Rural Water Resources Management
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Week: 02 Lecture: 05
Key Hydrological Parameters for Rural India

Hello everyone, welcome to Rural Water Resource Management NPTEL course, week 2 of lecture 5. This will be the last lecture 2.

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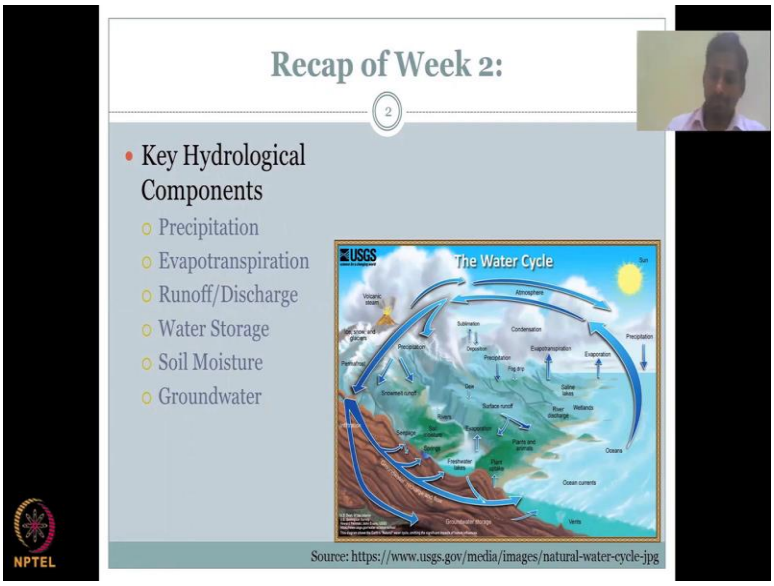

In this week, we have been looking at the key hydrological parameters, at the end of the hydrological parameters we focused mostly on the parameters that are important for rural India. And we broke it up in two parts, as I said week 2 was focusing on precipitation, evapotranspiration and runoff and discharge while the following week would be focusing on water storage structures, soil moisture and groundwater.

Water storage structures not as dams and stuff but where the water is being held. For example, you could see here some depressions where water is held. So, in this past week, we looked at how these three hydrological parameters namely precipitation, evapotranspiration and runoff contributed to the water budget or the water cycle equation. We also looked at, define which is a key input to the system and which of these components is a loss to the system.

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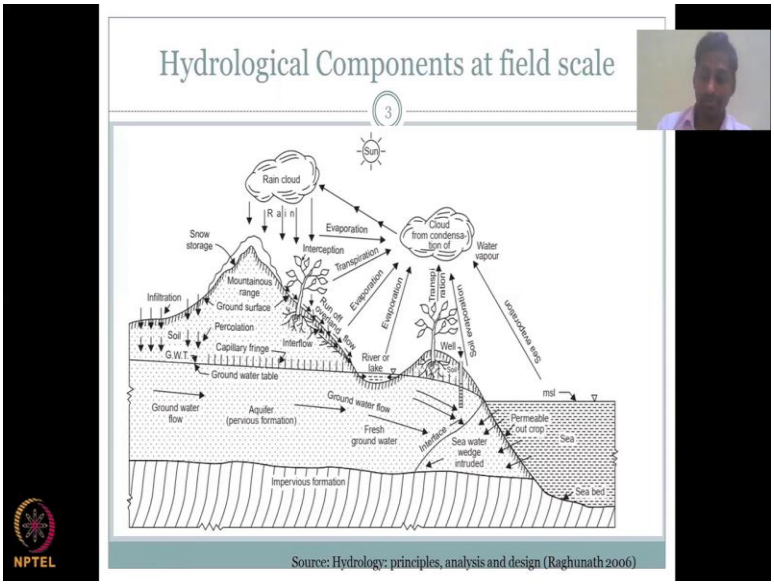

So, at field scale, how did we look at the hydrological components? In the precipitation part we looked at how rainfall occurs and we have multiple methods for rainfall and one of them is your frontal and it is very, very important for understanding the small, small rainfall that occurs in India. So, in hilly regions w have your rainfall through your orographic which is when a moist air or a cloud moves along the top of mountains and because it goes up there is rainfall that occurs.

