Sustainable Architecture
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Lecture – 28
Water Conservation - III

Good morning, welcome back to this III lecture on Water Conservation where we are studying this ongoing online course on Sustainable Architecture. So, in the previous two lectures, we have seen what are the different components of water conservation in a sustainable building on a sustainable site, how do we reduce the amount of consumption of portable water and reduce the burden on municipal water sources.

Next we also saw how to harvest the rainwater, what are the different design strategies, what are the different calculations which are required to store this rain water which is going to be harvested. Now, when we are talking about reduction in the consumption of water, we are going to talk about the reduction for irrigation requirement when we are talking about water.

Often for large sites specially, water which is used for gardening, irrigation is a huge amount of water it will not appear at the in the first but, eventually when we calculated the calculate the total amount of water which is going to be consumed by the building we see that gardening or irrigation requirement forms a huge proportion percentage of this total water requirement.

Fortunately, the water which is required for irrigation is not portable even the treated gray water or the captured rainwater can very conveniently be used into irrigation without any filtration or treatment much of it required, because it is non-portable use; however, even when we can do that we have to reduce the requirement for irrigation.

So, today we will be talking about water efficient landscaping.

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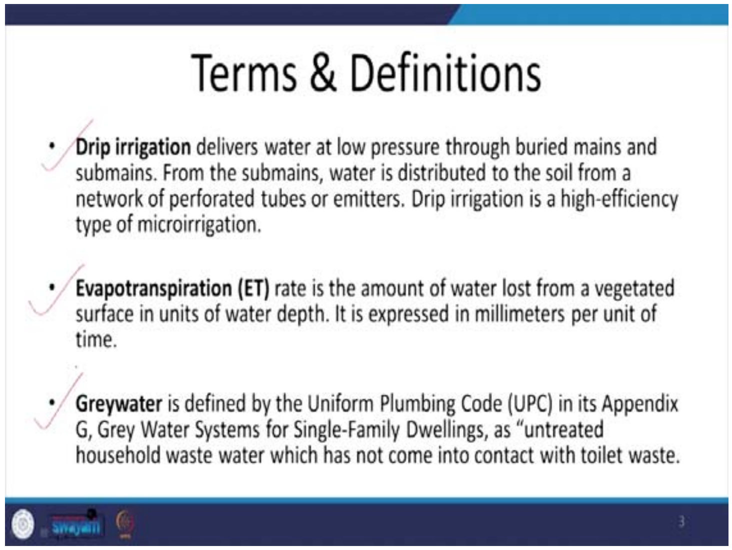

Now, before we go over it let us quickly look at some of the terms and definitions which we will be using in today's lecture. The first one is drip irrigation. Many of you would be familiar with what the drip irrigation is. What we do in our drip irrigation is that we have these supply pipelines, small thin pipe lines which are also perforated which are which are buried in the earth not too deep, but right beneath the surface of the earth and they are continuously supplied with a low pressure water and it continues to drip near the root of the plant.

So, there are reduced losses from evaporation; the losses, water losses from transpiration will be there, but the water losses because of evaporation from the surface of the ground they are substantially controlled. The next we have is evapotranspiration so, it is the rate of water which is lost from a vegetated surface and it is in the units of water depth. So, it is expressed in millimeters per unit of time.

So, suppose we have a grass lawn; now, when there is a grass lawn. So, the amount of water which is lost from that surface overall is the evapotranspiration rate and when it is for the native surface cover. For example, no landscaping has been done and the ground is left as it is in a natural state. So, the amount of above the rate of evapotranspiration is called as e t zero which is often taken as the base case.

The next is grey water. So, as defined by the uniform plumbing code of India it is the untreated household wastewater which has not come in the contact with toilet waste. So, it is used water, but it is not the water which is coming from the toilet, it is not interacted with the toilet waste. Next we have integrated pest management, it is the coordinated use of knowledge about pests and the environment, pest prevention and the control methods which are going to be used. Now, the in basic aim is to reduce the amount of environmental effects and also the economical resources.

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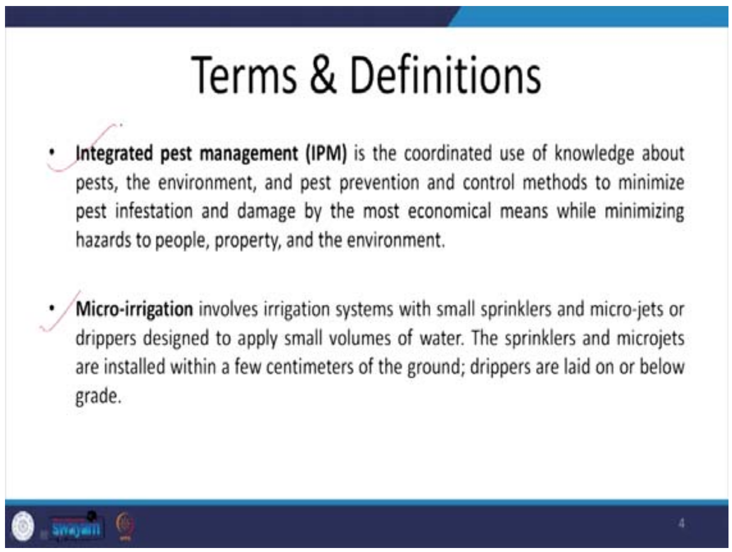

The next is micro irrigation which involves systems like drip irrigation sprinklers micro jets all of that together so, that is called micro irrigation for a given site. Next we have native plants, now these are the plants which have adapted to a given area. So, there is a list of plants for every region and we very clearly know we have already in our schools that the conifer trees grow in the high altitudes, the flat leaf trees they grow in the plains. So, and trees growing in the coastal areas and areas which receive a lot of rains they have very large leaves.

