Rural Water Resources Management
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Week 01 - Lecture 04
Hydrological Cycle Parameters

Hello everyone, welcome back to Rural Water Resource Management course, this is week 1 and lecture 4. In the previous lectures, we looked at why do you need to study Rural Water Resource Management, we looked at some components of a Hydrological Cycle, this give a brief introduction.

And then we looked into the composition of water availability of water LPCD rates to show why and how water resource managements are needed for rural India. Today, we will look into more specifics on the Hydrology cycle. We will first start with definition of it and then get into how you would like to use Hydrology to understand water management in rural areas.

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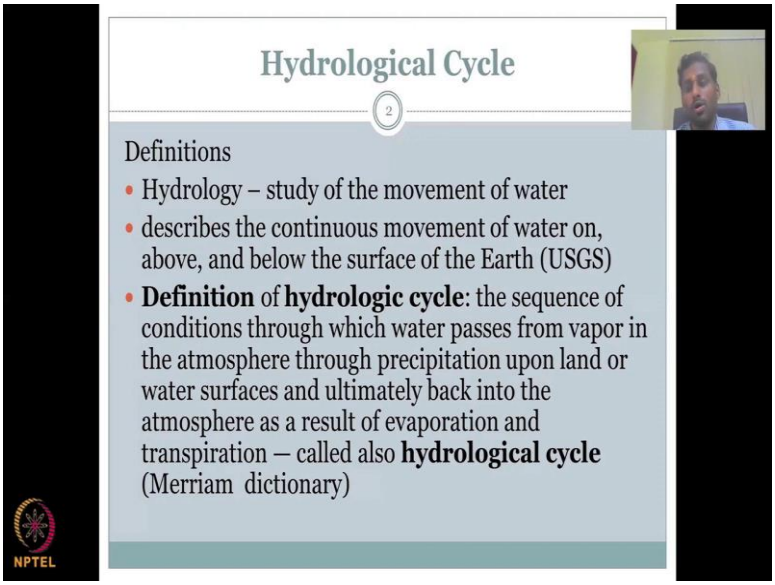

What is the Hydrological Cycle? How do you define it? The definitions can be simplistic or more in detail. In simple definition, Hydrology is the study of the movement of water, very simple 4-5 words you can explain people what Hydrological Cycle is. So, we know what are most from high potential to low potential and then by force by pumping etcetera to study this movement to different faces is called Hydrological Cycle.

So, the general subject is called Hydrology. And there are scientists and researchers who focus on particular aspects of the Hydrology or Hydrological Cycle and that could be coined

as a subsection hydrology. For example, there is surface hydrology, which means study of the movement of surface water. So, how water comes from snow melt to rivers and then rivers to lakes, dams and then Oceans. So, all of this would constitute surface hydrology.

Then, there is a subsurface or soil moisture that part of the Hydrology where water goes in and out of the soil and people look at the subsurface flow, those very focused studies are there. Simon ground water hydrologist wherein I focus more on groundwater. So, how water from the surface goes into or from the surface or atmosphere goes into the earth and through infiltration and percolation and then how different compartments are filled and converts from one form to the other. So, that is groundwater hydrology.

So, these are specific terms, but there are also some interdisciplinary terms also. Let us look at some few, you have socio hydrology and hydro sociology. So, how hydrology impacts the Sociology and those kinds of aspects people will discuss about it. And you have geo hydrologist scientist who is have has some aspects of geology and groundwater, those kinds of things, but mostly he is hydrology or he or she is a hydrologist.

So, a person who studies hydrology is called a hydrologist. And then the subsection wise also you could be labelled, for example, I am labelled as a groundwater hydrologist. And then there is a geo hydrologist where geo means geological terms and they study mostly well below the depth of groundwater, which means like, where magma flows, petroleum, those kinds of studies. And then you have hydro geologists.

So, if you see the word geo hydrologist, hydrogeologists, it can be interchanged. But when it is interchanged, the dominant science comes at the back. So, a geo hydrologist is still a hydrologist. However, a hydrogeologist is mostly in the domain of geology not hydrology. So, you have this interdisciplinary also approach, but in general it is called hydrology. And then there is subsections, sub, surface hydrology, soil moisture movement, and then groundwater hydrology and then the people who work on it are called hydrologist.

