Water management
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Lecture No 14
Irrigation Efficiencies

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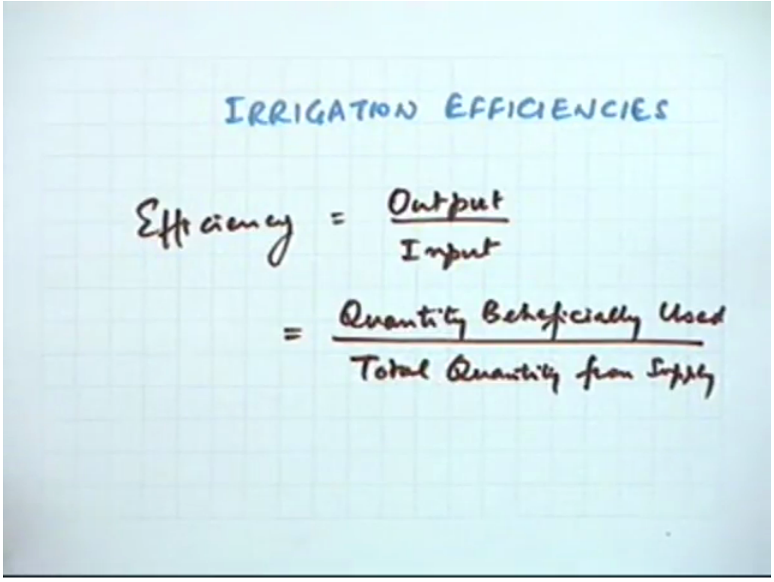

Okay, so today we will start with a new topic on irrigation efficiencies, so far we have looked into the various aspects of how to compute the evapotranspiration requirements of the crop and the next aspect which we want to dwell into is the various methods by which we will distribute the water to the crops surface or the fields and before we do that because there are various techniques, there are various ways by which you can supply the water, irrigation water to the irrigation field to the crop fields. Before we go to that level we want to find out what other ways and means by which you can look into…which is the best way of applying the water, so there the question of efficiencies come in, how you define efficiency in general?

When you look at the efficiency in general, what is it? It is the ratio of an output to input is what you mean by efficiency in general and you can also say that this is the quantity beneficially used to total quantity which you are received from the supply. So this is more closer to the irrigation aspects, what you are doing is that you are supplying you are diverting some water from the source, the source can be either in the form of a reservoir or the source can be groundwater to well or a sauce can be tank, so these sources there are various forms of sources which you can make use of in terms of artificial irrigation.

When I say artificial irrigation because they can be a possibility of having the irrigation water available because of the natural inputs, because of the natural rainfall, so then in that case if a sufficient quantity of water is available from the natural resources then you might not need the water to be diverted onto the fields with the artificial means. So when we say that the water has been diverted from the reservoir again the water in the reservoir is again the rainfall water but that has been stopped at a particular level it has been stored and then you are making that water travel from that source to the fields wherever is required and whenever is required.

So that is the difference between the water which you are getting from the rainfall and you are making its stored at the same place or (())(4:59) in the fields that is the water which is the effective rainfall what we are terming it as effective rainfall that is the rainfall which becomes effective at that location in the field, so the other water which you are diverted from some source and taking to another area of interest that is the irrigation water that is the artificial irrigation which we are discussing now.

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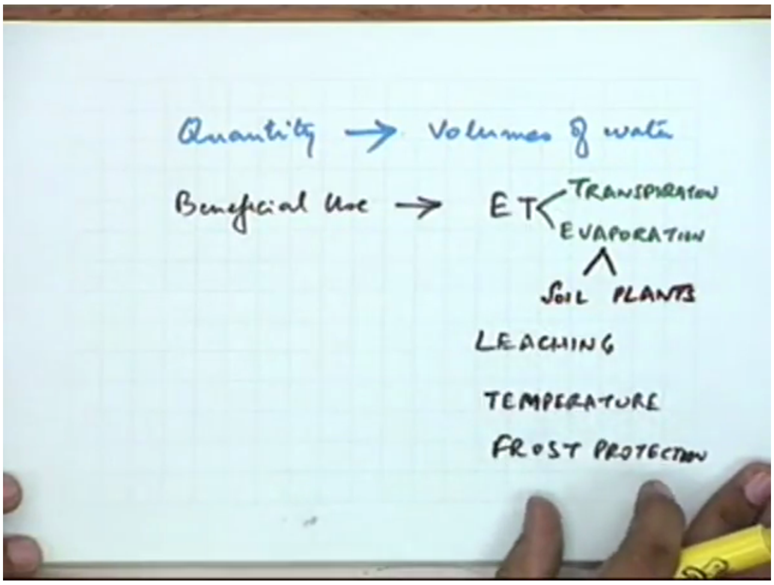

So when you say the quantity beneficially used, now first of all the quantity of water, we normally are dealing with the volumes of irrigation water. When we are talking of quantity, we mean the volume, how much volume of water has been diverted or it has been applied onto a field? And the beneficial usage of this quantity, the beneficial use can be in the form of now we know that there are various forms of this beneficial use, the primary is because of the evapotranspiration requirement, now which is again which is made of the components one is transpiration and the other is evaporation.