So, these trees have adaptive adapted themselves to the given area and hence they have become native to the place. So, every place every geographical area has a list of these native plants available.

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The next is their xeriscaping it is a landscaping method that makes routine irrigation unnecessary. So, that may be achieved through a combination of the selection of plants and also the selection of irrigation strategies. So, suppose we have drip irrigation and in through; that means, the irrigation the routine irrigation becomes totally unnecessary, it is a combination of all these techniques which will lead to their xeriscaping, it may also include a retention pond or many other strategies like that.

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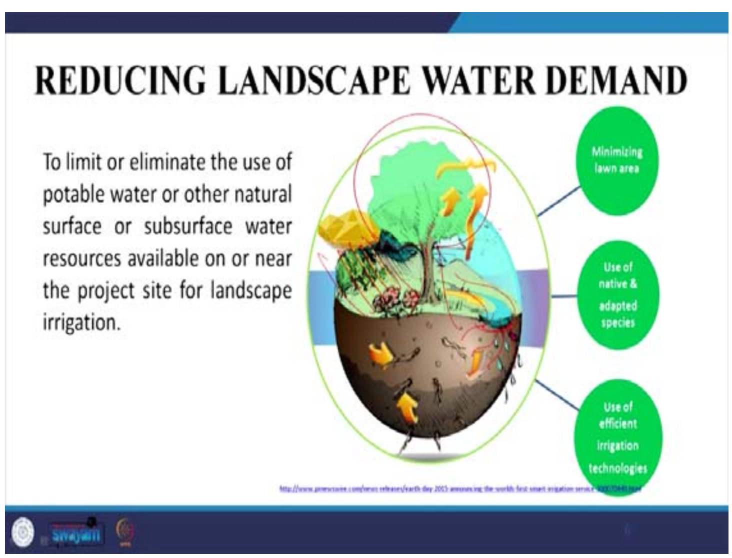

So, now we start discussing about reducing the landscape water demand. As I just was discussing about these are xeriscaping where the routine irrigation is totally eliminated the need for it is eliminated. Now, this may be through a combination of techniques first and the foremost is selection of the plant species. So, suppose we have a native plant which has adapted. So, for such kind of a plant even the rain which is there may be sufficient enough to irrigate it.

In addition to that we may plan for say a surface retention water body with the help of this the roots may draw the amount of moisture which is required for the growth of the plant. So, a combination of these may result in a landscaping where we do not need to irrigate it at any point of time once it has fully grown that is also our aim when we are talking about reducing the irrigation water requirement. So, how do we do it, what are the ways in which we can achieve that?

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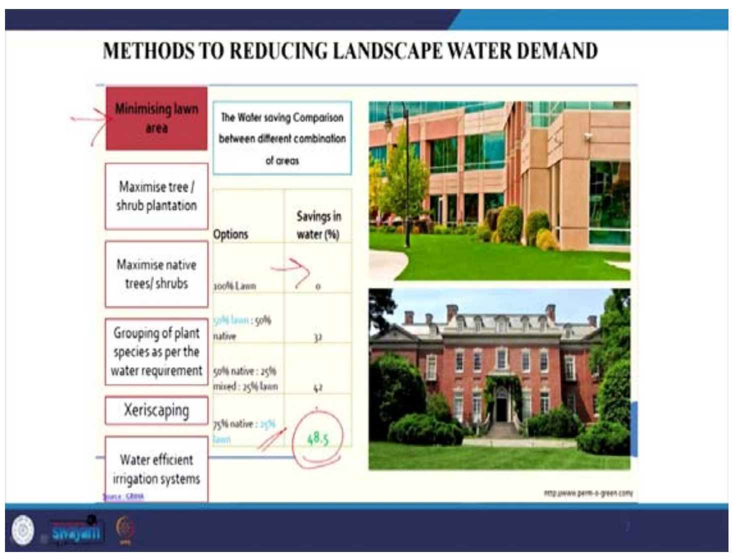

First and foremost is we have to minimize the lawn area. Lawns are water intensive, they require a lot of water and they also require a lot of maintenance for their upkeep, lawns just do not grow like that. Unfortunately, we in India are obsessed with lawns, how much ever maintenance and water they require we are still obsessed with lawns. Lawns are good for some special purposes for example, recreational purposes. For example, pedestrian walkways where pedestrians are going to walk there the maintenance of lawns is good grass lawns; however, in all other cases we can substitute the lawn areas with other species.

So, if we look at this if we have a 100 percent lawn, the total area of the landscaping covered with a lawn then there is there is 0 percent of water saving. However, if we reduce the lawn area to 25 percent, we can achieve a water saving of around 48.5 percent which is close to 50 percent just by reducing a substantial amount of area which was going towards lawns.

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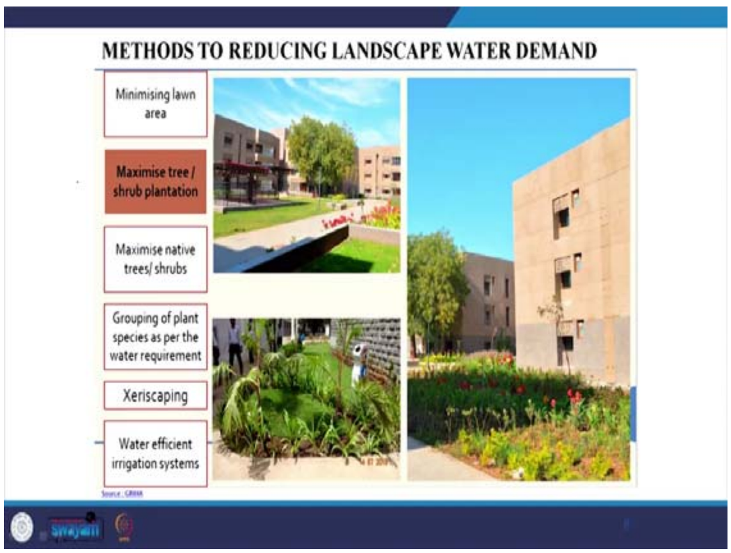

The next strategy is to maximize tree and shrub plantation. The moment we minimize the lawn area, we can increase the area for plantation of trees and shrubs. Now, trees specially require very less amount of watering irrigation and also if the shrubs are carefully chosen. They also require much less amount of watering, because both of these are hardy species, they have hard stems and they lose less amount of water. Since they lose less amount of water they also require less amount of water and thereby reducing the demand of water for irrigation.

