Rural Water Resource Management
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Week 02, Lecture 02
Rural Water Resources Management

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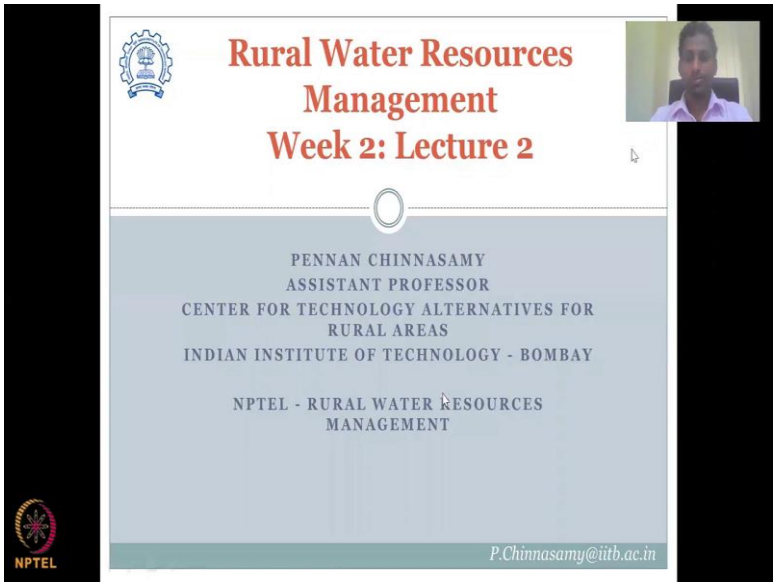

Hello everyone. Welcome to Rural Water Resource Management NPTEL course week 2 lecture 2.

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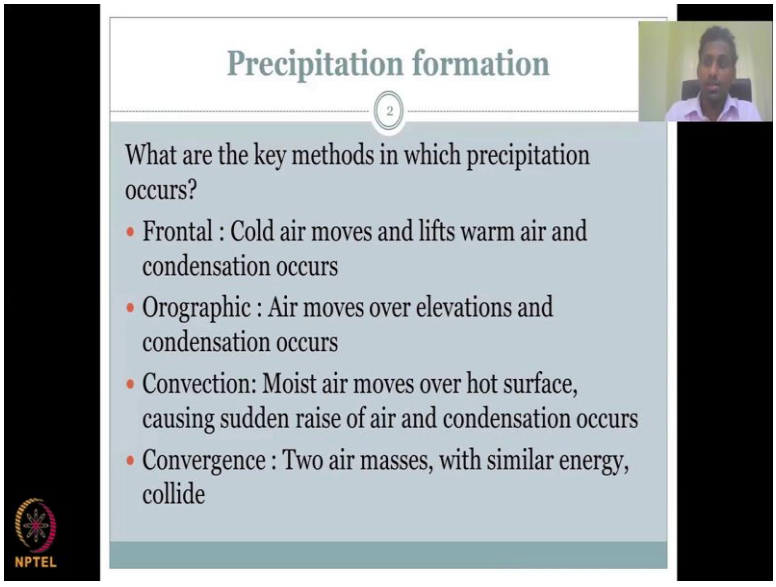

So, in the first lecture of week 02 we looked at what key parameters that we are going to look in the hydrological cycle. We identified six parameters out of which 3 parameters

would be discussed in detail in this week's lecture, which included precipitation, runoff and discharge and evapotranspiration. So, today we would look at precipitation formation. So, how is presentation formed?

And as I said we will focus mostly on rainfall of the types of precipitation, we would look into details of precipitation in the form of rainfall. What are the key methods in which precipitation occurs? So, it is important to understand how, what are the different methods in which precipitation occurs?

First method would be frontal, wherein cold air moves and lifts warm air and condensation occurs. Please understand that precipitation would occur rainfall, cloud formation and then rainfall would occur, because of condensation. So, when you have vapour, which is from your evaporation or transpiration or evapotranspiration where water as a liquid is converted to a vapour phase.

