BANGALORE DISTRICT

CHAPTER I

GENERAL

THE new Bangalore District came into existence from August 15, 1986 with the division of the erstwhile Bangalore District into Bangalore Rural and Bangalore (Urban) Districts. It is the smallest among the districts of Karnataka State with an area of about 2,191 sq km, smaller than even the Kodagu District. But in population, it stands first with 34,95,566 souls as per the Census of 1981. At the centre of this district is the Bangalore City Corporation with a total area of 151 sq km and a population of 24,76,355. Bangalore District has three taluks, *viz.* Anekal, Bangalore North (including Dasanapura hobli from the old Nelamangala taluk and Jala hobli from the old Devanahalli taluk) and the Bangalore South (including Tavarekere hobli from the old Magadi taluk and Bidarahalli hobli from the old Hoskote taluk). Bangalore city is part of the Bangalore North and Bangalore South taluks, the area being divided between these taluks. Being the headquarters of the State, the city is the chief administrative centre clustered with numerous State and Divisional level Government Departments and offices associated with the legislative, executive and judicial wings of administration. A heavy concentration of State as well as Central Government employees is now a characteristic feature of Bangalore City. The city is the headquarters of both the Bangalore Rural and the Bangalore Districts.

Agriculture is the main occupation of the people in the rural areas of the district and the major crops cultivated are paddy, *ragi* and pulses. The extent of land available per head works out to 0.06 ha. In the urban milieu, land has assumed different dimension on account of the ever growing demand for land that can be

Date	Location and details	Source
30.5.1971	East of Bangalore	GBA
17.12.1972	South and south-east of Anekal	GBA

*Gauribidanur Observatory

WATER RESOURCES

Surface Water

There are about 98 tanks in Bangalore North taluk irrigating about 2,102 ha of land. These are mostly seasonal and carry water for about six months in a year. From March onwards, most of the tanks remain dry. The biggest tank in the taluk is Hesaraghatta with a catchment area of 490 sq km. The total capacity including that of Byata and Kakolu tanks is about 31 million cubic metres. The total surface water potential created in the taluk is about 2,330 ha. Bangalore South taluk has about 166 tanks irrigating about 4,450 ha of land. The major tanks include those of Bellandur and Varthur with a catchment area of 3.5 and 1.8 sq km respectively. The taluk include parts of Chamarajendra reservoir and Hoskote tank. Most of the tanks have been filled up partially due to the accumulation of silt and remain dry for most part of the year. The total surface water potential created is about 5,610 ha. Anekal taluk has about 197 irrigation tanks irrigating about 4,500 ha of land. The total surface water potential created in the taluk is about 4,600 ha. Thus the total surface water potential created is 12,541 ha and forms about 54 per cent of total water resources of the district.

Ground Water

Ground water in the district occurs under water table conditions in the weathered mantle of the granitic gneisses and in the joints, cracks and crevices of the basement rock. The depth to water though dependent on topography shows variation depending on the depth of weathering. The depth to water in the low lying areas ranges from one to three metres and some of the wells in the valleys start overflowing in the rainy season. The depth to water may be as high as ten metres. Main source of ground water is through infiltration of rainwater. In the absence of reliable data relating to losses due to surface run-off and evapo- transpiration, it is difficult to precisely estimate the quantity of water recharged to the groundwater body annually. Taking note of the climatic water balance, soil characteristics, fluctuation in water tables etc., it is estimated that surface run off and evapo-transpiration account for nearly 80 per cent allowing only 20 per cent of the rainfall to recharge the ground water body and 10 per cent of water discharged from wells, again percolates and recharges the ground water reservoir. Ground water discharge takes place artificially by abstraction of water from wells and to a little

extent through lateral flow to the lower sections contributing to the base flow of streams.

Ground water is developed largely by means of open wells. Such wells normally range in diametre from three to ten metres and the depth ranges from three to 12 metres. Majority of the wells are fitted with three HP pumpsets and a few with 5 HP pumpsets. The wells are pumped at a high rate which is not commensurating with the rate of recuperation. The rate of recuperation during the first two hours shows a high rate of inflow which gradually slows down with the passage of time. By regulating the discharge from pumps to about 10 hours a day continuously, each well could supply 90 m^3 of water per day.

Bore wells

Dug wells give adequate quantity of water during rainy season. But as the dry season advances, due to lowering of the water table (as majority of the wells are shallow), they cannot sustain continuous pumping. Thus most of them go dry during summer months. It is suggested that sinking of dug wells may be restricted to lower sections of the valley where water table is encountered within 6 metres from ground level *i.e.* below 884 metres contour. Bore wells should be preferred in areas where water table exceeds 6 metres from ground level *i.e.* in the elevated area between 884 to 915 metres contour. Open wells as well as bore wells can both yield between 70 to 90 m^3 of water per day.

Most of the wells in the district are shallow. Such wells should be reconditioned and revitalised by providing proper lining, removing of silt, debris and putting one or two bores of 150 mm diameter to a total depth of 30 metres. To get maximum advantage from the wells to be sunk in the district, it is recommended that all new wells to be sunk should have a diametre not exceeding six metres and taken to a minimum depth of 12 metres. One or two bores of 150 mm diametre to a total depth of 30 metres may be provided at the bottom to augment the water supply. Such wells could be equipped with a three HP pump to pump the wells for a longer period at a steady rate. Spacing between the wells in the district should not be less than 250 metres to avoid mutual interference and additional wells may be provided at the rate of one well for every four ha of land. The following table indicates the ground water utilization (as on 1.1.1987) in the district.

Ground water utilization

Particulars	*Anekal*	*Bangalore North*	*Bangalore South*	*Total*
No. of open wells	2,782	1,984	2,975	7,741
No. of bore wells	NA	NA	NA	3,921

Particulars		*Anekal*	*Bangalore North*	*Bangalore South*	*Total*
Total gross annual recharge ha m		6,795	6,378	7,194	20,367
Net annual recharge ha m		5,776	5,121	6,115	17,012
Net annual discharge ha m	1983	1,262	1,434	1,771	4,467
	1987	1,724	1,867	2,260	5,851

The total ground water potential of the district is about 11,220 ha.

