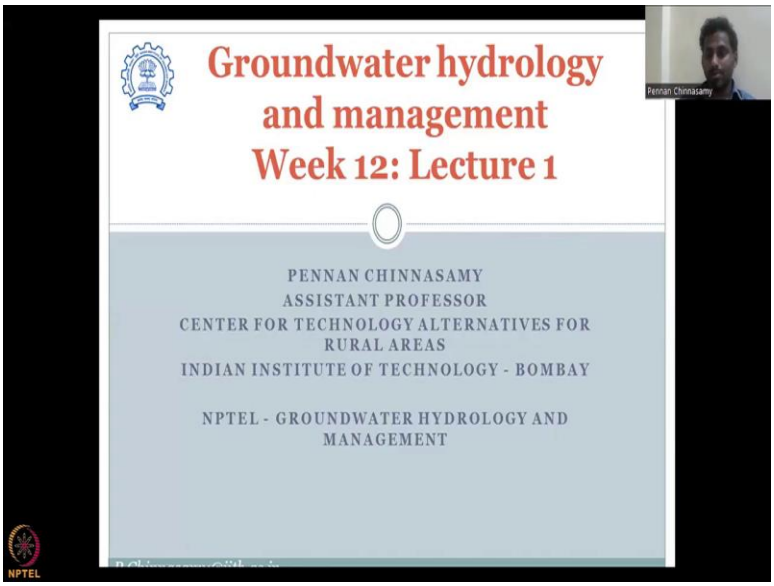
Groundwater Hydrology and Management
Professor. Pennan Chinnasamy
Center for Technology Alternatives for Rural Areas
Indian Institute of Technology, Bombay
Lecture 56
Case studies of Groundwater in India
Part - 1

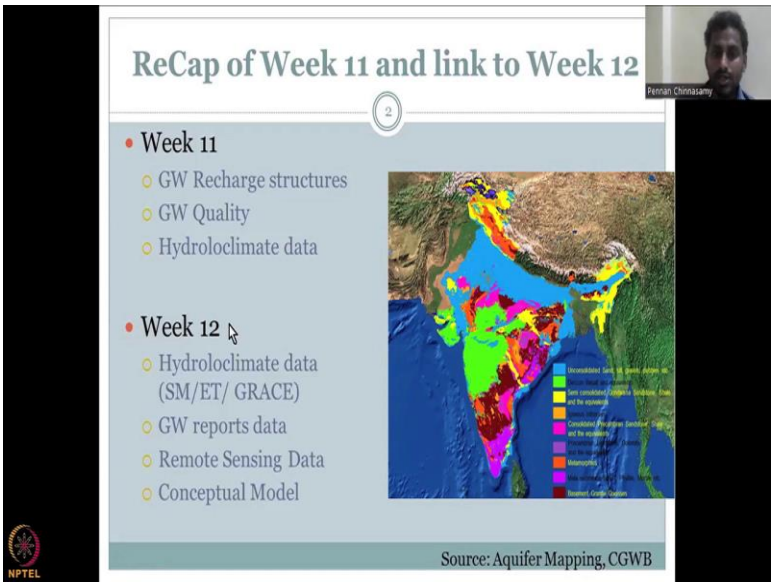
(Refer Slide Time: 00:16)



Hello, everyone, welcome to NPTEL course on Groundwater Hydrology and Management. This is the last week, week 12, on groundwater hydrology and management. I hope all these lectures have been in a coercive way, where we started with understanding what is groundwater. We understood the issues in groundwater management. And then we understood or we discussed about the important parameters for groundwater management.

And then we looked at finally the data that is needed for groundwater management. So, on the data side, we looked in the two weeks week 11 and week 12, we will be looking at what is the data that needs to be collected to assess groundwater damage and groundwater resilience, etcetera. It also is needed to understand what data is important for helping farmers in managing groundwater properly.

(Refer Slide Time: 01:21)



On that note, in week 11, let us do a recap of week 11and how it is going to be week 12. Week 11 we looked at groundwater recharge structures determined by the government and public private data where these structures are present and how are they helping the groundwater recharge. We also looked at groundwater quality as a tool to understand groundwater depletion scenarios and other aspects.

But also groundwater quality was very important to understand the usability of water, because if water has a lot of arsenic, you cannot use it for crops or use it for industry and drinking. So, quantity and quality are both important and have to be managed for sustainable development in rural India. So, the groundwater quality standards, we looked at using the CPCB board, Central Pollution Control Board data.

And following that we looked at different hydro climatic data that is needed for understanding the groundwater resources. The hydro climate data starts with your rainfall. And we looked at other data that includes your storage structures, river discharge, and other aspects. Now, we are coming to week 12, which is the second part of the groundwater data or data needed in the water balance. On that note, we will be looking at soil moisture data and evapotranspiration data which form a bulk in the groundwater budget equation.