It is on the land and from the land it has to move up. So, it has, it can move up by condenser or cooling. So, once it cools down, then it becomes condensed into clouds and then further condensation would lead to your rainfall. So, the first precipitation occurs. Now, we have the clouds and we have some amount of humidity. Humidity is the amount of water vapour led it to the amount of water vapour.

So, the first method we will discuss is frontal where cold air moves lift warm air up. So you have your cold air which is like coming at this space. So, for example, both are coming in different directions, this is a cold air front and you have your warm air front. So, when cold air moves, it goes down because it is heavier and pushes the warm air up.

So, it will be like this. So, the warm air would move up, by moving up eventually it will lose its heat or cools down and by cooling down it condenses. So, that is how condensation occurs. Why would cold air move down rather than up? Because cold air is more denser and so more heavier, so it will move down. So, when both are colliding, the heavier particle or heavier matter would go down and then go up.

Same like you have your small toy cars that you play with, you have a very heavy truck and a small car, you hit it, the truck would be still on the ground or it will go down and your toy truck car would go up. So, same way the warm air would move up because of

less weight and then your cold air is more denser, heavier, it will push it up, by moving it pushes it up. So, that is your frontal method.

Other one is orographic, in all these methods what you would find a consistent pattern is that the warm air is lifted up or it is lifted up in elevation and by lifting it up it goes down. Orographic is a process where air moves over elevations and condensation occur. So, when you have a mountain. So, this is for example, like a mountain and you have your water vapour filled air and current moving.

So, warm air current, it moves and when it hits your mountain or hill or higher elevation, it has to go up and by going up, because it is coming with a force, it is coming with a momentum, it has to hit and then it goes up, when it goes up as I said it will eventually lose energy and it will cool down, by cooling down it condenses. So, that is Orographic. Where would you see all this happening in India?

Mostly on the Western Ghats, so that is why you have a lot of rainfall on the Western Ghats sides. So, in India as a peninsula, this side where you have Kerala, Maharashtra, et cetera, Goa, you see that the air current moves and once it hits the Western Ghats, which is in elevation, it moves up, by moving up it cools and a lot of rainfall happens.

So, that is why you see a very good lush green colour and land cover in the Western Ghats, good forest, thick forest, because not a good rainfall is happening. Convection, convection is when moist air, which means air with a lot of water vapour moves on a hot surface, causing sudden raise of air and condensation occurs. So, you have a hot, hot surface.

The hot surface could be your lake which is really hot or road which is really hot and then you have your moist air, which is air full of water vapor, it moves and when it hits that plate, that area where it is very-very hot, suddenly it rises the temperature. So, that raise in temperature and the warmth, the air has to compensate. How will compensate is by moving up, it moves up and then cools.

So sudden movement, sudden increase in that energy would also leave it to cool down and it condenses, so that is convection. Now you would have an idea where convection would happen. Convection would mostly happen in regions like deserts where sudden hot

surfaces are available or urban areas, urban heat island we call, where we have a very hot road surface or covering with higher deflection or warming potential.

It suddenly raises the temperature and then when water vapour filled air moves up, it just suddenly raises the temperature and by raising it has to move, do something, it has energy now, so all it can do is just move up vertically and while moving up it reduces the temperature, cools down and then condensation happens. Convergence is when two air masses with similar energy collide.

So, in the first frontal we saw cold, which is a higher denser, cold and warm air moving, but here it is both same, when both similar energy collide, convergence happens. The energy has to be converted to some other way so it rises up, by raising up you cool down. If you break it into simple physics, movement is kinetic energy and potential energy is moving up.

Vertical movement and a higher elevation movement is potential energy, whereas moving is kinetic energy. So, kinetic energy is being converted into potential energy by higher elevation. However, when you go to a higher elevation, it cools down, so energy might remain, but you are cooling down and that is the important process which is needed for condensation to occur.