FLORA

The vegetation in general is regarded as deciduous jungle type with the exception of the valleys, and a majority of species inhabiting these areas exhibit xeromorphy. The Bannerghatta forests in Anekal taluk represent the original *flora* typical of this region, which includes dry deciduous and thorny shrub forests. Most of the area is under cultivation for several centuries and now there has been felling of all woody plants for fuel resulting in the growth of scrub vegetation. Vast areas are covered by thickets of extensive growth of lantana and other xeromorphic thorny shrubs rendering the area impenetrable and forming a most striking feature of the vegetation. The topographical and climatic features of the district are subjected to small regional variations and are, by and large, favourable for the growth of a variety of plants, shrubs and trees. The last few decades have witnessed an almost unabated denudation of forest due to over-exploitation and the simultaneous expansion of agriculture and industry. The natural vegetation of the district may be broadly grouped into seasonal vegetation, roadside and avenue trees which are planted and cultivated *flora.*

Seasonal Vegetation

Seasonal vegetation is common in open waste lands and cultivated fields. This type of vegetation is active during the major part of the year and remains dormant only for a few months, starting from November or December and extending to May. After the first showers of monsoon in May, the ground, which is barren, becomes covered completely by green grass, and a few pioneer members such as *Cassia hirsuta (kadu uttarani* in Kannada), *Cassia kleinii* (procumbent herb), *Cleome gynandra* (hispid herb), *Cleome monophylla (koli kalu gida), Cynodon dactylon (garike hullu,* perennial herb), *Cyperus iria (dabbe-jambu hullu,* glabrous

annual herb), *Chamaesyce hirta (achchegida), Heliotropium scabrum* (spreading villous herb), *Mullugo pentaphylla* (spreading herb), *Priva cordifolia* (pubescent herb) and *Tribulus terrestris (sannaneggilu).* As the monsoon advances, the ground vegetation becomes dominant and completely covered by many annual weeds, which continue to flower till late in November or December. This vegetation consists of *Ammannia baccifera (kallarive,* procumbent marsh herb), *Angallis arvensis (surya kanti soppu,* common weed), *Argemone mexicana (datturada gida,* prickly herb), *Aristida depressa* (annual herb), *Bidens biternata* (annual herb), *Borreria articularis* (procumbent herb), *Celosia argentea (annesoppu,* erect/procumbent herb), *Conyza stricia* (pubescent herb), *Corchorus aestuans* (hairy herb), *Crotalaria bifaria* (spreading hairy herb), *Croton bonplandianum (alpabedhi soppu,* bushy herb), *Digera muricata* (prostrate herb), *Eragrostis tenella* (tufted herb), *Eragrostis unioloides* (annual herb), *Fimbristylis barbata* (tufted glabrous herb), *Fimbristylis ovata* (densely tufted herb), *Heteropogon contortus* (Spear grass, *karipunagada hullu,* perennial tufted herb), *Imperata cylindrica (sanna dabbe hullu,* thatching grass), *Indigofera astragalina* (hirsute herb), *Indigofera glabra* (procumbent herb), *Lagacea mollis* (villous herb, common weed), *Merremia tridentata* (prostrate herb), *Nicotiana plumbaginifolia* (weed, sticky glanded herb), *Ocimum canum* (aromatic herb, *nayitulasi*), *Orthosiphon diffusus* (tomentose herb), *Rotala fimbriata* (acquatic/semiacquatic herb), *Rotala illecebroides* (marsh herb), *Tridax procumbens (gabbu sannasevanthi,* procumbent hairy herb), *Vicoa indica (muguti soppu,* slender erect herb), *Triumfetta annua* (scandent hairy herb), *Commelina benghalensis* (Prostrate pubescent herb), *Cyanotis axillaris (negalakanne soppu,* acquatic or marshy herb), *Cyperus articulatus (Yeletollu, jambu hullu,* erect herb), *Eriocaulon quinquangulare* (common marshy herb), *Gnaphalium indicum* (marsh herb), *Grangea moderaspatana* (prostrate herb), *Leersia hexandra* (acquatic perennial herb), *Limnophila sessilis* (erect marsh herb), *Limnophila indica* (acquatic odorous herb), *Sphaeranthus indicus* (aromatic marsh herb) and *Nesaea brevipes* (marsh herb).

There are several small puddles on the plateau on top of Bannerghatta which retain certain amount of rain water. These puddles are mostly inhabited by *Aponogeten natans* (acquatic tuberous herb). During September, October and November, these puddles are completely covered by *Aponogeten natans* and the thick mat of floating leaves along with other acquatic plants like *Nymphaea nouchali (kendavare,* rhizomatous herb), *Nymphoides indicum* (rhizomatous herb with floating branches) and *Nelumbo nucifera (tavare)* form a pleasant sight. There are certain characteristic formations. The tank near Kengeri is completely inhabited by *Eichhornia crassipes (antaratavare,* stoloniferous free floating herb or water hyacinth) and with its blue flowers and floating leaves looks picturesque. It was first introduced in Lalbagh and it has now invaded almost all the tanks in the

district. It forms dense patches rapidly by vegetative propagation and renders the place unfit for other plants, on account of its thick mat of floating leaves. Its eradication is a problem. There are few tanks and puddles here and there, where one notices a pure association of *Typha angustata* (*anejondu,* common water weed) and *Polygonum glabrum* (*niruganigalu,* stoloniferous herb) or *Nelumbo nucifera* and *Polygonum lanigerum* (branched marsh herb). *Polygonum plebejum (kempunellakki* prostrate herb) is a common weed in waste places, roadsides and cultivated fields. The water tanks are generally inhabited by members like *Aeschynomene aspera* (perennial herb), *Blyxa echinosperma* (submerged acaulescent herb), *Echinochloa colonum* (tufted herb), *Hydrilla verticillata* (*pachigida,* dense herb), *Hygrophila auriculata* (*nirugobligida,* stout thorny herb), *Limnophyton obtusifolium* (robust acquatic herb), *Monochoria vaginalis* (marsh herb with creeping root stock), *Ottelia alismoides* (*hasaru nirupatre,* submerged herb), *Scirpus articulatus* (glabrous herb), *Vallisneria spiralis* (stoloniferous herb), *Glinus lotoides* (prostrate herb), *Glinus oppositifolius* (branched herb), *Lindernia parviflora* (marsh herb) and *Sopubia delphinifolia* (branched herb).

Cultivated plants

The common roadside trees planted in the district are *Alstonia scholaris* jantale, evergreen tree), *Artocarpus heterophyllus (halasu), Azadirachta indica* (*bevu,* evergreen), *Cassia siamea (simetangadi), Citharexylum spinosum* (evergreen tree), *Dalbergia sissoo* (sissu, medium sized tree), *Delonix regia* (*kattikayigida*), *Ficus benghalensis* (*ala,* evergreen), *Ficus religiosa* (*arali/aswatha,* deciduous), *Firmiana Colorata (bilisoolige), Holoptelea integrifolia* (*tapasi,* deciduous), *Jacaranda mimosifolia* (*neeligulmohar,* deciduous), *Kigelia pinnata* (*marasouthe*), *Lagerstroemia speciosa* (*holedasavala,* evergreen), *Madhuca indica (ippe), Mangifera indica (mavu), Minusops elengi (pagade mara), Peltophorum pterocarpum* (*haladi gulmohar,* medium sized tree), *Pongamia pinnata (honge), polyalthia longifolia (ashoka or kambadamara), Samanea saman* (*male mara,* medium sized tree), *Tamarindus indica* (*hunise,* deciduous) and *Tecoma stans* (bushy tree). The villagers plant several species as protective hedges around their huts and cultivated fields. In such hedges are found *Acacia farnesiana* (*kasturijali,* thorthy shrub), *Agave americana (bhutale), Euphorbia milii* (spiny herb), *Euphorbia tirucalli (kolukalli), Flacourtia circumscissa (miradi), Jatropa gossypifolia (chikkakadu haralu), Kiraganellia reticulata* (straggling herb), *Lanatana tiliaefolia (rojanhuvu), Opuntia dillenii (papasu kalli), Pedilanthus tithymalaoides* and *synadenium grantii (yelekalli).*