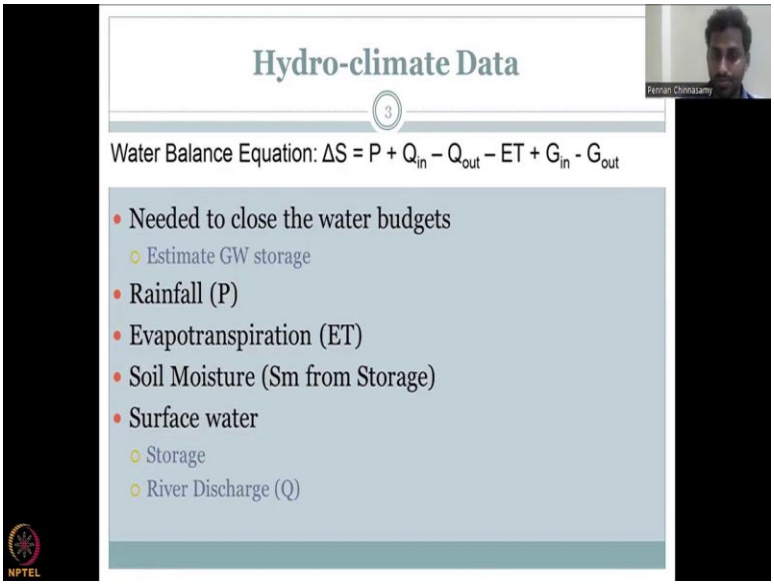
And we will be looking at groundwater reports, data, etcetera. We will be looking at remote sensing data in this week. Remote sensing is defined as the method in which you collect data

from an object without touching the object. So, because a lot of times you cannot have the luxury of measuring the parameter physically like using a meter or a measurement device like groundwater, sometimes you will have depend on remote sensing because of low cost high spatial and temporal resolution.

On that note, we will go through some remote sensing data, especially Grace data which is one of the most important satellites across the world, which is monitoring groundwater depletion. And finally, we will look into a conceptual model idea or framework, where we pull all the data that we collected into a single model. And that model will explain at time zero to time one what is happening.

Again, this cannot be done for a real life scenario or even a theoretical scenario for me, because every time has to be accounted for. Your conceptual model will therefore give you a timestamp. And that can be used in an automated model to run for different time zones. We will look into the consumption model in detail before we close this week. And the soil machine evapotranspiration are also driven by remote sensing data. It is not physical data always and that is what we will cover in this week lecture also.

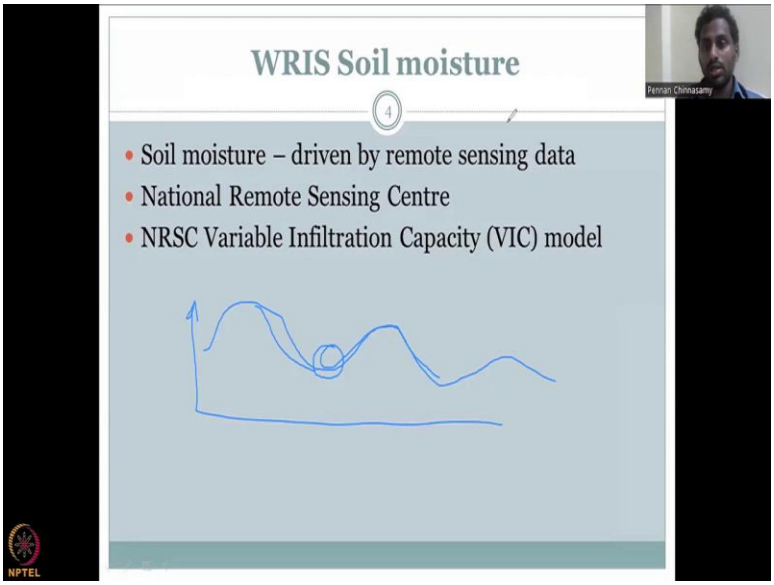
(Refer Slide Time: 05:07)