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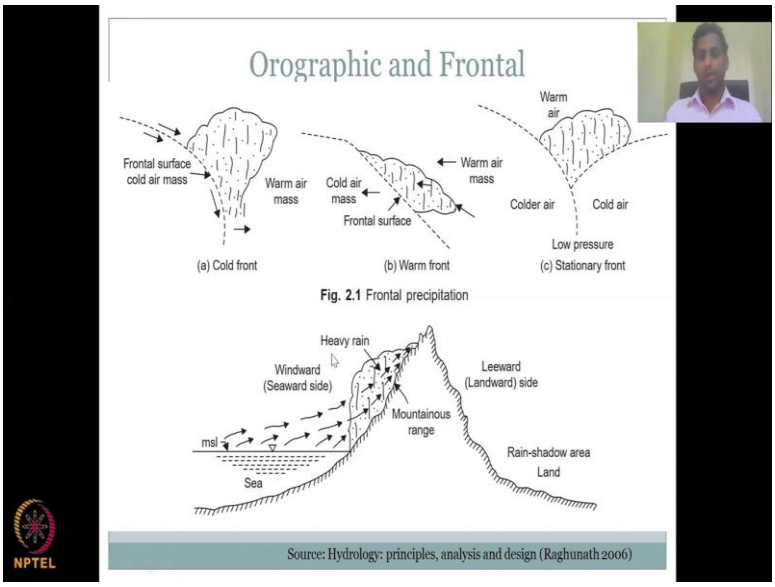

Let us look at some images for work better clarity. So, in the first method, this is also from the book that I have prescribed for the course, let us look at orographic and frontal

because these are the two major methods through which precipitation can occur in rural India. So, we again focusing on rural India, where we have a frontal surface cold air mass which is moving, it moves and warm air gets lifted up.

So, what happens is your frontal surface or cold air mass is moving in and your warm air which is on this different colour or different diagram, it starts to move up and that moving up would cause it to cool down further and then rain will occur. So, that is how precipitation is formed. In the second phase, where we are looking at the orographic, what you could see is this is the mountain range.

I give an example of the Western Ghats; it could be any elevation gradient. A gradient means a sudden change in elevation. So, what you see here is a elevation gradient or here let us take the example of Western Ghats. So, what sea would this be? This will be your Arabian Sea, so your air mass is coming.

So, your evaporation is happening on the surface of your sea. We will think about the water cycle that we discussed, evaporation is happening, which means water from the surface is converted into vapour and that vapour is being moved across the land surface. And when it moves across it is having a lot of moisture, but it is warm because of the temperature and it is moving towards seaward.

So, while it moves, it goes up, because of the mountain it has to go up and while it goes up as I said the warm air is in a different design, look at the warm air design. So, while the warm air is moving up, it cools down and because of that you have a lot of rainfall. So, these are the two major methods by which precipitation can occur in India.

But there is a downfall. What is this? So, in the orographic method, what you could see is on one side of the mountain you have so much rainfall, because all of the moisture is being deposited, it picks up from the sea, the moisture, the water vapour goes up and cools down, lot of rainfall. So, rainfall occurs on this area, but what happens to this area?

So, this area becomes as a rain shadow area where a land without rainfall, even though it is very-very close, sometimes even within 1 kilometre, 2 kilometres from your mountain region, you would see that there is less rainfall because all the rainfall occurs on one side of the mountain. So, while the mountains help the occurrence of precipitation, it can also take away the rainfall that could have happened on the other side.

And that is where we have a rain shadow area. So, if you go along with the Western Ghats one side of the Western Ghats is very green, lush, good tropical forest, very good rainfall, 3000 millimetres even, per year, but then when you go to the other side, it is really dry, all the water is already deposited on this side as rainfall whereas here it is very-very less rainfall, sometimes even 600 millimetres.

So, look at the difference 6000, 3000 on one side, 600 on the other side. The other issue is once the cloud and the air deposits all the moisture, it will pick up the moisture from the other side, which means it will take away whatever moisture is remaining on the other side. So, this is very important to understand for rural water management.

How do you manage this side of the land to preserve the water whatever water you have, and how do you manage the other side of the mountain for avoiding floods and droughts. So, that is where we will be looking at. So, now we have looked at the two major methods by which precipitation can occur.

