**Climate and Built Environment**
**Lecture 1**

**Climate and Weather**

What is climate? It has been said that "climate is what you expect; weather is what you get". Climate is prolonged for a longer duration; whereas weather is according to day to day variations. The climate of an area or a country is known through the average weather a long period of time. If an area has more dry days throughout the year than wet days, it would be described as dry climate. A place which has more cold days than hot days would make it known as to have a cold climate. Some of the factors which determines climate are – the factors of sun, the sky condition, and weather humidity levels, and topography and all these factors contribute to deciding the climate of your location. If you are leaving in a country like India it has mixture of different climatic classifications. When you consider places like southern India, we predominantly have longer hotter days, and which has high level of humidity. We classify ourselves as warm & humid or hot and humid climatic region. But, where as when you move to places like northern India it has places like Himachal pradesh or Shimla or Leh, Ladakh in which Colden days are much more prolonged. So, those regions are classified into colder regions or colder climatic conditions.

What is weather? Weather describes the condition of the atmosphere over a short time of period e.g. from day to day or week to week, while climate describes average conditions over a longer period of time. So, this is the major differences. Climate describes to longer duration of what we expect, and weather is the day to day variations that we see on every day. Even during our summer months few days might be rainy, so that rainy days it's due to the weather condition of the day. But overall when you look at the overall month or overall period it can be classified only as summer period. And Humidity, air temperature and pressure, wind speed and direction, cloud cover and type, and the amount and the form of precipitation are all atmospheric characteristics of the momentary conditions we call weather. It depends on lot of factors- such as cloud condition, humidity levels, precipitation, and the amount of rainfall, wind direction, wind speed etc. All these contributes to your day to day changes in weather, as well as over all this longer duration of the weather is been classified into climate.

Factors that determine the climate are: a) Elevations or Altitude affects climate- so in which means the location of your place in relevance to the sea level that is surrounded by you. Higher the altitude much colder temperature you usually experience. That is why we experience such kind of colder temperature in hilly regions. b) Prevailing global wind direction- so the wind direction of your place as well as the wind speed- if for 6 months the wind directions has been changing, for example in places like Tamil Nadu we have two different major wind directions – North east and South west. So it changes every six months. This is predominantly noticed in all tropical regions - the climatic directions or the wind direction to be changing for every 6 months. c) Topography of the place- if it's hilly, or if it's

flat topography, so this determines according to the area you are located, and also with relevance to the city in which your site is being located. d) Effects of Geography, e) Surface of the earth and f) Climate change over time. All this other than the existing conditions of the site such as topographic climate, elevation of the site etc. we also need to depend on climate change factors which we are facing every day and the Microclimate factors that happens in your locality and the surrounding places which contributes to major changes compared to the overall global climatic factors or climatic range that we expect. This depends on where your zone of climate is being located. As you look at this picture you can see lot of different various kinds of climatic locations, climatic classifications has been done for the entire globe and then this is where we have India, and we have lot of mixture of climatic conditions: from hot and dry; warm & humid; and cold regions; mixed climate; composite monsoon climate etc. So, you need to be conscious in which region your site is being located or which city you are designing for, and what climate that region experiences. The climate depends on Latitude, latitude which means this is the equator which is passing through the globe and from which these lines which is been drawn are known as latitude lines. And, the longitudes which are the vertical lines which are drawn and the altitude which means the elevation or height of the place which in relevance to the surrounding sea-mean level.

Now, moving on to Tropical climates: A tropical climate is a kind of climate typically in the tropics. Defined as non-arid climate in which all 12 months has mean temperature of above 64.4°F which is equivalent to 18.0°C. Tropical climate is usually defined as a climatic condition in which there is no much of seasonal variation throughout the year. Throughout the year it is usually warm & humid with high temperatures more than 18.0°C and even the humidity levels are higher throughout the year. And this usually experienced from the equator 23.5° above and below. As you see this is our equator line and 23.5°N of the latitude. This line 23.5° S from the equator, this forms tropic of Capricorn. This line between whatever the climatic places which are located between these two lines experiences tropical climate, which doesn't have much of a difference or seasonal variation throughout the year. Tropical climate can be divided in to 3 major climatic zones and 3 sub-groups:- 1) Warm & humid equatorial climate. Warm and humid island or trade-wind climate (which is the subgroup of warm & humid equatorial climate). 2) Hot and dry desert or semi-desert climate. These are the climatic conditions which we experience in arid regions are places like which has deserts- Rajasthan, Sahara and places like that. And it is sub-classified into Hot and dry maritime desert climate. 3) Composite or monsoon climate (which is a combination of both Warm & humid climate; & Hot and dry climate). So in some of the regions you might experience during summer months it might be very hot & dry, because higher the temperature the relative humidity that is present in the air is being evaporated which makes the air very dry. During the monsoon seasons due to the presence of continuous rainfalls the humidity levels present in the air is very high which experiences warm & humid climate. So when you experience both this combination of climates in one year -this is classified into composite or monsoon climate. Which is sub-categorised into tropical upland climate.

