Natural Resource Management (NRM)
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Week – 11
Lecture - 60
Climate Change, Vulnerability, Adaptation in NRM: Part 03

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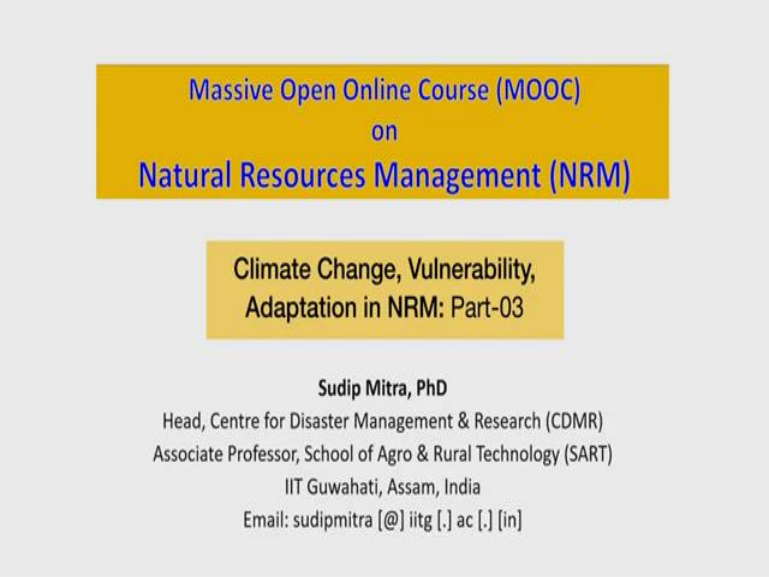

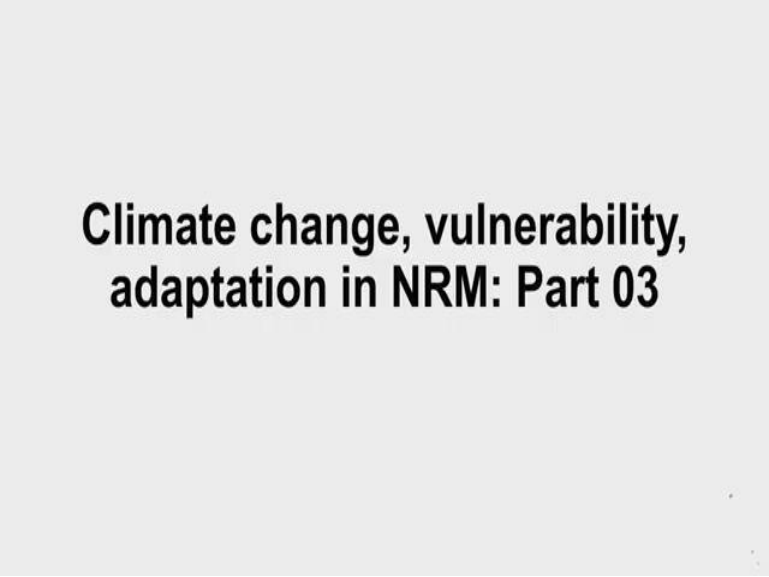

So, participants in continuation of our climate change vulnerability adaptation in natural resource management, part 3, and in this section we will be discussing the adaptation,

planning and implementation processes. In earlier lectures, we discussed about vulnerability assessment a various way that we can assess vulnerability.

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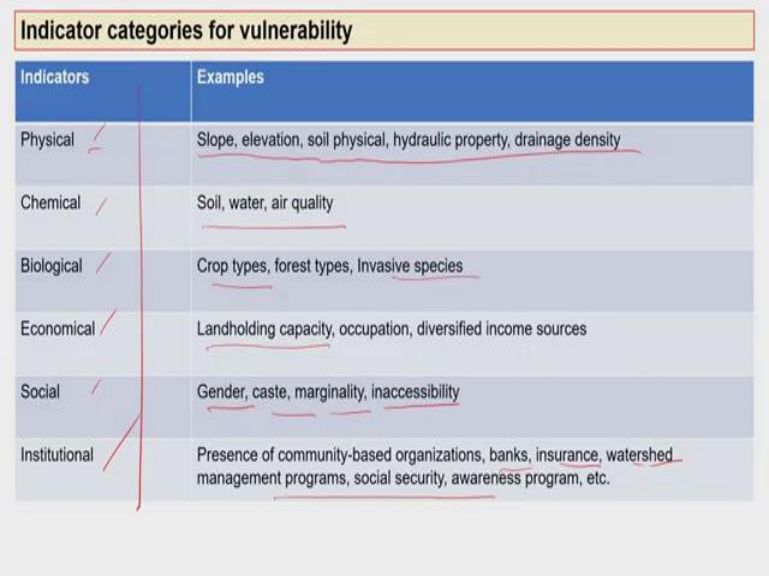

