POTENTIAL OF SUSTAINABLE WATER RESOURCE MANAGEMENT FOR THE AUROVILLE REGION

A Research Project Conducted by Auroville Water Harvest at the Demand of Auroville region

INTRODUCTION

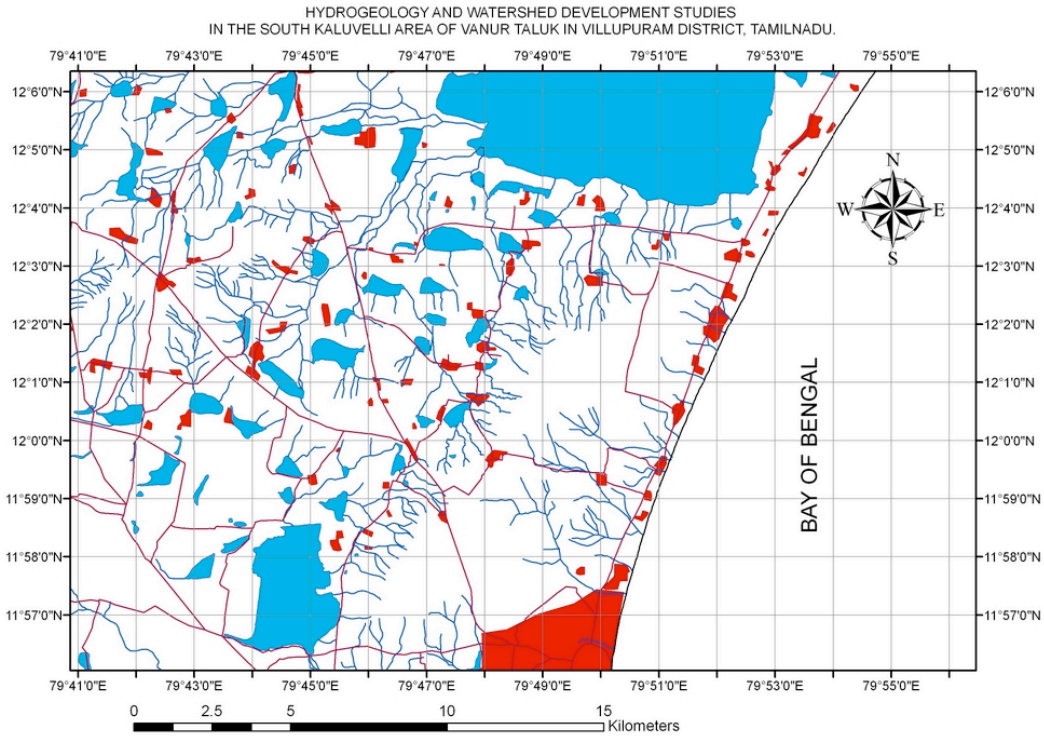
1.

Ground water is one of the prime sources of consumable water. It is a major resource for agriculture, industries and human consumption. The advent of modern technologies and the man's increasing quest for optimum use of the available natural resources had its impact on the ground water, which is being excessively extracted without any regulations. In India, Ground water accounts for more than 50% of total irrigated area, 80% of drinking water and other domestic requirements and a sizable portion for industrial requirements. Thus the magnitude of extraction of ground water requires no mentioning, causing adverse effects on the hydrologic balance and quality of water.

The groundwater studies carried out by Harvest (the Implementing Agency) in some of the villages and in Auroville covered by the Kaluvelli watershed showed excessive extraction of ground water in the region and seawater intrusion in some of the coastal villages. The intrusion is also seen in some of the interior villages of the watershed. The possibilities of seawater intrusion in other regions of the watershed were also very likely and if left unattended would jeopardize the entire Vanur region. The consequences of such intrusion would be disastrous, as it will affect the irrigation, which is largely dependent on ground water. The researches carried out by Harvest were displayed in many of the seminars, conferences and meetings with the Governmental and non-governmental organization and were recognized by these agencies.