**Classification of Tropical Climate**

Let's look into Classification - The type of tropical Climate has been divided into 3 major categories which is: a) warm & humid climate; b) hot dry desert climate; c) composite or monsoon climate. The Sub-groups are a) warm & humid climate is sub divided into warm and humid Island Climate; b) Hot & dry desert climate subgroup is Hot & dry maritime desert climate; 3) composite or monsoon climate is Tropical upland climate.

Now moving on having a closer look at each of the major sub categories- First, let's look at Warm & Humid Climate. Warm & humid climate found in a belt near the Equator extending to about 15° North and South. Examples: Malaysia, Jakarta, Singapore, Hawaii, US. So from the equator the tropic of Capricorn and tropic of cancer, which is located 23.5°N/S experience the tropical climate. But under which from the equator 15° North and the South experiences warm and humid climate. Some of the examples are Jakarta, Malaysia, USA & Singapore, even parts of Tamil Nadu like Chennai, Coimbatore experiences typical warm & humid climate, which doesn't have much of a difference between winter season or summer seasons. And we experience throughout the air temperature is above 18°c throughout the year. Even the humidity levels are very high. As you see in this picture, these are some of the places which experience typical warm & humid climatic conditions.

Let's have a closer look at climatic conditions, for warm & humid climate the usual air temperature during the day is 27°c and it can go up to 32°c. At night, it fluctuates between 21°c to 27°c. You might observe the diurnal observation from the day and the night is typically just between 6°to 5°c. This is because due to the presence of high cloud cover conditions during the night which lets to trap the heat within the environment and doesn't make the heat released to the outer space. 2) Humidity- relative humidity (RH) remains high. 75% for most of the time but vary from 55% to almost 100%. As we know warm & humid climate also experiences high level of humidity so the relative humidity might vary from 55° to even it might go up to 100% throughout the year. 3) Vapour Pressure is between 2500 to 3500 N/m2. 4) precipitation- high precipitation because we have extended period of monsoons and the rainfall is also high throughout the year, and summer also experiences few rainy days. High precipitation or rainfall throughout the year; generally becoming more intense for several consecutive months. Annual rainfall 2000 to 5000 mm in one year. Occurrence of gusty winds and electric storms. 5) Sky condition- is fairly cloudy throughout the year. Cloud cover is 60% to 90%, because of presence of high cloud cover we do not have much of variation in air temperature during the day and night. This is why we have very less diurnal variation. 6) Solar radiation- normally high/ maximum partly reflected and partly scattered by the cloud. Due to the presence of high cloud cover we have high solar radiation occurring, but we have also a combination of reflected and refracted solar radiation due to the presence of high cloud cover. Higher sun and longer days is distinctly wettest (as at Palembang, Indonesia); or the time of lower sun and shorter day may have more rain i.e., typical example is Malaysia. Solar radiation is usually high but even though we experience lot of monsoon days as well. 7) Wind velocities are typically low, calm periods. Strong wind can

occur during rainy squalls. During rainy days we usually have higher wind speeds. Wind speeds can typically vary from 4 to 6 meter per sec, but during summer days or which is prolonged seasons we usually experience very low wind conditions. 8) Vegetation- Grows quickly due to frequent rains & high temperature; Difficult to control. High humidity accelerates moulds algae growth, rusting and rotting. Due to the presence of high humidity levels and higher extended monsoon days we will have good amount of vegetation. Sometimes it becomes very hard maintenance or control algae growth etc. This is also a typical character of warm and humid climatic conditions

