Rural Water Resources Management
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Indian Institute of Technology, Bombay
Week 12 - Lecture 03
Rural Water Databases - Evapotranspiration

Hello everyone, welcome to Rural Water Resource Management NPTEL course, this is week 12, lecture 3. In this week, we have been looking at some more data for understanding the rural water resources and we have been using the water budget as a starting point. So, from the water budget, we have been estimating different water availabilities and losses in the system, so that we can capture more water and store it wisely or use the available resources more wisely without getting into losses. For that, let us look at some more descriptions.

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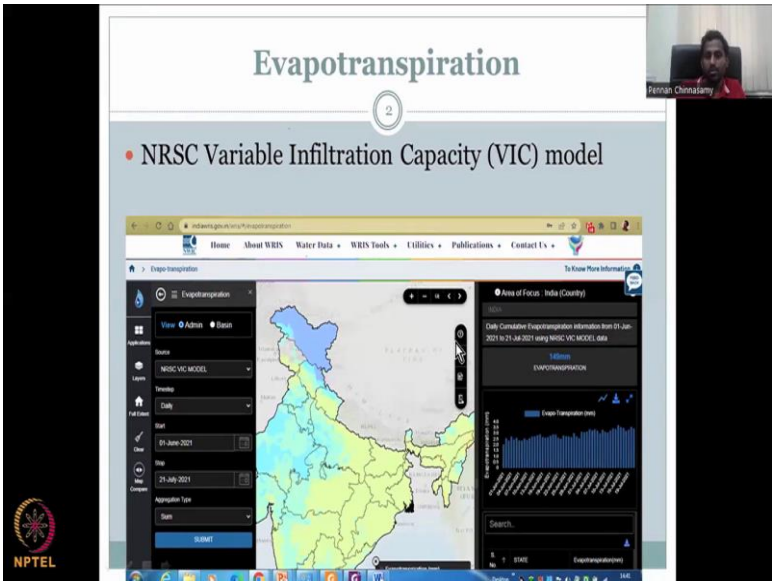

From the water balance, we understood that evapotranspiration is a big loss to the system. I am just again redefining evapotranspiration which was already defined, it is a combination word of evaporation and transpiration. Evaporation is from open bodies and land surfaces for example, you have water body, lake, a pond or a dam and water is stagnant.

From their water evaporates because radiation is happening is hitting on the water, there is some warming up and then evaporation happens it can also happen from open bodies as in rivers and streams while flowing, but it is much lesser compared to stagnant water, because when water moves it goes down.

Then you have your land surface on the land, there is soil moisture, there is some water pockets and all those can evaporate. So, that is where you see in a hot day, you see the soil cracking because the water has lost, taken up through evaporation and the soil cracks. So, evaporation is kind of conversion from liquid state of water to vapour state and leaving behind the cooling. So, the man wants to cool.

So, that is what happens. Same transpiration, we transpire our skin, we have holes and when we work out or when we run, we sweat and that sweat is transpiration where water takes up the heat and comes out of your body as sweat and you cool down. But there is also it also can some of it can also go to the upper stage. But most of the transpiration, which is bigger in budget and volume happens from plants and trees, where they take water, liquid water from the roots, pump it through the stem or trunk and then pump it back to the leaves and from the leaves, it goes out as vapor.

And this process happens during the photosynthesis, we will be reminded of the school experiments we did using a plant and a bottle, you cover it overnight and you will see vapour on the side. So, these are examples of transpiration. So, transpiration does have to happen, you cannot control it. But you can actually understand the volume that is lost from the system from which you could see your water budget.

So, if for example, you have a water volume in your groundwater storage, and per day, you are losing this much to ET let us say you have 100 cubic metres and then you are losing 1 cubic metre per day to transpiration or let us say ET, evapotranspiration. So, it is very important to understand that you are left with only 100 days more unless you have to recharge or stop the evapotranspiration by lessening down the area of the crop or use the crop.

So, most of the time because this understanding is not there, what happens is the farmers would put more water on the field, not conservatively, and then it grows but it does not ripen. For example, the seeds do not come for rice paddy, or the fruits do not come for tomato and before that the crop starts to die or dry. And at that point, there is no other way you just let cattle and livestock eat the crop.

So, that at least some energy and some feed is being created. But it is a big loss, it is still a loss. But you will see that is why some cattle are grazing in a field which is not fully grown. So, that could be less lost if we know how much water we have, to the rural water resource management framework, we have tanks, we have groundwater storage, we have dams, and then we have check dams.

So, we know how much water volume is there. And from the volume, we can syphon the water into the land, and then get more out of it through transpiration, reduction, evaporation reduction, et cetera. You can also reduce it by limiting the acreage. For example, if I have 100 acres, and it consumes 1 cubic metre per day, it is still a small number, just selling 1 cubic metre per day, you can say that I do not have that much water.

So, I am just going to cut it by half. Which means, I have put in the seeds for the 1 acre, but I am just going to do maintenance of half acre, 0.5 acre and that 0.5 acre only I love supplying water. So here, I know I have the land to get more profit, but I am reducing my profit so that I do not get a loss. If you want the whole acreage, you might get a loss because of water will not be enough for the entire acreage.

So, all these are built up in the system to the evapotranspiration. Soil Moisture tells you to irrigate or not, but how much to irrigate is taken from evapotranspiration. So now, as I said these data is very important. Now, we have set up why it is important. But we know that you cannot have each and every plant monitored for ET. Whereas every plant contributes to ET, every tree contributes to ET, it is impossible to put a metre on every plant and tree.

It is so expensive and also, the arrows might be coming through different settings and stuff. So, what a lot of countries use is remote sensing driven models. So, they understand the physics behind evapotranspiration, which is basically you have to have water, you have to have an incoming energy which is going to heat the water and evaporate or transpire through plants.

So, radiation they know they know the rainfall, the water storage, soil moisture, and then they know the characteristics of the plant, how much it can consume. And then from there, they estimate the evapotranspiration through a model. So, one of the models that has been used widely is the Variable Infiltration Capacity model, or called VIC model. And since it is driven by remote sensing data, and NRSC data, it is called NRSC Variable Infiltration Capacity model.

So, NRSC is under the ISRO as I said in the soil moisture class, it is the national remote sensing centre. And if he does have mandate to provide these kinds of advisories to farmers. And the website looks like this, it is mostly with the India map when it starts to the right-hand side, it gives you the area of focus, the time when the data was taken the average value and the other data metrics that you can download.

Here, there is no sensitive data. So, like your river data storage, all the data is available. On the left, you have the parameters how you could select the data for your model. Now, coming back is you will have this evapotranspiration understood. And because there is less data for example, you have to put every tree or every plant and every plant has a different area or a different weight.

You do not see all the fruits of same weight right similarly all the leaves are not same area. Some leaves transpire more some leaves transplant less and so you have this issue between plants and other intakes. Moving on and that is why we have this remote sensitive, but it also has a limitation on the pixel size. So, depending on that area, and the pixel size, the size of resolution of the camera in the remote sensing device or satellite.

