

**Course Name: Bioclimatic Architecture: Futureproofing with Simple and Advanced Passive Strategies**

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**Lecture 03**

Climate characteristics of Temperate Climate and Cold Climate

Hello there. So, in our last class we saw the characteristics of composite climate. In today's class we will see the characteristic of the remaining two climate zones of India. One is the temperate and another is the cold climate. So, today we will see the topographical influence, the climate characteristics, the environmental challenges and the building design considerations for first the temperate climate. Now, the word temperate means moderate or in the middle, meaning that the climate zone does not have any extremes as we have seen before. The warm-humid was one extreme, and hot-dry was another extreme. Composite was a combination of both warm-humid and hot-dry, but temperate means in between these. So, it is not in extremes.

It is generally considered thermally comfortable. The temperate climate zone covers only a small part of India and is the most comfortable climate zone. As of the most recent revisions of the NBC map of India, Bangalore is one city that finds a place as temperate climate, and its surrounding areas now fall under this zone. Sometime back, Pune was supposed to be zoned as temperate, but now it has been recategorized considering certain climatic changes. So, today we will see Bengaluru climate.

So, Bengaluru's moderate climate is a result of its strategic geographic location. It is located on a high elevation closer to the western ghats and historical green cover. These together create a very comfortable and pleasant environment throughout the year. Now, Bengaluru is located at the center of the southern Indian peninsula, not too far away from the Arabian Sea and Bay of Bengal. This strategic location allows the city to benefit from both the southwest and northeast monsoons, resulting in a more temperate climate.

If you look at the elevation, Bengaluru is situated at an altitude of around 900 meters above sea level. Higher altitudes generally experience cooler temperatures. Also, it has proximity to the Western Ghats. The Western Ghats mountain ranges act as a barrier, preventing the hot, moist air mass from the Arabian Sea from directly reaching Bengaluru. This moderates

the city temperature.

When it comes to green cover, Bengaluru was once known as the garden city due to the extensive tree cover. This helped to regulate the temperature and humidity. While the green cover has declined over the past few years, it still plays a role in maintaining the city's pleasant climate. Let us look at the climate characteristics of Bangalore. The temperature is fairly constant throughout the year.

If you see, the temperature is fairly constant and the temperature hardly ever crosses 35 degrees. Well within the human comfort range. So it remains constant. At around 27 degrees to 33 degrees centigrade during the hottest time with very little seasonal variation. The diurnal temperature range decreases during the monsoon season and increases in the dry winter and summer months.

If we look at the relative humidity, relative humidity is in the comfort range for most parts of the year except for during the monsoon, when it increases a bit. So a combination of the temperature and the humidity makes it a very comfortable place. So if you see, the average is about 60 percent relative humidity. So when you look at the combination of temperature and relative humidity, it neither feels too sticky nor does it feel too hot. Let us now look at the precipitation.

Rainfall starts in May and lasts up to October. It is fairly well distributed throughout the monsoon months. The annual rainfall exceeds 1000 mm. If we look at cloud cover, the sky cover increases in the monsoon months and is low for the rest of the year. So the cloud cover increases during this part.

And then reduces during the other parts. So, if you actually see in total, when in other parts of the country it is very hot, there is precipitation—considerable precipitation of about 100 to 150 mm in Bengaluru—and then the precipitation average rainfall peaks during the rainy season along September, October time. If we look at solar radiation, direct normal radiation is high in winter and summer, and it decreases with the increase in cloud cover in the monsoon. We look at the velocity; wind speeds are relatively high throughout the year, with more than 2 meters per second, and this increases further during the monsoon months, making it even more comfortable. So, with high humidity, there is also higher wind velocity.

If we look at the climate characteristics, vegetation. Due to the moderating climate and rainfall, Bengaluru actually has a favorable weather condition for the growth of a large variety of plant species. In fact, Bengaluru is called the garden city. The city had very large tree cover, mostly consisting of deciduous and palm trees. But as you can see in this picture

due to urbanization from 1973, the green indicates vegetation cover.

And only the purple indicates built spaces. In 1973, this is how the city of Bengaluru was. In 1992, you can see the urbanization. In 2002, you can see the urbanization. In 2008, the city has grown.

In 2014, there was so much more land and very little vegetation; by 2021, there is hardly any vegetation because of buildings. So, this is how the land use has changed; otherwise, the vegetation is conducive to being grown in Bangalore. Now, the environmental challenges are first climate change. In fact, by the time you take this course, you will probably be thinking that all that I said about Bangalore is actually a lie. Because I said that the maximum temperature in Bangalore is about 33 to 35 degrees centigrade.