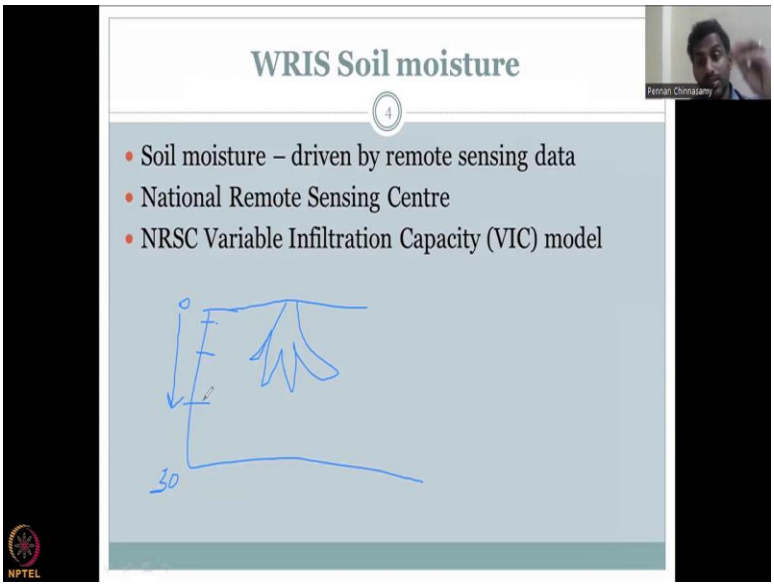


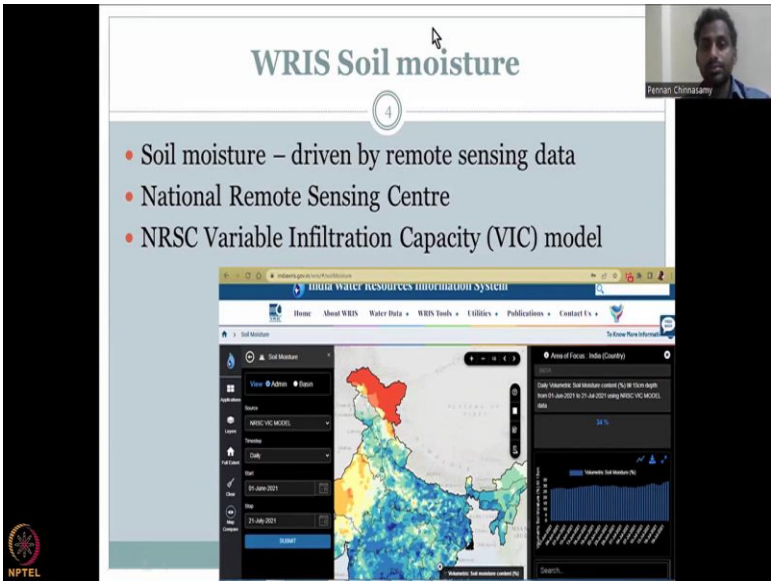
So, without further delay, let us jump into the big 12 groundwater data aspects. As I said, this is the balance equation that we started with, we understood what balance is which is the change in storage either groundwater storage or soil surface water storage, river discharge, etcetera as Q.

ET we will discuss in this week and your soil moisture which is part of your storage, water storage component, we will look at in detail in this week.

(Refer Slide Time: 05:41)







Soil moisture, so, soil moisture we already defined in the previous classes but let us give us a very small brief introduction. So, we have soil and within the soil we have materials and space, the pore space which is in between the soil material differs by different type of soil types. So, for now, we can understand that there are soils with high porosity and low porosity and that pore space can be filled by vacuum, air or water.

Vacuum is not always that easy, so it does not form that widely in nature, so most of the time it is either air or water. When it is fully filled with water which is the pore space the volume of void inside the soil if it is full with water we call it 100 percent saturated or saturation. And when it is only air present or vacuum present which would mean that there is no soil moisture it is called unsaturated, totally dry or unsaturated soil.

And unsaturated can be anywhere from 0 to 99.0 percentage because even if you have some particles any saturated soil. So, what soil is moisture is like a percentage, percentage of the void which has water in it, not the soil particles just the void and it can range from 0 to 100 as I mentioned. So, which is helpful for plants let us have a quick diagram on it, we could see that you have time on your x axis and soil moisture value on your y axis.

So, if the soil moisture is high and low it goes like sinusoidal because of the seasonality, rainfall, plant uptake. So, if the soil moisture is high, zero to high, then there is no need for the farmer to put water. And when it is low, yes, the soil moisture has to be enhanced by supplying water so there is water being supplied at this stage.

And that is why your soil moisture goes up and then down after harvest. So, during harvest, you will notice that farmers do not irrigate the field. This is when they are cutting the paddy, sugarcane, etcetera. Because the crop has grown all they have to do is cut it take it to the market or mills or sugar frickin factories. But in that phase, you do not have to irrigate the field but other phases, yes we do. So, this is what soil moisture variation is very important for.

And then the other aspect is at what depth you take soil moisture, let us say this is zero soil and then you go down deep, so from 0 you go to 10, 15, 20, 30 centimeters down, so let us say 30 centimeters. And we know that most of the plants have root zone within the 15 centimeters, this is your root zone, the roots spreading down into the soil. So, for that reason, mostly soil moisture is measured up to 0 to 40 centimeters or 30 centimeters.

Let us say here it is 15 centimeters is what the government reports to the NRSC. So, soil moisture can be taken from data physically like 0, 10, 15 centimeters deep, you put soil probes and take the data. But as I was saying it is very expensive time consuming. There are a lot of methods that use satellite data for driving soil moisture output. And that is what we will be looking at today through the government's data portal.

So, soil moisture data we are going to look at and it is driven by remote sensing data wherein you are not touching the soil and collecting data but using satellites or remote sensing objects to collect data. So, how it collects data is it sends a pulse of energy or traumatic wave, which penetrates into the soil and that penetration level is correlated with the soil moisture.

So, all this we have seen from other research and other works, but, since the class is not going to go deep into the remote sensing I will stop here and say that is it about remote sensing. Just for you, you can understand that it is a data source that is used to collect soil moisture without touching the soil and mostly these satellites. So, because the satellite it comes under the National Remote Sensing Center, which is an arm of the Indian Space Research Organization.

So, ISRO is big and within ISRO you have multiple agencies that work for soil, water and other aspects. So, basically multiple agencies that work on data and the key is the national remote sensing NRSC, then you have the SAC which is the Space Application Center and then the other RRSC which is the Regional Remote Sensing Center.