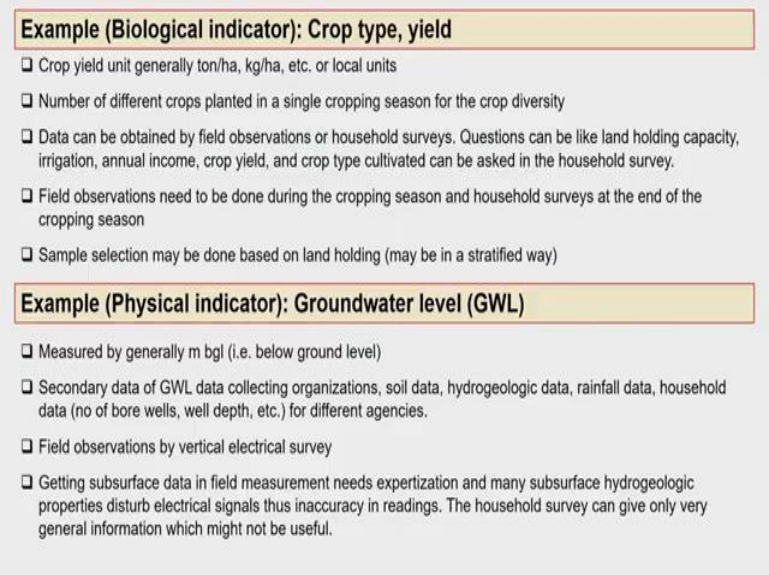

And also different aspects along with example, we have given various indicators we have discussed and also the examples of various indicators.

In these sections, we will look at the adaptation process. Once a particular society, community or individual is vulnerable to a certain stress; that could be water stress, lack of good quality soil, for a farmer availability of good quality seeds, for a company owner, it could be unavailability of raw material, problem with transportation. These are all any kind of changes and a particular community or individual who is vulnerable through our assessment we find then what you need to go. There are two ways one is adaptation, the other is mitigation that we discussed.

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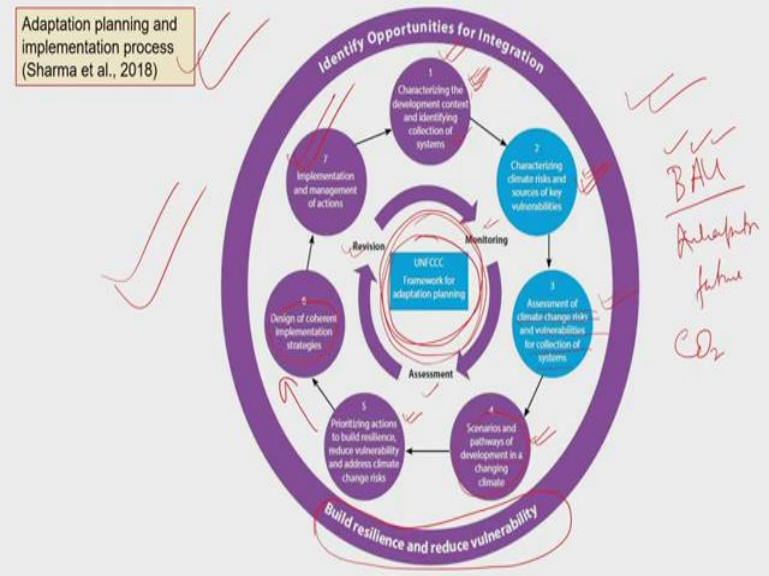

So, adaptation is actually one of the most important options that we can actually follow for addressing the vulnerability. Now, adaptation planning and implementation process, if you look at it involves various kinds of conditions and also different kinds of factors are also involved into that.

Now, in case of adaptation planning process, step one; on the first step is to characterize the development context in which actually the community or individual is exposed to and then you try to identify the different information about the system existing system. Now, this adaptation framework that we are discussing today is proposed by UNFCCC United Nations Framework for climate change.

So, they is one of the topics bodies looking into climate change adaptation, another aspect, so, here this adaptation planning framework given by UNFCC it looks at monitoring, assessment and revision of plan. So, this particular cycle keeps on going. But what happens in the practical condition is that you start with characterizing the context of development one then characterizing the climate risks and the sources of various vulnerabilities and that we have discussed a lot, how we can assess vulnerability.

Now, once you have done that assessment of risk and vulnerability, then we are going to go on to assess climate change, risks, vulnerabilities for collection of various systems. Then we move on to evaluate the scenarios and pathways of development in case of climate change.

So, one has to imagine that if there is a climate change, then what kind of pathways and development activities should actually go on.

So, once we have BAU situation, we call business as usual and other is scenario that you anticipate; anticipatory scenario for future. And this scenario in the case of climate change is largely based on, CO_2 concentration, increase of CO_2 concentration. So, once your scenarios, pathways of development in a changing climate is studied, evaluated, then we go for prioritizing our actions to build resilience and thus reducing the vulnerability then we go on to design of coherent implementation strategy.

And once we design the strategy next remains is implementation. So, you go implement and then start managing the system. So, this is a very well known framework for adaptation planning and implementation process which ultimately leads to build resilience and reduce vulnerability.

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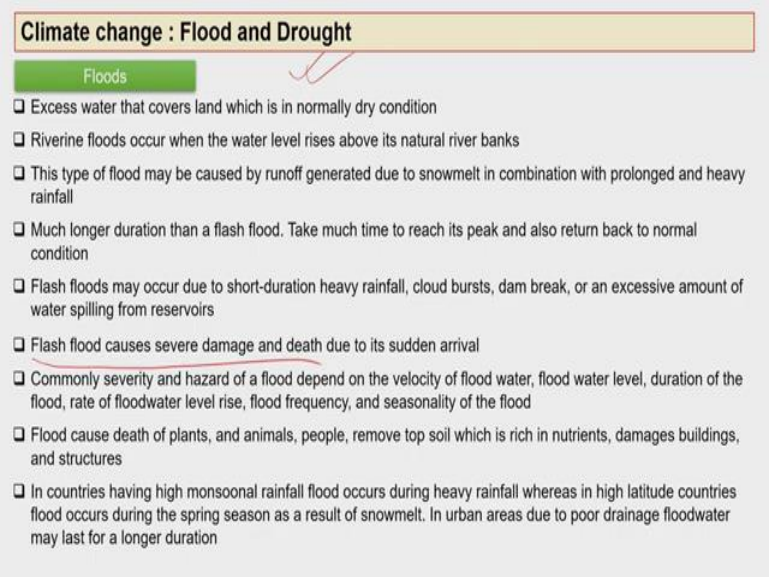

Now, I will discuss a few cases that often happen and then create lot of stress as well as, change the availability or accessibility of various natural resources to the people. Flood and drought; two important event that takes place and create havoc actually in many parts of the world. So, in India so, flood, it is a natural phenomena and especially the region where from I am speaking; Assam is known for annual floods.