During the monsoon, the common climbers found straggling on these hedges are *Argyreia cuneata* (*kallanahambu,* pubescent shrub), *Boerhavia chinensis* (*bekkinahejjeballi,* straggling herb), *Cardiospermum halicacabum* (*agni balli,*

climbing pubescent herb), *Cissampelos pariera* (twining herb), *Coccinia cordifolia* (*tondeballi,* scandent herb), *Cocculus hirsutus* (*kagemari,* straggling herb), *Cuscuta reflexa* (*badanike,* parasitic herb), *Dregea volubilis* (*kadehalballi,* twining herb), *Ichnocarpus frutescens* (*karehambu,* twining rusty villous herb), *Ipomoea maxima* (*talikiresoppu,* twining herb), *Ipomoea nil* (*gouribija,* climbing villous herb), *Melothria mucronata* (scandent herb), *Pergularia daemia* (*talavaranaballi,* climbing herb), and *Trichosanthes bracteata* (*kagemariballi,* scandant herb). The common roadside weeds which require special mention are *Chenopodium ambrsoioides* (aromatic bushy herb), *Cynodon dactylon* (*garike,* perennial herb with creeping rhizome), *Datura metel* (*dattura,* odourous herb), *Emex spinosa* (*doddaneggilu,* spreading herb), *Indigofera linnaei* (*kenneggilu,* prostrate pubescent herb), *Lepidium sativum* (*kurtike,* procumbent herb), *Oldenlandia umbellata* (annual herb), *Oxalis corniculata* (*puttampurle,* stoloniferous herb), *Plumbago zeylanica* (*bilichitramula,* scandent herb), *portulaca oleracea (doddagonisoppu), Solanum indicum* (*kempugulla,* prickly herb), *Solanum nigrum (ganike), Taraxacum officinale (kadusevanti), Trianthema decandra (kempu ganike soppu), Tribulus terrestris (sannaneggilu), Urena lobata* (*kadututti,* tomentose herb), *Vernonia cinerea* (pubescent herb) and *Xanthium strumarium* (*maralu ummathi,* pubescent herb).

Parthenium, a new pernicious weed, is a native of tropical South and North America. It is a herb growing to a height of one to two metres and possesses tendency to attain perennial habit. The seeds are easily blown by wind and are carried by rainwater besides moving along the blast associated with vehicular traffic and other agencies. This has moved gradually from one place to the other and could be seen along the highways, petrol bunks, on both sides of railway tracks and bus stops on the roadsides. Having reached to the city areas, it has moved to agricultural lands through city wastes lifted by the farmers and through rainwater and seepage water. In the residential areas, it has covered most of the vacant lands. From a few plants in Bangalore in 1973, it has spread all over the city and its surroundings now. Parthenium (*Parthenium hysterophorous*) occupied about 8,200 ha of which 1,600 ha was under cropped areas during 1977. This weed is rampant in uncultivated areas and is observed to suppress the useful vegetation like grasses. It has also been observed to be hazardous to the health of human beings and animals. Apart from chemical control, other integrated control measures have to be adopted to check the spread and growth of the weed. Considering the hazards of parthenium, it has been included under the Karnataka Agricultural Pests and Diseases Act of 1969 since 1975.

The cultivated *flora* of the district includes food crops like paddy *(Oryza sativa), ragi (Eleusine coracana),* maize *(Zea mays),* jowar *(Sorghum halpense),* bajra *(Pennisetum typhoidum), haraka (Paspalum scrobiculatum), same (Panicum miliare), navane (Setaria italica);* pulses like bengalgram *(Cicer arietinum),* redgram *(Cajanus indicus),* soyabean *(Glycine max),* greengram *(Phaseolus aureus),* blackgram *(Phaseolus mungo), avare (Dolichos lablab),* cowpea *(Vigna*

sinensis), horsegram *(Dolichos biflorus)*; root crops like potato *(Solanum tuberosum),* tapioca *(Manihot utilissima),* sweet potato *(Ipomoea batatas),* onion *(Allium cepa)*; plantation crops like *tengu (Cocos nucifera), bale (Musa paradisiaca), mavu (Mangifera indica),* grapes *(Vitis vinifera), geru (Anacardium occidentale);* oilseed crops like groundnut *(Arachis hypogea), ellu (Sesamum indicum), haralu (Ricinus communis),* linseed *(Linum usitatissium)* and *sasuve (Brassica nigra);* vegetable crops like brinjal *(Solanum nigrum),* tomato *(Lycopersicum esculentum),* chillies *(Capsicum annum),* cabbage *(Brassica oleracea* var *capitata),* raddish *(Raphanus sativus),* bhendi *(Abelmoschus esculentus),* french bean *(Phaseolus vulgaris),* cucumber *(Cucumis sativus), thonde (Coccina indica),* leafy vegetables; fruit crops like pomegranate *(Punica granatum),* pineapple *(Ananas sativus),* papaya *(Carica papaya)* and ornamental plants like rose, chrysanthemum, jasmine, marigold, crossandra, dahlia, tube rose, croton, bougainvillea, etc.

FAUNA

Since the forest cover is quite sparse and most of the forest areas are small and are surrounded by agricultural lands, very few species of wild animals are found in the forests of the district. Occasionally, herds of elephants make an appearance in the forests and villages of Anekal taluk from forests of neighbouring district. The larger game consisting mainly of cheetah or panther and the wild dog and animals such as the porcupine, jackal, wild cat, etc. are mostly confined to the forests of Anekal taluk. Among the smaller animals, field rats are numerous. Domestic animals consist principally of horses, cows, bullocks, buffaloes, sheep, goat, asses, pigs, dogs and cats.

The *avifauna* of the district is rich and varied. The birds which are regularly seen in the district are as follows:-

Babbler, whiteheaded *(Turdoides affinis),* Barbet, small green *(Megalaima/ zeylanica),* Bee-eater, blue cheeked *(Merops superciliosus),* Bulbul, redvented *(Pyconotus cafer),* Bushchat, pied, Coppersmith, Coucal *(Centropus toulou)* Crow, house *(Corvus splendens),* Crow, jungle *(Corvus macrorhynchos),* Dove, spotted *(Streptopelia chinensis),* Drongo, black *(Dicrurus adsimilis),* Egret, cattle *(Bubulcus ibis)* Egret, little *(Egretta garzetta),* Flower pecker, tickell's *(Dicaeum erythrynchos),* Heron, night *(Nycticorax nycticorax),* Heron, pond *(Ardeola grayii),* Hoopoe *(Upupa epops),* Kingfisher, pied *(Ceryle rudis),* Kingfisher, common *(Alcedo atthis)* Kingfisher, white breasted *(Halcyon smymensis)* Kite, brahminy *(Haliastus indus),* Kite, pariah *(Milvus migrans),* Koel *(Eudynamys scolopacea),* Lapwing, redwattled *(Vanellus indicus),* Lapwing, yellowwattled *(Vanellus malabaricus),* Lark, ashy crowned finch *(Eremopterix grisea),* Lark, red winged bush *(Mirafra erythroptera),* Lark, small sky *(Alauda gulgula),* Merlin, redheaded *(Falco chicquera),* Minivet, small *(Pericrocotus cinnamomeus),* Munia, red *(Amandava amandava),* Munia, spotted *(Uroloncha punctulata),* Munia, whitethroated *(Uroloncha malabarica),* Myna, brahminy, Myna, greyheaded *(Sturnus malabaricus),* Myna, Indian