Your estimation is based on that pixel size. So, here we are grouping the trees the plants and water bodies together within one pixel and taking an average value, because there is some characteristics which are reflected back to the satellite and those characteristics are used for estimating ET. It is kind of an estimation but it holds good in most regions across the world and it has been very helpful for farmers to know this value.

Because you cannot just look at a crop and then estimate ET always, yes, there is the ET method where you have a crop rotation method, you multiply it et cetera but the plant grows and there is demand based on rainfall and other characteristics, dryness, et cetera, all these are put in the VIC model, whereas in the FAO method it is just a certain assuming that the there is unlimited supply of water and the plant can grow freely, which is not always the case. There is a lot of constraints in growing and that is captured in these VIC models which are driven by real time data from the satellites. Near real time like two days one week. With this I will be showing the website so, I am going to share the website.

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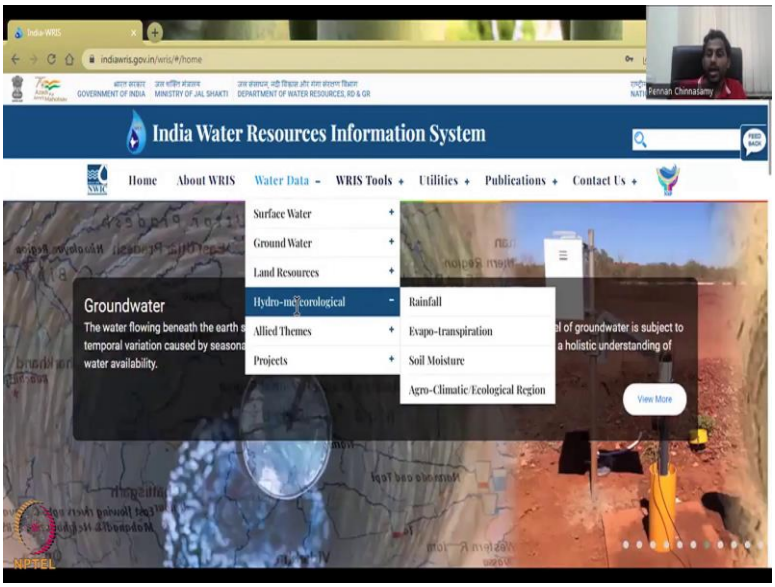

