CHAPTER II

PHYSICAL SETTINGS.

Location is a geographical resource and forms one of the natural conditions which provide encouragement to the organised life of mankind. The city of Bombay is located on an Island intersected by 18° 55' N. latitude and 72° 54' E. longitude. Thus the city lies in the northern part of the torrid zone. The location of the city has an obvious control over the thermal conditions and points to a probable type of climate prevailing in the area. The city's location has not always, rather hardly, been an asset from the climatic point of view. The heat of the tropics and summer sultriness are certainly not congenial to physical efficiency, though winter is quite pleasant. The economic advantages, however, far outweigh the adverse summer climatic conditions which can partly be ameliorated by airconditioning indoors.

Situated on the Arabian sea coast which presents a compound type where emergence and submergence seem to have occurred in turn, the city possesses all the advantages of a coastal town. It has developed on an Island known as 'the Island of Bombay' - a full account of the evolution will be given in sequel - separated by a creek, called the Mahim creek, from the Island of Salsette which in turn is separated from the main land by another creek. Situated very close to the foot of the western ghats it not only charms the travellers and navigators by its unique panorama, but fulfills a great
LOCATION OF BOMBAY CITY

1: 5,000,000

Fig-2
physical need - that of rainfall.

A significant aspect of a town's location is sea-frontage. The sea plays and has long played an important part in human history, climatically, culturally, commercially, politically and otherwise. Ocean is a universal highway and so a coastal town can never be isolated. Notwithstanding the fact that a coastal situation has manifold advantages, all the coastal positions are not equally fortunate in their situation. Bombay has a most advantageous situation because of indented nature of the coast suitable for a harbour and the rich hinterland. The moderating effect of the Arabian sea water on the climate of the city is an added advantage which saves the citizens from the enervating summer days of continental interior and the cold of winter nights. Bombay has been a threshold of India to the western world being nearer to Europe than any other part of the country.

It has been much influenced by the western culture and has enjoyed the advantage of receiving maximum benefit from the trade with the European and middle east countries. Konkan and Malabar coasts were the parts of India where the western influence was first felt and ever since the inception of navigation and trade overseas, Bombay had the leading hand in the international trade of our country. This can be explained by the past trade relations between India and countries of British empire, specially U.K. under the British rule. Bombay because of its situation on the western most fringe
of India provided anchorage to the European ship and attracted their early notice.

A town especially a port, is very often likely to suffer competition from the neighbouring town. As for Bombay, the Pakistan port of Karachi does compete in trade, but the former being a representative Indian port receives its due share, which would have been certainly affected in the case of another Indian port existing near Bombay with almost similar facilities. Situation of the city of Bombay in some respect can be compared, with the coastal cities of the Appalachian region of U.S.A., especially with New York. Coastal position, deep sea anchorage, rich hinterland mountainwall on the back and easy availability of water and power are some of the identical features in the two cases. A very unique advantage that Bombay is having over many Indian cities is the cheap water power. The heavy rainfall of the Western ghats is rushed over the steep slope and is harnessed for human use. Some sixty miles from Bombay hydel power is generated at the foot of the Sahyadries near Lonavala at a place called Khapoli.

Site conditions - A first hand idea of location and situation appear incomplete if the site conditions are not portrayed to give an overall idea of surface features that might have encouraged the growth of the city. The study of the site condition is limited to the immediate vicinity and the nature of the earth's surface occupied by the city.

Among the considerations which have determined the choice
of site selection in the past convergence of routes, availability of water and a site of defence as a place of shelter were some of the considerations for the old cities. Boundaries of two different natural regions, focal point of some region to cross a barrier as a pass or river valley traversing a mountain, and fall lines were some of the considerations during the medieval ages. In modern days the economic growth of a region and its potential resources offering economic opportunities provide the base for a town. The history of the development of Bombay shows that but for the harbour the site had little attraction, nor can it be said to have been suitable. The marshy nature of the creeks and the forest covered Islands with their venomous air could have hardly exercised any temptation on the minds of the Portuguese. The Europeans were primarily attracted because of harbour potentialities and the necessity of having a naval base secure from the booming guns of the enemies from the mainland.

Regional setting - Bombay forms the northern terminus of what is called the Konkan, the coastal strip along Arabian sea north of Goa. Paradoxically enough, the region in which Bombay is located is not well developed as a whole and very much leans on Bombay for its support. Subsistence farming characterised by rice cultivation, fishing and forestry are the chief features of the economy of this region. The regional support, therefore, to the growth of the city is cut to the minimum. The city has grown, on the contrary, out of the opportunity
provided by the historical and economic necessities of the people alien to this region and even the mainland. Specially in the pre-British days the city received all encouragement not emerging directly from the mainland but as a result of the historical forces operating over a much larger area including even some European countries.

Bombay which initially developed as a port town did not derive so much of benefit from its regional settings as from the prosperity of its hinter and foreland. In fact, the sphere of trade including both hinterland and foreland and their economy together with maritime organisation play the same part in the development of a port as the regional settings in case of an inland town developed to cater to the needs of the region. The regional influences in case of Bombay manifest themselves not so much in the economic development of Bombay as in the linguistic composition of its population, and the nature of its migration field. It is observed that a large percentage of the working force of the city is derived from Konkan, which is very densely populated. Of all the linguistic groups Marathi claims the majority.

THE EVOLUTION OF THE ISLAND.

In the remote geological times Bombay formed a part of the mainland of India. A number of successive earth movements subsequent to the volcanic activity, which occurred at the beginning of the tertiary era, caused faulting along the present west coast of India. Nothing is said definite about
the age of this fault which disassociated the group of Islands now called Bombay from the mainland. Probably, the fault is of post Deccan - trap period as late as pliocene. This is quite evident from the fact that the Deccan traps are several thousand feet thick along the Bombay coast and gradually thin down eastwards. During this period the existing ridge of the Western ghats must have been broken up into several Islands lying off and fringing the Western coast of the Peninsula.