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The next is when we are increasing the area for tree plantation and shrub plantation. The trees and shrubs and all other plants which are going to be planted should be chosen as native trees and shrubs. For example, if you go to any hot dry arid area, you would find thorny trees for example, kikar, babul which is the common name even neem for that matter.

Now, these trees are they have been they have adapted themselves to survive in extremely hot and arid conditions, they take very less amount of water, they release very less amount of water through transpiration and evapotranspiration. So, they lose it less and that is why they require less amount.

On the other hand suppose we have an area which is very close to natural surface aquifer and there is a very high water table and there is a lot of moisture which is available in the ground. There if we plant some such species they may just die out because they are not used to their roots are not used to so much of moisture and dampness, they may just totally die. So, in such cases the plants which can survive in moist conditions will be required. So, we have to maximize the native trees and shrubs, and this substantially brings down the amount of water which is required for irrigation.

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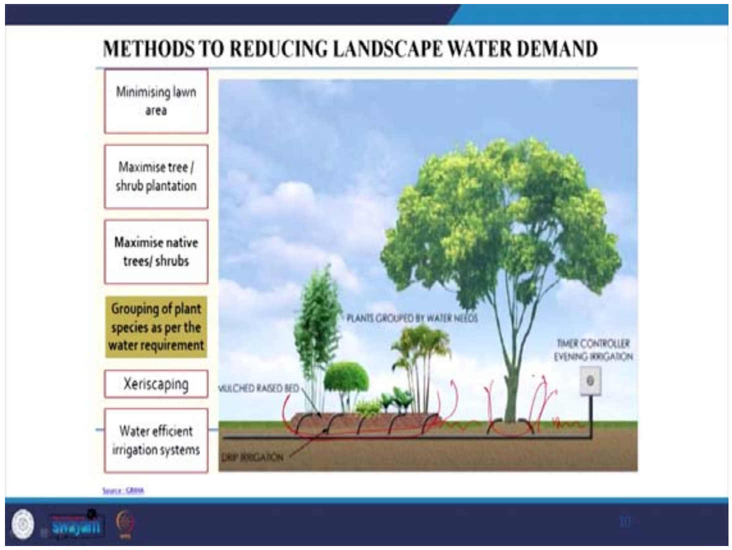

The next when we have even chosen selected the species of trees shrubs smaller plants to be planted we have to club them, we have to group them, we cannot do that; there is one tree and around that, there are shrubs and then there are smaller plants the ground covers, no; we have to group them. So, all these shrubs are grouped together, the trees are grouped together, now this grouping is on the basis of the requirement of water.

So, the species which require more water are grouped together, the species which require no water are grouped together. In this way the plants also grow healthily and the requirement of water for irrigation is also reduced. Next we have this concept of xeriscaping. Now, here we design for a landscape which requires no irrigation at all. Now, it also depends upon the climate of the place.

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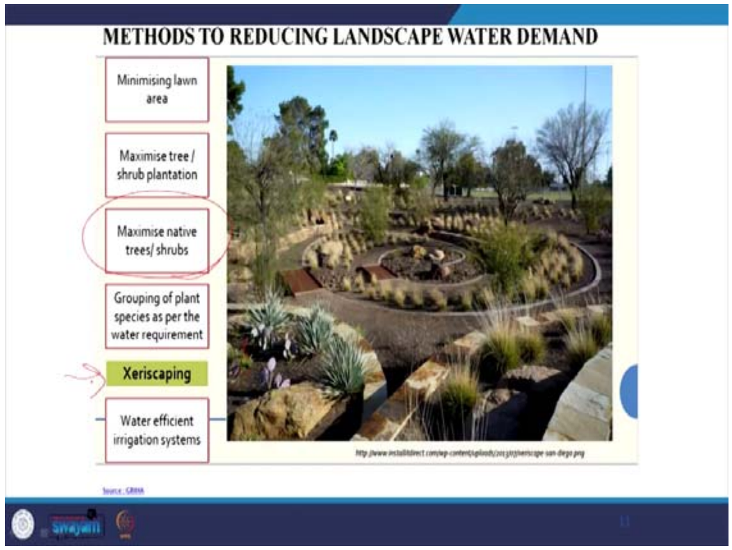

So, if we are selecting the native trees and shrubs we are doing half the job there itself because the native trees shrubs they anyways require no irrigation, they are surviving like that in the nature. Nobody waters them externally, there they survive by taking up the water which is available in the ground the moisture of the ground they survive, when they receive rains.

So, we are anyways doing half of the job when we are going towards xeriscaping, but in case it is required then specific plants which require no watering at all throughout their lifetime for example, cactus. So, different types of cacti may also be used, this is how we would go ahead with xeriscaping. And since the water is actually becoming a critical issue almost all over the world and we do not have enough water xeriscaping is coming up as a very popular concept, and almost all the dry areas and hot areas are opting for this xeriscaping.

Lastly, once we have decided and designed the type of plantation, the landscape scheme we will then add in the last the irrigation system. So, we will choose the appropriate irrigation system. Now, there are different irrigation systems which are available we have surface irrigation where we do; do we just flood it which is the most inefficient way of irrigation, because it results in huge evaporation losses and there is very little amount of water which is actually taken up by the roots of the plants.