Let us get into some of the more technical terms of hydrology and describes the continuous movement of water on above and below the surface of the earth, USGS this definition, it clearly tells that you study the continuous movement of water on above, so above the earth's surface, which is your lithography or on the top.

And then just below just below the earth's surface, which is your groundwater hydrology, they do not go too much in the depth because that constitutes, as I said, a geologist. So, the

continuous movement of water, the interactions between water, all of this comes in the terms of hydrology, because where it interacts, it moves, and then by movement, also you can have more interactions of similar things.

Let us take a definition from a dictionary. So, some people would like to have a dictionary reference. And I am going to read it out, because these are dictionary terms, the sequence of conditions through which water passes from vapour in the atmosphere, through precipitation upon land or water surfaces, and ultimately back into the atmosphere as a result of evaporation and transpiration called as hydrological cycle, Merriam dictionary.

So, each dictionary would give different terms and if you look at it here clearly, they look at water which comes from the atmosphere as precipitation, it comes down and then goes into the rivers and lakes and oceans as surface hydrology and then goes back as evaporate… because of evaporation, transpiration driven by the sun, it goes back into the atmosphere. So, here there is no mention of groundwater, there is no mention of storage, because it is just a brief overall definition of hydrological cycle.

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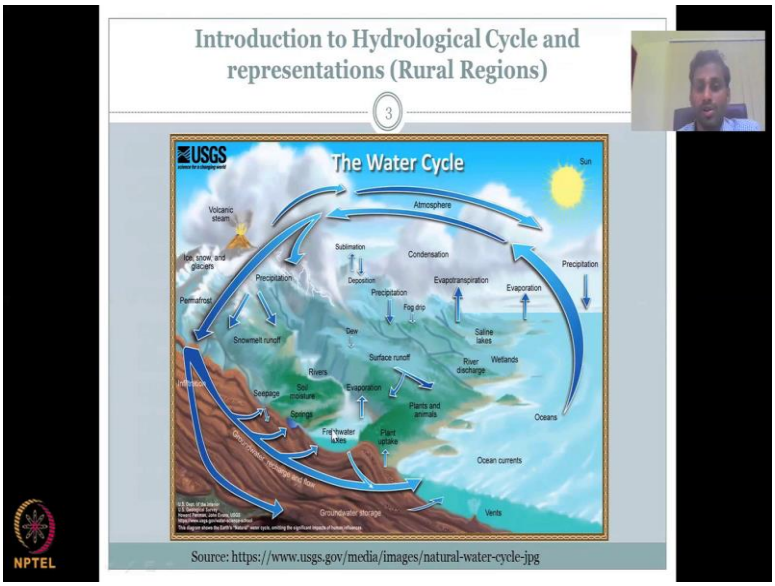

That is why it is always very important to draw it out, when you draw a hydrological cycle any physical cycle I would say then you understand where the priorities are, and how you could put more focus on different aspects of the hydrological cycle. Anyone your area as I said, if in India in a rural region, all these places I would remove of course. Frozen land are basically and ice, snow and glaciers not much we will have a active volcanic steam, so I can remove all this.

So, when you sit for and draw or discuss a hydrological cycle of a particular region, you should have a good understanding of these factors and which are relevant and not relevant to your system. Most importantly, you can write it in very simpler terms as given by the dictionary, which is precipitation.

So, you have precipitation is the input water cycle to the water cycle, and then you have your surface flows, which is your rivers, fresh lakes oceans, and then goes back into the atmosphere as evaporation and transpiration, then comes back as specification. So, you close the loop. So, this is how you relate to a definition of hydrological cycle, studying the movement, and also target which ones are very important for your area.

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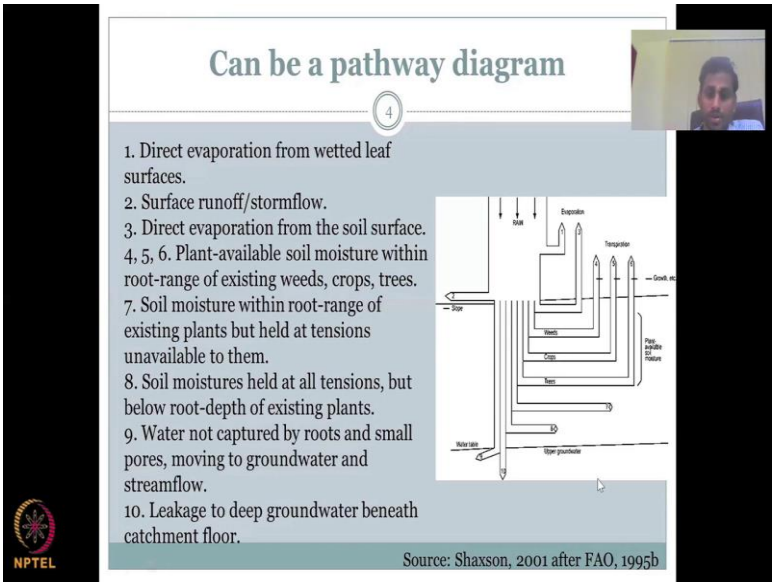