Moving on to Hot and Dry Desert climate conditions- occur in 2 belts at latitude 15 ° and 30° North and south. It varies from altitude of 15° and 30° North and south from the equator line. Examples that we can usually see the presence of deserts in India like Rajasthan; Saudi Arabia, South Africa, are typical examples of hot & dry climatic conditions. 1) Air temperature- during the day between 43° and 49°c. At night- cool season between 10° to 18°c. During dry seasons its between 27° to 32°c. As we observe, compared to warm & humid climatic conditions, in hot & dry desert climates we have good diurnal variation from morning to day. This is because of less cloud cover. 2) Humidity – the relative humidity (RH) is low from 10% to almost 55% because of high radiation levels and presence of less cloud cover the moisture content present in the air usually gets evaporated easily, so the relative humidity is very less. 3) Vapour pressure, it changes from 750 to 1500N/m2. 4) Precipitation is slight and variable throughout the year. Limited rainfall- 50mm rain in a few hours. Flash rain may occur but some region may not have any rain for several years. This depends upon the place and climatic weather conditions of how much rain it is going to experience. Because few days it might experience lot of rains or extended rainy days but overall it stays completely dry throughout the year. 5) Sky condition- normally clear clouds are few due to low humidity of the air. During storms, skies are dark and dull. Due to the presence of less cloud cover we have good amount of diurnal variation from day to night. 6) Solar radiation- strong and mainly direct during the day. Absence of cloud permits easy release of heat stored during the day. Using accrual radiation cooling or coupling, day and the night cooling effect can be easily done or it's much more effective in climatic conditions which experience good diurnal variation, which one of the typical examples is hot & dry desert climates. Due to presence of less cloud cover, the heat that is stored during the day can be easily released outside during the night because of lesser air temperatures. 7) Wind- hot and together with dust and sand. Occurrence of sandstorm, this is the typical example of what we must have observed in hot & dry desert climate, usually there is a dusty winds, like a storm which usually comes when there is higher amount of wind speed. 8) Vegetation- sparse and difficult to maintain due to lack of rain and low humidity. Examples are palm & cactus forms typical vegetation types that we usually observe in desert climates. Soil is usually dusty and very dry due to the presence of higher winds and as well as lesser relative humidity.

Composite / Monsoon Climate- usually occur in large land masses near the tropics of cancer and Capricorn, which are far from equator. Composite / Monsoon Climates usually occur

very close to 23.5°towards North & the south from the equator line. This comprises of New Delhi, Mandalay, Lahore are few examples of typical climatic regions which experience composite / Monsoon. Two Seasons-2/3 of the year is hot dry and 1/3 is warm & humid. As we discussed earlier it's the combination of both the climates of warm & humid and, hot & dry in which 2/3 of the year, climatic regions experience hot & dry seasons. And 1/3 it experience warm & humid. Localities further north and south often have a third season, best described as cool-dry. As we move above these 23.5° towards North & the south from the equator line, say such as Jammu & Kashmir , and places like closer to Russia, we might have observed there is one more season which is typically cool and dry season in which the air temperature is very less, and relative humidity is also very less.

The different seasons experienced in Composite Climate are classified under: 1) Air temperature (see Chart) - Season: Hot & dry, warm & Humid & cool & dry climate. During the daytime mean maximum can vary from 32-43°c. During warm & humid season it might vary from 27-32°c, and during cool-dry season it goes up to 27°c. During the Night-time, mean minimum temperature is 21-27°c, for warm & humid it's 24-27°c, for Cool & dry it can go as less as 4 to 10°c. The diurnal Mean range which means the difference between the daytime maximum & Night-time minimum temperature is 11-22°c , and warm-humid seasons it's is 3-6°c, cool & dry seasons its 11- 22°c. So, there is good diurnal variation during hot& dry seasons; cool & dry seasons. But when you observe warm & humid season the diurnal variation is very less. You need to make design articulations according to seasonal variation. 2) Humidity- Relative Humidity is low throughout the year, dry periods at 20-55% and Wet season it rises to 55-95%. 3) Precipitation- The monsoon rains are intense and prolonged during wet period. During dry season little or no rain. Heavy dew at night, hail and thunderstorm may also occur. This is a typical combination what we have seen earlier- warm & humid climate as well as hot & dry desert climates. 4) Solar radiation- strong and direct during the clear periods. It depends upon the cloud cover which changes according to seasonal variation. 5) Winds-variable, predominantly north –east and south-easterlies. The wind direction varies or changes according to season variation: when it is warm & humid climatic condition the wind direction is from one side. And when it is hot & dry desert climatic condition the wind direction changes. 6) Vegetation- green although not very luxuriant during the wet season but in the dry season when the ground can turn brown or red. Depending on climatic seasonal variations ground cover or vegetation growth also changes according to changes in air temperature & relative humidity level.