So, almost every year there will be flood, but, the question is that, how much the impact would vary from year to year and that depends on also on the good assessment, vulnerability assessment, and then good, robust adaptation strategy or mitigation planning.

Now, these all exercise are basically based on ground truth and also suitable policy framework. So, if you look at that, sometime in some parts of our country, we face a lot of issue with flash flood. Right now, in the Bangalore City, we are seeing we are viewing that what is happening with half of the cities is flooded.

Even some of the multinational companies' offices are flooded unprecedented situations. So, this kind of the situation when happens, this actually reminds us that we need to have a well thought well planned strategy in hand.

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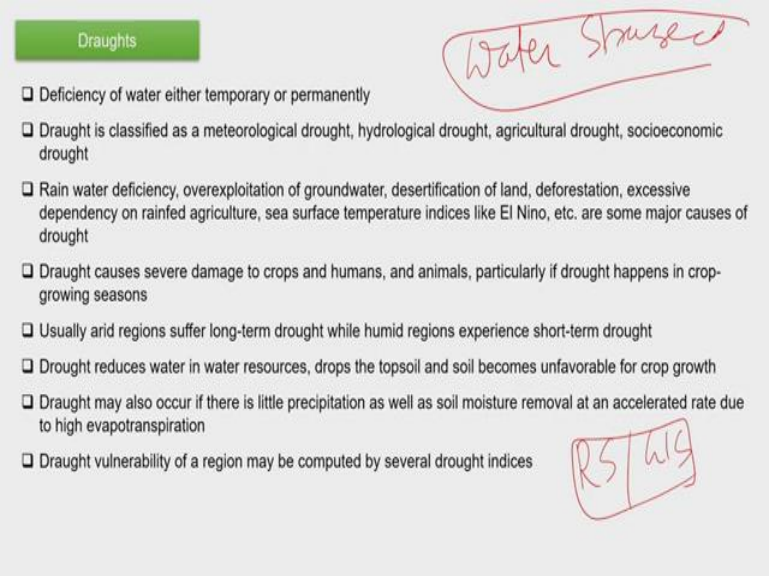

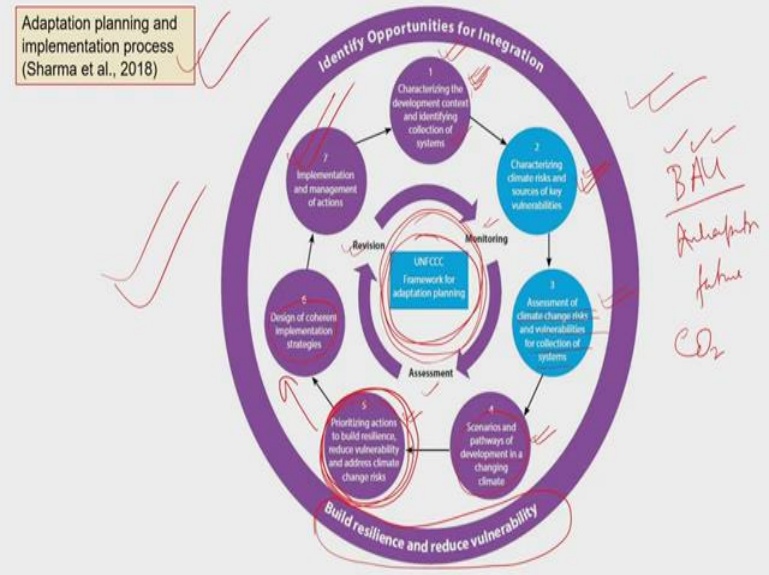

Similarly, in case of drought, if we know that the hot spot of water stress conditions across the country, and we have discussed that remote sensing, GIS help us to do to identify the hotspot. If we know all those informations, if we know also the history of our climatic events across the country, then, we need to actually prepare a robust plan a strategy for adaptation or mitigation. Now, several calculations several modeling exercise has been carried out in this two particular type of event flood and drought. Now, as of today, we have enough of technology in hand to assess.

So, the next step is that we are basically now here prioritizing our actions to build resilience; this is very important to act upon, otherwise, we have now a relatively good number of technologies to carry out various kinds of advance assessment.