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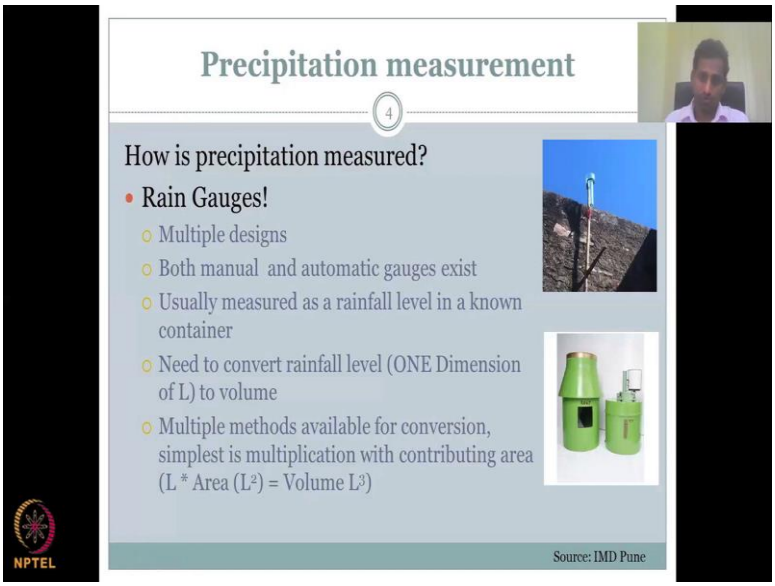

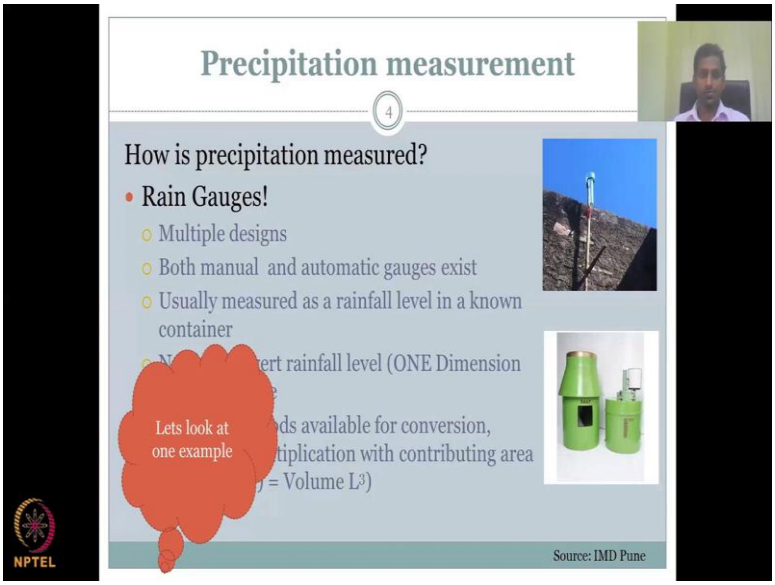

Now let us get into precipitation measurements. Where there are multiple, multiple methods, we will stick to the method which mostly the government agencies use and which you could apply in the rural setting. How is precipitation measured? As I said, it is measured as a unit of thickness to be consistent with your water mass balance equation.

Rain gauges, so the device that is used to measure rainfall is called a rain gauge. The multiple designs, many-many designs, and each has its own benefits, pros and why it can be used for a particular reaseon. So you have to be understanding the pros and cons of using a particular design in your field. If you do not know much, it is always okay to use the simplest one.

What you see on the top right corner is the simplest rain gauge which we used in Rajasthan as part of our project. and it is basically a plastic tube with markings to tell the thickness of rainfall. So, I put it on a school and when it rains water is collected in the plastic tube and since the tube has marking, centimetres, in centimetres, we call it graduated, what happens is you get a thickness of rainfall.

So, every day I would ask the students to go collect the rainfall in the gauge and then empty it and then put it back because if you do not empty, the second days rainfall also will be recorded. So, it is kind of manually intensive but it is the most simplest design. So, now you can understand there is both manual and automatic rain gauges.

It depends on your budget and how much technical capacities you have to install monitor, manage these resources, so it takes time. So, both manual and automatic gauges exist in

the market. If you want the simplest one you can go for manual, if you have the manpower you can go for manual, if someone is there to collect the data otherwise automatic it is good.