(Acridotheres tristis), Myna, jungle *(Acridotheres fuscus),* Owl, barn *(Tyto alba),* Own, collared scops *(Otus bakkamoena),* Owlet, spotted *(Athene brama),* Parakeet, roseringed *(Psittacula krameri),* Pigeon, blue rock *(Columbia livia),* Robin, Indian *(Saxicoloides fulicata),* Robin, Magpie *(Copsychus saularis),* shikra *(Accipiter badius),* Sparrow, house *(Passer domesticus),* Sunbird, purple *(Cinnyris asiatica),* Sunbird, purple rumped *(Cinnyris zeylonica)* Swift, house *(Apus affinis),* Tailorbird *(Orthotomus sutorius),* Tit, grey *(Parus major)* and Vulture white scavenger *(Neophron percnopterus).* The winter visitor birds (regular *or* sporadic) are Bulbul, red whiskered *(Pycnonotus jocosus),* Buzzard, long legged *(Buteo rufinus),* Dove, rufous turtle *(Streptopelia orientalis),* Drongo, grey *(Dicrurus leucophaeus),* Flycatcher, blacknaped blue *(Monarcha azurea),* Flycatcher, brown *(Muscicapa latirostris),* Fly catcher, paradise *(Terpsiphone paradisi),* Fly catcher, red breasted *(Muscicapa parva),* Fly catcher, tickell's blue *(Muscicapa tickelliae),* Harrier, pale *(Circus macrourus),* Hawk, asiatic sparrow *(Accipiter nisus),* Kestrel *(Falco tinnunculus),* Martin, Plain sand *(Riparia aludicola)* Oriole, golden *(Oriolus oriolus),* Red start, black *(Phoenicurus ochruros),* Sandpiper, common *(Tringa hypoleucos),* Sandpiper, green *(Tringa ochropus),* Shrike, bay backed *(Lanius vittatus)* Shrike, black headed cuckoo *(Coracina melanoptera),* Shrike, brown *(Lanius cristatus),* Snipe, common *(Capella gallinago),* Swallow, common *(Hirundo rustica),* Thrust, blueheaded rock, and Wagtail, grey *(Motacilla cinerea).* The birds which are occasionally seen in the district include Bee-eater, blue tailed *(Merops phillippinus),* Bluechat, Indian, Bulbul, whitebrowed *(Pycnonotus luteolus).* Buzzard, crested honey, Cuckoo, plaintive *(Cocomantis merulinus),* Dove, red turtle *(Streptopelia tranquebarica)* Drongo, white bellied *(Dicrurus caerulescens)* Egret, median, Kite, blackwigned *(Elanus caeruleus)* Martin, dusky crag *(Riparia concolor),* Munia, blackheaded *(Munia malacca),* Nightjar, small Indian, Owl, mottled wood *(Strix ocellata),*, Parakeet, blossomheaded *(Psittacula cyanocephala),* Patridge, grey *(Francolinus pondicerianus)* Pipit, Indian *(Anthus rufulus),* Pipit, Indian tree *(Anthus trivialis),* Pitta, Indian, *(Pitta brachyura),* Quail, yellow legged button *(Turnix tanki),* Roller Indian *(Coracias benghalensis),* Shrike, large Indian cuckoo *(Coracina novaehollandiae),* Snipe, painted *(Rostratula benghalensis),* Swallow, red rumped *(Hirundo daurica),* Swallow, wiretailed *(Hirundo smithii),* Swift, alphine *(Apus melba),* Teal, lesser whistling, Thrust, white throated ground, Vulture, whitebacked *(Gyps benghalensis)* and Weaverbird, Indian *(Ploceus philippines).*

FORESTRY

Consequent to the bifurcation of the Bangalore district into Bangalore and Bangalore Rural districts, the following three taluks *viz.* Anekal, Bangalore North and Bangalore South have come into the jurisdiction of Green Belt Division from April 1987. This division has been functioning under the nomenclature 'Bangalore Urban Division'. Green Belt Division, Bangalore was created by Government

Order dated 27.7.1982 and started functioning with effect from 1.10.1982. The main object of the creation of this division was to improve the ecological and environmental conditions in and around Bangalore upto a radius of 50 km by taking up extensive plantings in the lands of Forest Department, C and D class of lands transferred to the Forest Department, and the lands incharge of public sector undertakings like HAL, HMT, NGEF, etc. It was also planned to take up planting works on the roadsides which are under Bangalore City Corporation and Bangalore Development Authority parks, government schools and public institutions, etc. The following three territorial ranges are existing in this division since 1.4.1987, *viz.* the Anekal Range with headquarters at Anekal, the Bangalore North Range with headquarters at Bangalore and the Bangalore South Range with headquarters at Kaggalipura.

As many as 378 villages including eight from Hoskote taluk (four from Kasaba Hobli and four from Anugondanahalli hobli) of the Bangalore Rural District have been included in the Green Belt Area. The number of villages from each hobli in the Bangalore (Urban) District taluk wise are: Anekal - 26 from Sarjapur hobli, 25 from Jigani, 3 from Attibele; Bangalore North-20 from Yeshwanthpura hobli, 29 from Hesaraghatta, 39 from Yelahanka, 30 from Dasanapura and 13 from Jala; and Bangalore South: 31 from Varthur hobli, 9 from Uttarahalli, 35 from Kengeri, 29 from Krishnarajapura, 20 from Begur, 13 from Tavarekere and 48 from Bidarahalli.

Bangalore urban division had a forest area of 4,203.57 ha during 1988 *i.e.* 1.92 per cent of the total geographical area of the district. The reserved forest area is about 82 ha, State forest area is about 3,983 ha and minor forest area is about 139 ha. There are no protected and village forest areas in the district. From 1.4.1987, Hoskote range has been bifurcated from this division and attached to Bangalore Rural division. Further, Anekal range has been brought under the control of Bangalore urban division. As per the Annual Season and Crop Reports, the district had the forest area of 3,303 ha during 1988 (1.52 per cent of the total reported area; Anekal taluk 463 ha, Bangalore North 1,145 ha and Bangalore South 1,695 ha).

The topographical and climatic features of the district are subject to small regional variations and are favourable for the growth of a variety of plants. Among the timber yielding species, mention may be made of *honge (Pongamia pinnata)*, tamarind *(Tamarindus indica), nerale (Syzygium cuminii),* jack fruit *(Artocarpus hirsuta), Acacias, ippe (Madhuca latifolia)* and *Eucalyptus.* Trees of lesser order which are useful as firewood are found in all forest areas. In addition, there are casuarina and eucalyptus plantations and quite a few farmers have found it more profitable to raise such plantations than crops in agricultural fields with poor soils. These trees yield poles which are required by construction workers and also provide firewood which is in great demand. The forest area in the division consists of only shrubs and small trees. No major forest produce is available. Only small quantity of minor forest produce like tamarind, *honge beeja, hippe beeja* and fruits are available.