The extraction capacity (wells) is actually enough to cover the need of the area for the coming years.
Kottakarai village is the main problematic area because of the poor existing sanitation and the close connection with surface water bodies and groundwater.
The available data indicate a good potential for sub-surface flow harvesting, which then advocate for a full scale storm water management and integrated landscaping, thus allowing for a reduced stress on the deeper aquifers, already over exploited.

Further investigations are anyhow needed to consolidate the model. Accordingly, Harvest started to work on specific project proposal to target these most urgent questions. A project proposal concerning further investigations is the concern of the present document.



2. LOCATION AND OUR RESEARCH PROJECT STUDY AREA EXTENT

Statement of the problem

A recent study has shown that the net depletion from the aquifers that Auroville is dependent upon shows that a net loss of 600 Mm^3 is occurring. About *** Mm^3 is due to agricultural usage that is inappropriate to this area. A lot of the run off into the sea, which could potentially be retained (400 Mm^3) is through Kalivelli tank.

The water levels in the top aquifer have dropped below sea level, and Auroville and its surrounding regions face the threat of saltwater intrusion, leading to the aquifers here turning saline. This can happen within 6 month to 3 years from now.

The Auroville Township is located about 8 km North-West of Pondicherry and has presently an aerial extent of 800 ha spread over an area of 42 sq km and lies close to the seacoast. In the north, the area is bounded by the Kaluvelli Tank, and in the south by the Union Tertiary of Pondicherry. In the west, it is bounded by the topo low stretching in the NNE-SSW direction and in the east by the Bay of Bengal. Auroville center is the Matrimandir.

Auroville international zone area is having an extent of about 70 hectares. Anyhow, a correct assessment on groundwater must include the surrounding to have any relevance: the parks, the full village area, the canyons up to their starting area and the land on both side of the tar road. This defines an area of 170 hectares to survey.

3. OBJECTIVES

- To determine the groundwater level fluctuation in the upper part of the aquifer system
- To determine the groundwater flow
- To determine groundwater availability
- To determine the groundwater quality
- To determine the aquifer system's reactivity to rainfall
- To determine the interconnectivity of the aquifers if any
- To determine the most sensitive area of the Auroville Bio region and the surrounding as far as environmental impact is concerned
- To determine water logged area extend and its fluctuation in time and space,

4. METHODOLOGY

- Weather data collection
- Groundwater level monitoring of 32 wells (January, march and April, June, Aug, Oct, December) by aquifer systems: all formation wells.
- Geophysical survey to determine ground water occurrence and geological structure particulars
- Infiltration tests all over the area, with more emphasis on drainage structures.
- Data processing and analyses.
- Graph generation for piezometric level variation versus rainfall and electro conductivity
- GIS integration,
- Contour map generation with reference to topographic contour, salient features existing on the ground (canyons & drains, water bodies, roads, buildings, outcropping geological setup), planned main features (delineation of zones) and rainfall pattern
- NOTE: considering the strong consistency between the Manaveli and Kadaperikuppam water level, both set of data are processed together.

5. PHYSIOGRAPHY

The center of the Auroville Township is located on a high ground at an altitude of 52m above mean sea level (msl) recording steep and gently slopes in the west and east, gradients being 0.6 to 1.1 % respectively. The high ground runs in the NNE-SSW direction being parallel feature to the topo low in the western part.

There is no perennial river system in the area. The shallow Kaluvelli swamp, located to the north of Auroville, is a natural wetland with an aerial extent of 72 sq km and forms the main outlet for the drainage of the northern and western parts of the Auroville area. Man made irrigation tanks (Erys) and interconnecting channels are present all over this area.

Along the high ground, short flow courses of well-formed gullies drain towards west (topo low) are observed. Similarly, a few canyons occur in the eastern slope of Auroville that drain towards the sea.
Accordingly, the International Zone of Auroville is on the head of a sub watershed covering about 135 sq km and ending in Kaluvelly wetland.