Usually measured as a rainfall level in a known container, so as I said the plastic container I know, I know the centimetres, where the centimetres are drawn and if rainfall occurs, I can measure. What is the downside of it? If you do not collect the rainfall quickly, it will overflow. Once the tube fills up it will overflow.

So, that is what I am saying there is pros and cons, I cannot use that rain gauge in, for example the Western Ghats, where it can fill up within an hour, and every hour I cannot ask someone to take a measurement. So, it depends, if you can use in a other side of the Western Ghats where I said it is dry, yes, you can use it. So, not more than 20 centimetres you are expected on a particular day, 20 centimetres is like a flood.

So, what I am saying is 200 millimetres even easily you could measure. So, here this gauge would go around 30 centimetres. So, need to convert rainfall level one dimension to a volume. So, what you get through these rain gauges is a thickness which is one dimension. So the top one is a manual, the bottom one is a IMD automatic station, where you could see that water can come in and record on a graph sheet.

I will also show you the inside diagram from the book on how rain gauge will look at. But for you to understand this is how data looks like, rainfall would come in, rain will occur and you will take it as a measurement. Multiple methods are available for conversion; simplest equation is multiplication with contributing area.

So, if you know that for a school area or for that particular local village, one rain gauge is there, I just multiply the area of the village by your rain gauge depth, the rainfall depth, I will get the volume. So that is the total volume I can expect in the village because of rainfall. There are multiple protocols that you should follow while installing a rain gauge.

And those protocols are given in the booklet by a rain gauge. You can also refer to IMDs guidelines SOPs we call them or USGS SOPs on how to set up a rainfall gauge. Since this course is going to talk about how you can use this data, it is very important to understand how the data is collected. So, that is why we are discussing these in this lecture.

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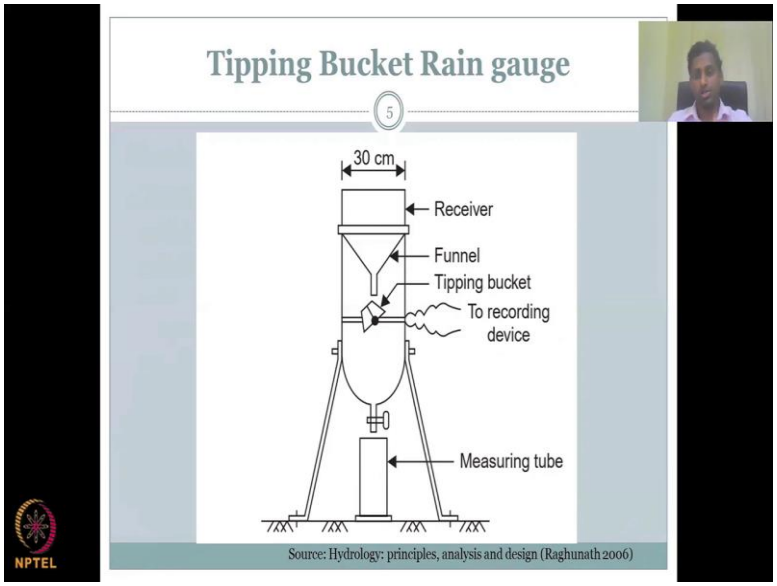