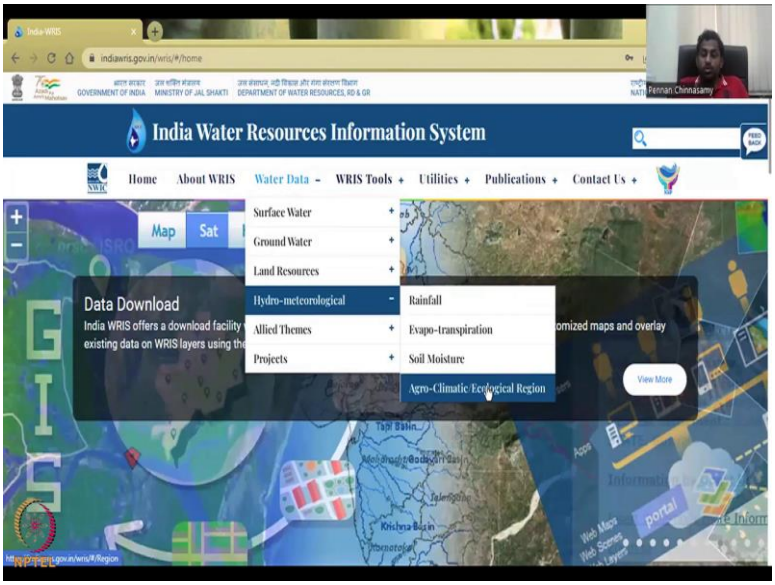

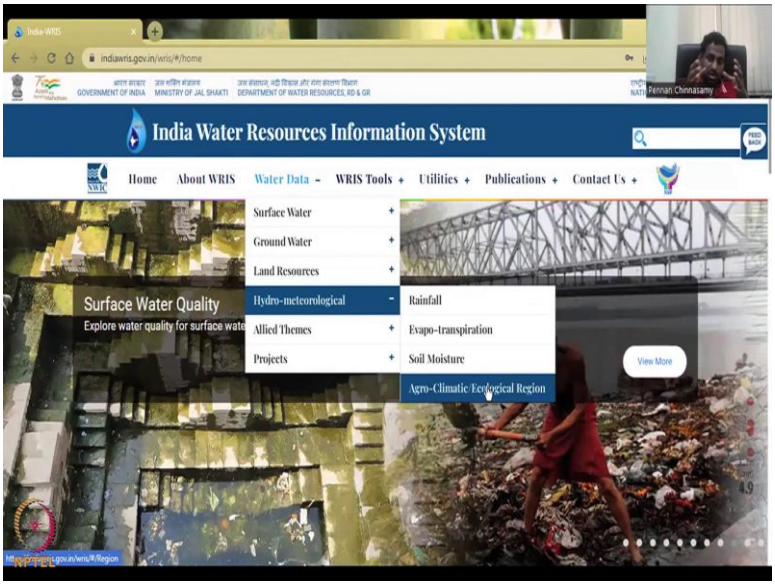

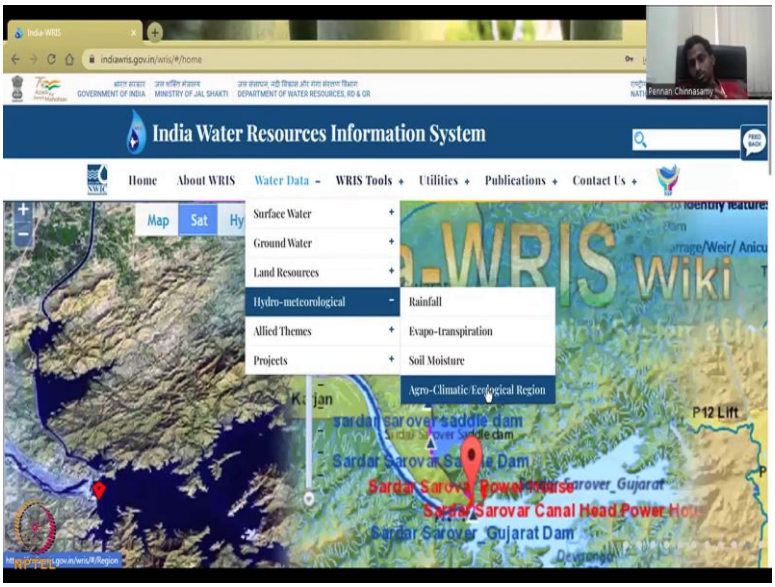
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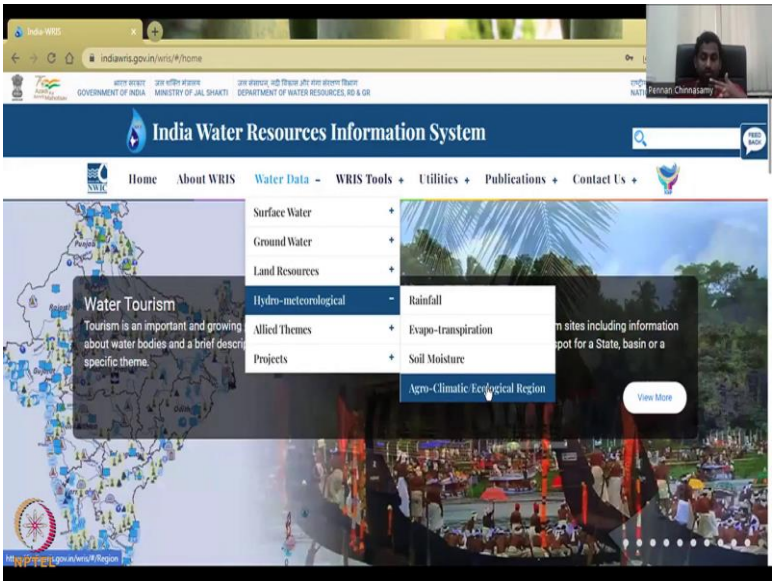
Sardar Sarover saddle dam
Sardar Sarovar Dam
Sardar Sarover_Gujarat
Sardar Sarovar Canal Head Power House
Sardar Sarover_Gujarat Dam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Tourism is an important and growing
about water bodies and a brief descri
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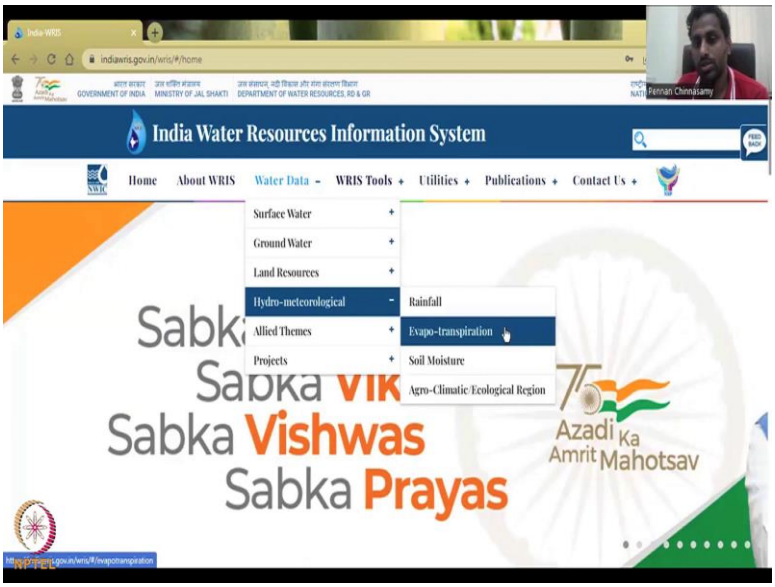
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Sabka
Sabka Vik
Sabka Vishwas
Sabka Prayas
Azadi Ka Amrit Mahotsav

I'll take you back to the homepage and from the homepage we go to water data and hydro metrological data we also see agro-climatic zones. So, these are zones, which you see in the bottom these are zones with similar rainfall soil and geology type and those types could be for your water assumptions, your ET assumptions because you cannot say that across India, this is going to be the water storage, but for that they have divided India into agro-climatic zones. And each agro-climatic zone has its own type of geology, rainfall, soil type, et cetera. So, then you can club it instead of having it as big boundaries, you can at least club it in sections of agro-climatic zones. So, you just click evapotranspiration.

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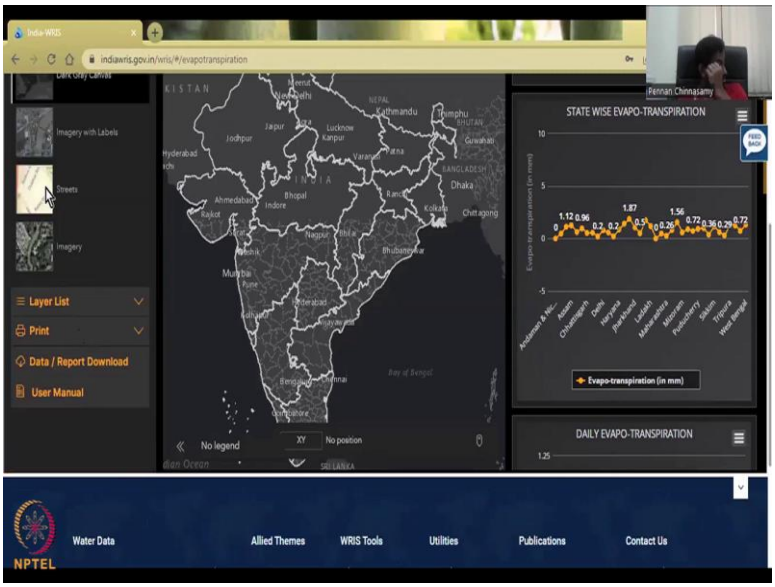