Development Programme

Bangalore urban division is implementing several plan and non- plan schemes apart from dealing with the following subjects *viz.* (a) conducting massive planting programme in and around Bangalore city and conducting Vanamahotsava to educate the public about forestry, (b) raising seedlings for department planting works and for supply to farmers for raising private plantations in their lands to make green belt, (c) prevention of smuggling of forest produce including sandal-wood, (d) extraction of sandalwood from private holdings as well as the forest and transportation to Government Sandalwood Depot at Mysore and payment of bonus to private land owners from whose lands sandalwood has been extracted, (e) disposal of minor forest produce available in the reserve forests and revenue lands by tender-cum-auction sale, (f) afforestation works under Social Forestry Schemes such as roadside plantations, planting in revenue wastelands, public lands and lands of autonomous bodies, (g) instituting and conducting vehicles confiscation proceedings as per Karnataka Forest Act 1963 and (h) control and issue of licence to the saw mills in the jurisdiction of this division.

During 1987-88, an area of 41 ha as detailed below has been covered under tree planting in advance trenched area: 9 ha at Badamanavarthe Kaval in Bangalore South taluk; 10 ha at Mahadeshwara State Forest, Thattikere in Anekal taluk and 10 ha at Shivapura in Anekal taluk; 12 ha at Rachenahalli; and Hennur in Bangalore North taluk. In Bangalore city, the following works have been carried out during 1987-88: (1) planting in Bangalore City Avenue 232 km, 46,400 plants; (2) planting in Bangalore city parks 3 ha, 1,400 plants; 3) planting in Bangalore city schools 12 ha, 5,000 plants; 4) city wood lot planting by pit planting 55 ha, 17,750 plants; (5) block plantations raised in C & D Class forest area and tank foreshore by trench mound method 49 ha, 98,000 plants and (6) free distribution of forest seedlings to public 3.6 lakhs.

Forest Nursery

Nursery is a place where seedlings are grown by sowing of seeds, then watered and subsequent maintenance. Nurseries play an important role in the artificial regeneration of forests. The number of seed beds is determined by the number of seedlings that are required to be raised. The standard seed bed is 12 metres in length and 1.2 metres in width. These may be either sunken or raised. Seeds are sown either in a broadcast manner or by making furrows depending on the size of the seedlings needed. Weeding is done periodically depending on the incidence of the weeds. Transplant beds are utilised for hardening of the seedlings. Depending on the size required, the seedlings may be kept in transplant beds after which they may be taken out and planted wherever necessary. Some varieties of seedlings will not sustain root shock and when planted will result in large scale casualties. Such seedlings are developed in containers. Polythene bag is one of the ideal containers for growing seedlings. They could be used for raising both bigger

and smaller seedlings. When seedlings are required to be raised of taller height, earthen pots are used for this purpose. Some species of plants withstand root and shoot shock. Such plants for the purpose of growing into tall plants can even be raised in sunken as well as raised beds. To develop tall plants, tar drums or concrete pots are also used. The department has also raised nurseries under the Kissan Nursery Project through the farmers and other interested people by supplying them with polythene bags, seeds and seedlings.

The Karnataka State Social Forestry Department has been laying parks and erecting rest houses every 80 km on the district, state and national highways and on main roads for travellers. Other than planting trees, people will be educated about nature. Facilities like shelters, tea stalls, places for relaxation, toilets, etc. have been provided. Arasinakunte (Nelamangala taluk) on the border of the district has one such shelter.

The particulars of forest nurseries in the district are given hereunder.

Sl. No.	*Name of the Range*	*Nursery location*	*Total no. of seedlings in lakhs (1987-88)*	*Name of the Scheme*
1	2	3	4	5
1)	Bangalore North	BUC Hebbal & BEL Nursery	1.83	FDF*
2)	Bangalore South	HAL Nursery	0.50	-do-
3)	Bangalore City	BUC Nursery	2.02	-do-
4)	Anekal	Gowrenahalli Nursery	0.20	-do-
5)	Bangalore North	Nagaruru	0.56	-do-
6)	Bangalore City	Lakkur Nature Nursery	0.55	WBSF **
7)	Aranya Bhavan	Sanky Nursery	0.75	-do-
		Total	6.41	

*Forest Development Fund

** World Bank Aided Social Forestry Scheme

Forest Research Laboratory

The Forest Research Laboratory, Bangalore was started in the year 1938 by the State Government and in 1956, it became a regional research centre under the Central Government. The objective of the laboratory is to work on the utilisation of major and minor forest products. In the beginning, two laboratories were set up, one for chemical and analytical work and the other for the identification of strength properties of timbers. Subsequently, research on the spike disease of sandal was also taken up. Later, a separate Sandal Research Centre was started in Bangalore in 1977. In the beginning some of the important projects handled were, suitability of local woods as battery separators, cultivation of medicinal plants like pyrethrum, lac and essential oil bearing plants such as bersera, etc., production of rayon from bamboo cellulose and a survey of the minor produces of the State. After it was taken over by the Central Government, the scope of the institute was widened so that it may cater to the needs of the southern states. The laboratory comprises of three branches *viz.* chemistry, minor forest products and timber utilisation and wood preservation. It has four centres at Madras, Vishakapatnam, Goa and Cochin, where the effect of marine organism on timber is under investigation. The other major functions of the institute include the identification of timbers, technical advice on utilisation aspects and supply of planting material such as bersera (Indian lavender) for trial cultivation.

Sandal Research Centre

The Sandal Research Centre, Bangalore, a Central Government Unit was established in 1977 with the objectives of studying intensively all aspects of sandal spike disease and its control, the formation of the hard wood and oil contents and its correlation with the rock, soil, climate, forest type, etc. and the variation in properties in different provinces and to select the most promising ones for propagation.

The Social Forestry Training Institute at Kadugondanahalli, Bangalore, trains motivators, representatives of voluntary organisations, farmers, women and other organisation members apart from department staff in raising kisan nurseries and plantations and their protection. The particulars of persons trained at the Institute during 1988 are as follows. Deputy Conservator of Forests 8, Assistant Conservator of Forests 12, Range Forest Officers 86, Foresters 186, Farmers 9, Representatives of voluntary organisations 4 and students 255.

Bannerghatta National Park

The Bannerghatta National Park is situated in Anekal taluk at a distance of about 22 km from Bangalore. It is an important pilgrim centre encircled by picturesque hills with several old temples around. The National Park at Bannerghatta has been established in 1971. The park enables lovers of nature and university and school students to go out on botanical and zoological excursions. One of

the reason for the establishment of the park is to develop and preserve the existing *flora* and *fauna* of the locality which has become the need of the day. The terrain in the park area is undulating and sometimes steep and rocky, altitude ranging from 760 to 1,035 metres. The Doddaragihalli Betta with an altitude of 1,035 metres is the highest point. Other higher places include the Chikkaragihalli Betta 969 metres above mean sea level, Hajamana Kallu 614 metres, Mirza Hill 952 metres, Mettu Bande 948 metres and the Suvarnamukhi Hill 1,002 metres.