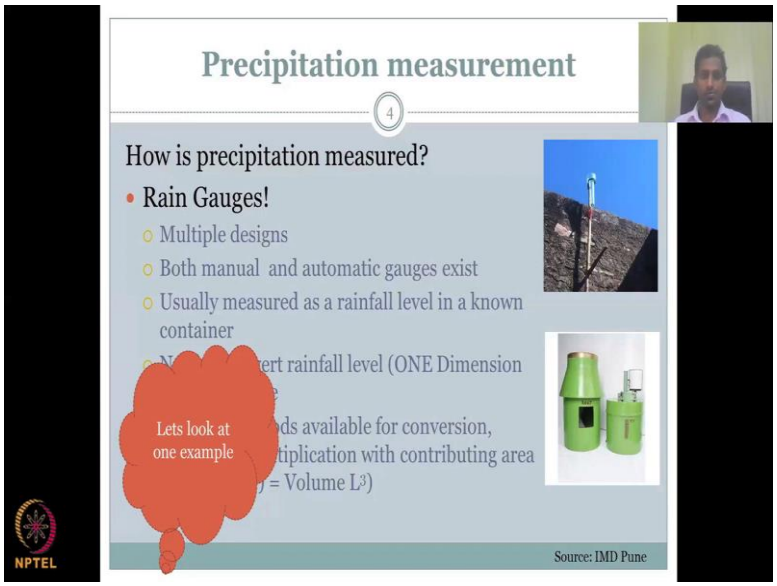

Let us take one, just one rain gauge type as an example. We call it the tipping bucket rain gauge. This is the receiver which is a funnel, a funnel which collects rainfall in a 30-centimetre diameter. So, rainfall occurs, you will collect rainfall through this. Rainfall will be collected and drips into the container part of your instrument.

It is the same as your green instrument here, but just a different diagram. What you have here is a tipping bucket. So, it is a small bucket divided into two. So, you can see two compartments of the bucket. So, once rainfall comes in, it fills one side of the bucket, once the bucket is full because of the weight it will tilt.

So, when it tilts, a recording device will record as 1, so 1 tilt would be recorded as 1 in your chart. So, then this part of the compartment will get the rainfall, then it will tilt this side. so then 2, so like that 3, 4, 5, 6. So, it will oscillate between the two compartments, depending on the rainfall received and the number of tips, the number of tipping of the bucket would be measured.

We know the volume of each bucket; we know the volume of each compartment because you put it in we measure it. And if you have the number of tippings, then we can just multiply the volume of one bucket times the number of tips that is recorded in the device to give the total volume. So, this is a automatic rain gauge, where you do not have to collect daily, but it gets recorded and sent to the servers if it is remotely connected or it be recorded inside the machine itself, in a digital or analogue fashion.

The water does not stay, which means the water would come, tip and then come out. You can also put a measuring tube here and collect the water and measure it, but it is not needed because water can flow up. What is the benefit? You do not have to change or go after a big, big event. Like the gauge I showed in the school, you have to empty it and then put it back, here there is no empty, you just measure the rainfall.

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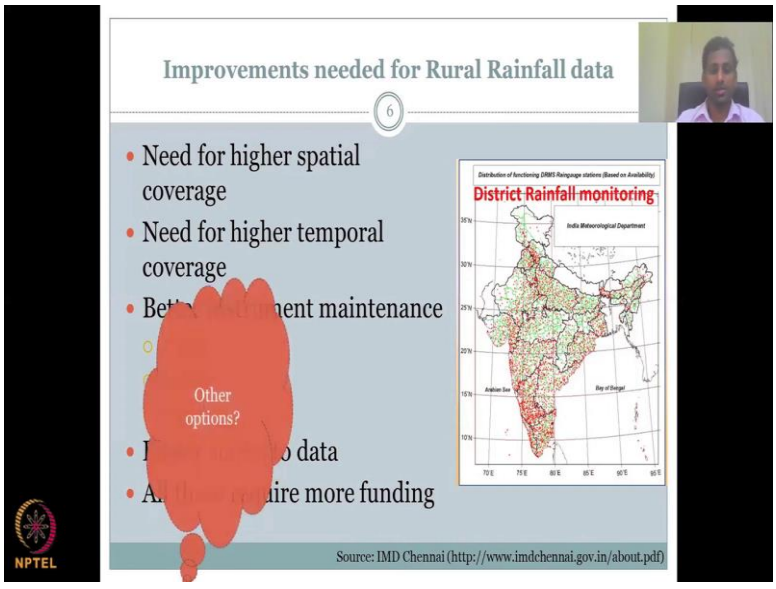

