL SOCIETY

1962

PRESIDENT:

DR. GEORGE KURIYAN, B.A., B.Sc. (Lond.), Ph.D. (Lond.),
Professor & Head of the Dept. of Geography, University of Madras.

VICE-PRESIDENTS:

DR. MISS A. R. IRAWATHY, B.A., (Hons.), B.Ed., Ph.D. (Lond.),
Principal, Queen Mary's College, Madras-4.

DR. S. M. ALI, Ph.D. (Lond.), F.N.I.,
rofessor & Head of the Dept. of Geography, University of Saugor, Sagar, M.P.

DR. P. DAYAL, Ph.D. (Lond.),
rofessor & Head of the Dept. of Geography, University of Patna, Patna, Bihar.

PROF. P. G. DOWIE, M.A., L.T., Dip. Econ., M.S. (Chicago),
F.G.S. (Lond.), F.M.S., ETC.
Professor of Geology, Presidency College, Madras-5.

MR. A. TIRUMALAI IYENGAR,
Gotha Vilas, G.S.T. Road, Chrompet, Madras

SECRETARY:

MISS M. N. VASANTHA DEVI, M.A.,
Dept. of Geography, University of Madras.

ASST. SECRETARY:

MISS DORIS ATHANASIUS,
No. 8, Barnaby Road, Kilpauk, Madras.

TREASURER:

MISS M. MEENAKSHI, M.A.,
17-C, Aravamuthu Gardens, Egmore, Madras-8.

EXECUTIVE COMMITTEE:

MR. M. P. RAJAGOPAL, B.A., L.T., *School Assistant, Sir M.C.A. Muthiah Chettiar High School, Madras-7*

MRS. R. RADHA, M.A., *Lecturer in Geography, Queen Mary's College, Madras*

(from the Council)

MEMBERS OF THE COUNCIL:

MISS R. ALAMELU, *Queen Mary's College, Madras-4.*
DR. O. P. BHARADWAJ, Ph.D. (Lond.), *Government College, Ludhiana, Punjab.*
MR. P. P. GEORGE, *M.C.C. High School, Chetput, Madras. 31.*
DR. A. B. MUKERJI, *Osmania University, Hyderabad, Andhra.*
MRS. R. RADHA, *Queen Mary's College, Madras-4.*
MISS M. SITHALAKSHMI, *Queen Mary's College, Madras-4.*

Printed by T Kannabiran at the Paramount Press (Proprietors: Jaya & [illegible]
Triplicane and published by Dr. George Kuriyan, University [illegible]
Chepauk, Madras-5.