Stratigraphically the Island appears to consist of a conformable series of the 'deccan trap flows' intercalated with the freshwater sedimentary beds. The general dip of the rocks is 10° to 15° towards the west and the general strike is N.10 E. to S.10 W.

The rock formations in Bombay point to four active periods in the history of their evolution (Fig. 3):

(1) The first period was one of the later volcanic effusions of the Deccan lava flows which forms the basis of the Island, though it has not been geological established without any controversy.

(2) The second period marked by fresh water deposits - The

2. Ibid p.60.
3. 'It is possible that the base of the Island was formed by a still earlier series of volcanic or trappean effusions upon which the fresh water formation was subsequently deposited, but definite evidence of this fact is not forthcoming and the theory, although plausible still lies within the limits of conjecture' Gazetteer of Bombay city and Island Vol.2 p.70.
GEOLOGICAL MAP
OF
BOMBAY ISLAND

CLAY
VOLCANIC BRECCIA
BASALTO DIORITE TRACT
FRESH WATER DEPOSIT
3RD EFFUSION

BEACH
DYKE, 4TH EFFUSION
AMYGDALOID
2ND EFFUSION
4TH EFFUSION

FROM: GAZETEER OF BOMBAY CITY & ISLAND
lacustrine deposits in the middle of cretaceous or eocene epoch is by far the oldest among the series of formations occurring over Bombay. This was a period of quiescence. It is possible that the lacustrine fresh water deposits originally extended all over the Island of Bombay. Its present position in some localities appears to be under the overlying highest lava flow of the series and resting on an amygdaloidal basalt which is subsequent secondary effusion of the nature of an intrusive sheet - a sill. There are strong indications that it must have been deposited subsequent to some volcanic effusions.

The thin layer of fresh water deposits is composed of material volcanic in origin and contains much organic matter in a fragmentary condition. The gradual, gentle and slow deposits of the sediments prove it to be one of a lake rather than of a running stream. The long periods of repose during which the lakes were formed intervened between the successive outflows of lava which spreading over an uneven land surface, cut into hills and valleys by subaerial denudation must have dammed up the valleys and the streams and converted them into lakes.

Other flows might fill up the first lakes but would produce fresh ones by isolating fresh hollows, for the flows however liquid, could not have presented an absolutely plain

1. H.J. Carter ' Summary of the Geology of India' Bombay 1857 quoted from the Gazetteer of Bombay City and Island.
surface and the outbursts from different foci must have crossed and dammed up the hollows between flows from the same crater.

(3) The third period - This period is marked by the last volcanic effusion of the deccan trap lava flows forming the highest and therefore the youngest lava beds in the series. At the outset of this period it is assumed that Bombay consisted of great lakes above the level of the sea, though owing to subsequent depression the general position of its strata now lies below sea level. This volcanic period is marked by 4 minor effusions in the Island which very probably are responsible for the present topography of the Island.

Secondary effusions of the third period.

(a) The first effusion appeared in the form of Basalto dioritic trap which covers the main ridges and was once probably continuous all over the Island. This is a typical volcanic rock and must have been much thicker than it is now. It is 90' thick on the eastern and 51' on the western side of the Island.

(b) The second (secondary) effusion - Immediately after the preceding effusion the site of Bombay must have been a black and arid plain, which became adequately hardened in due course. The effusion, however, came up under the main flow and met with serious obstacles caused by the overlying Basalto -

1. Blanford W.T. 'Sketch of the Geology of Bombay presidency printed in records of the Geological survey of India Vol.5.'
diorite trap. Finding no way out this second effusion forced itself forming a sill between the basement lava bed and the fresh water staļa underlyng the highest lava flow intercalating and breaking them up. The effusion which had obtained the amygdałoidal character apparently could not burst through the overlying highest lava flow and was most probably responsible for raising up the longitudinal ridges.

(c) The third secondary effusion - This is called as volcanic breccia. This combined with the second or amygdałoidal effusion to raise up the two longitudinal ridges which at present border the eastern and the western sides of the island. The effusion consists of the fragments of the two previous effusions and the fresh water formation. To this effusion of volcanic breccia is ascribed the great irregularity of the land in the vicinity of the island.

(d) The forth secondary effusion - This is proved by the existence of dykes of volcanic breccia through the third. After this the active volcanic effusion on the island appears to have ceased.

(4) The fourth period - This is characterised by the cessation of volcanic activity and the deposition of estuarine clay

and marine sand in the area. These marine deposits belong to the post pliocene epoch. The strata are composed chiefly of blue clay imposed upon trappean rock or occasionally upon the inter trappean lacustrine formations, where the latter had been denuded. The strata from the lowest are composed of blue clay, shall concrete and upper alluvium.

**Rocks**

The following are chief varieties of rocks frequently visited over Bombay.

**Green Stone** - Bombay like most of the neighbouring islands is chiefly composed of trap, but in consequence of successive volcanic effusions the trap assumes a variety of formations. Of these the most widely extended is green stone found at Kolaba, Naoroji hill, Chinchpoghly, Parel, Love grove and Varli. It covers about 1/5 of the whole island and appears both in columnar form and in detached masses being occupied by decomposed rocks. The higher beds of green stone are hard dark crystalline and are broken with difficulty while lower beds fracture easily and are well suited for building purpose.

**Basalt** - It occurs both in columnar and stratified forms.

Basalt in Malabar has a columnar structure but it turns

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stratified in Mahalaxmi. At many places it is traversed by greenish veins. It is easily breakable into petals though it has not got a superior binding property.

Chert - It composes the promontory of Sewri. In its appearance it greatly resembles the basalt of Malabar hill, but it has the specific gravity of Jasper. It is also marked by considerable traces of stratification.

Besides, there are some other varieties but are not widespread.