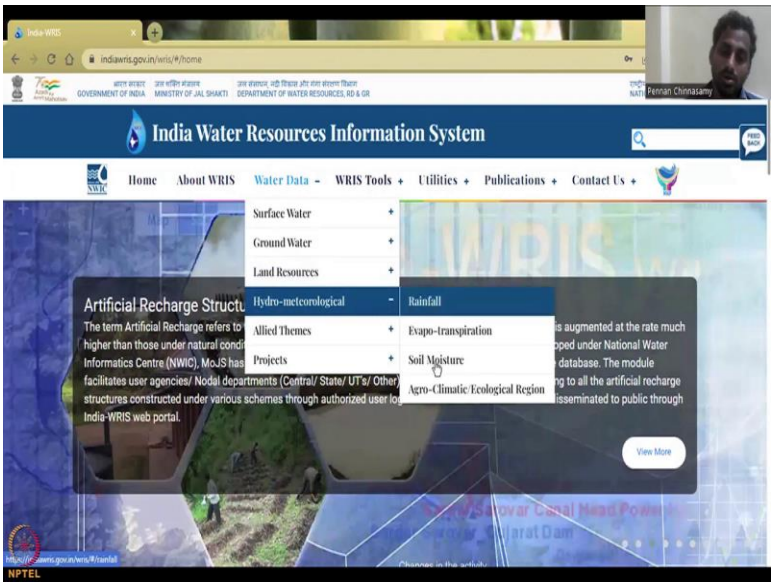
So, the National is at a bigger scale and within the national there are regional centers for example, there is one for South, West, East, North and also the central part of India. And these centers work on specific problems for that area using remote sensing data. So, where does the NRSC come cares? So, NRC what they do, they collect the remote sensing data and then put it into a model which gives soil moisture as an output and that model is called the variable infiltration capacity model, which has been developed by a very well known team.

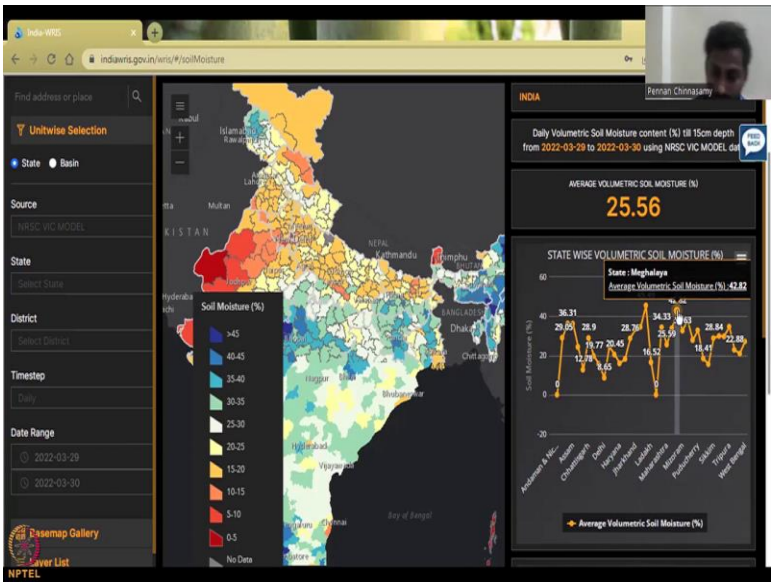
So, that team model is open source anyone can use it and the NRSC since it is driving it with their own data it is calling it as an NRSC VIC model, or VIC model. So, all this data is housed in the WRIS website. So, we will be looking at that website in detail in this upcoming lecture. This is how it looks, a snapshot I am showing. Why I am showing the snapshot is because it was having some issues to capture it in your class videos.

And as a result I was even thinking of taking some other material for the class but luckily it is working so, I am recording the session but please understand that there will always be issues with the website because of the data getting populated often and it is operated on a lesser budget and compared to the NASA, ESA, etcetera.

So, you cannot expect as high bandwidth for this website. So, there is some slow part however it is good data. So, please try it often if it does not work, and one time you can find it work and then download the data. Do not try to use this to operate with data and Exeter just download the data fixer location download the data and use a GIS software like UGIS, open source to run your models and instruments. So, let us go to the website.

(Refer Slide Time: 13:55)





So, now we are at the home website WRIS and then I go to water data and then I go to hydrometallurgical the last lectures we have looked at rainfall so now we are looking at soil moisture. As I said I will have to click and then wait for some time for the data to populate, the snapshot I showed you was for entire India and similar analysis is running behind now.

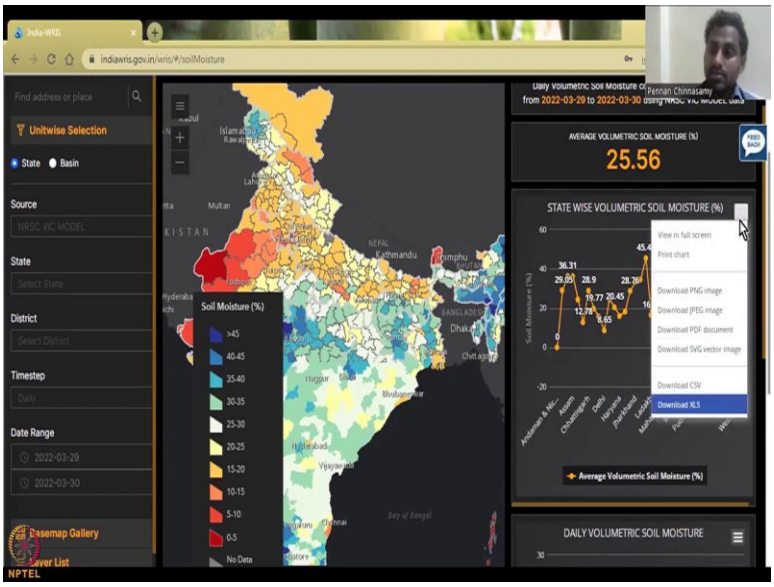
So, you could see that the date is being fixed up to two date ranges which is 22 year March 29 and March 30 of the same year. So, just two days this current population is happening, the data population. So, you can see slowly the data is coming up and they are taking only 10, 15 centimeters of depth.