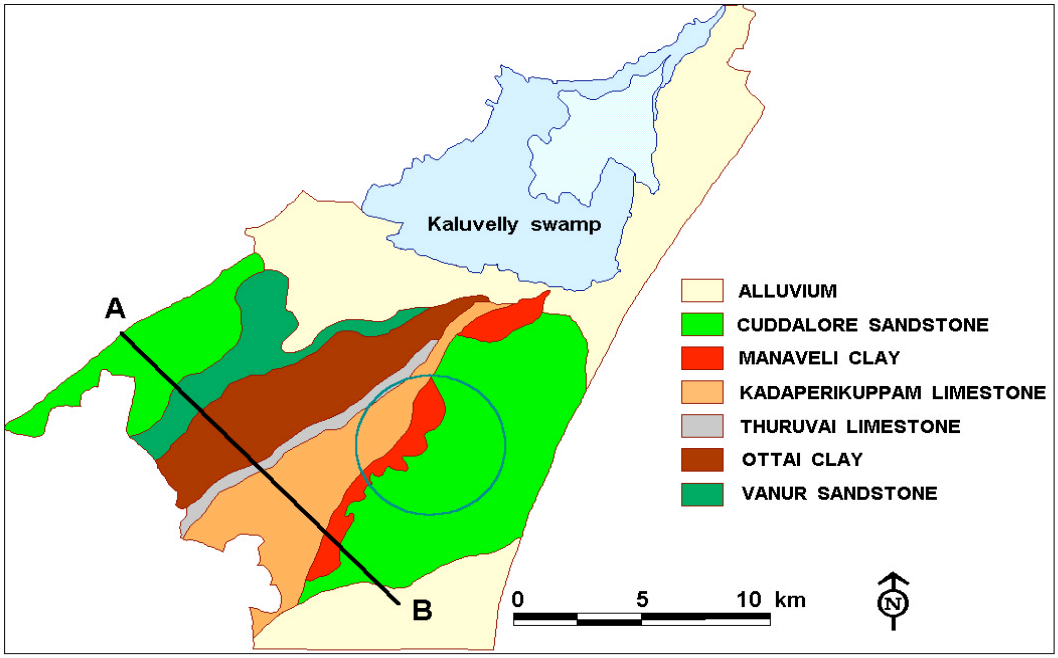
Most of the Auroville Zone is on the drainage area of the Variation irrigation tank, but a small part starting at Matrimandir is drained through a channel going through the sub watershed and connected further to other tanks.