Bannerghatta forest is a beautiful deciduous forest with hilly and undulating terrain, valley with a variety of trees like sandal *(Santalum album), jalari, chujjullu,* neem, tamarind, *borey* or zizyphus, *hale, muthuga, dindiga, bela, honne, tare,* etc. intermixed with small bamboos *(Dendrocalamus strictus)* in abundance. The rich bamboo growth in the park forms the fodder for elephants and other game. Many small tanks and seasonal streams (about 40) add to the scenic beauty of the park. The total area of Bannerghatta park is 104 sq.km which includes ten reserve forests of Anekal Range of Bangalore Forest Division. The Forests are bounded on the east and south by Tamil Nadu. There are stray herds of elephants during the most part of the year migrating from Kollegal and adjoining Tamil Nadu territory. In addition, there are wild pigs, sambar, spotted deer, black buck, jungle fowl and rabbits. Among snakes, cobra, pythons, kraits and Russels viper are met with. There are huge monitor lizards.

The Bannerghatta National Park programme was sponsored by the Forest Department as one of the items for execution by the Land Army under the programme Crash Scheme for Rural Development. The project consists of 1) The National Park, 2) The Safari Park, 3) The Picnic Corner, 4) Serpentarium, 5) Pets Corner and 6) Museum besides the park for pre-historic animals. Picnic Corner consists of play grounds for children, facility for seeing birds like pelicans, darter, cormorants, painted storks, geese, spot bills, white ibis, egrets, coots, spoon bills, peacocks, etc. In addition crocodiles, gharials, bears, otter, tortoises, panthers, lion tailed monkeys and jackals can also be seen. Snake Park is adjacent to the Picnic Corner. Poisonous snakes like cobras, russels vipers, pit vipers, kraits, etc. as also the non-poisonous snakes like python, rat snakes, water snakes, whip snakes and green snakes can be seen here. Herbivore Safari is at a distance of less than half a km from the Picnic Corner, 48 ha in extent. Spotted deer, sambar, bison, barking deer, hog deer, black buck and birds like jungle fowl, pea fowl, spur fowl, spot bill and egret are in this Safari. The Lion Safari is situated at a distance of about four km from the Picnic Corner. There are eighteen lions here and nine lions are let into the area each day. The area of the Lions' Safari is about six ha in extent. There is a valley in between the Doddaragihalli and the Chikkaragihalli Betta and an aerial ropeway connecting these two hills is being proposed. The Suvarnamukhi is the stream that originates on the Suvarnamukhi hills situated in the Kalkere State Forest. This hill stretches out further into a huge rock of one km length. The

Champaka Dhama Swamy Temple is situated at the foot hills of this rock. Government buses ply from Bangalore to Bannerghatta from where the park is about a km. Transport to visit Safaries is available at a nominal cost. Elephant joy ride for children visiting the park will be provided on payment subject to availability of elephants.

CLIMATE

Bangalore is considered to be climatically a well favoured district situated in the heart of South Deccan of Peninsular India. Physically its situation is of considerable significance as it is on a ridge-top running through the middle of the Mysore plateau from west to east, at an average elevation of 900 metres. The district enjoys a very agreeable climate and it is free from extremes. The climate of the district is classed as the seasonally dry tropical savana climate with four seasons. The dry season with clear bright weather is from December to February. The summer season from March to May is followed by the south-west monsoon season from June to September. October and November constitute the post-monsoon or retreating monsoon season. The main features of the climate of Bangalore are the agreeable range of temperatures, from the highest maximum of 33^0C in April to the lowest minimum of 14^0C in January and the two rainy seasons, June to September and October to November, coming one after the other but with opposite wind regimes, corresponding to the south-west and north-east monsoons. The marked thunderstorm activity with occasional hailstorms and squalls in April-May and September-October are also typical. Other important features are the predominant low clouding and the more or less steady temperatures with small diurnal variation during the whole monsoon season and the early morning dew and mist or fog during the months of October to February.

Temperature

Bangalore is among the few Indian cities for which an interrupted record of meteorological data for over 100 years has been maintained. The Central Observatory was established on 1st November 1867 at the Bowring Hospital, as a result of the recommendation of the Asiatic Society of Bengal. In 1892, the observatory was shifted to the Central College compound and in 1893 to the present building constructed on the lines of the Alipore Observatory, Calcutta. The second observatory was established at the Airport in 1947 and two others at the UAS, Hebbal and the IAF Station, Yelahanka were later started.

The records of the City Central Observatory may be taken as representative of the meteorological conditions in the district in general as they pertain to long period. The mean monthly values of air temperature were obtained by taking the half-sums of the mean maximum and mean minimum temperatures. On the basis of mean monthly temperatures, April is usually the hottest month with the mean

daily maximum temperature at 33.4^{0}C and the mean daily minimum at 21.2^{0}C. On individual days, in hot season, the day temperatures often go above 36^{0}C. With the onset of the monsoon early in June, there is appreciable drop in the day temperatures but that in night temperature is only slight. In October, the temperatures are as in the south-west monsoon season. Thereafter, temperatures decrease. December is generally the coolest month with the mean daily maximum temperature at 25.7^{0}C and the mean daily minimum at 15.3^{0}C. Nights during January are however slightly colder than during December. On individual days during the period December to February, the minimum temperature drops down to about 8^{0}C. The highest maximum temperature recorded at Bangalore is 38.9^{0}C on 1931 May, 22. The lowest minimum was 7.8^{0}C on 1884 January, 13. The mean annual range of temperature (defined as mean temperature of the warmest month minus the mean temperature of the coolest month) is only about 7^{0}C. The curves of mean monthly maximum and mean monthly minimum temperatures indicate that the mean maximum temperature is the highest in April (36.2^{0}C) and the mean minimum temperature is the lowest in January (11.4^{0}C). Thus the mean of the extreme annual range of temperature *i.e.* of the difference between the highest and lowest temperature recorded in a year is about 24^{0}C. The monthly mean diurnal range of temperature is maximum (about 15^{0}C) in February-March and minimum in July-August (about 9^{0}C). The maximum temperature of the day occurs at about 3 p.m. and the minimum temperature at about 6 a.m. except from May to July when it occurs about an hour or so earlier. The temperature at 9-30 a.m. and 9 p.m. is the mean temperature of a normal day within half a degree celcius. Table II gives the normal temperature and relative humidity at Bangalore.

The climatological data for Bangalore for three periods 1881-1940, 1931- 1960 and 1977-1980 were examined. No long term change between the two periods 1881-1940 and 1931-1960 was found. An attempt was made by Srivastava *et al* (1977) to examine if any significant changes occurred at Bangalore during the last century, using the annual mean temperature and annual total rainfall data for Bangalore for the period between 1875 to 1976. They found the mean value of the temperature to be 23.7^{0}C with a standard deviation of 0.39^{0}C and the co-efficient of variability to be only 1.6%. The mean value of the rainfall series was found to be 900 mm with a standard deviation of 18.7 mm and the co-efficient of variability was about 21 per cent.