So, rainfall, we also looked at what are the different methods to monitor, so that is this part of your hydrological cycle. Then, we looked at once rainfall occurs, how is water being relocated to other compartments mostly the first part was your evapotranspiration, so rainfall occurs, some water is lost by interception from plants, whereas some water would go into the soil matrix where water would be taken up by the plants and transpired.

So, that is where transpiration goes in. Some of the water would still be on the ground as on the top surface and because of the sun it evaporates. So, please understand this is a different analogical cycle figure I am showing and as everything is there, the most important part is the driver which is a sun. So, you have evaporation from your lakes, which is your stagnant water bodies, lakes and rivers and your oceans.

Water vapor is cooled down and goes and forms clouds as part of condensation. Further condensation and cooling gets into rainfall and that is where this arrow is connecting. So, you

have your rainfall, part of the water goes into the soil, part of it causes runoff and then the runoff can be evaporated. So, evaporation, evaporation, evaporation, and then there is also water that mixes with sea, evaporates into water vapor and then condenses as clouds goes back as rainfall.

The water that goes into the soil is taken up by plants and that is being transpire. So, you see about transpiration here from living organisms. Some of the water on the surface here can also be evaporated because of the sun and that is being shown here as evaporation. So, all of this give water vapor to the atmosphere and when the water vapor coalesce or join together and formed clouds, further condenses and cools down to form rainfall.

So, that is how you get. The other component we saw is yes, you have evapotranspiration, what happens to the remaining water. So, you had your precipitation which is coming down and off the parameters we saw only presentation is the input to the system or the input, the arrow coming down, whereas all the others is just relocation of water or and loss to the system. So, you see water from here goes out, so that is a loss.

So, coming back, we looked at water coming into the ground as infiltration and part of it would come back into the groundwater and come out as base flow. So, the water infiltrates, moves through the soil profile, hits the groundwater table or meets the groundwater table and then moves as groundwater flow, after some time it would come out to the surface as base flow.

Some of the rain would just hit the surface and was runoff and some of it as subsurface runoff. So, the three components are also shown here. So, this is a very focused hydrological cycle, which depends on the three parameters that we discussed over the week. You could see that what it does move down because there is an impervious savior layer.

What is an impervious layer? A layer which prevents water from going down. So it is impeding or impervious so that is why water does not flow and goes in. We are not going to concentrate on water moving from ocean to land, which is not most cases in rural India, we are only focusing on how water management can occur.

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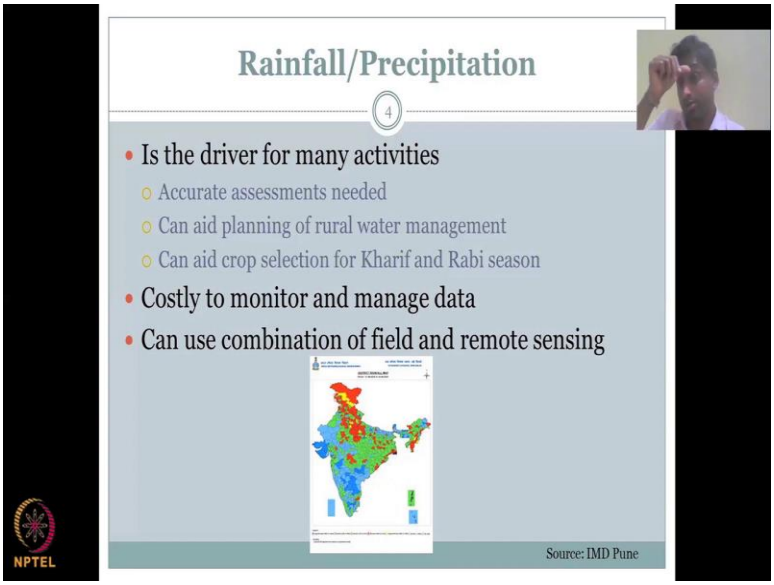

In the rainfall precipitation, we saw that rainfall is a type of precipitation. So, when you discuss papers on rural water management, sometimes they will use the word precipitation, sometimes rainfall because there is no snowfall for agriculture in small parts of India, whereas the Ganges water as I said could be because of snowmelt, but we do not focus it as snow water, we call it as discharge.