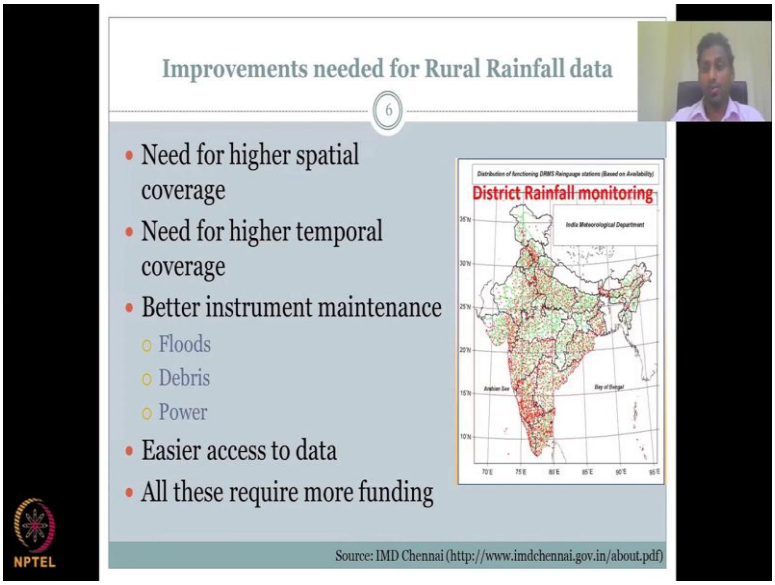

So, IMD is the key agency for monitoring rainfall across India, Indian Meteorology department, IMD. So, I have told you about rainfall presentation methods and how to measure the data. And now we could see how IMD has put up their rain gauges, automatic or manual across India. You could see there is a good representation on the Western Ghat side because there is a lot of rainfall.

But in central India is very less, according to this diagram. And also, in some parts of your Kashmir, you do have less rainfall measuring devices, in Rajasthan, Gujarat, Madhya Pradesh, Uttarakhand. So, all this is very important to understand where we could have more better input from IMD. So, we can get need for higher spatial coverage.

Looking at this we can ask, we can get for more data, we can get higher temporal coverage, spatial coverage means across the area of India, we can propose to have more stations. Higher temporal coverage means, if it is given daily, in some regions, can you do some daily, or hourly so that I can understand how rainfall can be converted into floods or I can understand how I could capture the rainfall for my rainwater harvesting, for example, across the Western Ghats

Also, there is a need for better instrumentation and maintenance because when there is a extreme event like flood, some of the rain gauges can be washed away or damaged. So, there is need for better instrument maintenance. This can be visible if you go to the websites and download the data. We will be looking at some websites in this class to download this data and you will see some gaps, some gaps in your data could be because of an instrumentation error.

Debris, so if you have a rain gauge debris is the unwanted material that can fall inside your rain gauge, for example a leaf. A leaf can fall inside the rain gauge and prevent the rainfall from going inside the rain gauge. This would affect your quality of data. The third thing is power. Some of these automatic ones would need a solar panel or battery power for operations, sometimes there might be a short circuit, the power is lost.

So, it is always necessary to have a backup power supply or good power supply. The other thing is easier access to data; sometimes it gets tricky to get all the data, the formats, et cetera. So, it will be good to have easier access to the data or more information on how to access all these data together. However, all these require more funding, more funding is required when there is an interest to take this data and use it for public good.

So, if we show that I am going to use this data then the government would be ready to fund more so that we could do better water management. For example, in a village if there is no rain gauge, the village people can ask for a rain gauge. For example, I want to do rainwater harvesting for which I need to understand how much rainfall is occurring.

So, for this funding exercise, you could say that I am having such deliverables, like for example rainwater harvesting, when we increase the storage capacity in the village, et cetera. So this is a physical measurement. Is there another measurement, other options? Yes.