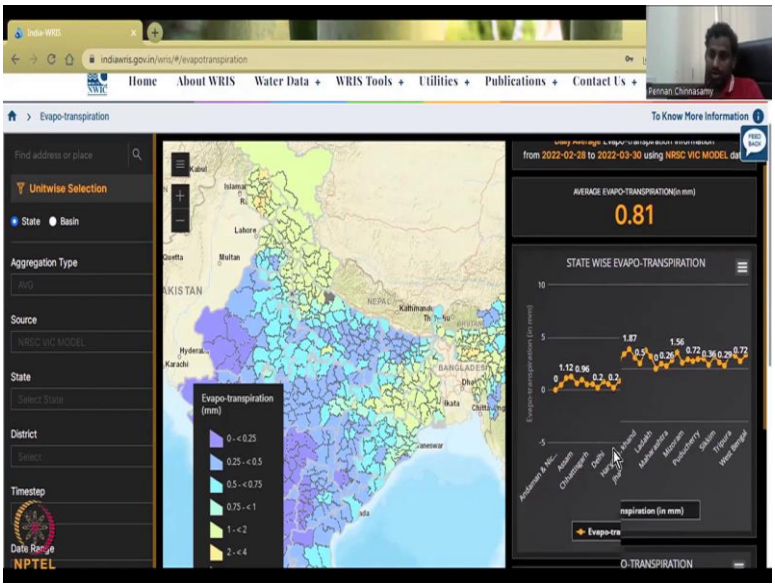
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NRSC VIC MODEL
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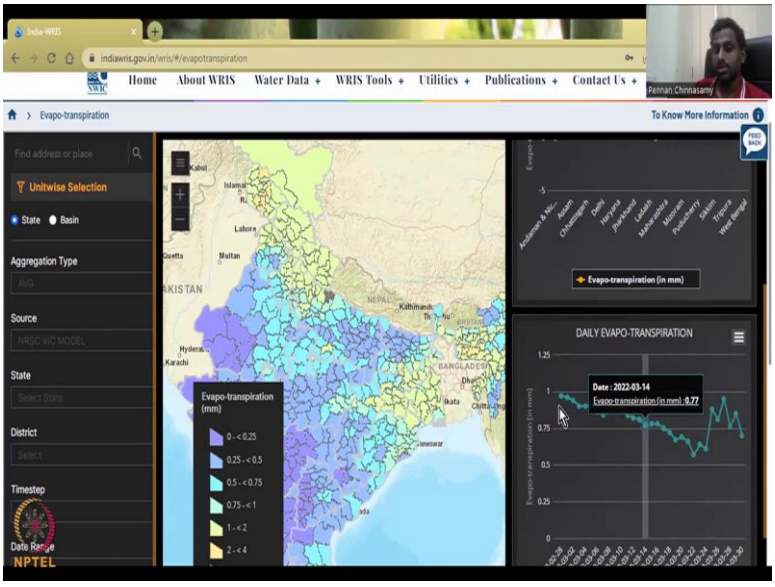
Timestep
Date Range
NPTEL
from 2022-02-28 to 2022-03-30 using NRSC VIC MODEL
AVERAGE EVAPO-TRANSPIRATION(in mm)
0.81
STATE WISE EVAPO-TRANSPIRATION
Evapo-transpiration (mm)
0 - <0.25
0.25 - <0.5
0.5 - <0.75
0.75 - <1
1 - <2
2 - <4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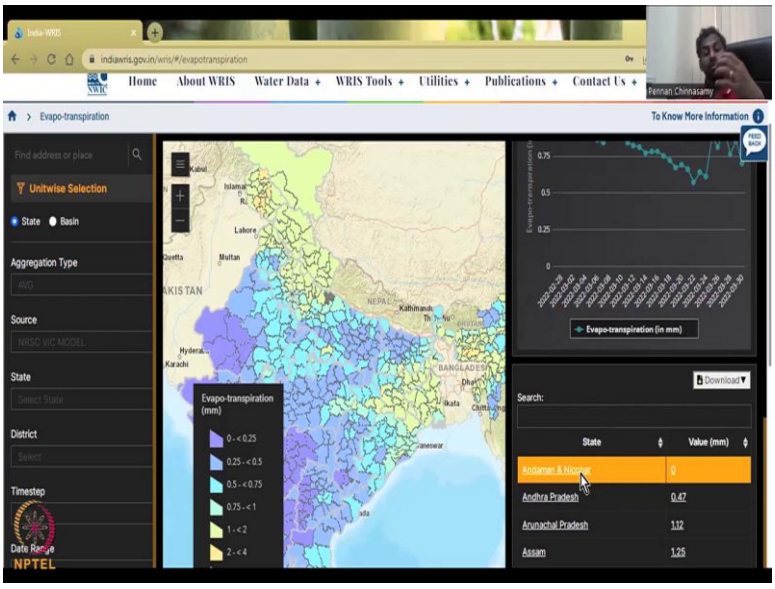
Evapo-transpiration (in mm)
DAILY EVAPO-TRANSPIRATION
Date : 2022-03-14
Evapo-transpiration (in mm): 0.77
Evapo-transpiration (mm)
0 - <0.25
0.25 - <0.5
0.5 - <0.75
0.75 - <1
1 - <2
2 - <4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Search:
State
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Andaman & Nicobar
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Andhra Pradesh
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Arunachal Pradesh
1.12
Assam
1.25
Evapo-transpiration (mm)
0 - <0.25
0.25 - <0.5
0.5 - <0.75
0.75 - <1
1 - <2
2 - <4

It does take time initially to load. The background is black. So, to make it faster, I am going to change the base layer into street layer which is much quicker than you can do now once the highlighting is gone, I go to base layer map and I clicked streets so first things first we did we just change the base layer so that it quickly loads and then on the right hand side, you see that automatically it has taken India as the boundary.

And it has taken two dates, three days actually 28, 29, 30 and taking the average value automatically. It still the data is populating while we talk, but I think we can continue until it populates. So just taking three dates, 2022 February 28. Actually, it is more than it is a month. Sorry, it is a month date it has taken and it is averaged it out. So, 0.81 is the average of almost a month because that is February 28 and then you have March 30. And the average value is 0.81.

So, now the question is, is it okay to have an overall India average? It does not make sense because across India there is different rainfall, different sunlight, which is actually helping for evaporation and transpiration and different soil types that can pull the water and release it for transpiration. So, it wouldn't be that useful to have an India average number but they are just trying to show you that you can scale up or scale down depending on your interest. So, moving on, we have the 0.81 as the average value and we have this state wise data.

State wise what was the average for that particular period? And what do you see here is the daily evapotranspiration average. So, for the whole of India, what is the daily ET taken per date and then you will see it comes down and then goes up slightly and comes down and going have slightly could be your rabi season crop. Whereas here it just goes down because it is drying from a high end.

But the point here to be understood is let us first take 0 because when it comes down you have states so when you look at the states is 0 a correct value? How can a state have 0 evapotranspiration similar to soil moisture we saw? So, the understanding is I am just going to click on the Andaman Nicobar So, as you can see it, it is very small size compared to the resolution of the satellites.

So, the satellite and data that goes into the VIC model cannot capture the dynamics inside the small island and for that, it puts 0. Technically it should have been in NA value because when you put 0 and when you average it, average across the states for India, the 0 will pull down the value. So, look at the graph here, you can see that it has been used widely for that.

So, Andaman is taking some time normally 0 do not have to show anything, but the I just want a refresh it. So, while it is refreshing as I said please understand that there is a data for all of India and the states which are smaller in size or the union territories which are smaller in size than the pixel will not have data and for example, actually will not have data. So, you will have to not use this in the averaging you can do a small exercise by yourself, you can take the India average and then the state's per day is given.

So, you take the state's total per day or average per day and average it for India with a Andaman and Lakshadweep, then you can do the same exercise without Andaman and Lakshadweep. You will find a different story. If the story is different, if the results are different, then 0 should not have been taken 0 is not correct. If the values are same, then 0 technically means NAN values.

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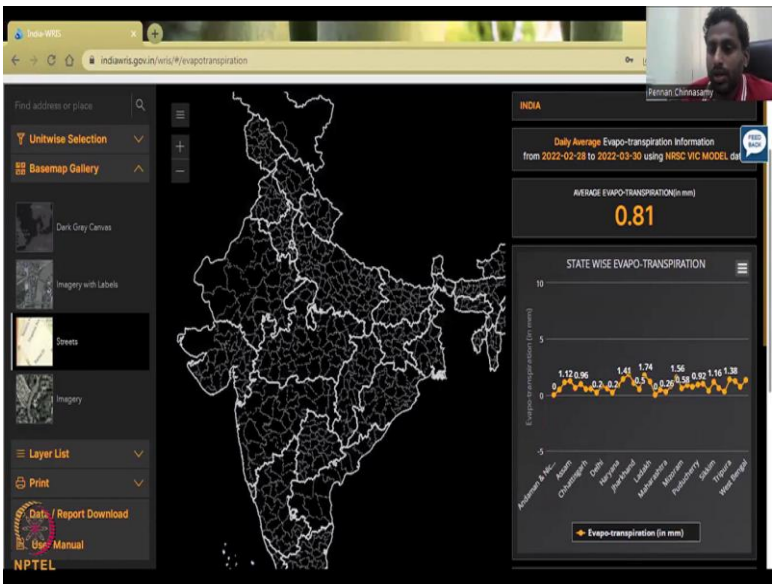