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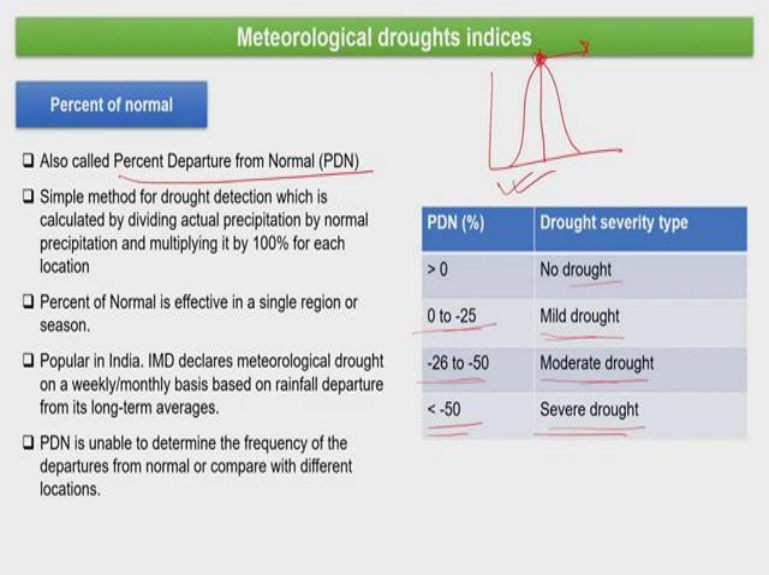

So, if you look at that, in case of drought, we can actually evaluate drought through various way. You can actually develop some drought indices, and those indices help you to understand the intensity of the drought. A simple method for drought detection, which is calculated by dividing actual precipitation by normal precipitation and then you multiply by 100 that gives you a percentage, amount of water coming into the system.

Percent of rainfall in certain areas over a period of time also changes. Now, if we have those data with us that certainly would help us to plan to have a very effective and robust adaptation strategy. Now, if you look at that, there are certain way that you can actually evaluate the intensity of supposed drought event one is your percentage departure from the normal.

So, suppose you have a drought condition suppose, this is suppose your normal kind of drought situation and if it goes a little bit in the higher end, the percentage by percentage level, then we will actually understand the severity of the drought and this is called as PDN, percentage departure from the normal.

Now, if you look at this table, it gives us some value and also the severity of the drought this is how one can actually identify the severity of the drought event. If it is greater than 0 no drought, if it is between 0 and minus 25 mild drought, if it is minus 26 and minus 50 moderate drought and if it is less than minus 50, then it is severe drought. So, this severity of drought will help you to understand that in which location what kind of adaptation major is required.

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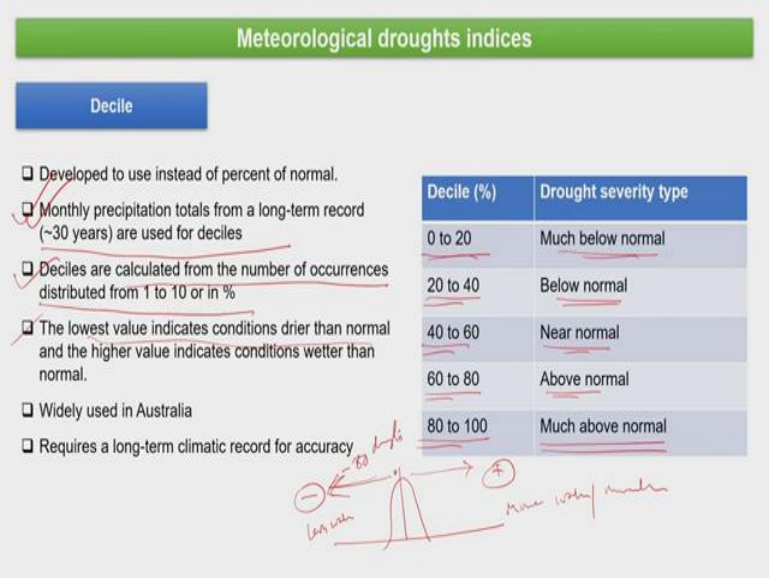

We can also have another way to express the severity of drought that is decile way and this has been developed to use instead of PDN. So, decile, you can use if you are suppose not comfortable with PDN. This method of decile also can help you. What you do is that monthly precipitation that you get from any kind of metrological station, you sum them from a long term record roughly around 30 years and that value actually is used for deciles evaluation.

And deciles are calculated from the number of occurrences which are distributed from 1 to 10 in person and the lowest value indicates condition drier than the normal. And the higher value indicates condition wetter than normal.

So, that means this is negative side means the less water or moisture this is positive side that means more water or moisture. So, if you move this side means it is drought very significantly without intensity or drought increases and here intensity of drought decreases.

Now 0 to 20 much below normal 20 to 40 below normal 40 to 60 near normal means somewhere here 60 to 80 above normal and 80 to 100 percent is much above normal. So, the value suppose minus 80, that means it is very severe drought.

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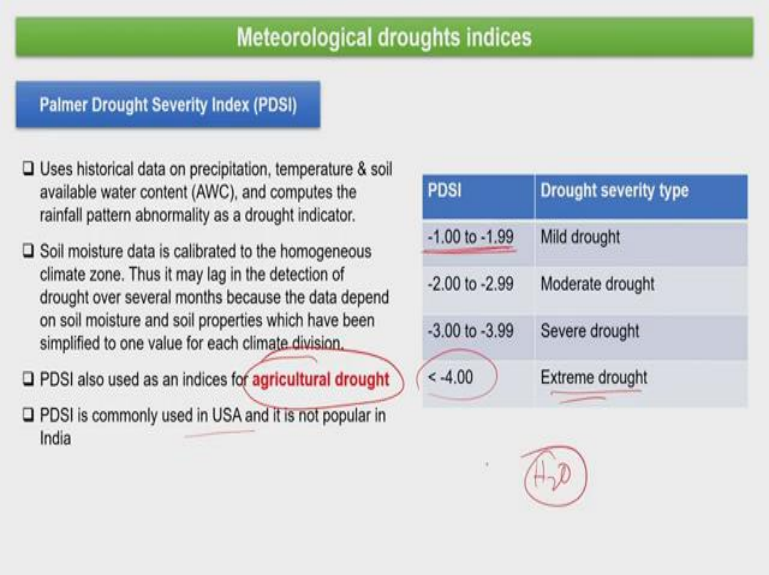

Then next another index method that we can use is Palmer drought severity index PDSI; and this index actually uses historical data of rainfall temperature and also available water content and then it computes the rainfall pattern which actually will tell you whether there is drought or not.