The crustal movements in the island

The possibility of earth movements after a series of effusions and later depositions is strongly advocated. The posture of the marine formations proves that the island subsequent to the cessation of the volcanic activities has undergone a series of upheavals and subsidences. Evidences are available which show that both uplift and subsidence have taken place. There have been a few minor movements of secular upheaval and depression along the coasts within the past as well as recent times. Of these, the most important is that connected with the slight but appreciable elevation of the peninsula exposing portions of the plain of marine denudation\(^1\). The steep face of the sahyadri mountains, looking like a line of sea -

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cliffs and their approximale parallelism to the coast lead to the inference that the escarpment is a result of a recent elevation of the ghats from the sea and the subsequent sea action modified by subaerial denudation. The phase of subsidence is very recent as is proved by the occurrence of submerged forests in princess dock area.

'After the Deccan trap volcanic activity had filled up the hills on the fresh water swamps on the mainland and these hills had by subsidence of the western coast of India broken off the main land and cast into the sea as islands and had there remained undisturbed long enough to allow the deposit of the silt which now forms the stratum on which lies the blue clay, there came an upheaval that raised the greater part of the islands above high water mark and exposed then to the action of the weather. So the lower alluvium had originally been a marine deposit—blue clay or silt most probably—which on being elevated and long exposed to the air and rain had acquired the peculiar appearance.

Prof. Kalapesi believes that the blue clay was devoid of any organic matter and it must have been allowed to remain undisturbed for a long time sufficient to allow the growth of trees (Acacia catechu) known as 'khair' trees of the submerged forest found during the excavations of prince's dock and Alexandra dock. The followed a subsidence sufficient to allow the trees to be completely covered by muddy silt. The submerged forests are a definite pointer to the fact of submergence. On the other hand, the western side of the island, the present Esplanade which is not more than a mile from the dock is composed of littoral concrete, the materials of which when first deposited must have formed a beach or sand bank below high water mark. Apparently it seems that there have been alternative movements of emergence and submergence. The alternation of elevation and depression is supposed to have been rendered probable by the fact that the two movements can scarcely have occurred simultaneously over so small an area as that of the island. This seemingly logical argument fails to explain many of the difficulties that arise by resorting to alternative movement.

1. The Gazetteer of Bombay city and Island Vol 2 p 76.
The evident emergence of coastline on the back. Bay side and the submergence on the harbour side appear inexplicable, if the whole island is taken to have been uniformly affected by a single movement.

It appears that a three dimensional movement has occurred which associated with the fault has given rise to elevation on one side and the subsidence on the other.

**EARLY PHYSIOGRAPHY**

Some four hundred years back the present Bombay city did not exist and had in its place a cluster of seven islands longitudinally arranged (69, 5). These seven islands which form the basis of the structure of the present island of Bombay, were hilly. Several of these hills that were not very prominent have now been levelled down. There were two more or less parallel lines of ridges. The western ridge from Worli to the steep cliff of Malabar point is part of a basatic extrusion discussed under Geology which runs as a great sea wall from Bassein to Alibagh, a distance of 70 miles broken only by creek opening into Bombay harbour. The eastern ridge was a mass of trap mostly greenstone, which though continuous from one end of the island to the other often sinks to sea level and is in places traceable only in wells and quarries. The chief gaps in these two lines of hills formed the breaches.

The southernmost of the group of islands was Colaba. The Kolis lived in this island which was named after them
as 'Kolibhada', and in due course by progressive
deformation became Colaba. The present Colaba of Bombay
is composed of not only one island of Colaba, but merged
in it is also the personality of another island called the
'old women's island'. Before Bombay developed to its
present status, Colaban and old women's island were separated
from each other by a breach-somewhere near the demolished
B.B. & C; I-railway station of Colaba - which was not
formidable and was only covered by the sea at high tides.
Later, both the islands were linked by a causeway under
one name 'Colaba.' Lower Colaba is old women's island and
the upper Colaba is the original Colaba.

The old women's island and the island of Bombay were
separated by a deeper channel about 800 yds wide. This
channel was usually crossed by a ferry worked with rope.
The creek was, filled up and a causeway was built in 1853.
The area now occupied by the Fort as well as the part of the
city upto Pydhonie belonged to the island of Bombay. This
area had direct contact with the other parts of this island
esp ecially Malabar hill along the sandy beaches.

The sea in the past encroached upon the areas which
now form the central part of the city especially at the time
of high tides. The only village on the island was 'Girgaum'
located somewhere on the projecting spur of the Malabar hill
on the Back Bay shore. The eastern side of the island (Bombay)
was bounded from the north by a rocky ridge called Dongri.
The next island - the island of Mazagaon - was separated from the island of Bombay by a creek called Umardhadi or 'Fig tree Creek'. The creek extended from the eastern sea to the west up to the point, where the present Pydnonie is located. It seems the most extension of Umardhadi merged in the central low land at Pydhonic, where the people coming from Mahalaxmi, Salsette and Mahim used to have foot-wash before entering the island sanctified by the temple of 'Mumba-devi'. The creek, however, evidently seems to have been silted up by the time the British occupied Bombay.

The fourth island across the fig tree creek, named Mazagaon was perhaps a hamlet of fishermen and was named after them. This island was gradually sloping to the central lowland giving rise to marshy land on the extreme west where now stands Byculla.

North of Mazagaon was another island with very irregular coast, and possessing a number of villages like Parel, Sewri, and Sion. This island was separated from Mazagaon by a shallow valley named 'Chinchpogi', the dale of tamarinds. North of this valley on the island lay the village of Parel to the west and Sewri to the east. The land had a gentle slope from Sewri to Parel. The northern most extremity of this island was marked by a village called Simva - which means boundary. This seems justified in its setting as the present Sion which is a Portuguese corruption of Simva forms the northern boundary of the island. The northeastern limit was marked by a hill, still
existing in the form of a hillock, where stood the fort of Sion.

West of the island roughly parallel to it was Mahim separated by a breach which was filled up in 1710. The breach had to be crossed in stages in order to reach Mahim. The first breach was between Sion and Rewa, the second was between Riwa and Dharavi and the third was between Dharavi and Mahim. All these breaches together were designated as breach of Sion.