Typically, for composite/ Monsoon climate the architectural elements that we need to follow is – a) Roof and external walls to be constructed in solid masonry or concrete. b) Resistant insulation is placed at the outside surfaces of external walls or roofs. We need resistant insulation to according to the climatic changes that's been happening throughout the year. These insulations have to be placed outside to protect our interior from harsh climatic variations. C) Large opening in opposite walls- preferably with solid shutters. We need to have huge openings during hot & dry seasons, we might want the wind to come

inside but during cold and dry seasons we might want to cut down all the winds by having wooden shutters. These are some of the typical examples we observe in architectural articulations that can be made for composite/ Monsoon climates.

**Human Body & Heat Balance**

The Thermal regulatory system- this is how the Thermal regulatory system works to maintain the human body in thermal comfort. The CNS is central neural system which is been connected to our body tissue, skin, clothing & Environment. Depending on factors such as Activity changes, Environmental Control, clothing changes, posture which are the actions that is going to arise from subjective to warmth. If you are sitting you might feel activity level is very less. But when you are dancing or practicing a martial art your activity pattern is very high which means you are going to sweat more. Environmental control such as having control to your environment by presence of wooden shutters, closing & opening of windows, movable insulation panels etc. Other activities which is involuntary actions which we do without our control to maintain our thermal comfort are shivering, sweating, Vascp – regulation. When there is cold wind passing through us, when we are lesser than the thermal comfort we usually shiver and we feel much colder. This is how skin reacts usually when we need to adjust to the thermal comfort. Body tissues, the mechanisms to keep body temperature constant at about 37°C. the skin temperature for human body is 37°C, so to maintain within that temperature range body usually reacts with shivering, Vasco- regulation or sweating to heat loss or to gain the heat from surrounding environmental conditions. This is how the heat flows from body tissue to Skin and to clothing and then to the environment. These are the actions formed by the body tissue; and the skin passes on the information to Central neural system. The Central neural system acts by involuntary actions such as shivering or sweating. These are again the factors, the physics which goes into maintaining human thermal comfort are body tissue to skin to clothing and environment. These are some of the physiology actions that we do are shivering, Vasco- regulation, and sweating. Behaviour is also an essential component- the posture, activity changes, the Environmental control, and the clothing changes. Depending upon which type of activity that is going to take place in an environment you need to change your design to meet or maintain the human body in thermal comfort, or to maintain human-heat balance. All this depends on your Central neural system. All these are controlled by your basic information's.

Heat exchange of the body with the Environment happens by respiration, Radiation, Convection and Evaporation. The examples of evaporation is when you sweat out, you might have observed our fingers or feet becomes much more wetter acts quicker to the surrounding environment so these are the active points of which evaporations constantly happens to maintain the human body to heat balance, and to maintain the skin temperature to 37°C; by radiation, convection and respiration these activities which happen involuntarily due to the central nervous system. The Physics of heat loss for the body to remain at constant temperature the metabolic heat produced must balance the heat lost by convection which is air temperature, air speed present in the environment that is

surrounding us. Radiation that is surface temperatures, the surface in which we are in contact with is meaner surface temperature which is very essential for places in which we are going to be constantly in touch with the surface or the ground. Evaporation is temperature, humidity, air speed. When there is an evaporative loss it depends upon temperature, humidity, & air speed.

Conduction & Controls- Occupants can use controls offered by the building to change the environment to suit their needs. Window-opening, fans shading devices are such controls. They are available, but there are many constraints on their use such as conflicts between occupant needs & accessibility etc. you must have to provide controls in such a way- single occupants or 2/3 occupants can control each & every openings, or windows or aperture depending on their need or body regulations to maintain each & every individual's human heat balance. Some of the controls are having controls towards your windows, or having controls to your mechanical equipments, if there is a fixed glass window there is no point of having it, if the occupants cannot control – open or close it to control their day lighting as well as natural ventilation levels.