Relative Humidity

The humidity aspect of climate is a crucial study depending on the nature and purpose of the activity though almost in all cases low relative humidities are most desirable. The mean monthly relative humidity is the lowest in the month of March (44%), the morning and evening observations being 63% and 24% respectively. Relative humidity is high during the period June to October, being between 80% and 85% on the average. Humidity decreases thereafter and in the period February

to April, the air is comparatively drier, the afternoon relative humidities being 25% to 35%. From May, the relative humidity increases. The maximum relative humidity during the day occurs at about 6 a.m. and the minimum at about 3 p.m. The total annual range between the maximum morning and minimum evening observations is 64 per cent, which is of significance in several industrial operations such as textiles, plastics, fertilizers, etc. The vapour pressure which represents the absolute moisture content of the atmosphere is however minimum in January, being equal to 12 mm. The largest number of hours of bright sunshine (9.5 hours) occurs in February-March. The number of sunshine hours decreases in later months reaching a minimum of 3.8 hours in July and increases later. The decrease in the sunshine hours between May and June by about 3.9 hours is the most marked. The mean daily hours of sunshine at Bangalore (based on data from 1958-67) are as follows: January 8.5, February 9.1, March 9.0, April 8.7, May 7.6, June 5.0, July 3.3, August 4.2, September 4.0, October 5.7, November 6.9, December 7.4 and Annual 7.7.

Rainfall

The mean annual rainfall is 859.6 mm and the mean number of rainy days is about 57. Bangalore has three different rainy periods covering eight months of the year followed closely one after the other. Of these, June to September is the principal rainy season. The annual variation of rainfall shows two maxima and two minima. The principal maximum is in September and the secondary maximum in May. These are also the months with the maximum frequency of thunderstorms. Bangalore receives 54 per cent of the total annual rainfall in the south-west monsoon period (June to September) with a rainfall of 496 mm and 34 rainy days. The rainfall increases from June to September. During the north-east monsoon period, the mean rainfall is 241 mm which is a quarter of the annual total rainfall and the mean number of rainy days is 14. Thus about 80 per cent of the annual rainfall falls during the six months June to November. In April-May, the mean rainfall is 156 mm and the number of rainy days is 10. December to March is a comparatively rainless period, with a mean rainfall of 33 mm and about three rainy days. The heaviest rainfall that has occurred in 24 hours in the 70 years (1881-1950) is 195 mm recorded on 29 September 1912. The highest total rainfall in a month was 485 mm in September 1897. About 85 per cent of the rainfall at Bangalore occurs between 4 p.m. and 7 p.m. and the minimum rainfall between 10 and 11 a.m. The year 1874 was the rainiest year with a total of 1,428 mm while 1876 was the driest year receiving only 441 mm of rainfall, during a 70 year time span (1881-1950).

The water balance chart gives detailed information about water supply by rainfall and water loss by evaporation. Bangalore has no water surplus in any month. The excess of rainfall over evapotranspirational demands from August to November is hardly sufficient even to replenish the soil reservoir with the result that there is no saturation of the soil climatically and therefore there is no surplus moisture for

contribution to sustained stream flow. While the soil has the capacity to hold as much as 300 mm water, it receives only around 190 mm of water during the entire rainy season which is completely used up during the prolonged dry period of the year. Bangalore, thus experiences a large amount of water deficiency of 300 mm in a year. The normal and extreme rainfall data for Bangalore are given here below.

Normal and extreme rainfall (1901-1950)

Station	No. of years of data		Jan	Feb	Mar	April	May	June	July
Bangalore	50	a	7.1	8.9	10.7	44.5	107.4	70.9	111.3
		b	0.7	0.5	0.8	2.7	6.7	5.7	8.5
Anekal	50	a	6.3	7.4	11.2	46.5	119.1	57.7	83.1
		b	0.7	0.4	0.5	2.8	6.6	5.0	6.7

			Aug	Sep	Octo	Nov	Dec	Annual
Bangalore	50	a	136.7	163.6	153.4	61.2	13.2	888.9
		b	9.5	8.7	8.3	4.4	1.2	57.7
Anekal	50	a	115.6	137.7	141.2	64.8	14.0	804.6
		b	8.2	7.9	8.2	4.5	1.3	52.8

a - Normal rainfall in mm
b - Average number of rainy days with rain of 2.5 mm.

In the 50 year period 1901-1950, the highest annual rainfall at Bangalore occurred in 1916 (152 per cent of the normal) and at Anekal in 1903 (172 per cent of the normal). The lowest annual rainfall which was 61 per cent of the normal occurred in 1913 at Bangalore and at Anekal in 1950 (51 per cent of the normal). The highest rainfall in 24 hours recorded at Anekal was 185.4 mm on 1887 October, 9.

Average water balance chart of Bangalore is given in Table III and taluk-wise rainfall statistics from 1970 to 1988 in Table IV. (in page No. 33)

Winds

The surface winds over Bangalore have a fairly clear cut seasonal character with easterly components predominating in one period and westerly components

in the other. During the period May to September, the winds are WSW to W while during the period November to March, they are ENE to ESE. April and October are transition months when the change over from the easterly to the westerly wind regime and *vice versa* take place. The annual variation of the monthly mean wind speed shows two maxima and minima. The primary minimum is in July when the

Table IV

Taluk-wise rainfall statistics from 1970 to 1988

Year	*Anekal*	*Bangalore North*	*Bangalore South*	*District*
Normal rainfall (mm)	804.6	888.9	885.2	859.6
1970	977.4	1,024.3	1,013.3	1,005.0
1971	926.3	956.9	799.7	894.3
1972	845.6	964.7	813.4	874.5
1973	864.6	967.7	881.5	904.6
1974	863.8	954.5	871.2	896.5
1975	1,175.1	1,058.8	973.9	1,069.3
1976	570.7	743.4	720.0	678.0
1977	1,031.4	1,020.6	1,056.7	1,036.2
1978	890.1	791.9	722.8	801.6
1979	1,061.5	1,210.4	843.7	1,038.5
1980	1,090.3	722.6	737.3	850.1
1981	962.7	776.0	794.7	844.5
1982	556.2	746.6	753.2	685.3
1983	945.0	951.2	706.0	867.4
1984	487.4	851.9	702.0	680.4
1985	558.4	642.1	595.9	598.8
1986	1,006.1	1,146.2	898.7	1,017.0
1987	1,031.4	801.4	840.9	891.2
1988	835.00	1,198.0	831.0	954.6

Source : Directorate of Economics and Statistics, Bangalore

westerly winds are prominent, with a mean speed of about 17 kmph and the secondary maximum in January when the easterly winds are prominent, with a mean speed of about 10 kmph. The two minima occur in the two transition months, April and October when the mean velocity is about 8-9 kmph. The diurnal variation of wind speed also shows two maxima and minima. The principal maximum occurs generally between mid-day and 2 p.m. and the principal minimum between 4 and 6 a.m. The subsidiary minimum occurs between 7 and 9 a.m. The diurnal variation in wind direction is not prominent during June to September when the direction is mainly WSW nor in November to February. The direction is mainly ENE in November, ENE to E in December and January and ESE to E in February. In March and April, winds have a slight southerly component in the morning and night after 6 p.m. and northerly component in the morning. The highest wind speed recorded so far is 106 kmph at about 3.20 p.m. in a squall from the NE on 3 May 1950. Two other severe squalls occurred on 10 May 1948 and 26 May 1947 when the highest wind speed reached was 102 and 99 kmph respectively. The mean daily wind speeds in kmph at Bangalore (based on the data 1969-80, height of sensor 19.2 metres above ground level) are as follows. January 8.8, February 8.3, March 7.8, April 6.8, May 9.2, June 13.1, July 13.3, August 12.4 September 8.6, October 7.1, November 7.7, December 9.2 and Annual 9.4.