The present Mahim fort is situated on the Nw. most point of the island of the same name. During the 16th Century Mahim was a port and the sea between Bandra and Mahim was the harbour for the sailing vessels. The port was located on the other side of the creek, now called Bandra. Unlike the En. face of the island, the Wn. shore has been marked by beach deposits. Mahim had a beach which has still retained its form between Mahim and Worli.

The breach between Mahim and Worli was not very large and was passable at low tide, though at high tides huge amount of water used to rush in towards the central flat of these islands. Beyond the island of Mahim to the south lay the island of Worli. The most noteworthy feature of this island was a fine grove of banyan trees (Ficus Bengalensis) and this gave rise to the name 'Wad ali' i.e. Banyan Row which later on became Worli.
The island is the last of the seven islands marking the Wm. limit of the island of present Bombay. The island of Worli had on the extreme north point a promontory and a landing ground. The southern and is marked by a precipitous fall into the great breach, the largest of all between the Sn. point of Worli and Mahalaxmi, the northern most point of Cumballa hill.

The breach which was the biggest was the widest inlet for admitting sea water at high tide, which covered practically the entire lowland enclosed by the islands on the periphery. The water through this breach used to rush over Cumballa sweeping the area now occupied by Bellasds road, Grant road and even Khetwadi. The Hornby Vallard which was constructed during the governorship of Mr. Hornby in 1783, closed the breach and rendered available for settlement and cultivation wide stretch of land. This welded together the En and Wm. shores of the island into one united land mass.

Surrounded by these islands in the middle was the low lying area which turned marshy at the time of low tide and used to get inundated at high tides. In fact the structural identity of all the islands was not manifested in their surface feature and they were supposed to be seven islands in place of one.

**The present surface configuration**

The most outstanding physical appearances on the island
of Bombay are the two longitudinal ridges bordering the island from the east and west and progressively showing a tendency for convergence as they move to the south. Enclosed between the two is a shallow lowland which is the reclaimed area formerly occupied by the waters of high tide. The two marginal ridges, however, are not continuous, but their direction is clearly shown by small hillocks, which have occasionally risen into prominence. The wn. ridge is quite bold between Malabar and Cumballa points and is composed of black lava, andesite. This runs for about 3 miles with a width of \( \frac{1}{2} \) mile and has attained an elevation of about 200 feet above sea level. The hill shows an asymmetrical slope with gentle on the west and a steep gradient on the En. side. The hill beyond Mahalaxmi to the north is not regular and appears very prominently only in Worli.

The other ridge extends from Colaba northward all the way to Sion fort on the En. side of the island facing the harbour. Instead of forming one continuous ridge like the one from Walkeshwar to Mahalaxmi it often sinks down to the level of the sea where it is covered with alluvium and is only traceable in wells, quarries and other excavations. It sometimes rises in knolls and little huts of about 100 feet in elevation e.g. Mazagaon hill, Sewri hill, Parel hill etc.

The central part of the island now built up is a low lying plain almost flat (about \( \frac{1}{4} \) of it being really under
the level of the sea). This level plain between 2 lines of high rocky ground on its west and east is evidently of different formations. It seems the §ni portion facing the Back Bay was sandy partly due to elevated sea beaches and partly due to its elevation. This is also obvious from the dense growth of Coconunt palm indicating a sandy soil. The leave treeless rice fields stretching away northwards show that the soil here was clayey, though along the Mahim shore again the soil is sandy.

The pattern of relief traced over Bombay does not seem to end here but appears to continue even on Salsette island.

The shorelines.

The shoreline of Bombay is a part of the indented-shore line of the Konkan coast. It is marked by a number of creeks and indentations. The development of the island has rounded the angularities of the shorelines and obliterated the fretted nature of the shore.

The wn. section of the shoreline presents a large number of beaches and shallow water. The existence of Mahim sea beach, Worli sea beach and Chowpati sea face on the Back Bay all point to some likely emergence of the coast in the western part of the island. The eastern shore on the other hand is deeper, probably a result of submergence. The En sea face, though deep is studded with prong reef and is very risky for navigation and piloting is compulsory for all the entering
ships. The harbour is, strictly speaking, a part of Thana creek which encloses the island beyond salsette.

The Thana creek, which was the scene of heavy traffic in 16th century has the disadvantage of receiving a number of rivers from the slopes of W. Chat. These rivers are debouching silt in the creek which gradually slipping down reaches the harbour area, which is being silted.

The shallow water of the Back Bay and Mahim Bay provide not only good fishing ground but also a recreation ground for the people.

The climate of the city

"Of all the factors that may assist or retard the development of a nation, the most important is climate" says Markham while making a geographical analysis of the climatic elements and their reflection in human behaviour. "Great men come and go and their wisdom is often undone by the successors less noble, laws rescinded, races intermarry with other races, economic resources vary in importance with changing needs, but climate fickle and changeable as it is, is still the most stable, the most consistent and in many ways one of the least controllable of all the external effects that influence men".

Climate holds a lion share in the geographical control caused by environmental factors. Cultural landscapes like

roads, towns and other vestiges of human civilization always bear the imprint of climate on their designs. The pattern of the city, type of architecture, layout of streets and location of the town in general are considerably influenced by the climate directly or indirectly.

Not only have some geographers tried to explain the development of civilization by climatic factors, the growth of towns in particular has been shown to bear some relation with climate.

Subtle in its style, the morphology bears necessarily the imprint of climatic influence and the human and economic activities also keep climate as one of their guiding considerations. The climate of Bombay, though tropical in its broad features in often marked by departures from the normal. Lying within the tropics the city never experiences the extreme temperature conditions of the continental interior because of its favourable location on the Arabian sea shore. It has two maxima and one minimum of temperature annually, but local breezes prevent the temperature from rising or falling to the extremes. Inspite of the apparent advantages which emerge from

1. Taylor G. has shown by an 'isopract graph' the control of temperature and rainfall on the location and 'Urban Geography' p.176 fig.29. The universality of this graph, however is subject to serious doubts.
the proximity to the Ocean, the relationship between temperature and humidity conditions of the atmosphere shows that the conditions are not always suited to human comforts (fig 9b). The three months of monsoon are very rainy and timely heavy showers sometimes badly interrupt the daily routine of the people and suspend the city's transport services for hours. The October heat is quite oppressive. Bombay is at its worst in three summer months from March to June; the suffocating sultriness is dreaded by everybody.