So, I am just concentrating on the right hand side now to show you what the data is and how it is being stacked up. We have the India scale and India scale is a spatial scale, temporal is only two days, you have March 29 and March thirtieth of 2022 year which is just a week ago of this recording. And the average volumetric soil motion of these two dates is 25 percent which is pretty low compared to the plant requirements and then if you look at soil moisture as state wise only some states are given you can add more states by going down and then going to the next page etcetera.

Let us come back to 0 because that is theoretically okay but practically it is not possible. So, some issues there we will see what issue. But other states are recording good soil moisture of the best in this lot is Kerala with 45.49 and then you have Manipur Meghalaya region also high. Why is soil moisture high in Kerala region?

As I mentioned in my Western Ghats rainfall precipitation aspects, Western Ghats is there, so you have lot of rainfall is pouring in on the Kerala side and with water and sloppy land there is always deterioration of soil, formation of new soil etcetera and then decomposition happens at a faster rate. We have thick soil and that thick soil can hold a lot of water maybe because water is also available lot. So, you have a good soil moisture profile in Kerala.

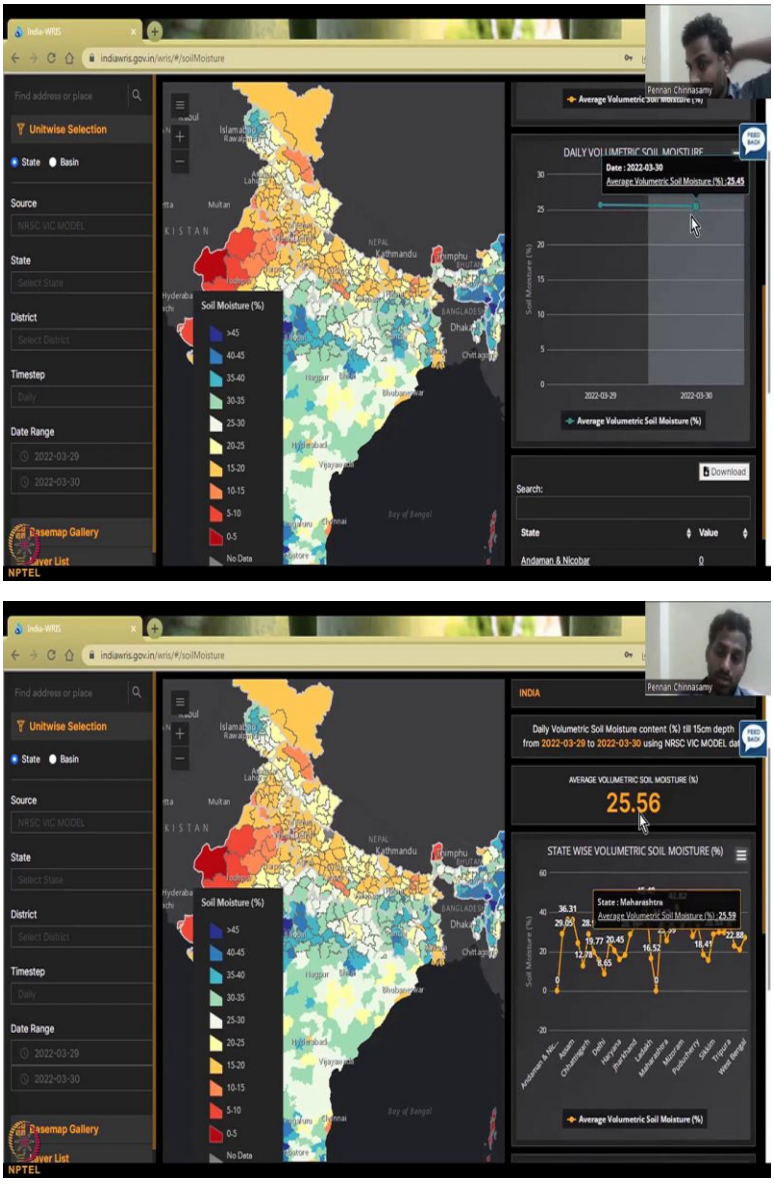
(Refer Slide Time: 16:33)



Going down, you have to, so you can download this data by just clicking on this as CSV Excel or an image if you like the graph, you can just go and download as an image for your report. If you