Special Weather Phenomena

In November and December some of the storms and depressions which originate in the Bay of Bengal move westwards causing widespread heavy rain and gusty winds in the district. Thunder storms occur during the period February to November, the highest incidence being in April-May and September-October. There are on the average as many as 43 thunder storms in a year. May experiences the largest number (12) with April and October (7) coming next. Thunder storms occur generally between 4.00 and 9.00 p.m. They are associated with moderate to heavy, though short-lived, rain showers, sometimes with hail. Some of the thunder storms are accompanied by squalls which may at times be severe. Some thunder storms in September and October occur late in the night or very early in the morning hours before 4 a.m. Early morning mist or fog occurs during October to January with more frequency in December-January. There is considerable dew deposition in the late night and early morning hours during November to February. The fog and mist start early in the morning at 4 or 5 a.m. and clear by about 9 or 10 a.m. A thick fog sometimes lifts up and stays as low stratus cloud for sometime. An important feature is the low cloud which covers almost the entire sky during the greater part of the day in June to September and to a lesser extent in the post-monsoon season. In the rest of the year, skies are mostly clear or lightly clouded. There is some increase in cloudiness during the summer afternoons.

Special Weather Phenomena

Month	*Number of days with*				
	Thunder	*Hail*	*Dust-storm*	*Squall*	*Fog*
January	0.0	0.0	0.0	0.0	3.0
February	0.5	0.0	0.0	0.0	0.4
March	1.2	0.0	0.0	0.1	0.2
April	7.0	0.1	0.5	0.4	0.1
May	12.0	0.2	0.1	0.9	0.2
June	4.0	0.0	0.0	1.1	0.1
July	2.0	0.0	0.0	0.6	0.3
August	4.0	0.0	0.0	0.6	0.7
September	4.0	0.0	0.0	0.3	0.6
October	7.0	0.0	0.0	0.2	1.5
November	1.3	0.0	0.6	0.0	1.6
December	0.1	0.0	0.1	0.0	3.0
Annual	43.0	0.3	1.3	4.0	12.0

*number of days 2 and above are given in whole numbers.

Comfort Parameters

The important climatic factors which enter into a quantitative estimate of human comfort or discomfort are air temperature, humidity, radiation and wind. D.H.K. Lee of the UNESCO formulated an index (1958) of comfort based partly on heat transfer mechanisms and partly on observations of the way in which the human body evinces strains of various kinds as conditions get progressively hotter. He prepared a strain chart for a man acclimatized doing moderate work, with moderate air movement and wearing normal clothing. The comfort is classified as follows: Uncomfortable- strain value 1.5 to 3, less comfortable- 3 to 4, most comfortable-4 to 4.5, less comfortable-4.5 to 6, uncomfortable-6 to 8.5. Bangalore, by virtue of its elevation, experiences lower humidities and temperatures. The

strain values at Bangalore range from 2.3 to 6.2. Bangalore with its equable climate rarely becomes uncomfortable. It is most comfortable in March (4.8), June (4.3) and September (4.1), while February (3.5), April (6.0), July (3.9), August (4.0) and October (3.6) are quite comfortable. Conditions of poor comfort prevail during November (3.6), December (2.3), January (2.3) and May (6.3). The discomfort index hour-by-hour for Bangalore for each of the 12 months showed that while there is discomfort in all months from 13 to 17 hours, it is greater during March to May from 11 to 19 hours. Afternoons are fairly uncomfortable. The nights are pleasant throughout the year except during March to May. A study of the discomfort index in 1959 and 1980 shows no marked increase in the discomfort index since 1959, except during the afternoon hours 12 to 16, from August to October. Experience in air conditioning has shown that with an air temperature between 16 and 24^{0}C and a relative humidity between 40 to 70 per cent, one can work indoors with maximum comfort.

Climatic effects of urbanization

The average changes in climatic elements caused by urbanization are given by Landsbery (1970). Buildings and roads, ponds and ploughed fields modify the micro-climate of a region. Around every such feature, we have 'climatological sheath' within which wind, temperature, humidity, rainfall and soil moisture will be different from that outside it. When groups of structures merge into towns and cities, they form what is known as a 'climatological dome' within which exist meteorological anomalies. The micro climate of urban parts and the shaded sides of streets remain as special anomalies within the urban climatological dome but on the larger scale of the city, many common features can be detected sometimes upto a height of one km. The main factors which cause these changes in urban climate are: increased surface roughness, changed *albedo,* accelerated run-off and changed heat storage capacity, (*albedo* is the proportions of solar radiation which is reflected from earth's surface, *e.g.* asphalt surfaces reflect less, while gravel and concrete surfaces reflect more than their surroundings). Accelerated run-off of rainfall is caused by the impervious nature of road surfaces, roofs and paved areas reducing evaporation and cooling.

The replacement of forests and fields by concrete buildings and asphalt roads significantly changes the heat balance of the region. Essentially, we are converting the spongy and moist soil of rural areas of lower heat conductivity and appreciable *albedo* into an impermeable surface layer with a high capacity for conducting heat and storing it in the stone, asphalt, concrete and deeper compacted layers of the City. Add to this local heat production from combustion and metabolic processes and end result is the so called 'urban heat island'. To identify and locate urban heat islands, if any in Bangalore, a mobile survey of air temperature and humidity over the Bangalore Urban area was first made during April and May 1977. Two traverses were made of the city on 28th and 30th April 1977 at the time of the maximum

temperature epoch from 12-15 hours IST, from north to south, from Hebbal to Banashankari on 28th April and from West to East on 30th April. The crowded built up areas of Rajajinagar were found to be as expected warmer than Cubbon Park and Lalbagh. The survey was repeated during the minimum temperature epoch from 4-07 hours IST on 20th, 21st and 22nd May 1977. It was found that temperatures in the built-up areas were in excess of those over the suburbs by about 2^0C. Mobile temperature survey was repeated during December 1985 and January 1986. The highest temperatures were noticed again in the crowded areas, the temperatures being the excess of those in Lalbagh and Cubbon Park by 3.2^0C in the afternoons and 2.5^0C in the mornings.

Urban heat islands expand and intensify as a city grows and stronger winds are needed to overcome them. But the effect of urbanisation is to reduce the winds at the street level. Evidently nature cannot provide all the solutions. With the rapid increase in population coupled with a massive increase in energy production, the heat radiation in the atmosphere may rise to half that received from the sun in near future. The solution naturally rests with the town planners and city authorities. Human settlements in recent years have tended to be designed without adequate consideration of environmental factors. Extravagant designs, poorly related to local climatic impacts, have been adopted and the buildings are heavily glazed and poorely insulated, with far too little consideration for outdoor space. Outdoor space adds to indoor space and if its design is well conceived and environmentally compatible with human needs, such space can help in reducing the stresses of living in over crowded or small dwellings.