Suppose you cannot draw in detail. For example, you could not draw in detail, the mountains, the slopes, I do not know how much comes in, you can still do pathways. So, this is a pathway diagram or a flowchart kind of diagram. And you have to be clear on mentioning what is 123, which comes 123 first. So, let us look at this. This is from the FAO, Food and Agriculture Organisation, I would have a lot of references from FAO because many governments including government of India, has a lot of recommendations taken from the FAO's booklet.

FAO is an international organisation, like your WHO for health for food and agriculture, it is the FAO and they give a lot of research outputs recommendations where a lot of these governments are taking into action. So, let us first look at the hydrological cycle representation from them. It is a very simplistic take, so which means you do not need to be very artistic to draw rivers, lakes etcetera, but you could draw it as a simple arrow diagram.

So, here you have rain in that particular example from clouds you have only rain, no snow. So, the precipitation is coming in as rain. And because of the so let me bring out the definitions. So, direct evaporation from wetted leaf surface is the first one. So, what happens is when rain happens the first, the first before it touches the ground, so your slope is your ground. What does it touch the rainfall, falls on the leaf of the plants or trees and there is evaporation, not transpiration.

Transpiration is when plant takes the water through the soil, and then gives it off, we will come to that later you could see it here, what is the evaporation? The leaf is a little bit warmer, and then there is active sunlight. So, when water comes and hits your leaf, it evaporates. So, just evaporation, conversion of water into vapour.

So, that direct evaporation from a wetted leaf surface is the first because it interacts on your rain the first. Then whatever rain remains would come down. That is why when you go to a forest when it rains, you stand under a tree, because the leaves kind of shade you. Initially, all the all the water would be falling on the leaf it wets the surface and then there is evaporation, that is what this is telling you.

You might be amazed to see how much this wetted leaf evaporation is, sometimes it might be tremendous. So, that is why we still have to account for it, in some regions it may not be that important. For example, a coconut tree may not give you that much shade as a banyan tree. So, you can neglect in a coconut tree because the leaf shape is like this, water falls and it comes down. So, it does not wetted evaporate. So, those kinds of things analogies as I said you should have from your field experience.

So, the second dominant process becomes your slope surface runoff, stream stormflow. So, that is the land now the rainfall has hit the leaf and then come down into the land and then starts to flow as runoff, runoff is a process where rainfall converts into a flow surface flow, it can be storm flow, it can be rivers, those kinds of things is counted as surface runoff. So, that is number 2.

Here the arrow size is the same, it does not mean they are equally, volume is equal, so please do not look at the arrows in some diagrams, you will see a bigger arrow which means more water goes into runoff here we are not doing that, we are only looking at the pathways. Then what happens?

Number 3 is, direct evaporation from the soil. So, as the plant leaf or the tree leaf is warm and it evaporates, same way your soil can also evaporates. So, if you look at it, the first drops on the road, the first drops on the soil can evaporate it, that is why you have the smell of the soil comes when rainfall occurs, you suddenly smell the vectored soil, that is because of some of gets evaporated. So, that evaporation happens. So, that is number 3.

Now, 4, 5, 6 is plant available soil moisture within the root range of existing weeds, crops and trees. So, for this area, the author has seen weeds, weeds are grasses or crops that are not necessary or useful whatever it is. So, it is not that necessary in a plot. Then you have crops and then you have trees, so the water after it goes to runoff. After the evaporation water starts to slowly move down.

When it moves down the plants take it up and then transpire. So, this is the difference between evaporation and transpiration. Evaporation is on the surface, the plant does not use it just evaporates. Transpiration is when the plant takes the water from the soil, and then it pumps it to the chute and then transpires this just breathes it out.