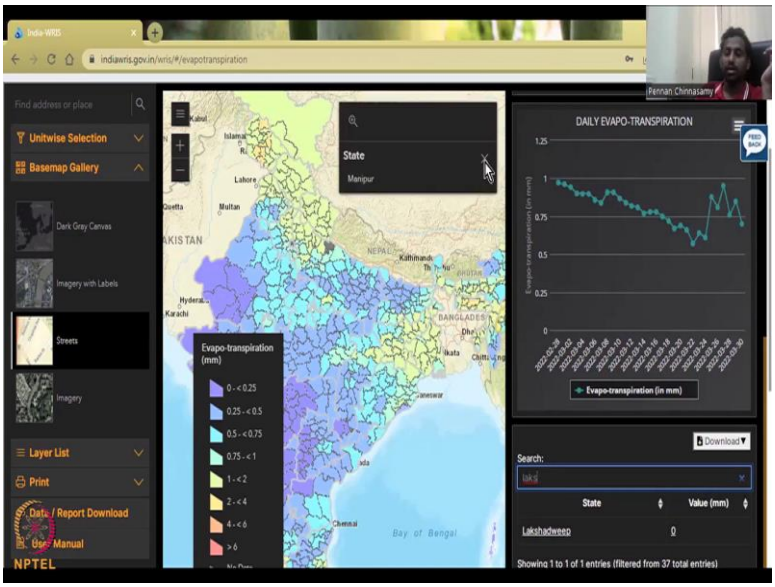
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Evapo-transpiration (mm)
0 - < 0.25
0.25 - < 0.5
0.5 - < 0.75
0.75 - < 1
1 - < 2
2 - < 4
4 - < 6
> 6
Bay of Bengal
DAILY EVAPO-TRANSPIRATION
Evapo-transpiration (in mm)
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Evapo-transpiration (mm)
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0.25 - < 0.5
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0.75 - < 1
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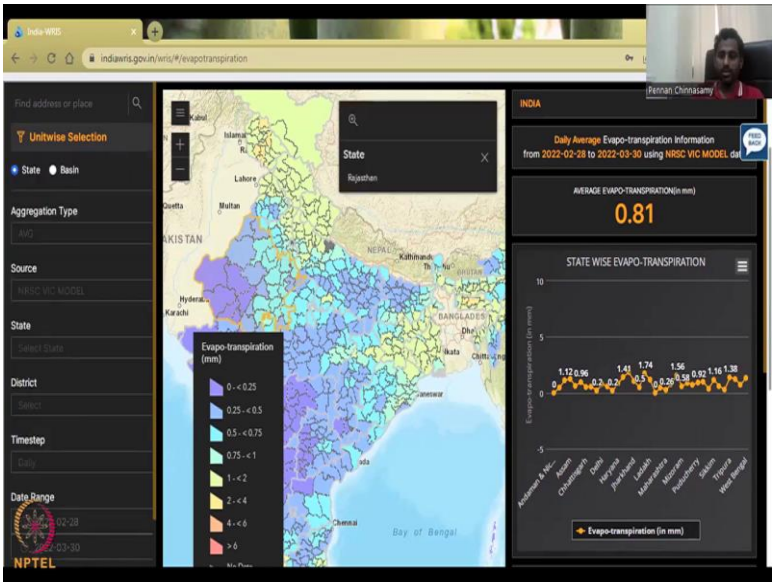
2 - < 4
4 - < 6
> 6
Bay of Bengal
INDIA
Daily Average Evapo-transpiration Information
from 2022-02-28 to 2022-03-30 using NRSC VIC MODEL
AVERAGE EVAPO-TRANSPIRATION(in mm)
0.81
STATE WISE EVAPO-TRANSPIRATION
Evapo-transpiration (in mm)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Evapo-transpiration (mm)
0 - < 0.25
0.25 - < 0.5
0.5 - < 0.75
0.75 - < 1
1 - < 2
2 - < 4
4 - < 6
> 6
Bay of Bengal
INDIA
Daily Average Evapo-transpiration Information
from 2022-02-28 to 2022-03-30 using NRSC VIC MODEL
AVERAGE EVAPO-TRANSPIRATION(in mm)
0.81
STATE WISE EVAPO-TRANSPIRATION
Evapo-transpiration (in mm)

I am going to put the base layer back again so that you can have it load up. So, I hope the Lakshadweep and Andaman, why 0 is when it is correct. They understood see Lakshadweep is also 0. So, this cannot be 0 especially we know that Andaman has a lot of forest and trees transpire a lot much more than plants. So, saying that there is no transpiration or ET from that land is wrong.

You have to understand this when you write your reports and articles. So, let us look at India now. So, we have this data for entire India, this search box will come so do not entertain it you can close it if you want it just picks randomly states and districts. So, for you to understand what you are looking at the data here, just go up it will say India is the location where this data has been taken.

So, when you look at the data here, you see that there is some states which are blue, high ET. So, now the high ET does it mean that there is a lot of water so it is evaporating and transpiring or people are pumping in water and then that pumps help to increase that transpiration? So, the overall et rate increases. Unfortunately, in this region where we are I am showing the latter is that correct reason which is the values are not the same, they pump a lot.

For example, Rajasthan, Gujarat, are known to be highly using groundwater resources. Punjab, etcetera, Haryana. But they have good ET so, it means there is lot of crop activity that goes on and for that crop activity there has to be pumping of water into the land and that pumping of water is then taken up as evapotranspiration. So, this can be used to understand regions where excessive pumping excessive cropping is going on, so that we can manage the water resources better.

If you look at the Ganges plain, not much of water is there, use is there. So, ET is still almost in the blue region, 0.5, 0.75, 0.25 region. Whereas, the evapotranspiration, if it is very, very high, it has given us red. In this region, we do not see much red colour, but we will be changing the date so that we see more of a red colour. So, I am going to go back to the unit wise.

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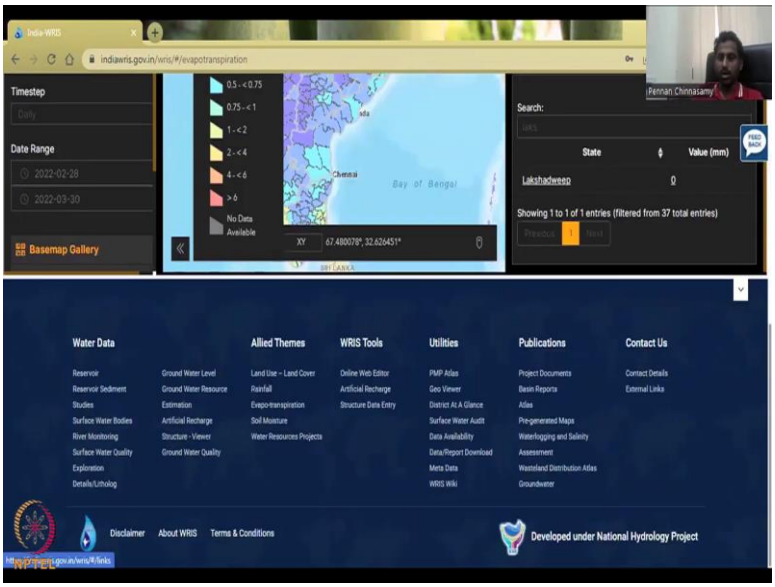