Temperature: Being located near the tropic of Cancer the temp. varies with the season and march of the sun. During July the city experiences the maximum amount of temp. when the sun is shining vertically over the cancer. Since Bombay is located slightly south of the tropic of Cancer, sun is vertical on Bombay in the last week of May and the first week of July. This can be verified from the 5 day normal table of Max. Min. temp. for Bombay, in which the temp. begins rising in the third week of March remains almost stable till the third week of April and rises gradually to the maximum for the year in the last week of May and the beginning of June (fig 6). There is no trace of any sharp rise or fall of temp. as in case of an interior town. In May the means of daily maximum and minimum are 91.9 F. and 79.6 F. respectively. The temp. in June is less than May. This seems to be the obvious result of early advent of Monsoon in Bombay. On the other extreme January is the coldest month of the year. Notwithstanding the latitude of the place, Bombay retains a fairly good temperature even in
TEMP, HUMIDITY AND RAINFALL IN BOMBAY

MONTHS

RAINFALL IN INCHES

RELATIVE HUMIDITY IN PERCENTAGE

TEMP. IN F°

R. HUMIDITY

Fig. 6
January and the conditions are quite energising for human energy. The mean for daily maxima of Jan. is 83.2, whereas for daily minima it is 66.7 (Fig—). This is a temperature within the range of climate conditions for brisk human activity.

Table I - Monthly Mean Maximum and Minimum Temp.

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<td>86.2</td>
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<td>14.3</td>
<td>13.0</td>
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<td>91.6</td>
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<tr>
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<td>75.7</td>
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<tr>
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<td>22.1</td>
<td>24.4</td>
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Range of Temp. A high range can not be expected at Bombay, because of its coastal position. The month with the maximum range of temp. is Dec. From the symmetrical curve showing the annual range of temperature, it is obvious that it is the daily minimum which mostly determines the range in case of Bombay. Because of comparative higher radiation as a result of low humidity, Dec. shows the lowest daily minimum of temperature.

1. Climatological tables of observation is India Govt. Central Press Bombay p.295
and also the highest daily range of temp. Though the coldest month is January, it does not necessarily provide a clue to infer that it will show the maximum range. Mean minimum of the months in winter is adequately affected by surges of secondaries which are brought from the Mediterranean in an attempt to avoid the continental high prevailing over central Asia. These secondaries some times visit Bombay also following a sinuous line. With the approach of the sun on the latitude of Bombay range is also reduced. A not very prominent cause for lowering down of range is also the latent energy of the Monsoons, which do not allow the minimum to go too low. Cloudiness is another very important factor, which causes blanketing effect, prevents terrestrial radiation and releases heat at the time of rainfall. All these factors combined together work in summer. On the other hand during winter the sky is clear and offshore winds also sometimes descend down from the Sahyadris. In addition to that the temp. is also low because of latitudinal shifting of the sun and this leads to a lower mean minimum and higher range.

The diurnal variability of temp. which is so important from the point of view of weather suitability shows the average change in temp. from day to day, the magnitude of which practically determines the degree of severity of the climate affecting organic life. The average variability during the year is 0.76 per day. It is 0.96 in June, and 0.83 and 0.84
in January and February. The change in temperature from
day to day is least in May (0.42) which is generally the
healthiest month in the year.

Five-day normals of the Maximum, minimum and
average temp.

(See on the next page.)

From the five day normal table of temperature for
certain months it is obvious that variability as calculated
in the gazetteer is very high.

Increase in variability is the result of atmospheric
restlessness, caused either by monsoon, storms or by the
factors which have a modifying effect on temperature. In
Bombay the variability of temperature in the month of June
is the result of cumulative force of monsoon and its effect
to cool the atmosphere. A very surprising statement in the
gazetteer is that May is the healthiest month. No geographer
can believe it in face of the existing weather conditions of
high temperature and humidity making the weather more sultry
and enervating.

Pressure-Conditions: Pressure conditions are not unstable
in Bombay and a fair degree of stability is marked, though
it fluctuates timely with the march of sun and the temperature
change. Dynamic causes do not disturb the pressure nor do they
induce a change in the atmospheric calmness. There is smooth-
news in the pressure curve as recorded on the graph (Fig—).

1. The Gazetteer of Bombay city and Island Vol.2
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1st to 5th</td>
<td>84</td>
<td>82</td>
<td>90</td>
<td>91</td>
</tr>
<tr>
<td>6th to 10th</td>
<td>63</td>
<td>67</td>
<td>73</td>
<td>80</td>
</tr>
<tr>
<td>11th to 15th</td>
<td>74</td>
<td>74</td>
<td>84</td>
<td>85.5</td>
</tr>
<tr>
<td>16th to 20th</td>
<td>83</td>
<td>82</td>
<td>84</td>
<td>90</td>
</tr>
<tr>
<td>21st to 25th</td>
<td>67</td>
<td>67</td>
<td>85.5</td>
<td>91</td>
</tr>
<tr>
<td>26th to 31st</td>
<td>75</td>
<td>74.5</td>
<td>85.5</td>
<td>91</td>
</tr>
</tbody>
</table>

1. 'Five day normals' Indian Meteorological department, Govt. of India 1931
Max, Min, temp. and accumulated rainfall.
Abseence of any sudden change or departure from the normal inclination indicates the probability of a single cause operating all the year round leading to pressure variation. January shows the maximum air pressure whereas the minimum is recorded in July. Pressure seems to be decidedly determined by thermal causes. Bombay records the least amount of insolation in January and the contracting tendency of the air causes an increase of pressure. The condition is reversed in July when the excessive heating of the island increases the volume of air which seeks relaxation by moving aloft and creating a low pressure over the island.