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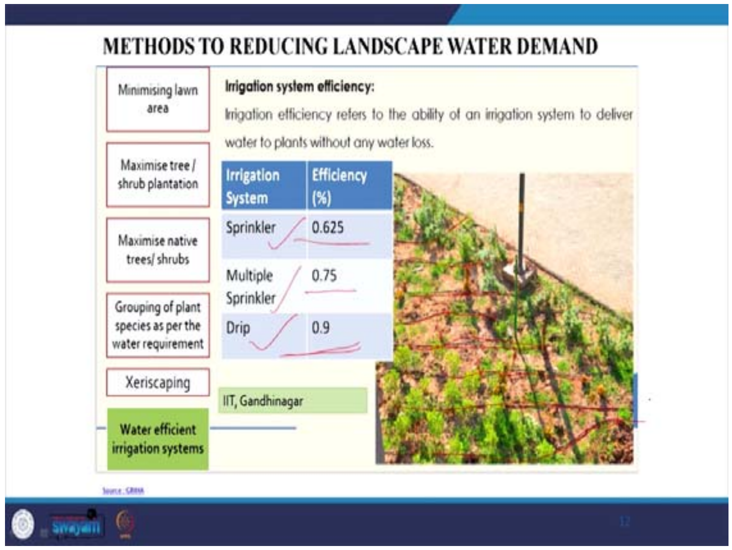

Next we have sprinklers. We have multiple sprinklers where small sprinklers are distributed over the entire landscape, and last we have drip. Now, if we look at the efficiencies drip irrigation has the maximum efficiency which is around 90 percent while multiple sprinklers is around 75 percent efficient and sprinklers are around 62.5 percent efficient. This is an image which shows how drip irrigation was planned. Now, these pipes are a well are visible because this is the initial stage of this landscape development, later when the plants and shrubs have totally grown up these pipeline would not be visible actually.

So, these thin pipes which we are seeing, these actually are perforated. So, they have small-small holes within them and these holes allow for this water to release water very close to the root of the plant which is immediately taken up by the root of the plant and there is zero; very less amount of evapotranspiration losses through the ground. So, an efficiency as high as 90 percent which is very high.

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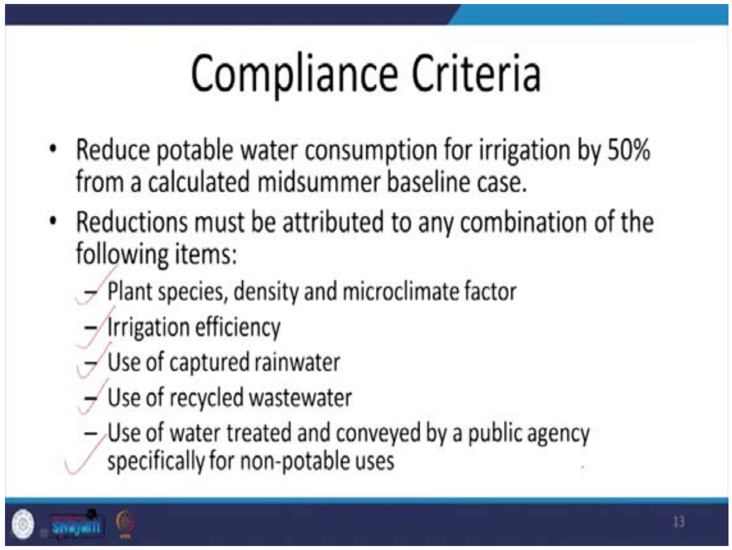

If you look at the green building rating systems programs, it could be IGBC, it could be LEED, it would be GRIHA. There are different types of compliance criteria here. Now, when we talk about this irrigation water requirement, the compliance criteria requires us to reduce this portable water consumption for irrigation by 50 percent from a calculated midsummer baseline. So, we have to calculate it for the midsummer which is the peak hot and dry season, and from that base line we have to calculate that how much of the portable water requirement for irrigation has been reduced.

Now, this could be done through a combination of all these strategies that we have just seen I will quickly list them again. So, one is with the help of selection of bright kind of plant species, the density and microclimatic factor. Second is by improving the irrigation efficiency by selecting the right kind of irrigation technique. Third is through the use of captured rainwater. So, what we have already seen is that the rainwater can very conveniently be used for irrigation because for irrigation it will not require any kind of cleaning or treatment, it could also be done through the use of recycled wastewater.

So, all the wastewater gray water and black water which is generated from the household may be treated and then it can be used back into the irrigation system. And, then use a water which is treated and conveyed by a public agency specifically for non potable uses. Now, here in case the municipality has installed a big STP and the treated water from the STP may also be supplied by a dual supply line. So, one supply is a portable water, the other supplies a non potable water for non-potable uses that may also be used for irrigation.

So, by using a combination of these steps strategies we have to show that we have reduced the water requirement for irrigation by 50 percent ideally. When we are talking about sustainable buildings, we should try to use 0 amount of water for irrigation and it is absolutely doable, practical if we design right from the beginning, right from the concept stage if we design our landscaping appropriately.