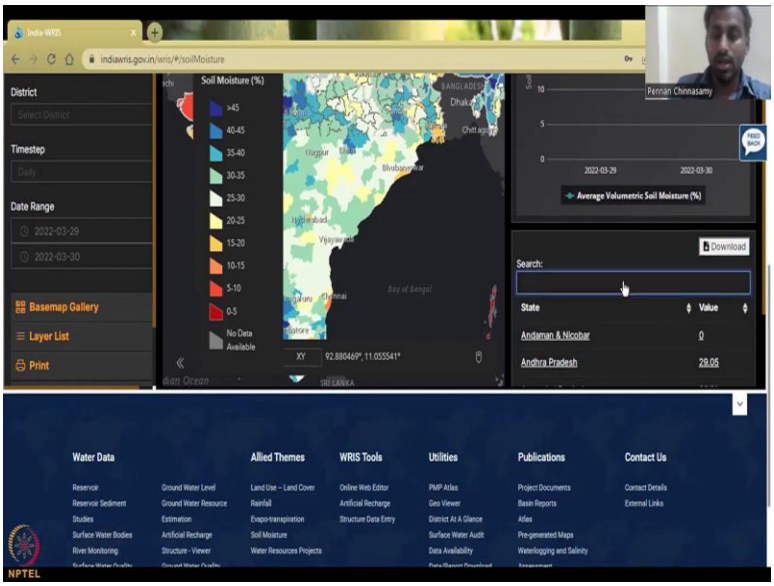
want to work on it, you can download it as an Excel or CSV file and then apply other algorithms to it for better graphing.

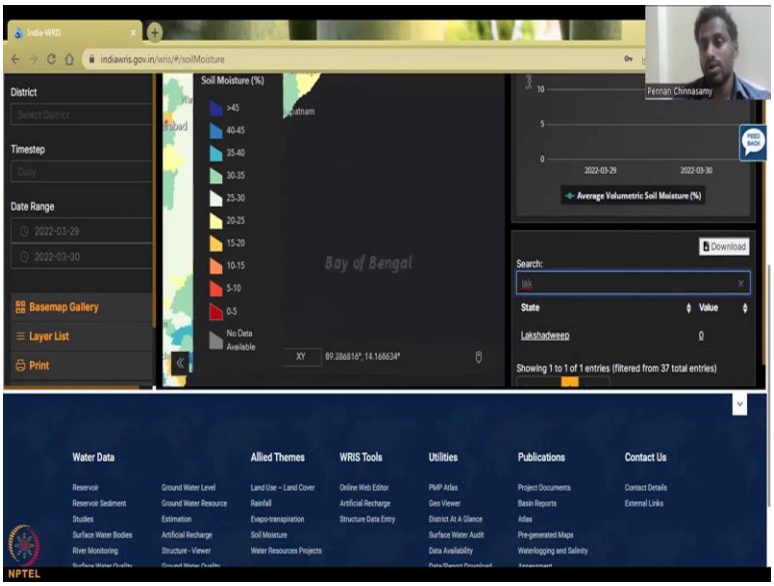
(Refer Slide Time: 16:57)

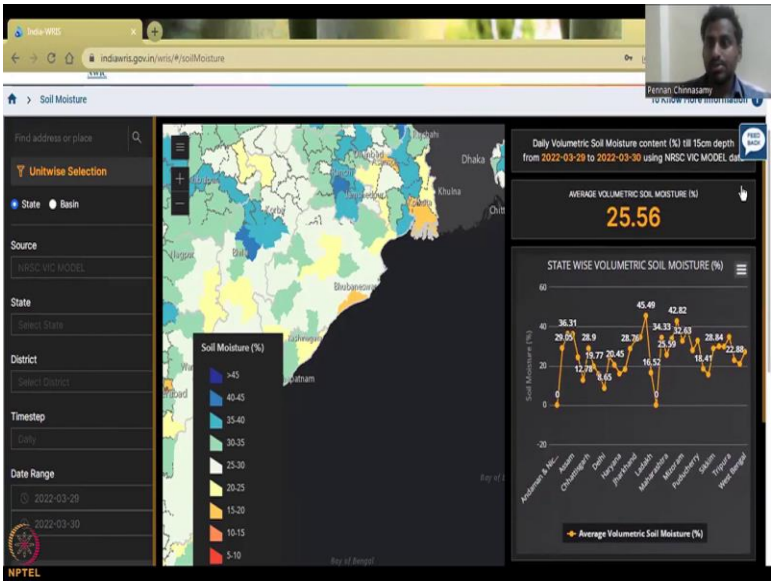


Then now we are down to daily volumetric soil moisture, this is a point data average for the entire country. So, you can see that on 29 it was 25.67 and then on 30th, it was 25.45. And the average of these two dates is given here as 25.56. So, what we have seen here is on the right hand side, the data for the entire country and per date as an average.