**Table Pressure Condition**  (See on the next page)

The average pressure for the whole year is 1007.65 mbs. The average pressure for the whole year recorded at 8 hrs. is slightly higher than that noticed at 17 hrs. in the afternoon. This phenomenon is due to the nocturnal radiation which considerably lowers down the temperature and causes consequent increase in pressure in the morning; whereas in afternoon at 17 hrs. accumulated insolation during the day and movement of the wind aloft. This reduces the pressure. The decrease in pressure is caused directly by increase in temperature.

**Humidity** - Absolute humidity is mostly a matter of temperature in Bombay. The greater the temperature the more will be the absolute humidity, because the air mass on the island can
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1013</td>
<td>1010, 1009</td>
<td>1007, 1004</td>
<td>1013</td>
<td>1012</td>
<td>1010</td>
<td>1007</td>
<td>1007</td>
<td>1006</td>
<td>1005</td>
<td>1003</td>
</tr>
<tr>
<td>Average</td>
<td>1012</td>
<td>1011, 1009</td>
<td>1007, 1005</td>
<td>1012</td>
<td>1010</td>
<td>1007</td>
<td>1006</td>
<td>1006</td>
<td>1004</td>
<td>1003</td>
<td>1003</td>
</tr>
</tbody>
</table>

suck up plenty of moisture from the sea. Besides the sea breezes import moisture, to assimilate which is mostly a matter of temperature. This condition may coincide with the relative humidity, but this is not necessarily the case. Relative humidity is not directly proportionate with temp., because decrease in temperature with the same absolute humidity increases the relative humidity. Relative humidity is subject to modification due to impact of monsoon.

In Bombay, since the warmest and the rainiest months are almost coinciding, the relative humidity is following the line of absolute humidity.

Relative humidity for various months.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3 hrs.</td>
<td>73</td>
<td>74</td>
<td>76</td>
<td>73</td>
<td>77</td>
<td>82</td>
</tr>
<tr>
<td>17 hrs</td>
<td>61</td>
<td>61</td>
<td>60</td>
<td>65</td>
<td>67</td>
<td>73</td>
</tr>
<tr>
<td>Average</td>
<td>67</td>
<td>67.5</td>
<td>63</td>
<td>71.5</td>
<td>72</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8 hrs.</td>
<td>36</td>
<td>36</td>
<td>33</td>
<td>34</td>
<td>76</td>
<td>73</td>
</tr>
<tr>
<td>17 hrs</td>
<td>34</td>
<td>81</td>
<td>79</td>
<td>71</td>
<td>63</td>
<td>59</td>
</tr>
<tr>
<td>Average</td>
<td>35</td>
<td>83.5</td>
<td>83.5</td>
<td>77.5</td>
<td>69.5</td>
<td>66</td>
</tr>
</tbody>
</table>

The lowest recorded relative humidity in the whole year comes in the month of December when the humidity is 66%. In

---

January and February also the relative humidity is fairly low, though the temperature in these months is lower than the average and consequently one can speculate an increase in relative humidity. But this decrease in temperature also affects the moisture holding capacity of the winds. Apart from that, the weakening of the sea breezes in winter also does not allow the relative humidity to be very high. Another factor of secondary importance is the blowing of easterly land winds during winter which are dry and comparatively colder and therefore reduce the relative humidity.

After the winter till May the humidity increases owing to the rapidly increasing force and duration of the westerly breezes, inspite of the retarding drying effects of the seasonal rise of temperature. The temperature falls in June because of the advent of Monsoon and helps to increase the relative humidity. The increasing vigor of the south west monsoon adds to humidity figure and that reaches about 35% in the middle of July, when the south west monsoon has attained its fullest force.

A very striking phenomenon in this connection is the steady nature of humidity after the month of July. From July onward till september a fairly high relative humidity prevails, because of the moisture laden monsoon winds coming from the Arbian sea. The cessation of S.W. monsoon again withdraws the moist affects of its winds and reduction in temperature again
reduces the absolute humidity directly and relative humidity indirectly. Humidity conditions on the whole are not very satisfactory as a factor of climatic control to the healthy life of Bombay.

Winds - Atmospheric movements are important as a potential cause to determine the climate of a place. They constitute a complex phenomenon involving two factors - velocity and direction. The average of the total movement of winds over Bombay for the whole day shows a velocity of 11.9 miles p.h.

The maximum velocity of winds is reached during the month of July, when the average speed of wind is about 18.3 m.p.h. This is followed by a gradual average decrease, which comes to about 9.3 miles in the month of October. After October the conditions seem to be somewhat stable and the wind velocity has a very steady nature with slight disturbances because of the reversal of monsoons. After December the velocity again begins to rise and velocity noted in the month of March is as high as 11 m.p.h. A slight fall in May is experienced because of increase in humidity and the lack of impulse for the on-shore winds to blow, but again with the advent of Monsoon the velocity shoots up to the maximum in July. A very important cause for maximum velocity in the summer months is also the establishment of a steep barometric slope, which induces the stormy monsoons.

Wind velocity in Bombay in different months.

(See on the next page.)
### TABLE V

*Induces the stormy monsoons.* (Wind velocity in Bombay in different months.1)

<table>
<thead>
<tr>
<th>No. of days with force</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 8 or more</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. 4 to 7</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>10</td>
<td>17</td>
<td>16</td>
<td>9</td>
<td>15</td>
<td>21</td>
<td>15</td>
<td>17</td>
<td>8</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>c. 1 to 3</td>
<td>31</td>
<td>27</td>
<td>30</td>
<td>23</td>
<td>23</td>
<td>13</td>
<td>10</td>
<td>16</td>
<td>26</td>
<td>23</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>13</td>
<td>14</td>
<td>14</td>
<td>22</td>
<td>15</td>
<td>10</td>
<td>16</td>
<td>23</td>
<td>23</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>d. 0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

I. Readings taken at 8 hrs

II. Readings taken at 17 hrs.

The calculation of average in case of wind is not a quite true picture of the prevailing wind. It presents a lot of complexity and uncertainty. It is possible that most stormy winds sometimes show the minimum average wind velocity. For example December in Bombay is ordinarily a month of low average velocity. Majority of the winds hardly keep a range of 1 to 3 of the Beaufort's scale and the frequency of winds in the range of 4 to 7 seems to be insignificant, yet sometimes the strong gales are experienced in Bombay. These may be because of the secondaries originating in the Mediterranean in the winter.