Now, the soil moisture data that you collect is calibrated to the homogeneous climate zone, climate is not changing too frequently, you also sometimes imagine that okay, within this grid, my climate is same.

So, PDSI also actually used as an indices for agricultural drought, because, there is also some thing is there that when agriculture department looks at drought, they actually always relate it with productions, productivity yield.

So, their way of calling a drought depends on how much it has affected the crop productions and yield and associated aspects. So, unless Agriculture Department find it that yes, it is agricultural drought, till then no kind of assistance are some things which are available under some schemes may not be facilitated to the people.

Now, PDSI is commonly used in USA and this is not much popular in India. So, in case of PDSI again, minus negative value, negative value if it is low, you have low drought low intensity drought, if negative value is high, then you have extreme drought. So, this is largely on the basis of water content.

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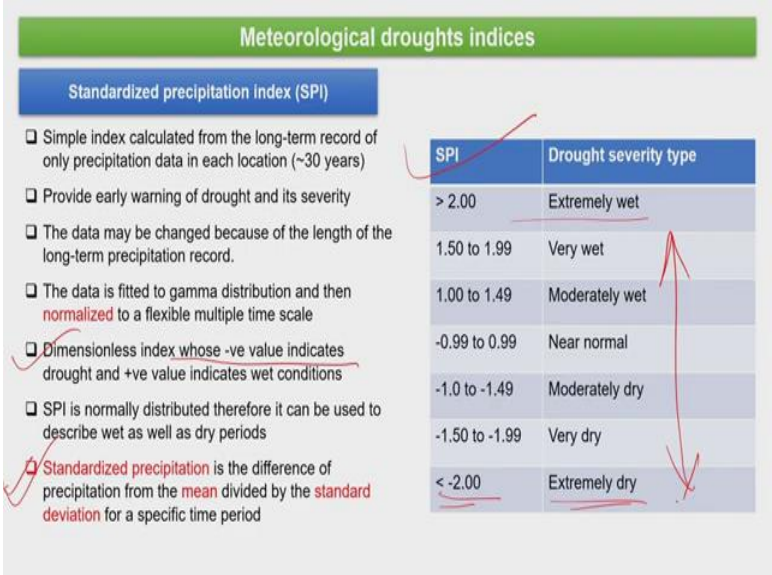

The next is a standardized precipitation index, SPI. Now, this index calculated from a long term record of precipitation for each location, suppose you want to calculate SPI for your campus. So, in that case, you need at least 30, 30, 40 years of rainfall data. And this SPI it provides you an early warning of drought, it gives some idea about its severity.

Now, the data that you get, it is fitted to a gamma distribution and then you normalize it to a flexible multiple time scale to calculate SPI. It is a dimensionless index whose positive value will indicate drought and positive value will indicate wet condition like previous ones and SPI also normally distributed therefore, it can be used to describe wet as well as dry period.

If you look at that, standardized precipitation is the difference of precipitation from the mean divided by the standard deviation for a specific time period that is how you get actually your standardized precipitation SP. Now look at the SPI so greater than 2, extremely wet, less than minus 2 extremely dry and then in between you have various category of drought.

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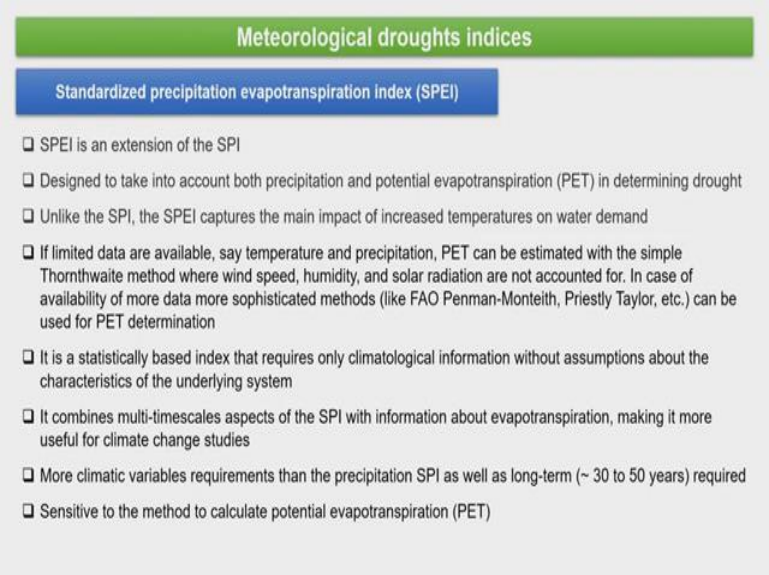

Next standardized precipitation, evapotranspiration index, SPEI. Why I am just actually introducing this different methodology to you because within Natural Resource Management, if any one of you has a background of suppose agricultural physics or hydrology, this kind of subject then probably you may like to focus on this aspect.