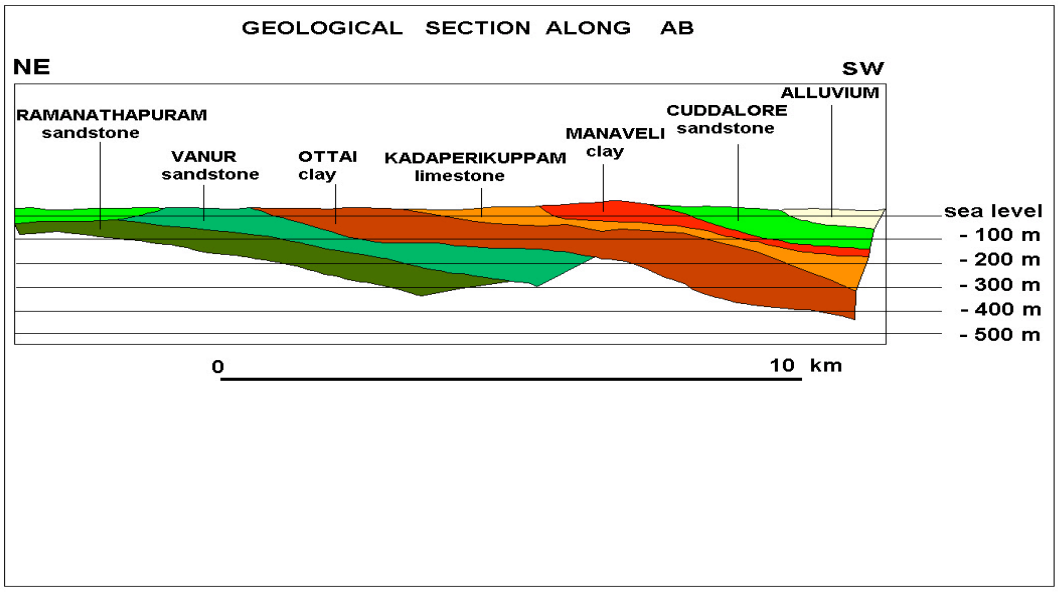
GEOLOGY

General situation

The Kaluvelly watershed, 760 sq. km area, is build of Archean bedrock (Geological map of India, 1/1000 000,Geological survey of India, 1958), which outcrops on the western part (¾ of the total area), overlaid by Mesozoic and Cenozoic sedimentary beds. The bedrock is made of charnokites (rock intermediate between a plutonic and a metamorphic one, with granite composition: K feldspar, Quarts, plagioclase, hypersthene's and some biotite). They are considered to be highly fractured in the first 100-m and compact in depth. Sedimentary beds lay on the down streamside of the watershed. They are made of sandstone; limestone and clays refer the geological map. Pleistocene alluvium overlaps the NE part on which lay the Kaluvelly swamps. The sedimentary part is very flat (between 0 to 54 m high) sedimentary beds are characterized by a thickens of the layers from NW to SE, reaching 550m depth on seaside. The layers have a smooth regional dip towards the Bay of Bengal of 2 degree and could be affected by NE – SW and EW faults. A literatim blanket (maximum observed + - 7.5 m) lays on the SW part of the sedimentary basin. On the border of the bedrock, the area is spindled with small charnokite peaks (up to 100m high) the following table shows the stratigraphy sequence.

GEOLOGICAL MAP AND CROSS SECTION LOCATION





Stratigraphy successions

Era	Period	Formation	Lithology
Quart nary	Recent	Alluvium	Sands, Clays, silts, kankar and gravels
Tertiary	Mio-Pliocene	Cuddalore formation	Sandstone, Pebbly and gravelly and coarse grained with minor clay and siltstones and thin seams of lignite. ----------

----------	----------	UNCONFORMITY	
Tertiary	Pliocene	Manaveli	Yellow and Yellowish, Brown, Grey calcareous siltstone and Claystone and shale with thin bands of limestone.
Tertiary ----------	Pliocene ----------	Kadaperikuppam UNCONFORMITY	Yellowish white to dirty white, sandy, hard fossiliferous limestone, calcareous sandstone and clay. ----------
Mesozoic	Upper Cretaceous	Thuruvai limestone	Highly fossiliferous limestone, conglomeratic at places, calcareous sandstone and clays.
Mesozoic	Upper Cretaceous	Ottai formation	Grayish to Grayish green Claystones with thin bands of sandy limestone and fine grained calcareous sandstone
Mesozoic	Upper Cretaceous	Vanur formation	Quartz sandstone, hard, coarse grained, occasionally felspathic, or calcareous with minor clay.
Mesozoic ----------	Lower Cretaceous ----------	Ramanathapuram Formation UNCONFORMITY-	Black carbonaceous, silt clays and fine to medium grained sands with bands of lignite and sandstone, medium to coarse grained ----------
Achaeans		Easternghat complex	Charnokite and biotite Hornblende gneisses.

GROUND WATER MOVEMENT AND AQUIFER PARAMETERS

Groundwater movement is generally studied conventionally by the data of hydraulic gradients and aquifer parameters estimated using pumping tests. Velocity of groundwater is generally calculated along the flow direction using Darcy's law V=K dh/dl where V is the velocity of groundwater, K is permeability and dh/dl is hydraulic gradient.

Interconnection between Aquifers

Interconnections between different aquifers play a major role in the groundwater development. In the present investigation, this aspect has been studied in detail using water level data from piezometers installed at the same site but in different aquifers. e.g. Cuddalore sandstone, Manaveli and Kadaperikuppam lime stone formations.