So, the key precipitation of a key type of precipitation that we use is rainfall. So, most of the reports and government records will call it as rainfall. Why is it important? It is the water for many activities, which means because it is the input to the system and in most cases it is the only input for the system accurate assessments are needed.

And such assessment, such information on rainfall would aid in planning of rural water management. You get better ideas on how to manage water if you know how much water is coming through rainfall. Can aid crop selection for Kharif and Rabi season? What do we mean here? So, Kharif is the monsoon crop and if you know I get 1000 I mean of rainfall, I would go below 1000mm rainfall, water demand crop.

Because at the end of the day you do not want to take excess water from other resources for supporting your Kharif. Rabi season is fine, Kharif is your monsoon crop. So, you want to have the crop mostly taking the monsoon back for. So, normally people do not overshoot or put a crop above the rainfall level or the average rainfall level. Then you have the Rabi season.

Rabi season is the seasonal crop that is grown in a non-monsoon period. For that rainfall still helps, because if you know how much rainfall occurred and you know what are the storage losses in the system, the remaining rainfall goes into the groundwater and that can be pulled up again for your Rabi season.

However, as we know how important rainfall data is, it is costly to monitor and manage data. It is a big network you need, do a very good job, but still there are some issues and to overcome the issues we looked at how the observation data can be merges or used along with management. We also looked at many Indian, US, French, European satellites that are mapping the world, especially for hydrological parameters like rainfall, temperature, et cetera.

So, those data can be used along with your observation data assessing rainfall. Once you assess rainfall, you can know the average rainfall for 10 years 20 years like the one they have done in the map I am showing what they are showing is the current year rainfall above or below the average rainfall. If it is about we are happy, we color it blue.

And the excess water can be used for future planning, storage, maybe excision of Kharif crop, another crop along with Kharif and Rabi, et cetera. But if it is lower, that is your red spots you have, what it means is that you need to supply a subsidized water, you have to get other water resources for agriculture, dam, groundwater, et cetera or you will have to face crop loss because of water. So, this is where your rainfall data can help.

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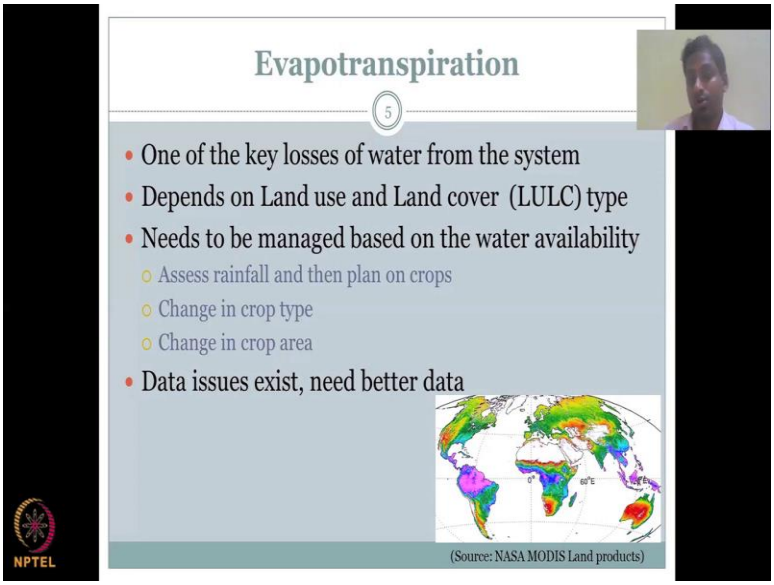

So, after we looked at the input to the system we looked into the evapotranspiration. It is one of the key and major loss of water from the system. Even though plants do require water to transpire and that transpiration is important for plant's growth the water is lost from the system. Suppose the plant took the water up and then deposited it back into the land, then it is fine, we will not call it as a loss of the system.