Predominantly the winds keep a velocity of 12 to 15 miles per hour for the whole year as is apparent from the table making July an exception when the monsoon force adds to the general force of the winds. This additional force of Monsoon partly continues till October when 50% of the winds have got a velocity more than 15 miles. But from September onward winds attain their usual velocity of 1 to 15 miles.

A very prominent feature of wind velocity is its diurnal variation. The observations recorded show that the normally the winds in the morning are feeble and those observed at 17 hrs are comparatively faster. This can be explained in the light
of nocturnal radiation making the winds all the more weaker in the morning and setting up of the convectional currents in the afternoon. This is the case all the year round barring July when the wind velocity is invariably the same all the 24 hrs.

The frequency of days showing velocity more than 15 miles p.h. is observed as a rule more at 17 hrs. whereas at 8 hrs it is almost insignificant.

Wind Direction: The direction depends generally upon the barometric slope which is reversed with the oncoming of winter, and also on the direction of permanent or periodic winds. The normal wind system is determined by two contrasting sets of periodic atmospheric movements which are dependent upon the reversal of temperature and pressure conditions over land and water. These movements are seasonal and diurnal. The normal monsoon winds are dependent upon the difference of temperature and pressure over a large area extending from Pacific and Indian ocean on the south to the central plains of Asia on the north, modified by local conditions. Similar conditions restricted to a much smaller area also guide the land and sea breezes.

Considering the changes in the wind direction it can be seen that directions are set seasonally. During winter starting from November we get the northerly component gaining in strength. From the frequency table given below it can be seen that in November in the morning hours North east to Easterly
WIND DIRECTION FREQUENCIES
AT BOMBAY

LENGTH OF LINES FROM THE CENTRAL CIRCLE IS PROPORTIONATE TO THE FREQUENCY OF WINDS FROM A PARTICULAR DIRECTION

N.B. THE CENTRAL CIRCLE REPRESENTS CALM
winds are predominant, while in the afternoon North west winds become vigorous. This seems to be induced by the local breezes which generally flow from land to sea in the morning and sea to land in the afternoon.

Table showing frequency of winds from different directions

<table>
<thead>
<tr>
<th>Month</th>
<th>North</th>
<th>North East</th>
<th>East</th>
<th>S.East</th>
<th>South</th>
<th>S.West</th>
<th>West</th>
<th>N.West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>15</td>
<td>43</td>
<td>31</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feb.</td>
<td>19</td>
<td>37</td>
<td>30</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mar.</td>
<td>23</td>
<td>27</td>
<td>30</td>
<td>19</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>13</td>
<td>56</td>
<td>0</td>
</tr>
<tr>
<td>Apr.</td>
<td>21</td>
<td>12</td>
<td>13</td>
<td>16</td>
<td>11</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>13</td>
<td>63</td>
<td>0</td>
</tr>
<tr>
<td>May.</td>
<td>13</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>7</td>
<td>9</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>13</td>
<td>35</td>
<td>43</td>
</tr>
<tr>
<td>Jun.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>23</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>Jul.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>29</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>26</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>Aug.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0</td>
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<td>0</td>
<td>1</td>
<td>13</td>
<td>34</td>
<td>39</td>
</tr>
<tr>
<td>Sep.</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>0</td>
<td>16</td>
<td>9</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>34</td>
<td>39</td>
<td>1</td>
</tr>
<tr>
<td>Oct.</td>
<td>9</td>
<td>31</td>
<td>31</td>
<td>13</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>Nov.</td>
<td>4</td>
<td>40</td>
<td>43</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Dec.</td>
<td>6</td>
<td>44</td>
<td>41</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>63</td>
</tr>
</tbody>
</table>

Cloudiness: Cloudiness is important in the climate of a place because it helps to prevent terrestrial radiation and also effects insolation because of direct absorption and reflection phenomena. This also serves as a potential agent for making the atmosphere more restless. This is possible because of the latent heat in the vapour, which is released in condensation.

Clouds also serve as an indication of the amount of rainfall that is expected. An overcast sky is ordinarily supposed to be a greater potential store of precipitation that a clear sky.

Usually in the western part of the peninsula i.e. south of Kathiawar the monsoon is associated with steady rain without thunder storms. The clouding is of sheet type, also stratus, strato cumulus and nimbo stratus and sometimes fracto nimbus.

During the winter months the cloudiness is comparatively smaller. This has the background of off shore winds which do not bring any amount of humidity. The mean cloudiness from November to April is 1.5 whereas from May to October it is 6.4. This increase in cloudiness in summer can be accounted for by the break of S.W. monsoon, which sweeps over the Arabian sea and being moisture laden condenses because of forced ascent due to the Western Ghats (\textsuperscript{\textcopyright} S.L. Malurkar)

The table given below gives a fair idea of the cloudiness over Bombay. The mean cloudiness for the whole year is 3.9.

\begin{itemize}
  \item Observations made at 8 hrs.
  \item Observations at 17 hrs.
\end{itemize}

---

1. Malurkar S.L. 'Notes on the analysis of weather of India and neighbourhood' p. 136
AVERAGE NUMBER OF RAINY DAYS IN EACH MONTH

NO OF RAINY DAYS

0 5 10 15 20 25

MONTHS

(FIG. 8a)