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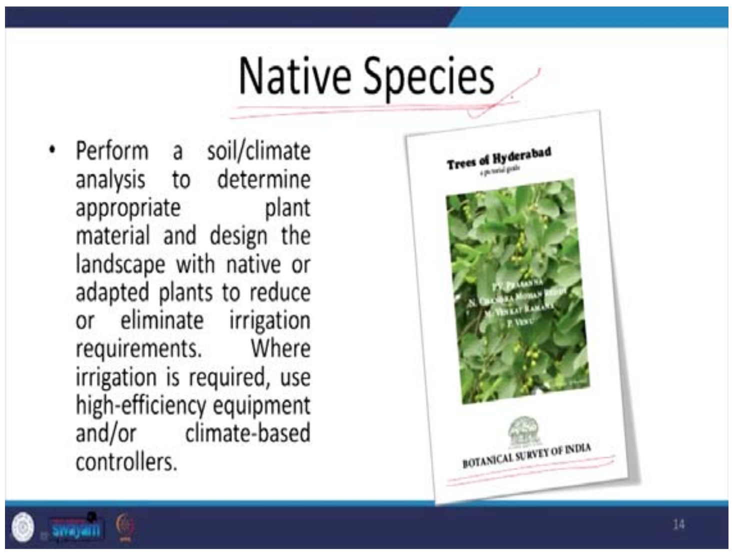

So, what would we do, how would we know that what are the native species of a given place. The botanical survey of India has taken out several guidebooks where they have classified different types of plants and tree species for different zones the agro climatic zones. So, it is not just the climate, but it is a combination of climate, geography, topography, soil. So, all of that put together results in a agro climatic zone and for each agro climatic zone there is a list of native species which is available.

So, we should try to use the trees, shrubs the species plant species given in the native species booklet for the given agro climatic zone. The next is we have to control and manage the invasive species. Sometimes a species which has entered into a new ecosystem is an alien species which does not belong, but since it is so dominant, it is robust that it flourishes, it captures, it changes alters the ecosystem. We have to identify these invasive species and we have to control their growth when we are planning the landscape.

For that again we have to refer to the native species booklet which is published by the botanical survey of India. Now, this entire exercise brings about several benefits, there are environmental benefits to a tune of to an order which is very huge.

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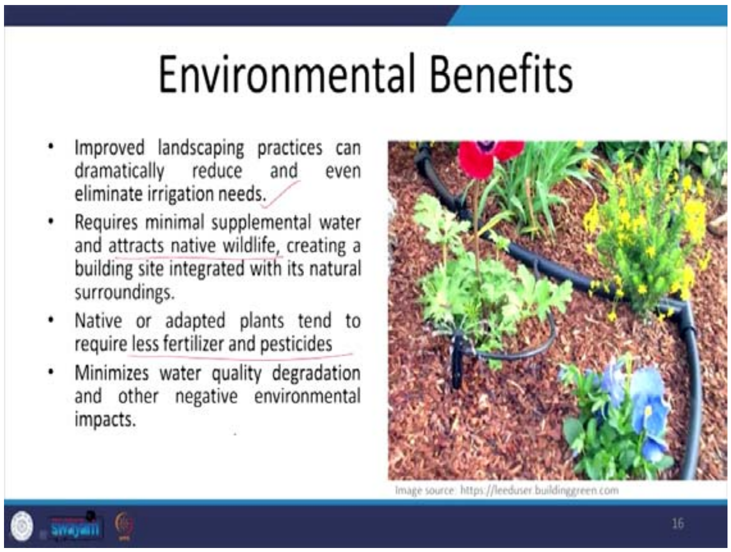

Several environmental benefits, now this includes eliminating the irrigation needs which implies reduced pressure, burden on water resources. Then, when we use native plant species for landscaping it attracts native wildlife, it promotes to create a healthier, better ecosystem. The native species also require less fertilizers and pesticides because they have adapted to this environment they have also adapted to the pests which are common to the given region.

So, it requires less amount of pesticide and fertilizer to grow and it also minimizes the water quality degradation because of all these previous reasons which I have just discussed about it reduces the water quality degradation that might happen.

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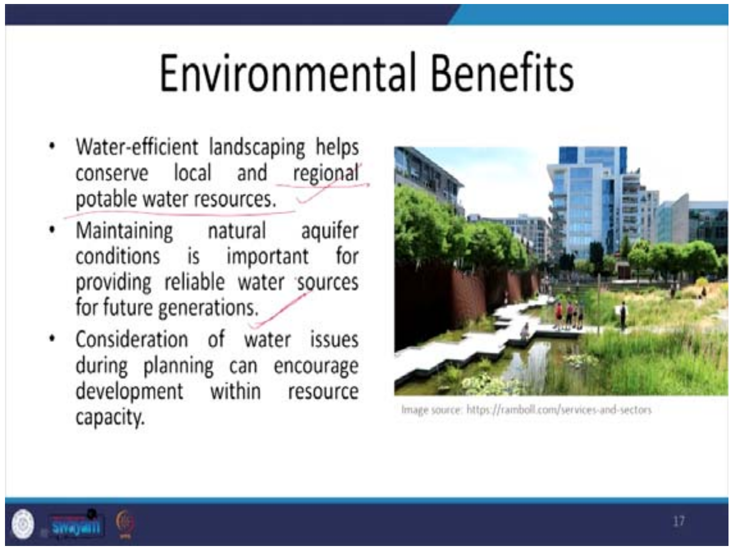

At a large system level because whenever we talk about sustainability, we talk about a long term plan a futuristic plan on also large boundaries, we are not confined within our domain, within our boundaries. So, it actually helps to replenish and conserve the regional potable water resources.

So, we are talking about creation of water bodies, surface aquifers as part of landscaping which not only irrigates the landscaping, but it also helps in replenishing the regional water resources. It also helps in maintaining the water resources, water sources for future generations for a longer duration of time as I was just discussing as a concept of sustainability.

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Besides environmental benefits it also brings about the economy benefits, if we reduce the amount of irrigation water requirement it implies that less amount of pumping will be required, it implies that less amount of energy will be consumed, less amount of treatment will be required all of that implies that they will be saving off economic resources. So, when we are starting with it we have already seen the different factors, we have already seen the different steps how do we do that. So, we have to develop the site plan of the given project right in the initial stages.