Let the plant take the water and put it back into the ground. What it does is it takes the water and then converts it into vapor, pushes it into the atmosphere as transpiration. If the wind blows, then the water vapor can go somewhere else. So, it is totally taken out of the system. So, it is a loss to the system. So, Evapotranspiration is a loss, however, it is one parameter that the transpiration part, at least that we need to do in order to get the plant growth.

It depends mostly on land use and land cover, we call it LULC. It is a very common phrase that we use. So, your evapotranspiration depends on your land use, how land is being used and land cover type. Land cover could be agriculture, forest, barren, et cetera and land use is how you use it. For example, you are using a road on top of it or your using management practice on top of it for agriculture, all these would impact your evapotranspiration.

Needs to be assessed manage based on the water availability. If you know evapotranspiration, you should go back and check how much water is available from the precipitation and other resources, so that you can better manage crops. Let us see some examples, assess rainfall and

then plan on crops. Once you know the rainfall you can actually estimate evapotranspiration rates and then check the volume needed, water volume needed for plan and choose those plants that are within your water budget.

For that we did go through in the evapotranspiration lecture, we did go through how to estimate a particular water demand for a crop using the Kc method, crop coefficient method, FAO. So, once you know that the rainfall is not enough for the particular crop, what can you do? You could change the crop type. For example, if I cannot grow sugar cane, can I grow cotton?

Sugar cane is a very water intensive crop. So, I can tell a farmer, “Sorry, farmer, this year you did not have 1500mm, you only have 600 mm of rainfall. So, you cannot afford to grow a high evapotranspiration, ET plant, you have to go for an lower plant and water consuming plan and that is where we can prescribe maybe turmeric, cotton, some other crop.

So, that is change in crop type. Suppose the farmer says, “No sir, I would only want to grow sugarcane.” Then we could say, “Okay sir, instead of a one acre, you do not have the volume for one acre, you could go 50 percent of your acre, half an acre, 0.4 of an acre, for example.” So, that calculation can be done based on your rainfall availability and evapotranspiration.

As I explained in the previous slide for rainfall still there are some data issues and that is because not all plants are transpiring the same rain. The FAO method to says, for example, for a plant the Kc values is a assumed value from a greenhouse experiment or a value which is being used for a long time based on physical field experience. But your eggplant might not have as big leaf or there could be differences between 3 - 4 eggplant plants in the same field.

So, still there are some data issues, that is why we are trying to say that ET estimations are even in the hard part there is some data issues. There is need for better data and for which there are a lot of these satellite base data for ET. Even the government websites, like ISRO could have a data driven model for ET estimates, which can help the farmers to tell how much water is being used for.

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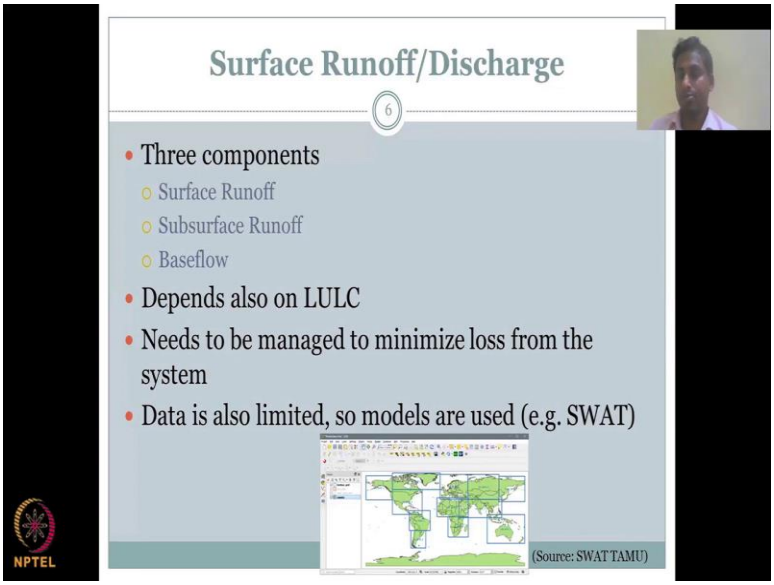

Then we came about this surface runoff discharge wherein we looked at what are the three key components of surface runoff, which include your surface runoff from the top overland flow, subsurface runoff, which goes, according to the rainfall which goes into the soil, moves laterally, which is called a subsurface runoff.