Depth to Water Level

Presently, there are 30 observation wells (Abandoned wells) in the Auroville zone area being monitored continuously for measuring the water level by Harvest ground water team. Data on water level are being compared with the monthly rainfall of the year in order to see the impact of rainfall in the aquifers. Like wise hydrograph has been prepared with water level and rainfall for each well.

According to our study area we can describe the four main exploited aquifers, which are as follows.

a) The Cuddalore sandstone aquifer

This is the most potential aquifer in the investigated area and occupies approximately an area of 115 sq km as outcrop and about 375 sq km underlies below the alluvial deposits, but auroville area is having the Manaveli clay. This formation mainly consists of 80% granular zones consisting of sands, sandstone, gravel etc. Groundwater occurs under unconfined, semi-confined and also at some places under confined conditions. In the southeast portion of Pondicherry region, a seasonally flowing well at Krishnapuram is located. Recharge to this

aquifer occurs by direct infiltration and percolation within the outcrop area and also through leakage from the alluvial deposits.

In Auroville area Tertiary formation of sandstone that is unconformable with the other sedimentary beds. They have been eroded or they have not deposited in the middle of the sedimentary basin. This unconfined aquifer is a moderate quality of reservoir. Its exploitation is made through open well with large diameter, 4 to 6m. Water electrical conductivity range between 385 to 875 microsimens / centimeters near the Kaluvelly swamps. Its potential reserves are limited.

Natural flow goes from NW to SE with a hydraulic gradient from 7 to 28.5m in the study, which was done in 1948. Transmissivity and field permeability of the aquifer ranges from 420 to 600 m²/day respectively, as cannot be seen in the western portion. Moreover, at present the trend of the water flow is moving to the direction of SW. In the eastern and central portion thickness of the formation is more. Because of its large thickness and favorable aquifer parameters this formation is the most potential aquifer for the groundwater development.

b) The Kataperikuppam formation

It is essentially calcareous sandstone, yellowish to dirty white in colour. It also comprises thin lenses of clay and shale and bands of shell limestone. No data about thickness is available at outcrop area. Transmissivity and field permeability of the aquifer ranges from 320 to 460 m²/day.

c) Ottai clay stone formation

It is outcropping relatively in larger area than other cretaceous sediments; covering the villages Ottai, Pullichapallam and Ravuthankuppam. It is mainly black to greenish gray clay stone with a few bands of calcareous and micaceous siltstone. Thinning of the formation at Auroville and further at Kalapet and absence of top most formation of upper cretaceous called Thuruvai limestone is the indicative of tectonic disturbance accompanied by Unconformity. The total thickness of this formation in the southern side is not known. Transmissivity and field permeability of the aquifer ranges from 60 to 70 m²/day

d) The Vanur sandstone aquifer

Unconfined at the vanur sandstone outcrop, it becomes ottai clays. Because of good hydrodynamic properties (Transmisivity between 250 m² and 800 m² 1948). This aquifer was a reservoir of high quality and adequate quantity of water potential for several years.

Natural flow goes from NW to SE with a hydraulic gradient from 7 to 35.7m in the study was done in 1948. The intensive drilling of deep wells equipped with electric or diesel pump (Depth can reach 100m to 450m) has drastically modified the flow and the aquifer is withdrawn at a rate exceeding the recharge one. Waters of the Vanur sandstone aquifer show varying electrical conductivity from 950 microsimens / centimeters to 1750 microsimens / centimeters related to space and related to time depending on climatic conditions and pumping rate. This aquifer could be in hydraulic connection with: 1.Sea water of the Bay of Bengal; 2.saltwater of the Kaluvelly swamps (2700 to 4500 microsimens / centimeters) .3. Waters of the Ramanathapuram aquifer underlying, which are not used because of sulphide content and 4. Waters from the charnokite aquifer could be involved, aquifer underlying the Ramamnathapuram sandstone.