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And identify the different kind of strategies which can be incorporated, which can be used it could be it will be dependent upon as I have said different factors. So, it will be dependent upon the geography of the place, topography, climate, the type of soil and also the list the type of plants which are available and in addition to that the kind of buildings which are going to come up. So, how much of the ground is going to be covered, how, what is going to be the height of the building. So, suppose there is a tall building which is going to come up on a particular site.

Now, planting vegetation in the shadow side of this that building may result in a lot of extra maintenance and care that may be required. So, we may push the building to one corner and allow landscaping in an area which is likely to receive more amount of sun. Now, then it will not be limited to just your own site, it will also be we will also be considering what are the different types of buildings which are surrounding the site what is the height of these buildings, what is the shadow pattern. So, whether the plants would receive enough sun or not. So, can I plant a certain species in a shaded area shaded portion so, I might actually require to select species which thrive well in a shaded portion.

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So, we identify the different types of strategies which may be used on a particular site. So, once we have made a note of all these strategies, then we start to design then, then we start to plan them on the site, assign them spaces, depending upon the slopes and all these factors. So, we have to identify these spots for example, the silt retention pond has been created here where we see that there is a lake which is adjacent.

Now, for that all the water which is coming before it flows on to the lake there will be a silt retention point; so, that the silt is not passed on to the natural surface aquifer. In addition to that we may also have some trenches which will be there, we may have these collection chambers the rainwater harvesting trenches and pests, we may have trenches which will be taking the water together and then we may also have different types of the groups of plants which are planned based upon the their water requirements. So, all of that has to be planned right in the beginning.

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Another strategy that we have already seen is limiting the grass turf areas. So, we have to limit the grass turf areas only for recreational areas and pedestrian uses and where we require soil conservation. There too the type of grass which should ideally be used is the native grass which is locally available wherever it is going to be used for soil conservation. So, that the purpose is only to hold the soil and not for people to walk on it. So, the soft and the more fancy kind of grass species may not be required.

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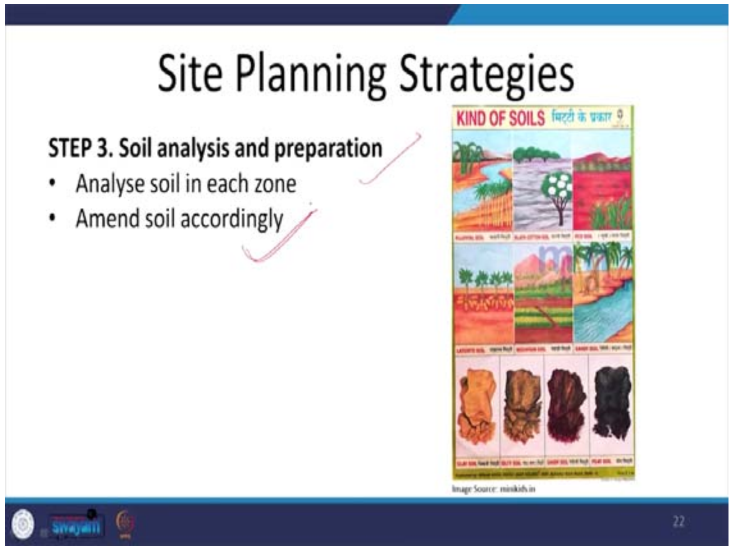

In addition to that when we are doing that we should ideally get a soil analysis done. So, we should get the proper soil analysis done and in case required the amendments to the soils may be done. For example, if you want to create a retention pond; however, the soil is too loose to allow the water to retain and it allows all the water to percolate down. There some kind of amendment may be required may be a geo membrane at the bottom of it or some other treatment where the pond actually serves the purpose of retention pond or other strategies for that matter.

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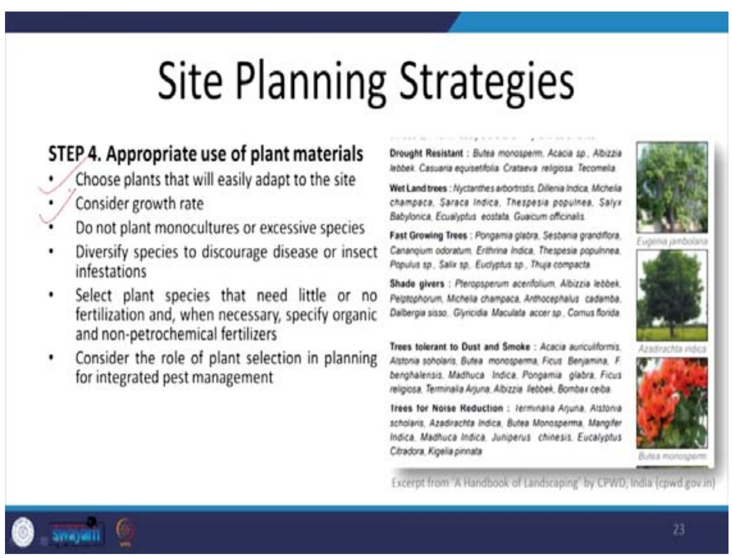

Then appropriate use of plant materials. So, we have already seen that we choose the plants carefully, we also consider their growth rate. It should not happen that two different plant species were planted side by side and one since it rose at a very fast pace, totally overshadows the other and the other plant grows. So, their growth rate their water requirement everything has to be looked at. We also have to look at the invasive species that the plant is not an alien species, we have to select specific plants which discourage the growth of insects given the type of building that we are looking at.

For example if we are planning a landscape around a school and we want to encourage children to use the outdoors, the open playground areas; their mosquito repelling or insect repelling species may be planted because the children will be playing outdoors and similarly for other outdoor areas. However, for a landscape for an office building, a commercial building a different kind of landscape may be required.