(Refer Slide Time: 17:28)







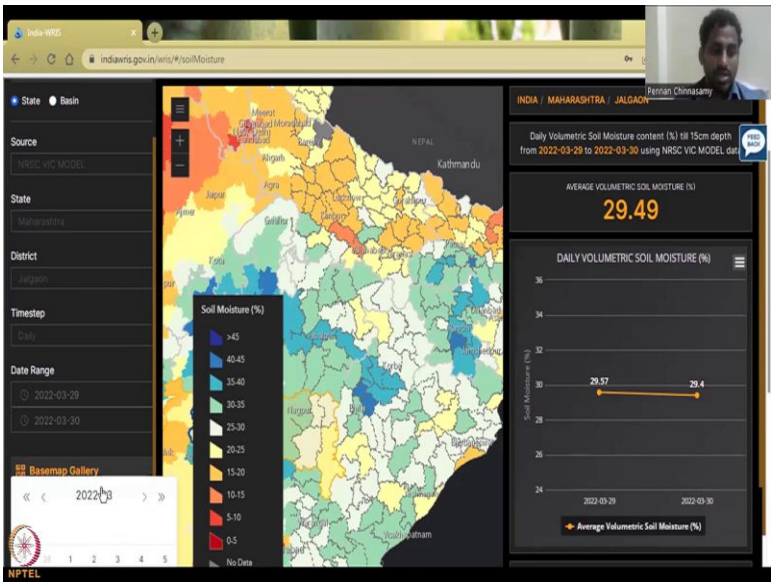
When you come down to see how the states perform, you will see that Andaman has 0. As I was saying there is no practical 0 value, you can have a theoretical 0 value, and here it is more likely like theoretical, because Andaman Islands for sure would have good rainfall and soil formation, less industrialization has happened, so there is less groundwater abstraction.

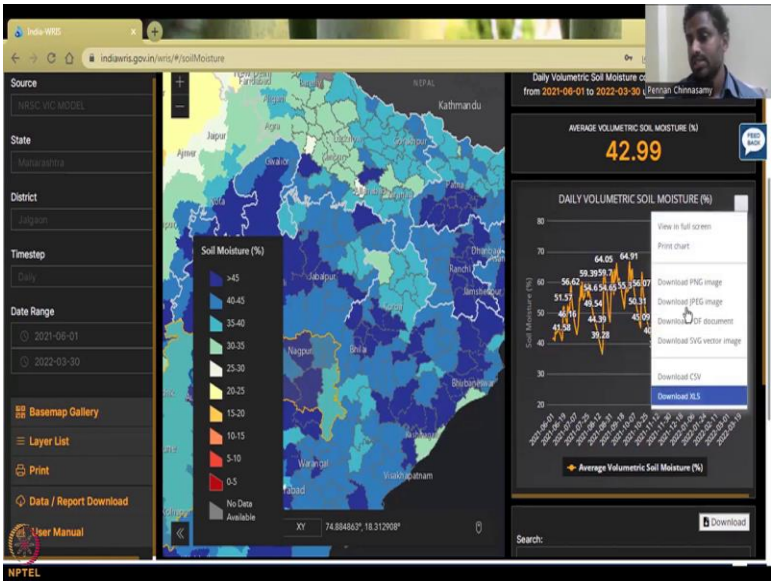
So, what is happening there is because here so here is your Andaman, because you are Andaman is smaller in size than the pixel of the satellite, it cannot drive the model. See, your pixel is the size lens the image per pixel per grid of what the satellite can do or higher the resolution of a satellite and if the resolution is bigger than the actual size of the land, then it will cannot capture the data because you will have more noise coming, that is why Andaman is removed.

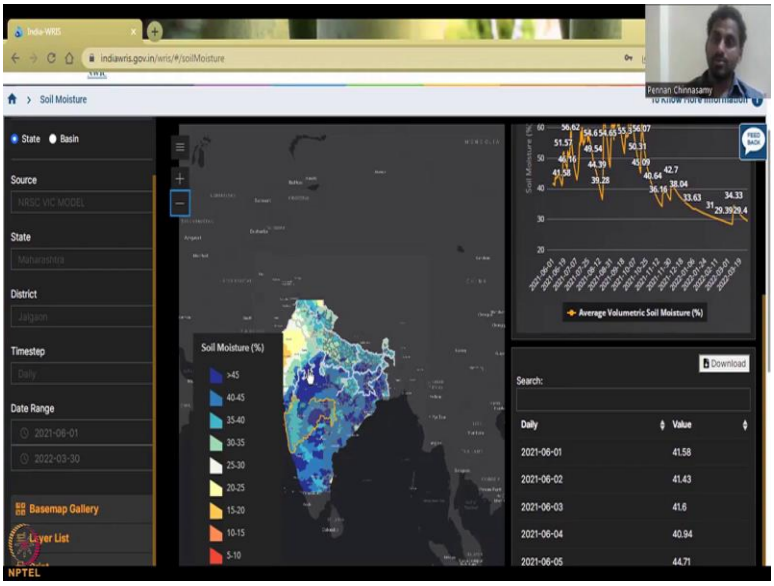
And the other similar land is your Lakshadweep, you can see Lakshadweep is also zero for those two dates, it is not because of high evaporation low water availability there is no water, just think of that. So, this is the right hand side. Now, we will go slowly to the left hand side, but before that, we just have a look at the coloring that has been used. So, this is the legend.

The legend says the blue colors are higher in water content regions, whereas red and orange are lower water content. See that most of the central India has issues with the soil moisture, because there is no blue color in that region. You would see blue only mostly in the western ghat region and other regions. Going to click India again so that the India scale comes up.