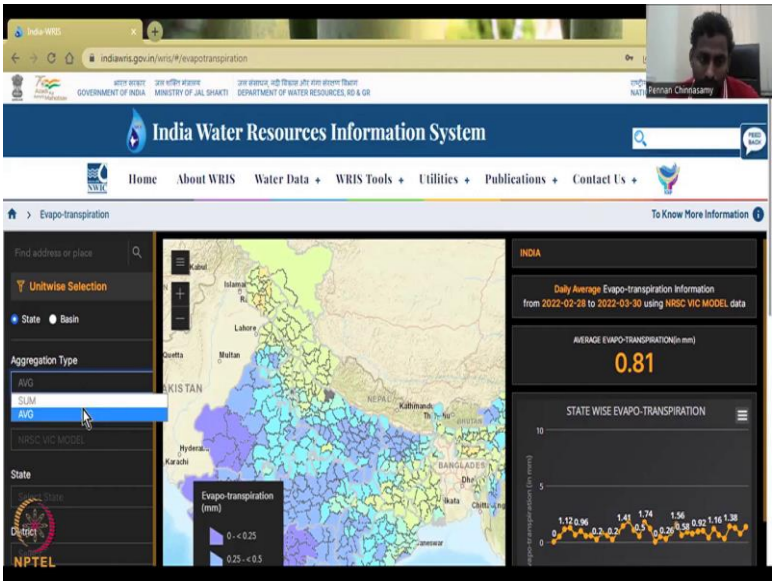

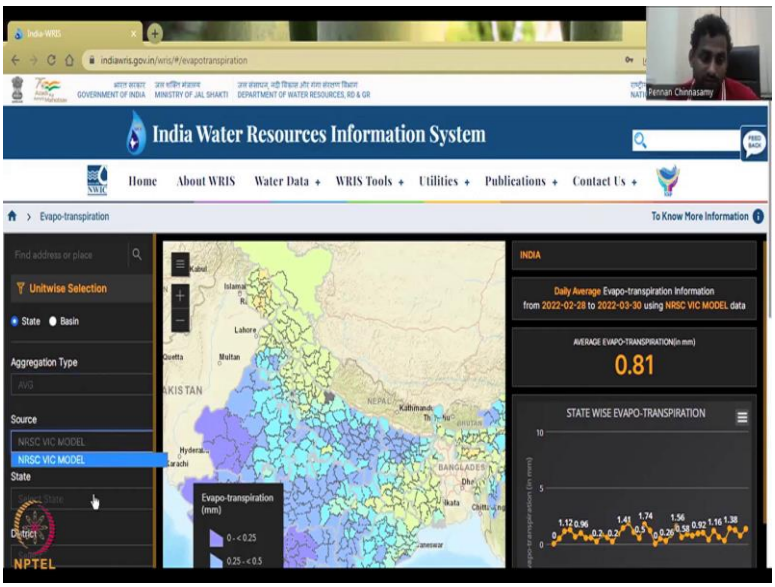

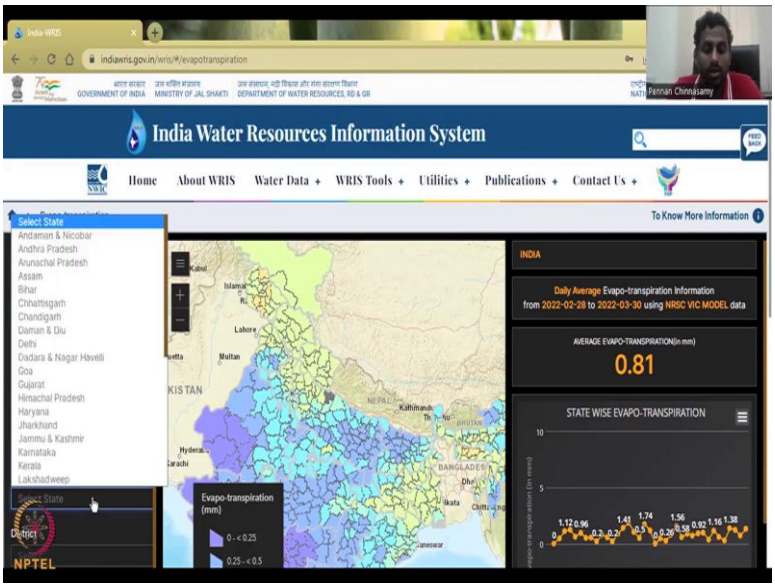

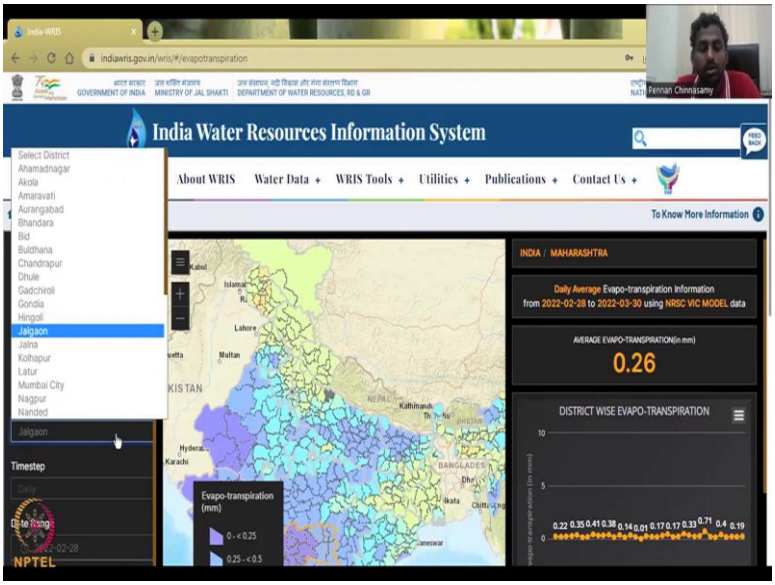

And if you come down here, you will see other states like Lakshadweep and other regions. Now, the side is clear, I am going to go to that type of aggregate. So, you know, we want a sum. If you click it, it will ask you do you want to sum the ET or average? Average is good, because you take an average per day, whereas some would be adding up all the averages per day and not most normally it looks kind of confusing if you look at some for ET.

Because every day just cumulatively going, well you want to do is average, and then you can multiply that by the area to get average daily water loss from this system, ET is a water loss. It may have beneficial aspects of for example, plant growth is important. But at the end of the day, since it is a groundwater budget, or a rural water budget, it is a loss to the system, ET is a loss.

So, I am going to do average and there is only one source NRSC VIC model, we can keep it. Let us do Maharashtra because there is a lot of sugarcane that grows here more than a year, because then we can say Jalgaon. And then slowly, the map was zoom into Jalgaon, and then shows the data. If it does not, you can just pull the map to one location and it shows.