Occurrence of Groundwater

In the study area, groundwater generally occurres in the intergranular pore space of the sandstone. It also occurs in the fractures of the hard and compact limestone's. These area mainly occupied by the sedimentary formations underlined by the crystal lined basement. Groundwater occurs in the area of both under unconfined and confined conditions in the sandstone and limestone aquifers. The sandstones of the cuddalore formation (Territory) sandstone. And Kadaperikuppam, Vanur and Ramanathapuram sandstone (Cretaceous) formation constitute the potential aquifers of this area. Though some granular zones exist in the manaveli and ottai formation (Cretaceous) they may not form promising aquifers due to their limited aerial extent and poor permeability but may yield meager quantities of water due to leakage from other aquifers. Hence Manaveli and Ottai formations act mainly as aquitards.

GROUNDWATER LEVEL FLUCTUATION

What emerge out of the research is on one hand the clear difference between the Cuddalore formation and the following ones, with a flow from West to East and a much lower water level for the Cuddalore , and on the other hand **the connectivity and opposite flow** (East to West) of Manaveli and Kadaperikuppam, with high water level.
Accordingly, and in regard to water level difference between this 2 systems, Cuddalore is not included in this part of the research as it is of no significance in addressing the water potential and risks for the International Zone.

Methodology

- Usage assessment of wells
- Selection of open wells and borewells for monitoring purpose by different aquifer systems
- Monthly groundwater level monitoring of 28 observation wells based on (January, March and august 2005 are missing). No observation wells exist on the eastern part of the Manaveli formation.
- Data processing and analyses in regard to geological formation and rainfall pattern
- GIS integration
- Contour map generation with reference to topographic contour, salient features existing on the ground (canyons & drains, water bodies, roads, buildings, outcropping geological setup), planned main features (delineation of zones) and rainfall pattern.

Water level fluctuation in comparison to ground level

As per WHO researches, **contaminants from raw water discharge point will contaminate laterally 10 meters away, and vertically 3 meters away**, providing soil is homogeneous and of appropriate structure. Moreover, consideration must be taken for the water column in the unsaturated part of the soil during the monsoon which can create temporarily direct connection to the water table. Accordingly, no unprocessed or poorly processed wastewater must be discharged in areas where the water table can reach 3 meters below ground level, or areas getting flooded temporarily during rainfalls.

Water level fluctuation in comparison to Main Sea Level (MSL)

GEOPHYSICAL SURVEYS

Objectives

Geophysical studies comprising electrical resistivity surveys and nuclear and electrical logging of boreholes have been made in the Auroville area with the following objectives

i) Delineate the aquifers occurring at shallow and deeper horizons and demarcate their lateral extents
ii) estimate the quality of formational water
iii) determine the nature and extent of different sub-surface geological formations
iv) delineate the basement configuration

Electrical Resistivity Survey

The field survey was started on 05/05/2005. According to the plan of action the field survey work of Resistivity survey has been conducted in the International Zone of Auroville at different locations. The resistivity survey was conducted in 53 locations as per the proposal.

We carried out electrical resistivity and seismic refraction surveys in the area for ground water investigations and for delineating the basement configuration. Since the resistivity survey conducted was of shallow depth range, precise data on the nature of formations of greater depth could not be obtained. Hence they concluded that the possibility of ground water development has to be restricted within 120 m. However, further exploration by drilling coupled with the geophysical surveys have brought to light the occurrence of moderate potential of aquifers even beneath 450 m down to the crystalline basement.

INFILTRATION TEST

Most of the people commonly use the method to determine infiltrations is to flood an area contained within a bund, and to record the water level over a period of time (Ponded method).

The measured infiltration rate is markedly affected by cylinder diameter, the rate measured being lower for larger diameters because of the reduced effect of lateral flow. Better estimates are therefore obtained if two concentric rings are used, the water level maintained in the both, while measurements are made in the inner; this compensates in part with lateral flow an excellent in general.

Climate

Weather parameters

Auroville Water Harvest has an observatory station in Vanur. Data on the following are being collected with the help of an Automatic Weather Station.