MEAN CLOUDINESS OVER BOMBAY

NO. OF DAYS IN THE MONTH

0 5 10 15 20 25 30

J F M A M J J A S O N D

(FIG. 8b)
### TABLE VII

**Number of days with cloud amount**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1 to 3</th>
<th>4 to 6</th>
<th>7 to 9</th>
<th>10 (overcast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>17</td>
<td>15</td>
<td>8</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Feb.</td>
<td>14</td>
<td>14</td>
<td>9</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Mar.</td>
<td>17</td>
<td>17</td>
<td>3</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Apr.</td>
<td>3</td>
<td>11</td>
<td>12</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>May.</td>
<td>1</td>
<td>5</td>
<td>17</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>June</td>
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</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Aug.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Sep.</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Oct.</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Nov.</td>
<td>3</td>
<td>6</td>
<td>12</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Dec.</td>
<td>14</td>
<td>11</td>
<td>8</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td><strong>Annual</strong></td>
<td><strong>Total</strong></td>
<td><strong>85</strong></td>
<td><strong>35</strong></td>
<td><strong>39</strong></td>
<td><strong>117</strong></td>
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</table>

Rainfall: Out of the two chief elements of climate, depending upon each other, rainfall is in certain cases even more important than temperature. Rainfall in Bombay entirely depends upon monsoon. The S.W. monsoon is the primary source of rainfall. The city lies

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on the windward side of the western ghats and gets the fullest advantage of being located near its foot. The winter season is practically dry, because of the N.East monsoon coming from the continental land mass. Rainfall in winter is occasionally brought by the storms, which are generally shallow depressions in the wake of the westerlies passing over the western Asia.

Rainfall as recorded varies from place to place considerably. The vicinity of the small hills to the north of the island affects to a marked proportion the amount of precipitation. On the average rainfall is somewhat greater in the N.East part of the island than at Kolaba in the south. The average rainfall as recorded at Kolaba is 71.15. The maximum fall recorded in a single year so far was 114.89 in the year 1849 and the minimum is 23.42 in the year 1904, the year of the famine.

Among all climatic elements, the fluctuations of annual total rainfall show the greatest departures from the mean, which must have a reflex action, to a marked degree, upon the general conditions of the atmosphere.

Out of the sixty years, the average of which is reproduced in the compilation of the meteorological table, two years registered annual total fall more than 100", 12 between 80 and hundred 36 between 60 and 80", 70 between 40" and 60", and 3 between 20 and 40". This shows a marked variability from year to year though major number of years is having rainfall between 40 and 80".
The tenure of monsoon rainfall over Bombay extends roughly from 1st May to the end of October. Usually the monsoon breaks in the first week of June, after which rain increases steadily and rapidly. The middle of July receives the maximum intensity of rainfall from S.West monsoon. The period after July shows a gradual drop of the curve which suddenly comes down in the month of October. By the middle of October the effects of receding monsoons completely disappear.

The Probability of rainfall: The ratio of number of rainy days to the number of days in the month expresses the probability of rainfall expressed in percentage. On an average the probability for the months of June, July, August, September and October is 70, 90, 85, 64 and 15% respectively. The greatest monthly fall in Bombay was 59.26" in July 1907, and the greatest daily fall was 16.10" on the 13th June 1886, and the greatest hourly fall was 4.22 between 3 and 4 p.m. on 12th June 1847.

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean #</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
<td>0.3</td>
<td>14.6</td>
<td>22.1</td>
<td>19.0</td>
<td>12.7</td>
<td>3.7</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Number of rainy days</td>
<td>0.8</td>
<td>14.6</td>
<td>22.1</td>
<td>19.0</td>
<td>12.7</td>
<td>3.7</td>
<td>0.8</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HYTHERGRAPH OF BOMBAY

CLIMOGRAPH OF BOMBAY

(Fig. 9a)

(Fig. 9b)
Besides the climatic elements discussed above, there are other factors which modify the climate of Bombay to a marked degree. The chief among them are the land and sea breezes and the storms.

**Land and Sea Breezes:** The occurrence of the land and sea breezes is observed throughout the year and is most definitely marked from October to May. During Monsoon the land and sea breezes are very feeble because of their merger in the monsoon. The amount of rainfall brought about by the monsoon also reduces the temperature over the land and consequently the contrasting conditions of pressure on both sides are not so marked as to stimulate the local breezes.

The intensity of these breezes is most marked in the month of December when the daily temperature differences over land and sea are most emphasised. In Monsoon, they are least effective because the radiant heat of the sun is almost cut off by the clouds, and the phenomenon of diurnal heating of land is obliterated. During the winter months the maximum land
breezes at 8 a.m. due to perfect radiation overnight on the land making temperature contrasts all the more effective for the movements of local winds. On the contrary during the summer the maximum land breezes are visible earlier. This change results from early sun rise, which by 8 a.m. makes the land warm enough to resist the flow of land winds by weakening the barometric slope. The maximum sea breezes occur at about 3 p.m. on an average throughout the year. The beginning of the sea breezes depends also upon the movement of the winds from reversed components. In case the wind is easterly, the sea breezes may be delayed so long as to become strong enough to overcome the force of winds from the other components.

On many occasions the influence of the land and sea breezes has been discussed. These local breezes impart insularity to the climate, provide moderating effect to the temperature, affect humidity and avoid undesirable extremes of weather.

Storms: The storms passing over Bombay are not always identical in their nature. They depend upon the source region, causes of origin and the paths they have followed. The Indian cyclones originating in the Bay of Bengal normally do not reach the city limits, because of the W. ghats. But the tropical cyclones originating in the Arabian Sea very frequently run parallel to the coast and also visit the island and the city, sometimes dislocating the life of the city. More frequently
the storms occur in the form of squalliness associated with rainfall. A very important feature of rainfall on Bombay coast is the fact that "precipitation even during the worst monsoons is not of a continuous nature unless it is due to special synoptic situations". It has been shown by George that out of the total showers at Juhu - a sea beach of Bombay - 47% were accompanied by squalls and about 20% associated with gusty winds. This means that 67% of the showers occurring at Juhu are accompanied by squalls or strong winds of unusual gustiness.