Then, in the end we will talk about and pick up the effective and efficient watering practices, we have also seen couple of them and we will take them. Besides the irrigation systems we can also look at strategies which retain the soil moisture for example, mulch. So, the soil is covered with the help of this organic matter and it retains the moisture which is provided to the soil with the help of irrigation.

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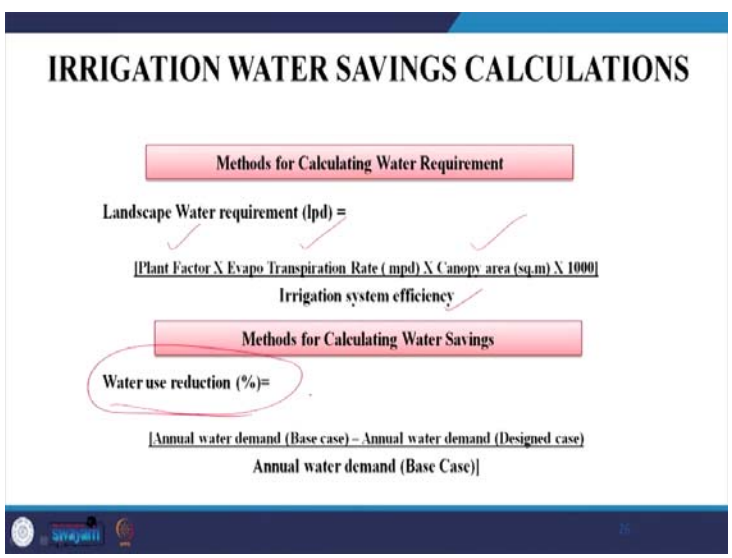

Now, all these factors they have to be demonstrated through calculations. So, the very simple formula for demonstrating the savings irrigation water savings is where we have the plant factor; a product of plant factor, the evapotranspiration rate and canopy area and dividing it by irrigation system efficiency. So, when we compare this base case to the design case the proposed case, we can actually calculate the water usage reduction in percentages. Let me explain this clearly.

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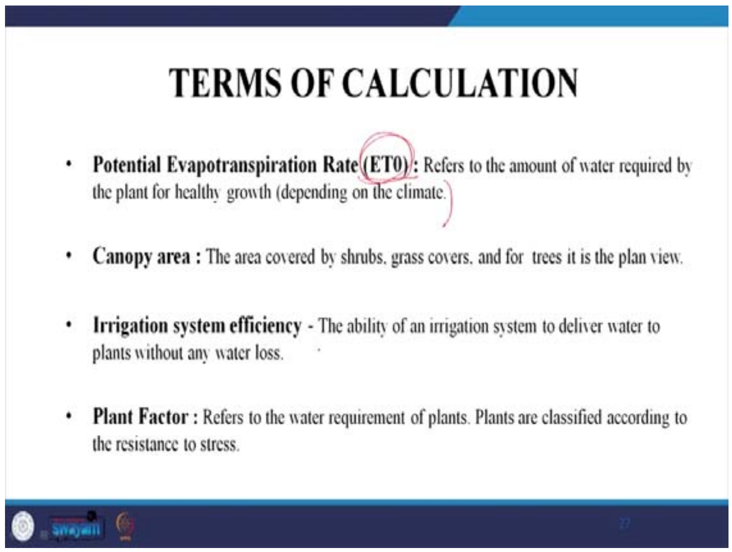

So, this potential evapotranspiration rate it refers to the amount of water required by the plant for healthy growth and it depends upon the climate. So, it depends upon the climate, the soil and the climatic factors so, all of that refers and is consolidated in this term as evapotranspiration rate. The next is canopy area which is the area covered by the particular type of plant. So, it could be the area under the shrubs, it could be the area under the trees and like that, it is actually the when we draw the landscape plan. So, it is the area which is seen in the plan being covered by different plant species.

The next is irrigation system efficiency we have already seen the efficiencies of different systems which we take here and plant factor it is dependent upon the water requirement of different plants. So, different plant species based upon different plant species this plant factor is varying. Now, the values for all of these have been researched a lot and these values are available through different organizations largely working on the forestry and plants and agriculture.

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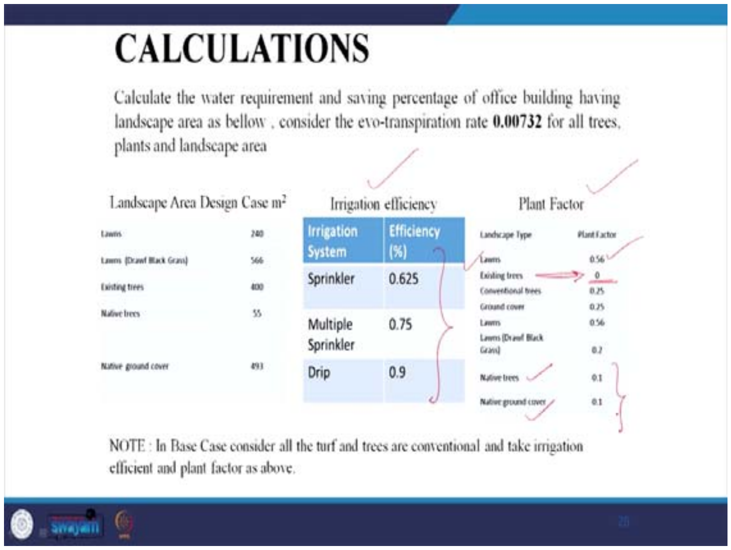

So, we can see the irrigation efficiencies which we can use, we can also look at the plant factors. So, for different types of plants we have the plant factor. So, suppose we have lawns it is it has a very high plant factor of 0.56 while if we look at existing trees, it has a plan factor of 0 which implies that no water will be required. If we look at the native trees and ground cover which are planted later as part of the landscape, they also have a very less plant factor which is 0.1.