So, I am just, that is why introducing this is another aspect which is linked with the natural resource management especially with water. So, SPEI is nothing but an extension of standard precipitation index. And this is designed to take into account both precipitation and potential evapotranspiration to determine the drought.

If you look at that, unlike SPI, this index captures the main impact of increased temperatures on water demand. And then it is sensitive to the method that to calculate PET. So, if you want to calculate PET for further understanding of the intensity of moisture stress in soil, then SPEI is one index which can help you and this index is statistically based index, which actually requires or need only climatological information without any assumption about the characteristics of the underlying system in a particular area. So, it just requires the climatological information does not need the underlying conditions.

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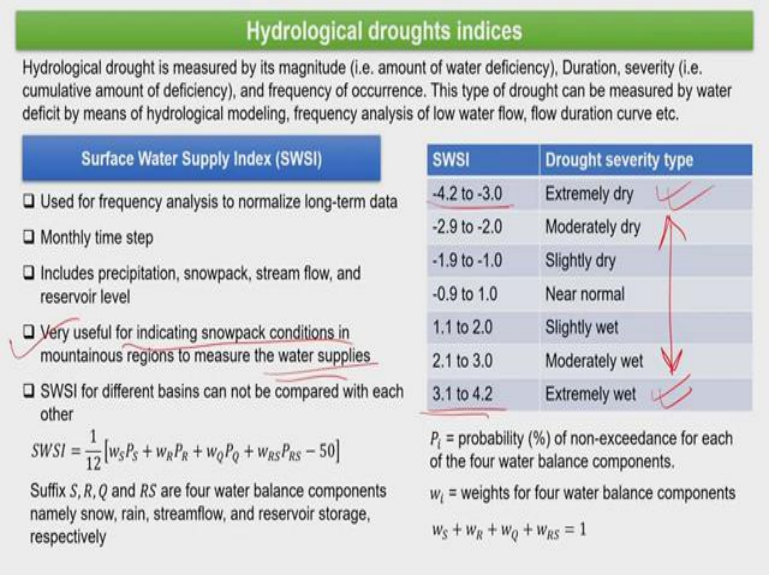

Next surface water supply index SWSI. Now this index used for frequency analysis to normalize long term data and it is very useful this index for indicating snowpack conditions in mountain. In mountainous regions, it also helps to measure the potential water supply. Majority important river in India, the river water is coming from glaciers.

So, surface water supply index is one index which can actually help you to understand that how much water actually can come in into the stream flow. So, in case of SWSI, once again, lower the value, dryer is the condition. So, minus 4.2 to minus 3 extremely dry and 3.1 to 4.2 is extremely wet and then in between you have various other intensities of drought condition.

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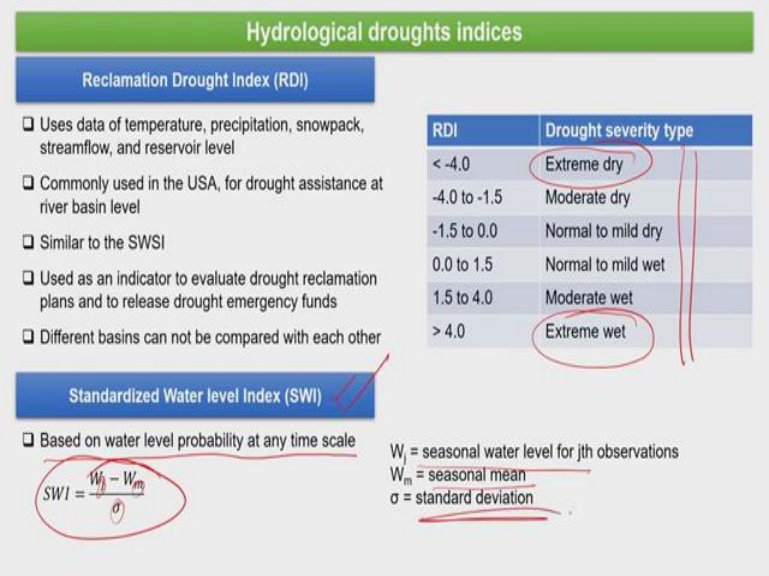

Then comes reclamation drought index, RDI. RDI uses temperature, precipitation, snowpack, streamflow and also reservoir level information data. So, this is more or less like SWSI. And this is used as an indicator to evaluate that drought reclamation plant how to manage drought and also to release drought emergency fund. When government announce that a particular district is drought affected, then only actually some of the funds from various schemes will go to that particular state.

And that is why you might have seen that sometime the chief ministers or the state government actually pushes central government to announce their state is drought affected. Because, if centre announces that it is a drought affected district, then that district of that particular state will become eligible to get certain amount of grant so, that is the also one policy aspect which is related with this all these indices. So, here also in case of RDI lower the value dryer is the condition, higher the value it is a wet or moist condition.

So, then we have another index also sometime it is used in some countries standardized water level index SWI and this index is based on water level probability at any time scale, you calculate through this particular formula,

SWI is equals to Wj minus Wm divided by sigma

where Wj stands for seasonal water level for the jth observation, Wm seasonal mean and your sigma is the standard deviation. So, you then calculate SWI.