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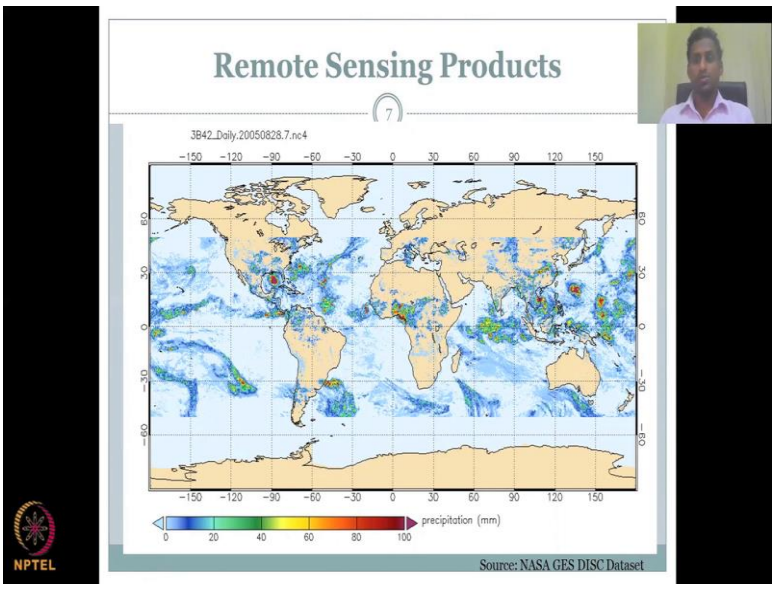

Remote sensing – So remote sensing products, just a quick definition what a remote sensing is; in our lectures remote sensing is the process of satellites collecting data for your hydrological parameters. So, satellites are known to estimate rainfall or collect data on rainfall at a global scale. Here the entire globe is mapped as a precipitation.

For example, you could see Western Ghats here and the rainfall is around, it is in the blue and green colours, so I could say around 20 millimetres for that particular day, it is a day on 2005 year and then you have the months and then you units. So, this is daily. So normally remote sensing products, the data file name, like dot nc4 is a type would give you the details about the data. 3D photo is the level of processing of the data.

It is a daily timescale, as I say spatial and temporal; spatial it is global, so we do not have to worry about it. Temporal is daily, daily coverage 20050828. So, this is a remote sensing product, which is a satellite sense product of the rainfall. So, you can also have this, which is free of cost, just go to the website I have given at the bottom or you can also look at other sources for rainfall through remote sensing.

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And it is a big problem. There is a lot of international collaborations for mapping rainfall. Let us see an example. So, this is a picture of the globe, and tremendous amount of funding and energy has been put and at the rainfall because rainfall occurring in one region can impact another international boundary. As I said Ganges is cross boundary.

So, it is not, it is very important for us to understand what is the rainfall in Nepal to understand the Ganges flow in India and how we manage it in India and Bangladesh. So, for this, there is a lot of these collaborative programmes and this is one collaborative programme GPM Constellation, where India is a part along with United States, Japan, France and European union.

You could see the satellites that they have put up across the globe to monitor these rainfall events and how much precipitation occurs. The data is free of cost, which means it is open source, anyone can access it, all you have to do is just set up an account in the NASA download webpage and then download the data.

How to use this data is a part is not the scope of this lecture, it may be covered in a GIS lecture. But what I am trying to tell here is do not say there is no data, there is some data, it is at a different scale, you could still use it for rainfall. So, of these satellites, most of the satellites are from the US, let us say NOAA, NASA JAXA and then TRMM is a very successful rainfall monitoring satellite, you have NOAA, you have Jason, JPSS, et cetera.

Then you have the Indian French satellite Megha. So, Mega-Tropiques is a satellite which is between India's mission between India and France, and it is a very good satellite, that you can collect data from ISRO website itself. So, there are multiple platforms that can support the estimation of rainfall using remote sensing products.

So, in this lecture, what we came across is precipitation occurs by different methods. We looked at the key methods that occur in India, even though we discuss in methods overall, the more dominant methods and then we looked at orography and frontal precipitation methods. Once precipitation occurs, it is important to capture the precipitation so we discussed about rain gauges,

We looked at how a rain gauge collects data and then we showed the map of where rain gauges are present for India through IMD. Then we said there might be some issues or to say where, how you could use other data products, we looked at the remote sensing or satellite products. And with this, I am showing the satellites that are available for free to download data for rainfall estimations.

We would conclude the precipitation later in lecture today and move on to the other parameters in the next lecture. Thank you.