So, those are because of growth as here it is clearly mentioned because of the growth 4, 5, 6 happens and this one happens because of the slope because of the slope you have runoff. So, let us move on. We have weeds, crops and trees plant available soil moistures, so the water from the soil which is from the rainfall gets into the transpiration cycle.

Let us go to 8, I am sorry 7. Soil moisture within root range of existing plans, but held at tensions unavailable to them, which means in the soil not all water can be taken up by the plant. So, there is some tension because the soil also wants to hold on to the water and the plant can only exert some pressure to take the water out. If it is too much pressure it cannot it will wilt.

So, it would rather not take the water from the soil and some water is held in the soil. I would not get into the soil physics because that is beyond the course but just understand that if I give 1 litre of water to the soil, not all the water I can pump up some water still remain in the soil that is what is happening here number 7.

So, this is the one which contributes to the soil moisture and also to the properties of soil depends on the property. So, soil moistures held at all tensions, but below root depth of existing plants. So, this is below the root depth, so 7 and 8 what is the difference is just the depth, 7 is at the root zone, the plant cannot take the water still remains, and then there is

some water which moves still down, why does water move down? Because of gravity, so gravity exerts and then it moves down in the column soil column, and then at 8 it stays there, so you have waters staying in the soil moistures at 7 and 8 not being taken off.

So, number 9 and 10, here is the groundwater dynamic. So, if you see from the slope until the upper groundwater it is purely soil water, where plants can take it up soil can take it up and some stored in the soil, after that phase is done, water still moves down. So, when it moves down, it goes into 9 and 10.

And 9 is where the water which is not captured by the roots, and the small pores in the soil, the small holes in the soil moves downwards to the groundwater. And there are two types of groundwater there is shallow groundwater and then there is deep, so number 9 is shallow that is why it stands here. And number 10 is your deep groundwater. It is interesting to see that some part of your 9 which is your shallow groundwater goes back into the river as base flow or stream flow. So, here it says moving to the groundwater and streamflow.

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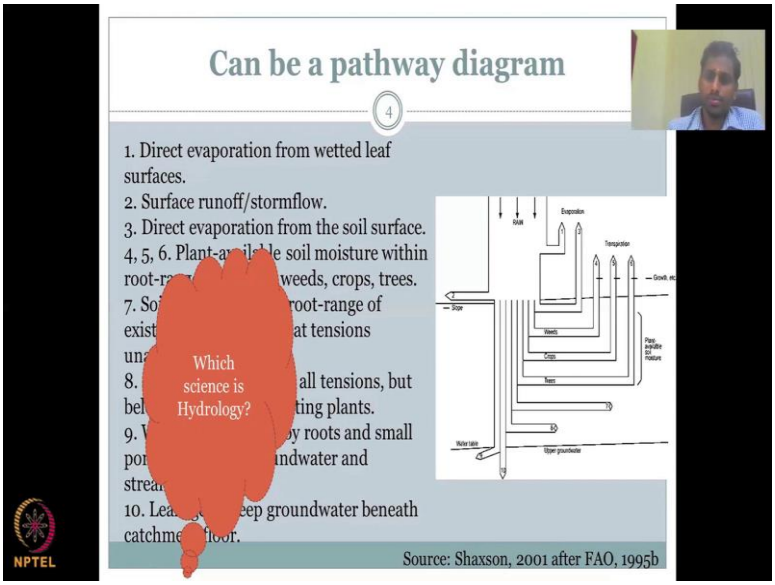

So, now you have seen that you are discussing about when we discuss about hydrological cycle, we had start from atmosphere, which is rain, then we go to the ground and ground dynamics slope angle etcetera. And then we look at once the radiation and then that driving the evaporation, and then you go to transpiration, sort of plant dynamics and then you go down more further into the geological aspects. So, where does the science stay? Is it a civil engineering topic? Is it a plant science topic? Let us look at it.