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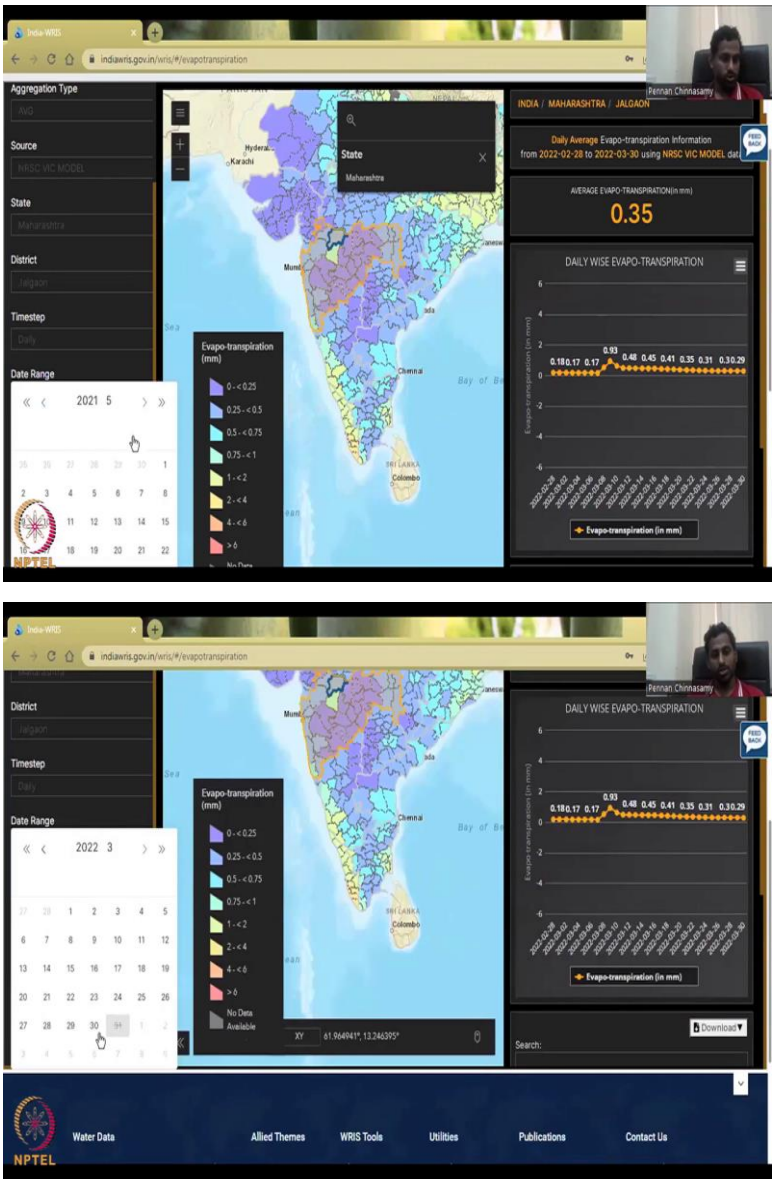

So, it does not centre map there, but Jalgaon is shown. Then what you do is you click on the data range. So, now you have set the area of interest, which is Jalgaon and now we can set up the date range. And I am going to do the monsoon post monsoon period until the summer right now before the summer period, which is the march end. So, we have to go to June, June 1.

So, just before the onset of monsoon until the 30th March, which is the day here so this is striked out which means that we do not have the data yet. So, once you click it automatically the data starts to populate, there is no submit button as in other data bases for within the WRIS. So right now, the data is running crunching the numbers while the map is being populated, you can see the data already here.

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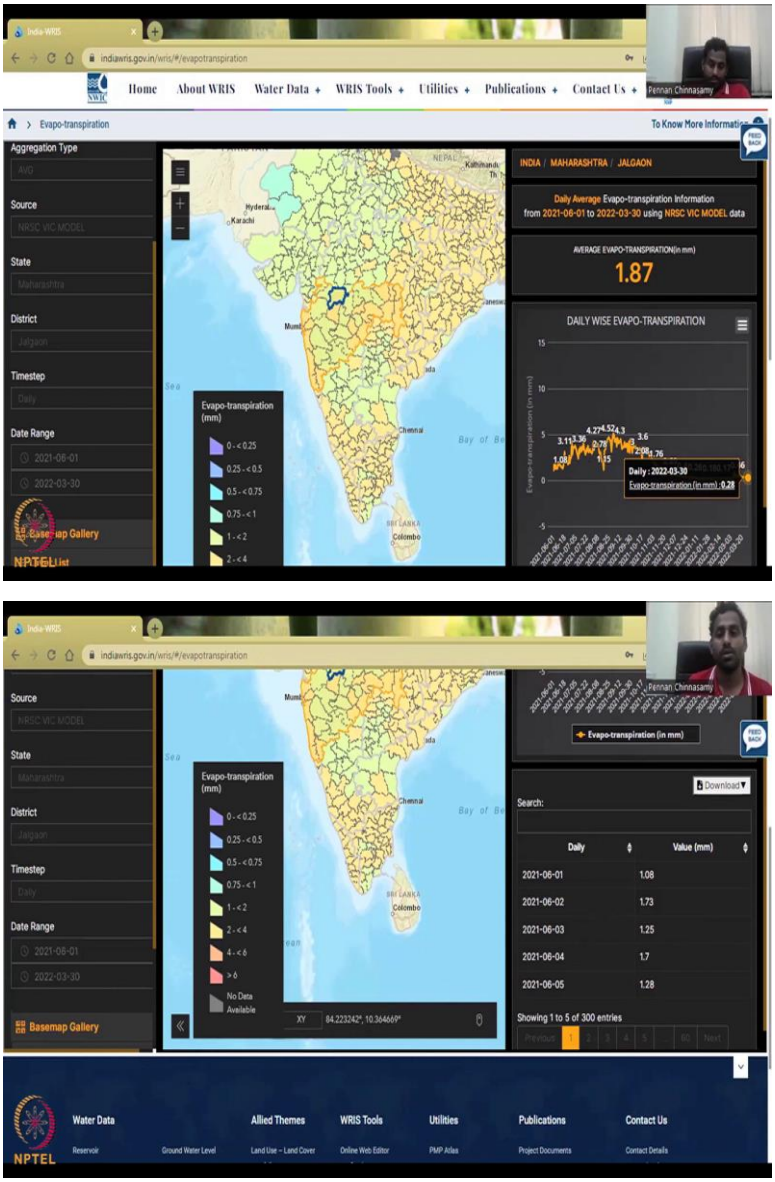