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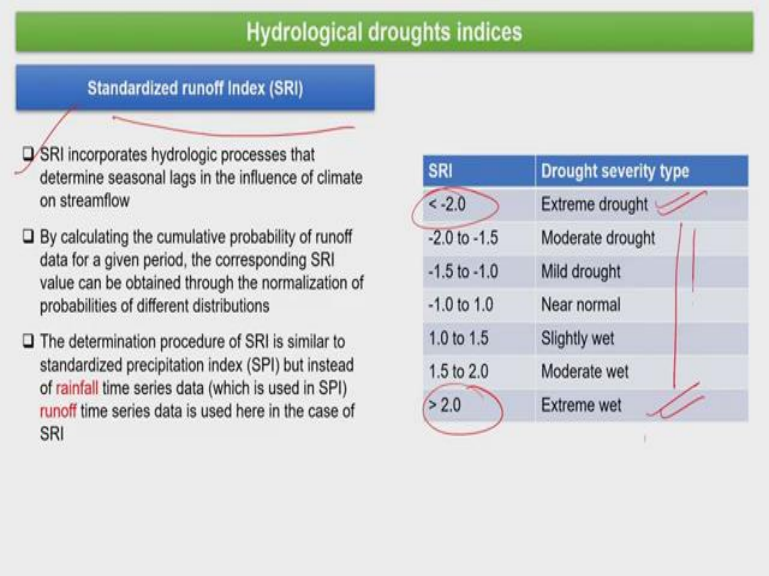

SRI which is known as standardized runoff index. Now, SRI incorporates various hydrologic processes, which determine the seasonal lags or gaps in the influence of climate on streamflow. So, what actually SRI gives you that it actually helps in understanding the amount of moist condition in a particular area and SRI also is calculated on the basis of your rainfall and also runoff data.

So, in case of SRI, when you have high negative value index, you have extreme drought condition, when you have high index value you have extreme wet condition. So, this particular phenomenon is same across all the indices.

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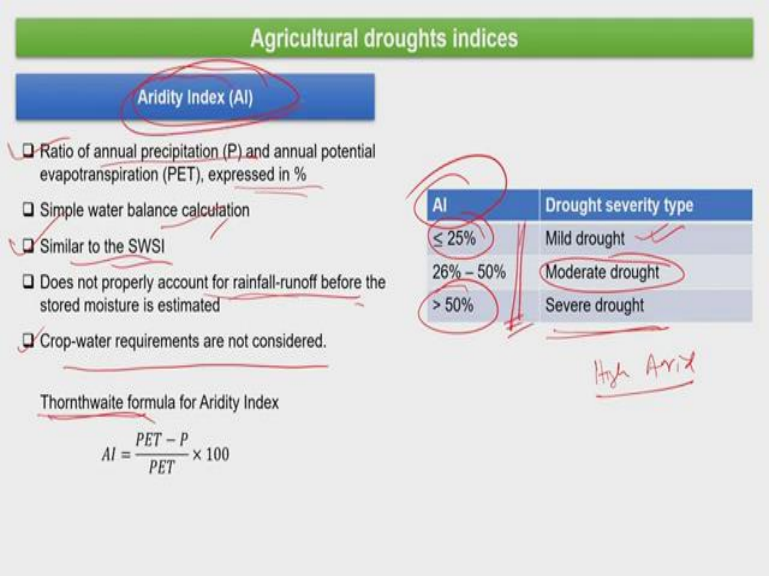

Aridity index; very important many parts of our country are actually arid as far as the classification of land is concerned. So, but the intensity of aridity can be actually understood by aridity index; it is a ratio of annual precipitation and annual potential, evapotranspiration and you experience a PET in percentage.

And this is again very simple water balance equation similar to almost SWSI, which we discussed a few minutes back, it does not properly account for the rainfall runoff and here crop water requirements are not considered.

So, if you look at the formula, which is famously known as Thornthwaite rate formula for aridity index, here you use PET, potential evapotranspiration data, precipitation data and then you calculate AI. In this case we are going to call it highly arid and low arid.

So, here if the value is greater than 50 then you have severe drought meaning high arid conditions. And if you have the value less than equal to 25 percent you have mild drought in between you have moderate drought.

So, this is perhaps the only index that we have positive value higher value means severe drought because we are calculating actually the aridity or dryness index.

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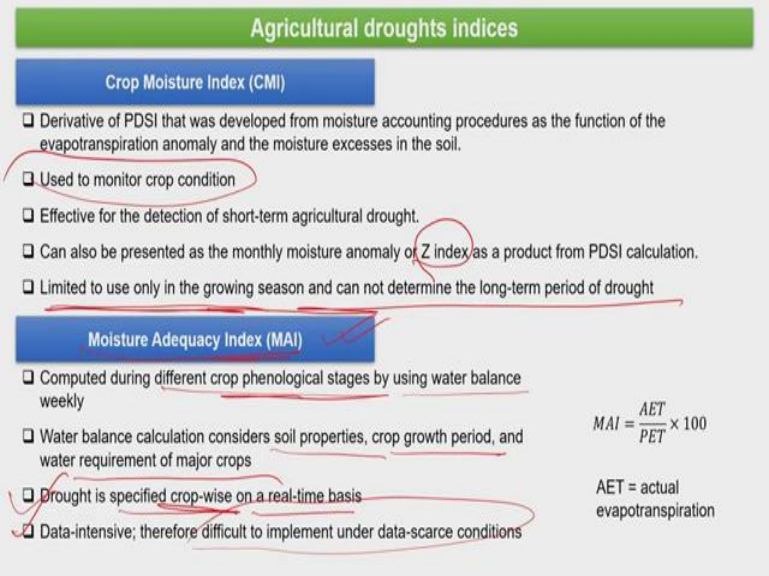

Next is Crop moisture index or CMI. Here CMI it is actually used to monitor your crop condition. And these kind of indices when you carry out in remote sensing lecture we discussed so, after those data that you get spectral images and you analyze it, then you can actually compare with this kind of ground based information.