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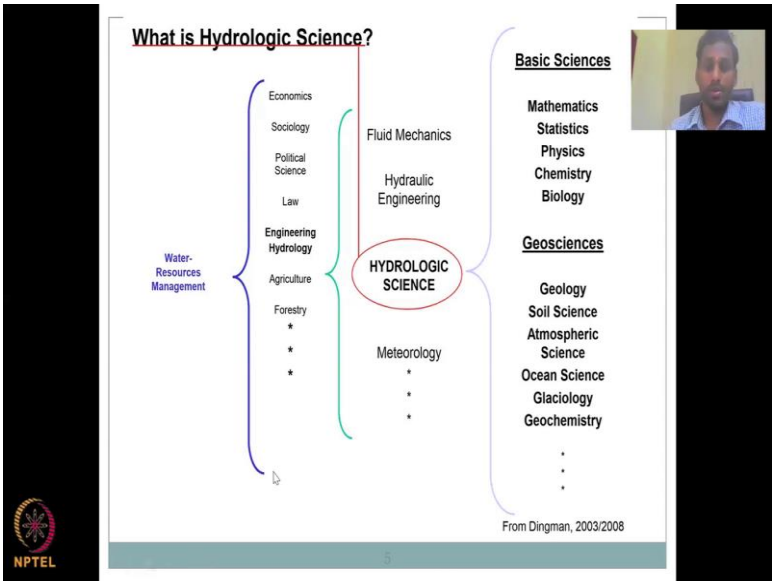

So, what is hydrological science? Someone asked you, for what resource management person in have multiple multiple as I said, it is interdisciplinary. So, you can add sociology and hydrology together hydro economics is a topic. So, all of this constitutes your water resource management. So, to be a good water resource management, we need to know understand the hydrology, but not alone the hydrology but all these other sciences.

Then what do you have? You have fluid mechanics. So, some part of the engineering hydrology where a lot of engineers are built. So, what is the difference between hydrology as a science and Hydrology as an engineer, hydrological science is driven by physics and other laws mathematics, whereas engineering hydrology, a lot of engineering competence would come in, construction those kinds of things.

So, hydrological science is right in between your fluid mechanics and physics, the hydrologic, engineering and the atmospheric sciences of metrology, oceanography all those things. So, it is a very, very interdisciplinary science. And as I said, where you want to apply defines your boundary if you want to apply more in the groundwater, you become a groundwater hydrologist, if you want to be in a surface water, you would be a surface water hydrologist and if you just want to be a general you know, everywhere I would like to contribute you are a hydrologist.

So, same like a doctor your general doctor, you can be a surgeon, you can be a diabetics specialist, paediatrics for children. So, same thing we have different doctors and very specific, so here hydrological science is not a science by itself. It is a combination of different sciences, different engineering aspects.

And what are they in the basic sciences it includes mathematics, as I said, mathematics drives all the science without equations without solving equations. It is very difficult. So, math, does mathematics driven physics, chemistry, biology, etcetera. Some people do a lot of statistics. But again, it depends on how you want to use your statistics. So, please understand if you like to use statistics, you understand the limitations and strengths of our statistics before jumping into applying it.

So, there is the basic sciences and the basic sciences are helping out or probing more the geosciences, the geosciences start with the geology. The geology would be your ground earth composition, soil, etcetera. So, it comes us Soil science, Atmospheric science, Ocean science, Glaciology, Geochemistry. So, what do you understand from this diagram to be a water resource management person, we have to understand hydrology.

And Hydrology is not a one discipline. It is a combination of other engineering science factors. And so, it is very easy to understand. So, that is what I have done. I am a physics by training physicist, Masters in Physics, but then my PhD was in Hydrology, it was such a easy transfer, because a lot of physics, is there applied physics, is there in hydrology.

Hydrology, I would say is that applied science, applied engineering. So, think about those terms. So, those who want to become a water resource person, do not refrain, saying that maybe I am not an engineer, I am not an engineer too. But you can still do good hydrology by understanding the science or mathematics part of it, wherever you are strong, you could still contribute to the hydrology this is from the Dingman book.