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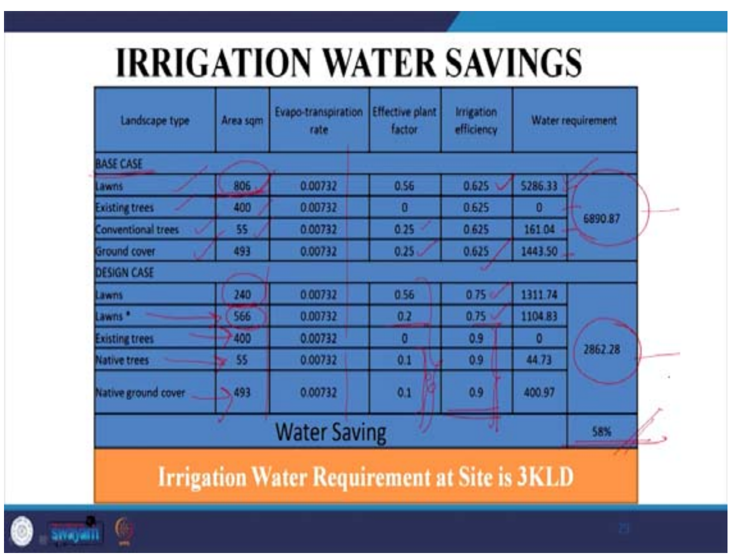

Landscape type	Area sqm	Evapo-transpiration rate	Effective plant factor	Irrigation efficiency	Water requirement	
BASE CASE						
Lawns	806	0.00732	0.56	0.625	5286.33	6890.87
Existing trees	400	0.00732	0	0.625	0	
Conventional trees	55	0.00732	0.25	0.625	161.04	
Ground cover	493	0.00732	0.25	0.625	1443.50	
DESIGN CASE						
Lawns	240	0.00732	0.56	0.75	1311.74	2862.28
Lawns *	566	0.00732	0.2	0.75	1104.83	
Existing trees	400	0.00732	0	0.9	0	
Native trees	55	0.00732	0.1	0.9	44.73	
Native ground cover	493	0.00732	0.1	0.9	400.97	
Water Saving						58%
Irrigation Water Requirement at Site is 3KLD						

So, once we have all these we will actually put them in the same equation which we just saw and calculated the total irrigation water requirement. One of such calculations is shown here and so, suppose as a base case in the initial stages of the design. We proposed 806 square meter of lawns, 400 square meter of existing trees were retained and conventional trees were planned as 55 square meter of area and there was a grand ground cover which was proposed.

Now, taking the evapotranspiration rate which remains the same because it is dependent upon the climate, we have the effective plant factor which gets calculated from the tables which I just show which I have just shown and then we select the type of irrigation mechanism that we are going to use. So, this one is for a sprinkler irrigation. So, we have a large sprinkler and this is used for irrigation and accordingly we calculate the water requirement for each one of these.

Now, as a proposed case we change this slightly. So, what we have, we have reduced the total ground, total lawn cover from 806 square meter to a 240 square meters only and the rest of the area is actually 566 square meters where the native grass cover has been provided.

So, it does not require as much of the irrigation because it is the native ground cover. Existing trees have been retained as the same and the native trees also have retained as the same, instead of ground cover native ground cover has been provided. Once we make those changes and we get the resultant affective plant factors.

So, we can see that from 0.56 a large portion of lawn has a plant factor of 0.2 and the native trees and native ground cover which was earlier 0.25; here has been reduced to 0.1, in addition to that we see that wherever the there is improvement of irrigation we will provide that.

So, instead of a sprinkler we have brought in drip irrigation process which has increased the efficiency to 0.9 and instead of sprinkler we have used multiple sprinklers. Together we calculate the total amount of water requirement and compare the base case with the proposed case and we see that here we have been able to reduce the requirement of irrigation by 58 percent.

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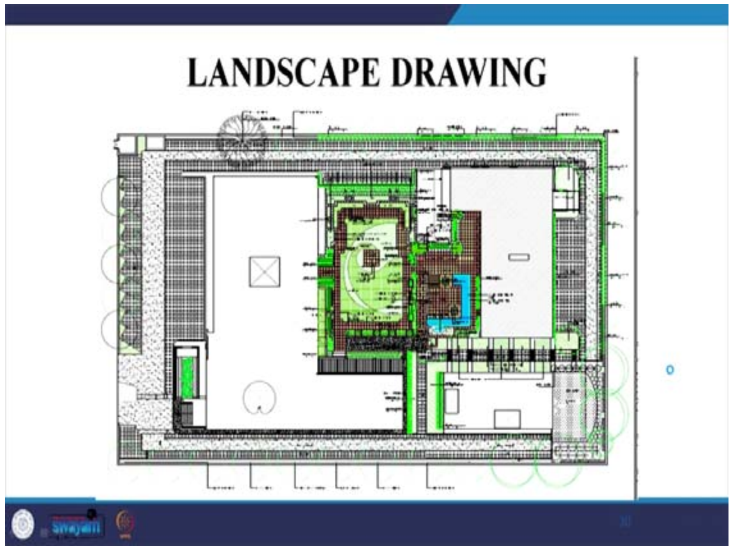

On top of this, this water requirement may be substituted through the water which is collected by rainwater harvesting. So, a detailed landscape land needs to be prepared right in the beginning with the detailed list of native tree and plant species which are going to be planted. The rain water harvesting which is going to be taken in the type of irrigation system which will be deployed employed and all of that should be reflected in the form of this detailed drawing so that whatever has been shown through the calculations is actually implemented on ground.

So, I will stop here for this lecture on water conservation. See you in the next lecture we will be discussing about more of such strategies towards water conservation.

Thank you and see you again.