(Refer Slide Time: 19:44)







Let us give it a second and then we will move slowly to the left hand side panel where we had data on the tables what data is etcetera. So, because I clicked India I think it has refreshed its page, so let it come. While it is coming, I am going to I explained these points. So, you can take the unit, the unit of analysis as state or basin.

As I said in my previous classes, the state is more important here because the rules regulations apply at state level, not on basin level. And the state has its own missionaries to supply water, your state water department or department which can supply water for agriculture. So, that is why we will keep the state as a unit wide selection.

And then the source of the model is always going to be NRSC VIC MODEL, there is not much we can pick but you can pick the state. So, I am going to say because we know that Rajasthan and Gujarat are in the red, so let me select Gujarat and then one district we can pick later, Gujarat we want and so, yes, Gujarat is selected and you can see the selection is here.

For some reason, it is on the other side of the web page, which is fine we can bring it back later. Then you can see which region we will do. Let us do Maharashtra there is a reason why we do Maharashtra is because you have sugarcane going more than a year, okay, so soil moisture properties can vary from between the season, but also because of the data on rainfall and other things.

So, I am selected Maharashtra, let us give it a second it is populating, there you go. So, Maharashtra it is 24.29, which means it is lower than the national average, not much you can deal with the national average is because the soil type is different rainfall is different, and management is different. So, comparing it with a national average might be an over stretch, but let us see.

And then we come here to select the district, I am going to select Jalgaon because Jalgaon and Parbhani there are a lot of agriculture happening using sugar cane. So, we will go into see how this can be captured in this website using remote sensing data. So, now you can see that the coloring scheme has come up. And then as I said, we will select Jalgaon. So, now we are zooming in.

So, hopefully the other areas populating the data may not be and then you are going to see this. So, here you see what you see is the data for Jalgaon, which is populating here, which is 29.49 percentage, and you do not see the line graph of the states because that is irrelevant here. And you have the district wise two data points, which is average 29.49. And then the next aspect is the time step.

Do you want daily, monthly or yearly? See monthly and yearly is of less use because a farmer wants to see the soil moisture, and then apply water. What are they going to do with a monthly estimate or last month soil moisture what is it going to help me. So, daily is good. But because of the way the website is slowing down with data, it may take time to run larger timestamps or time period. So, just make sure you run little by little and then add the data.

So, I am going to do one time zone, let us do one month, just to showcase how it is. And you can see that in April, there is no data, so only 5 days in April. So, let us take March 1 to march thirtieth. There is no submit, it just runs by itself. So, now you could see that while it is still running the date, and the data has already populated so first of March, end of March, and you could see that the water, the soil moisture content was almost stationary and suddenly it went up.

Maybe there was some water application in the area or a big rain that can push the percentage up by 5 percent and then slowly decreasing. So, why is it decreasing? It is decreasing because summer has already kicked in. So, by the end of March, the summer is at full swing, which means that this evaporation is happening, less water is going into the soil profile and so the soil moisture is less. Overall on a national average, it might be healthy.

But technically at least more than 4 50 percent soil moisture is needed for all crops to grow. So, still there is some need for irrigation. So, how do you know that, the full potential? For that you need the whole time series of soil moisture, so what I am going to do is I am going to go up to the month where you have rainfall, which is June, and then we will map it to the end of today, data availability, which is March 30.

So, leave the image, the image is of not much used because it is just going to be a color for a district, what we are worried about is this pattern, this up and down pattern which is happening. So, we have a soil moisture, when does it go up when water goes into the soil. And as I said there has been a good rainfall season from June month till August, September also we had good rainfall.

So, that actually increases the soil moisture value, you can see that the peak values of 64, 64.91 all were available during the monsoon season. So, once the rainfall stopped the farmer still grows the crop and he or she will use other resources if there is no groundwater or surface water. Here what he is they have been waiting patiently every time and then rainfall comes saves them and then the rainfall comes saves them.

But after this period, you do not see that fluctuation much, why? Because there is no recharge into soil moisture to enhance the soil moisture, it is purely coming down because of your climatic factors especially your weather patterns of summer and spring. So, your spring had good water, your water soil moisture levels were up, but then after that it slowly comes down.

So, most of these reasons you will not see much farming in summer season because they cannot afford to pump and put the water into the soil and that is part of the game in understanding this properties. You can download this data is using the same tool as CSV or Excel and then you can make different analysis using this data. And you can come down to see the date, per date value.

So, this is also an Excel sheet which you could download or a table. So, most of India has been blue in that time showing that the soil moisture was healthy. However, it does not make sense to compare between states because every state has their own different soil and crop. So, it is very important to compare within the state within the districts how the soil moisture is changing.

And then based on that some help from the government can be given to farmers in growing crops sustainably, otherwise they just invest in groundwater and keep on pumping these water until it is depleted with no more left for agriculture. So, we have seen all these data aspects and then I will close this come out a little bit, then have the whole India picture.

And you can see that slowly the other data is properly, it is not like the South or the North will have data measured, it is a satellite data, so the whole of India is measured using these products. So, with this, I will end today's lecture on Soil Moisture. I will see you in the next class on a different data product. Thank you.