Whereas by the time you take this course, probably, most probably due to climate change, Bangalore may even touch 40 degrees centigrade. So, the major effect of climate change can be seen in the temperate climate zones. Now, this one example is Pune. Pune was categorized as moderate until some time back, but now it is categorized as warm and humid. Bengaluru is also facing similar situations.

Bengaluru is facing heavy floods, severe storms in the monsoon season, and major water crises during the summer season. The second environmental challenge is the increasing temperature and urban heat island effect. Bengaluru is experiencing a rise in temperature, with peak summer temperature increasing from 19 degrees in the 1900s to probably 40 degrees currently. The urban heat island effect, exacerbated by factors like glass facades and skyscrapers, is further contributing to the warming of the city. Now what impact does this have on the building? First is the reduced thermal comfort.

The rise in temperature and humidity level is making it more challenging to maintain comfortable indoor conditions in buildings through passive design strategies alone. There is also a need for increased energy consumption. This is leading to a greater reliance on energy-intensive air conditioning systems. This further exacerbates the urban heat island effect. The third impact is on the deterioration of building materials.

Changing weather patterns and increasing exposure to extreme events can accelerate the deterioration of building materials, reducing the lifespan of structures. Next, we will see the building design considerations for moderate or temperate zones. Designing thermally comfortable buildings in a moderate climate is much easier compared to many other extreme climates. Buildings should be designed such that they are able to accommodate seasonal changes in weather passively with minimum use of active systems. Shades must be provided to prevent overheating and to allow the breeze to move through the building

and pass into the building.

Window overhangs designed for this latitude or operable sun shades can help to reduce or eliminate air conditioning or the load on air conditioning. Good natural ventilation must be facilitated because the ambient air temperature itself is quite comfortable and not in extremes. To facilitate cross ventilation, doors and window openings must be located on opposite sides so that there is ease of breeze movement. On hot days, ceiling fans or indoor air motion can make the place cooler and minimize or eliminate west-facing glazing to reduce summer and afternoon heat. Use plant materials, especially on the west, to buffer the western wall from the harsh summer sun.

Then screened porches and patios can provide passive comfort cooling by ventilation. Use light-colored building materials and cool roofs to reflect away intense solar radiation, and try to use the stack effect for building ventilation. So, we have stopped this as far as moderate climate is concerned. Next, we will move on to the cold climate characteristics. So, the National Building Code of India, which has divided the country into five climatic zones, says that the cold climate zone in India lies mostly in the north and the eastern part of the country primarily.

Though there are small spots here and there, it is primarily along the north and northeast parts. particularly in the Himalayan region. So, cold climate zones in other parts of the country are usually found at high altitudes. This zone is characterized by low temperatures, heavy snowfall, and low humidity. It can be further subdivided into cold and cloudy like Shimla or cold and sunny like Leh depending upon the humidity and precipitation levels and solar radiation.

So, under cold itself, you can have cold and cloudy and cold and sunny. Let us look at the topographical influence. The topography of the Himalayan mountain range is the primary factor responsible for the formation of the cold climate zone in northern and northeastern India. The high elevation of the mountain ranges leads to a significant decrease in temperature due to increasing altitude. The Himalayas influence the distribution and timing of precipitation in the region.

On the southern slope of the Himalayas, the mountains force the warm, moist air from the Indian monsoon to rise, causing it to cool and precipitate. This orographic lift leads to heavy rainfall and snowfall in the eastern Himalayan region, such as Sikkim and Arunachal Pradesh. The Himalayan mountain range acts as a barrier to the cold, dry winds from Central Asia. This creates a rain shadow effect on the leeward or northern side of the mountains, resulting in low precipitation levels and clear skies in regions like Ladakh. The cold climate in India can be further subdivided or classified as cold and sunny in Leh and

cold and cloudy in Shimla.

If we look at the climate characteristics in terms of temperature, for a place like Shimla, as can be seen from this graph, there is a large seasonal variation in temperature. The temperature goes from 30 degrees Celsius at the peak of summer to 0 degrees Celsius in winter. The diurnal temperature range is not very high and remains mostly constant at 10 degrees throughout the year, decreasing a little only in the monsoon months when the relative humidity is high. But if you see the cold and cloudy climate of Leh, as seen from the graph, here too there is a large seasonal variation in temperature. Temperatures go below freezing in winter and as high as 20 degrees in August.

The diurnal temperature range is not only very high but remains constant at around 7 to 8 degrees throughout the year. When it comes to relative humidity, the relative humidity of Shimla is high for most of the year, and it is greater than 75%. Hence, this subtype is humid even when it is cold. It decreases only in the summer months with the increase in temperature. Whereas in Leh, the relative humidity remains below 75% throughout the year and decreases even further as the temperature increases from July to September.