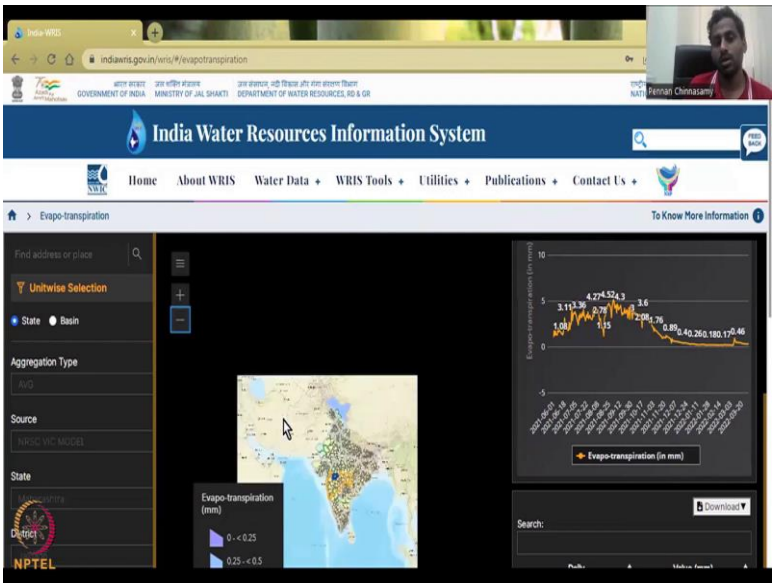
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Evapo-transpiration (mm)
0 - < 0.25
0.25 - < 0.5
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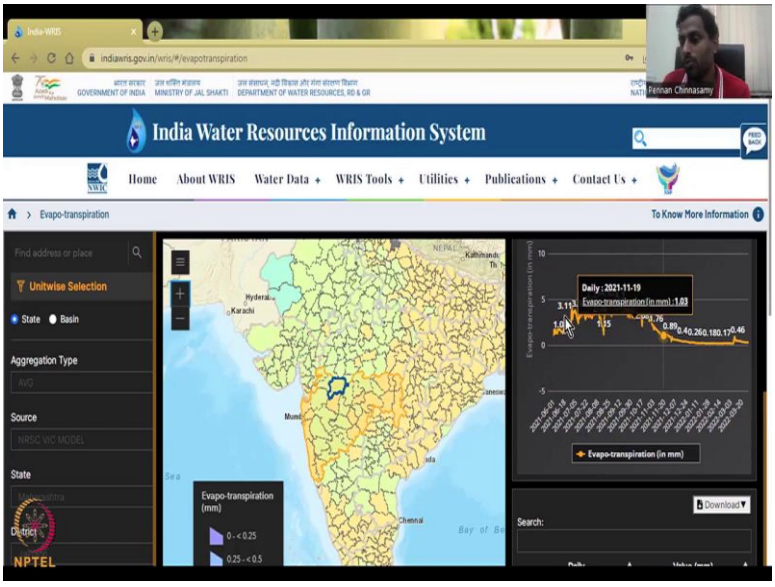
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AVG
Source
NRSC VIC MODEL
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District
Daily : 2021-11-19
Evapo-transpiration (in mm) : 1.03
Evapo-transpiration (mm)
0 - < 0.25
0.25 - < 0.5
Evapo-transpiration (in mm)
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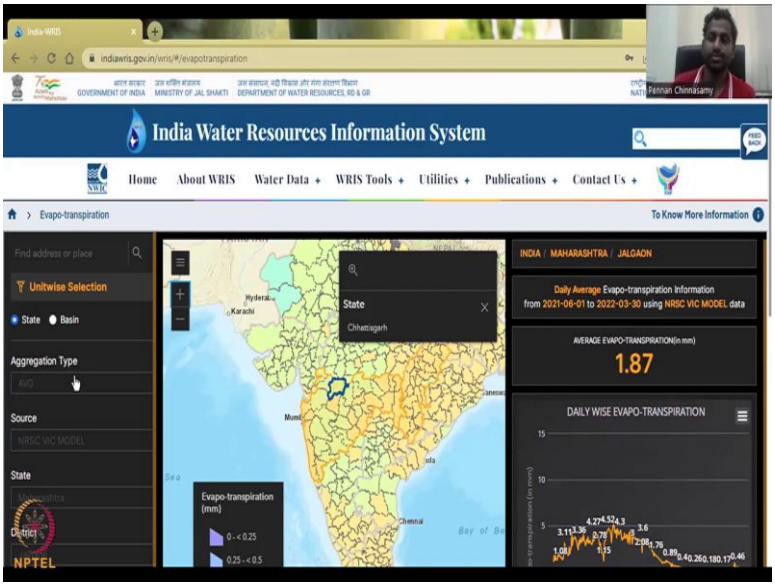
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State
Chhattisgarh
INDIA / MAHARASHTRA / JALGAON
Daily Average Evapo-transpiration Information
from 2021-06-01 to 2022-03-30 using NRSC VIC MODEL data
AVERAGE EVAPO-TRANSPIRATION(in mm)
1.87
DAILY WISE EVAPO-TRANSPIRATION
Evapo-transpiration (mm)
0 - < 0.25
0.25 - < 0.5
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So, it says India, Maharashtra, Jalgaon. So, the steps are taken as India average Maharashtra and then Jalgaon. So, we have zoomed into Jalgaon district and then taken average ET from 2021, 1 June, to much end using an NRSC VIC model, et cetera. So, it gives you around 1.87 millimetres per day is always there for ET but it is not mentioned because we are doing a daily count.

We cannot say daily is equal to millimetres per day. So, that is where when you know that you are giving a daily data you can remove the per day out. So here we have daily wise evapotranspiration rate. So, evapotranspiration in millimetres, there is no per day, but since here it is daily, you can just see it go up and you can see it grow up and then come down. So, growing up is the growing period of the crop, and then also the availability of water to evaporate because when they apply water this evaporates.

Here this period is mostly your kharif crop where rainfall is giving water and then there is a lot of transformation happening. The rainfall also gives water to the ponds, lakes dam, so there is a lot of evaporation happening. And then it comes down because the rainfall has come down but the crop also is trying to slow down. It has grown well and now it is going down.

And right now, before the summer there is very less evapotranspiration happening because the crops are also being harvested most of them and or the water is not enough to sustain the entire area. So, maybe some areas are given the water for cropping. So, this is how you could look at one section in detail here is your data for the for this WRIS website you can also download it from here.

Here, video panel which is not activated now. But you do have other aspects in the data columns, and the others are given here just to report, download, et cetera. To make it zoom out I am just going to use this and then you can have this box to show where the water is coming from like where to zoom in and zoom out. So, here's how you would do evapotranspiration data it is per date, it is per location you cannot go smaller than a district size block is not available.

So, you will have to continue with the district size. So, here we are, we are combining both the systems of losses evaporation and transpiration one data is taken which is driven by the NRSC VIC model, the data can be taken as a daily time step which is correct monthly is kind of averaging and summing into monthly, but you can do that in Excel. Annual loss et cetera.

But normally because rainfall is not annual, you can take an annual rate but per day rainfall is available. So, if you look at it per day rainfall is there, per day soil moisture per day, evapotranspiration per day, river discharges is there, all this is per day, the groundwater, yes, storage is not per day, but you can kind of do it indirectly and then measure it at a monthly scale.

That is where you put the monthly budgets monthly or seasonal. So here, we have downloaded the data. We have looked at how it looks on the screen when you download it. It is the same thing on Excel sheet. And we have picked one location for this system. That is it evapotranspiration data. I will see you in the next class on more tools for data management. Thank you.