So, this CMI actually helps you monitoring crop condition. It is also helpful for understanding that how much moisture, how much water is already there in the plant system. This can also be presented as the monthly moisture anomaly or we call it Z index as a product of PDSI calculation which we just discussed a couple of minutes back. So, there is a limitation of using CMI and that it can be used only in the growing season and cannot determine the long term period of drought.

Next is moisture adequacy index. MAI; this is calculated during different crop phenological crop phenological stages by using water balance every week. So, water balance calculation considers soil property crop growth and water requirement of various major crops, drought is again specified crop wise on a real time basis because what is drought for rice.

It cannot be drought for wheat different crop requires different kinds of water intake. Well MAI is data intensive. Therefore, it is difficult to implement under condition where that you do not have much data or information; primary or secondary.

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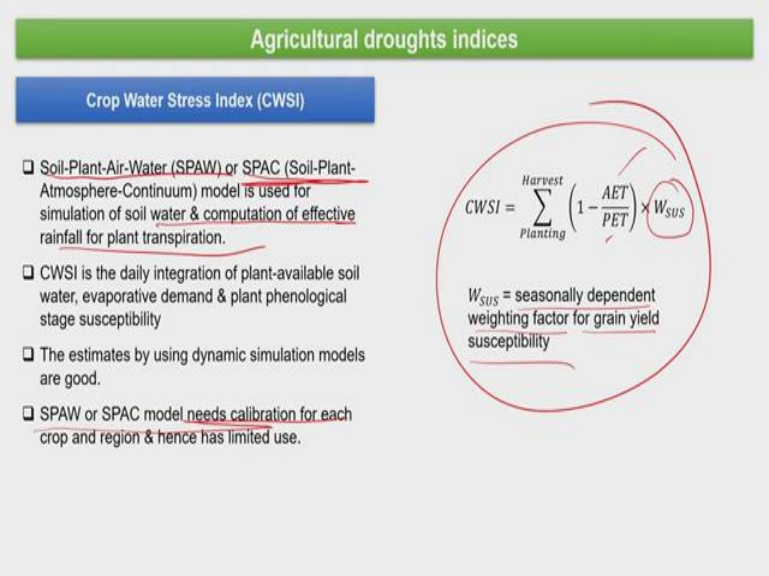

Crop water stress index, CWSI, this is again another very important index. Soil, plant, air, water or SPAC system is a model which is used for simulation of soil water and competition of effective rainfall for plant transpiration.

Now, CWSI is a daily integration of plant available soil water evaporative demand and plant phenological stays susceptibility to water. So, SPAW or SPAC model needs calibration for each crop and region and that is why this index has limited use, you can actually estimate CWSI through these simple formula equations here,

CWSI is euals to summation planting to harves 1 minus AET divided by PET multiplied by WSUS

$$CWSI = \sum_{Planting}^{Harvest} \left(1 - \frac{AET}{PET}\right) \times W_{SUS}$$

all only these things WSUS it means seasonally dependent weighting factor for grain yield susceptibility.

If you recall that one of the earlier classes I mentioned that how much important it is the water for plant growth and also productivity and yield. While discussing remote sensing aspect we also discussed that how plant water stress also can be captured sometimes through remote sensing. Here these kind of indices actually can reinstate the fact which probably will get through remote sensing without going into the field; without actually studying the plant

water stress in the field. So, these are indices which help us to understand the drought condition.

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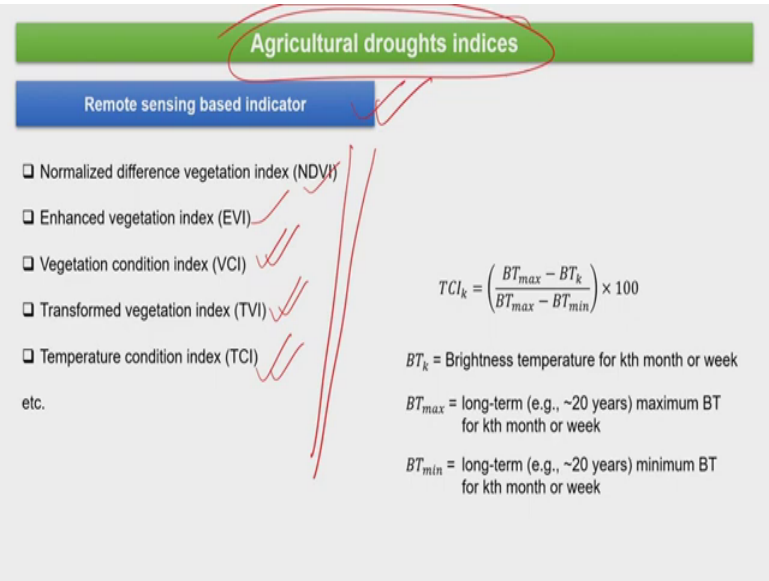

Now, as I was telling about remote sensing, here is a remote sensing based indicator. Now, these are the remote sensing based indicator, NDVI most popular enhanced vegetation index, then vegetation condition index, transform vegetation index, temperature condition index, various these indices are used for estimating the agricultural drought situation.

Why I am discussing this particular aspect, because it is very very important. Your all grant financial help in case of drought situation will only come out when it will be announced as a agricultural drought. And to understand that there is a process this kind of evaluation will be carried out. And for that evaluation, you need to know some of these important indices.