Hence, this climate subtype is dry compared to the cold and cloudy subtype. If we look at the precipitation of Shimla, the precipitation in this subtype is about 1000 mm annually. Rainfall starts in the month of June and lasts till September. The topography of the Himalayas influences the rainfall in this region. Whereas in the cold and cloudy of Leh, precipitation is very low in this subtype.

This is normally below 200 millimeters annually. The Himalayas create a rain shadow effect in this region, blocking the cold wind from Central Asia. Due to the extremely low rainfall combined with low humidity, this subtype is also known as the cold desert kind of climate. If we look at cloud cover, in Shimla, the sky cover is high. It is above 60%, especially during the monsoon season.

Whereas in Leh, the sky cover is low throughout the year. In fact, it is less than 50% for most parts of the year. This exposes the region to harsh sunlight. Let us now look at the solar radiation. In Shimla, the direct normal solar radiation decreases significantly during the monsoon months due to the increased cloud cover.

The diffused radiation remains almost constant throughout the year. Whereas in Leh, direct normal radiation is high throughout the year as the cloud cover is low. The diffused radiation remains almost constant throughout the year. When it comes to wind velocity, in Shimla, wind speeds vary throughout the year, especially during the monsoon, but remain below 2 meters per second. The topography of the mountains causes wind patterns at a

microscale.

Whereas if you look at Leh, wind velocity is low in this zone. It normally does not exceed 1 meter per second. Let us now look at the vegetation characteristics. In Shimla, due to a good amount of precipitation and the humid climate, there is a wide variety of vegetation in this region.

Forests of coniferous trees like pine, deodar, etc. are found in abundance. Many species of flowering plants are found here, especially in the summer. Whereas if you look at Leh, the dry desert-type conditions with severe cold climatic conditions have made this region unsuitable for most vegetation. There are only a limited variety of herbs and shrubs that can grow here. The plants begin to grow in early summer and get most of the moisture from the melting snow.

The plants begin to disappear in early winter in September. Let us look at the environmental challenges now. Cold climates experience prolonged periods of low temperature, which can affect living organisms, water bodies, and infrastructure. Snow and ice is very common in this region.

Accumulation of snow and ice presents multiple challenges. Heavy snowfall can disrupt transportation and infrastructure, leading to closures and delays. Ice formations on roads, runways, and ships can be hazardous. Permafrost, or permanently frozen ground, is common in this kind of climate. It's thawing due to climate change, and this can destabilize infrastructure such as buildings, roads, and pipelines, leading to damage and safety risks.

Besides, there is an issue of limited vegetation. Cold climates often have very sparse vegetation due to the short growing season and extreme conditions, which affect biodiversity and food availability for wildlife. What is the impact of this on buildings? The first is heat loss. In cold climates, buildings require more energy for heating due to the temperature differential between the interior and exterior environment. Condensation and moisture are another problem. Cold climates often experience temperature fluctuations that can lead to condensation issues inside buildings.

Condensation can promote mold growth, reduce indoor air quality and damage building materials over a period of time. Snow and ice accumulation is another issue that has to be dealt with. Snow accumulation on roofs and around buildings can add significant weight to the structure- building structure. This can lead to potential damage to the structure or collapse if not properly managed. Ice dams on roofs can cause water leakage and damage to ceilings and walls.

Energy consumption is increasing here due to the need to maintain indoor spaces at a much higher temperature to achieve thermal comfort in living spaces. Material durability. Building materials used in cold climates must withstand temperature extremes. Freeze-thaw cycles keep happening. So, the material should be able to withstand this and moisture without deteriorating.

Regular building materials could require specific treatments or additives to enhance their durability. Let us now look at building design considerations in brief. While deciding on building massing and spatial configuration in the cold climates, the most important factor is to keep the cold out and the interior spaces thermally comfortable. This can be achieved by orienting the building to take full advantage of the sun's energy.

Maximizing solar heat gain is another major criteria for designing. The building must have high thermal mass and insulation to minimize heat loss. The other building design considerations include sunny wind-protected spaces and sunny wind-protected outdoor spaces that can extend the living areas. Then organizing the floor plan so that the winter sun can penetrate into daytime.

Small, well-insulated skylights. Having trees. But then they should not be planted in front of passive solar windows. So buffering. With the help of trees is not at all advisable in cold climates, and in wet climates, well-ventilated attics and pitched roofs should be there. The building size should be kept small because excessive floor area wastes heating and cooling energy. We will be looking at how the perimeter to area ratio and volume to surface area ratio have a direct relation to this in the next few lectures.

So, today we saw the climate characteristics of temperate climate and cold climate. With this, we have completed the module on climate characteristics of the five climate types, of which India is classified as warm and humid, hot and dry, composite, temperate, or moderate and cold. We will meet next class with yet another interesting topic. Thank you.