- Rainfall
- Temperature
- Humidity
- Wind speed
- Potential evapo-transpiration
- Wind direction

These data are being analyzed along with the monitoring data (water level and quality) of groundwater in order to see the trend over a period of time for the proper planning of water management.
The data on different climatic parameters are given in a format table.
The Format contains data on the average value of climatic parameters for each season and the mean value in a year.
The annual average rainfall of the two Taluks* is approximately 1200 mm. The maximum rainfall occurs (more than 60 percentage of total rainfall) during northeast monsoon period (October - December) every year. High intensity within short duration can be seen during the season. The average intensity of rainfall in the region is approximately 120 mm / day and sometimes the rainfall exceeds 30 cm in 24 hours period. The average rainfall in the block is 1220 mm.
As the rainwater recharges the groundwater, heavy and intense rainfall is essential to create stagnation of water in the water bodies like lakes and ponds for further recharge of groundwater over a long period. Less intensity for longer time increases the soil moisture content of the top layer, but it will not help to increase the groundwater potential, as the groundwater table is lying deep.

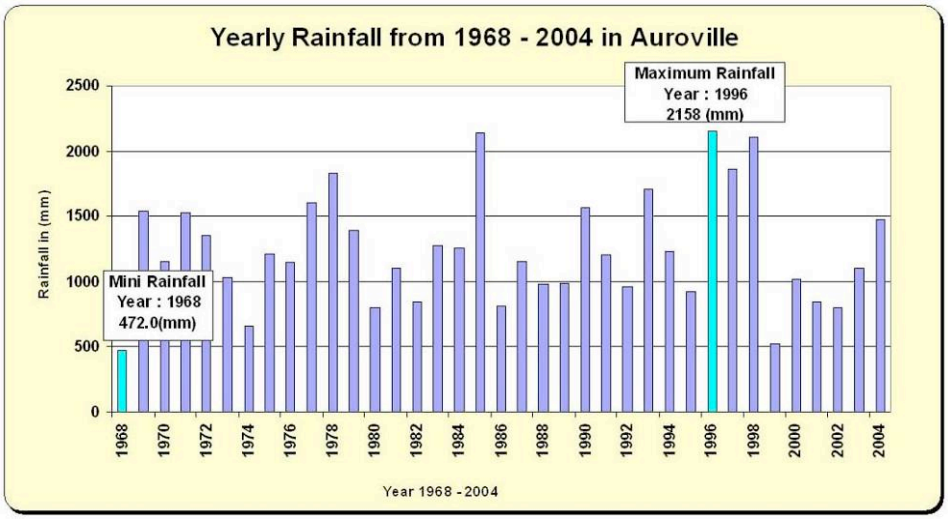
Type of climate : Semi arid

Average annual rainfall : 1220 mm

Rain fall Distribution

SN	Season	Average rainfall (mm)
1.	Northeast	415
2.	Southwest	759
3.	Others	46

No. of rainy days: 60 days/ year.
The following graph shows the monthly rainfall.



Weather Station: Auroville Water Harvest, Center for Water Resources Management, Auroville

Temperature

Season	**Temperature** (º C)	
	Max	**Min**
Winter	292	1935
Summer	333	245
SW Monsoon	348	2495
NE Monsoon	295	216
Mean	**322**	**231**

Humidity

Season	**Relative humidity (%)**	
	800 hrs	**1800 hrs**
Winter	81	705
Summer	773	75
SW Monsoon	74	70
NE Monsoon	87	796
Mean	**7925**	**7375**

Wind

Season	**Mean wind velocity km/hr**		
	830 hrs	**1730 hrs**	**24 hrs**
Winter	87	125	945
Summer	1023	181	127
SW Monsoon	112	1405	1117
NE Monsoon	88	96	86
Mean	**997**	**1367**	**1065**

PET

Season	**PET mm)**
Winter	965
Summer	1623
SW Monsoon	17275
NE Monsoon	1203