And then you have a base flow, the water which further goes down vertically because of gravity meets the ground water and then moves laterally and comes out from the surface as base flow. All the three components are very important and contribute the discharge. It also depends on your land use land cover and your slope and what type of geological setting et cetera.

How does land use, land cover play a role? If you have a road concrete path or a building that does not infiltrate water then how the water will go down? What would happen to the base flow component? It is very much lowered as where would be the evapotranspiration, there is some to no evapotranspiration because everywhere there is concrete.

So, all the water which falls on the road, part of it is used to wet the road, evaporation happens, some water may go seep in very little water, but it does not stay there because not a soil. So, all the water comes down as runoff. So, this is a learning curve. Initially days you will not see much floods in rural villages, there is very less amount of impervious layers, but in urban areas, you see a lot of floods because of high surface runoff.

This is because of the land use land cover which is being more urbanized, less water infiltration more runoff. So, needs to be managed. It is a very important resource that needs to be managed to minimize loss from the system because all the water that is going into the rivers and your streams are away from your watershed or your body of risk free field for example, and it goes out of the system.

So, once it goes out of a system, it is a maximum loss. So, it is very important to address the water, store the water, runoff water and use it for agriculture. One quick example would be rainwater harvesting. I did not want to give all the methods for each of them because we do have lectures in the following weeks on very specific waste to conserve water.

So, this week, let us just understand the different components so we are in a better position to pick a method for rainwater harvesting. As we explained further precipitation and evapotranspiration, data is also limited, comparatively you do not have remote sensing images for surface runoff, however, you can use models.

So, if rainfall, if I know the LULC time, the land use land cover, and I know the evapotranspiration that occurs, I can estimate the runoff using hydrological model. One model is this one. So, soil water assessment tool. So, all these models and different aspects are available for us to understand at a very very high scale or a village field, et cetera, what is the runoff, how can we reduce the runoff.

So, once we know how much discharge is happening in the rivers we can know how much is excess discharge and once we know how much surplus runoff is generated in a village, we can look at how we could minimize this loss from the system, maybe create some storage structures that could stop the surface runoff, put the water back into the groundwater or as a surface storage and then use it in a later period of time.

So, all these are very important aspects that we need to cover when we discuss the different hydrological parameters for rural India. So, of the precipitation is always an input, it is not a loss, evapotranspiration is always a loss. However, surface runoff and discharge can either be input to the system or loss, in most cases it is a loss because when rainfall happens, water combines together and moves out of the system so it is a loss.

But that water which moves out of the system can be an input to the next field. So, then it adds up with your precipitation in the next field and it is a positive or an addition to the watershed. So, let us take a watershed. So, this is my watershed initially, as I said you can have a shape as a leaf or a fern type. So, let us keep as this is the watershed and you have rainfall coming in and discharge happening and water does flow out.

When it flows out it can go to the next watershed so, that is what I mean when I say it could be an input not to your system, but the next system. So, when you have a feel, you should look at what are the key inputs of water into the field. If it is rainfall, it is only one, which is easier, but if you have a channel that brings water then it is a discharge that comes in as a positive.

So, on the left hand side in our equations we had precipitation is equal to evapotranspiration minus runoff minus, et cetera, et cetera. But if you bring your runoff or discharge to the left hand side; then you have precipitation plus runoff would be a positive or input to the system. So, these models also which are used like SWAT for understanding the surface runoff and discharge, initially you had to create all the databases and understand how to run the model.

How to get the data and then validate the model? Nowadays, you do have data for India, website that are given SWAT TAMU, Texas A and M University does have good data for India. So, you can go and check the data sources and run these models to understand surface runoff and most of it is derived by hydrological parameters.

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With this I would like to conclude a week and look forward to meeting you all in week three where we discuss more of the hydrological parameters, three more, not much, three more, so that we then close the watershed analysis, water scale, water cycle analysis, and then we get into details on how to conserve the water.