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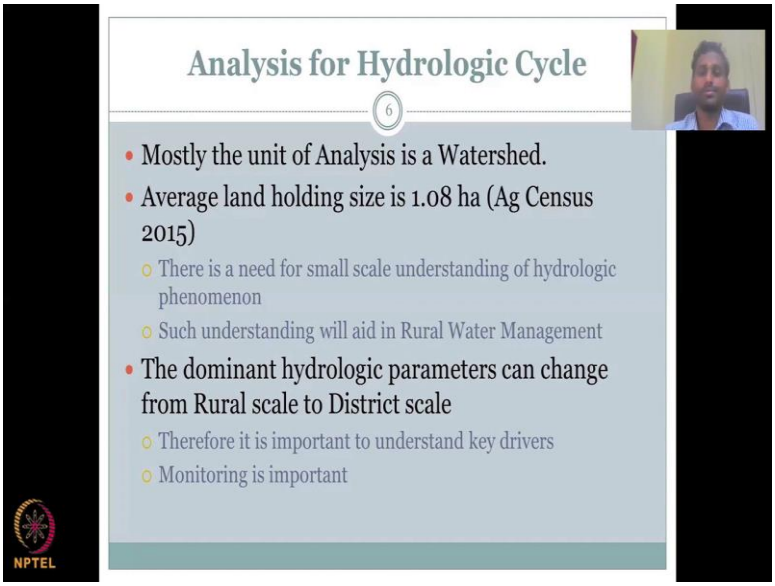

So, Analysis of Hydrological Cycle, now you have seen that, there are different components of Hydrological Cycle and different pathways, but before that, you need to address a particular area, what would happen if you do not address a particular area, you do not have a boundary.

So, how do you know what crops I told you the previous example you have weeds, you have crops and trees, that is because my area of focus is having all these. So, it is very, very important to first foremost determine your area of interest or area of research. So, that is we call the unit of analysis.

Mostly it is the watershed. It is not a district, it is not a nation, not a continent, it is a watershed, why? Because within the watershed, you have a clear demarcation of the rainfall pattern, you have a clear demarcation of flow where the rainfall converts to runoff and all the other parameters can be placed within that unit.

But where is the problem? The problem comes because the average land holding size in India is around 1.08 hectares according to Agricultural Census 2015. This is such a such a small area. So, when you want to do rural water resource management, our watershed might be too big. I will come into definitions of watershed, but as a unit it can be too big. So, there is a need for small scale understanding of hydrological phenomena.

Small scale understanding means, what are the priority pathways, what are the key variables in your system? So, that is where you understand where in your particular area small scale, small scale these smaller area in your smaller area. What are the key hydrological drivers? Is it rainfall, is it snow, is it streamflow, groundwater anything. So, that is very important to understand.

So, first foremost, fix your unit of analysis. If watershed is too big, because your average landholding size in India's is 1.08 hectares, then you have to go to the field and understand what is your analysis size. So, that is what is very, very key for rural water management.

Because I can sit in my office here, and then say no, I want to do a rural water resource assessment somewhere in Orissa, without going there, how do I know what crops are growing? What are the trees? How much water do they consume? Someone can give me the data, that is fine, but it is fine if it is a bigger area, but if it is a very small scale, it is best to go there and understand what are the key factors.

That is why the science is driven now. So, dominant hydrological parameters can change from rural scale districts scales. So, this is very important. If someone says no no, in Tamil Nadu, for example, the rainfall on the border of the Western Ghats is very, very high. Very high because the water rainfall comes from the Kerala side and there is a lot of Western Ghats deposition of rainfall. Does that mean entire Tamil Nadu gets the same rainfall? No.

Not even half of it comes to the other region so it is very very dry in the centre of Tamil Nadu and along the coast of Chennai and other things is semi-arid, which is around 600 to 700 millimetres, whereas along the Western Ghats along the Kerala border, it is around 2000. So, you see how different it is.

So, your unit of analysis is very important because your rainfall is the key parameter into the system. So, therefore, it is important to understand the key drivers and monitoring is important for a larger scale size or for a largest size project, it is okay to escape with the data you get, but for a smaller scale it is very very important, because the drivers may be different.

So, with this I would like to conclude and stress on the fact that you it is best to have an field level understanding of the rural drivers, what are the key crops When do they grow, how much water do they consume, when you want to discuss the hydrological cycle. If you do not do this, what would happen is everything is assumed or estimated as an assumption which would derail your understanding of the Hydrology.

They are very very small components. So, the very small rainfall would be a plot if it is a district okay some of the rainfall can be converted to groundwater. So, there is give and take, you can lose here give their etcetera it is fine. So, we call it as a noise which is smoothed out, but in a small small size, it is very, very difficult to let go of these checks' changes.

So, you have to understand what are the key exchanges and documented after you document it you do a flowchart of how we did in class today slide 3-4 etcetera. So, you write it down, this is the key products and then you stop there. Then you put the volume of water coming all this we would be discussing in the future classes. Thank you.