The evaporation can be from the soil or from plants, so that is what is the evapotranspiration component, we have gone into the details of this component. The other beneficial uses also be incorporated when you are looking at the quantity which can be used beneficially, the other usages can be maybe there can be some quantity which is used for leaching, leaching of the soluble salts, so when you want to displace those salts or you want to flush those salts which or not very useful salts for the crop production or the concentration is…sometimes the salts can be useful but once the concentration goes high they can be can no more be useful, so they can affect the growth of the crops. In the situation you would like to flush those salts below up to a level which is beyond the root zone depth, so that is that process known as the leaching process. Any water which is used for the leaching purpose can also be called can be termed as the beneficial usage of water.

Student: (())(8:32 - 8:35)

Yes the question is that how the evapotranspiration can be the evaporation can be termed as the beneficial use. Here that is where the method which method you are using come into picture because if the method is such that you cannot avoid that evaporation from the soil then that is inherent component of the beneficial use because you cannot avoid that for example if you method is such that you have to wet the whole surface you are using the gravity flow, in that case unless you let the water move from one end of the upstream end to the downstream end with the help of the slope of the field or even in some case you are using the surge of the water.

In that situation it is not possible not to wet the total area, in some cases, yes if you have shaped your field in a way that you cannot avoid wetting the whole area even in the case of the surface flow which will cover which is the farrow case still majority of the area will be wetted and that wetting is not it cannot be avoided so that is the reason that it has to be taken as something which is not avoidable, so anything which is avoidable and you are still making you are incorporating that then it is not a beneficial use but in this particular case if the soil evaporation cannot be avoided then it has to be part of the essentially usage, if not beneficial you can say it is essentially usage.

So leaching and similarly there can be some other requirements in some cases you want to keep the temperature of the crop down and if possible if you are using a sprinkler irrigation method then you might use that component which you are which you are using for lowering the temperature that can also be termed as one of the essential requirement, so for the temperature control similarly for frost protection, if you have if the area is having the frost problem then again you might be using some water to avoid the frost because frost can be detrimental again for the crop production, so in that situation all these things are part of the beneficial usage. So in literature you will find that there are many different efficiencies which have been defined with the intention of giving the user some possible yardstick or some possible some possible (())(12:16) when they can compare their efficiencies with in terms of knowing how effectively they are using systems or effectively they are managing the system.

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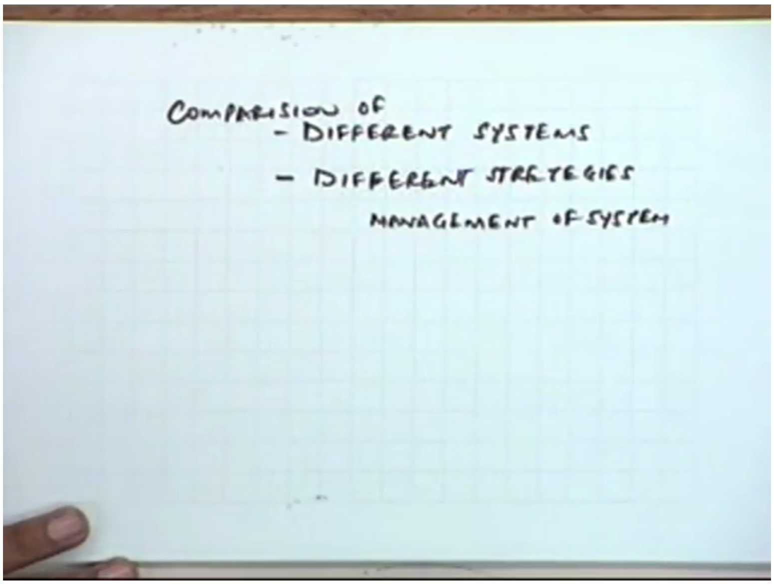

So basically you are using the efficiencies for comparison of different systems, if you want to check whether one method is better than the other method in terms of some efficiencies you can use those efficiencies for the comparison of the effectiveness of various systems.

Student: How you can compare the 2 efficiencies if the drip irrigation is (())(13:18) evaporation loss and how you can compare?

Yes, in that case will come down to…let me just he wants to know whether because he have some idea about which other various methods which we have not yet discussed because at this stage I am trying to talk in terms of the general efficiencies and the actual usage of these efficiencies will be more clear when we will go to the various methods and we have covered those methods, what those methods involve? But at this stage if you want to know that in the case of drip irrigation system you have a situation where you are not wetting the total area you are only that portion which is supplying the moisture to the root system is getting wet.

So in that case that particular efficiency which is talking in terms of the water usage at the plant level that will be highly influenced but the other efficiencies might not be influenced when you talking terms of the conveyance all those things, so we become to all those individual things because the efficiencies, what I have said that is the…it will give you a yardstick in terms of comparison between the various systems and it will always it will also give you the strategies, different strategies for management of the system. If you want to some of these efficiencies will be geared towards these aspects that if you want to manage your systems in different ways and you want to know what is the impact of that change in the management strategies, how are you going to evaluate those aspects.

So these 2 are the basic reasons that why the different efficiencies which you are going to cover now they are defined and that many of them you will find that there is lot of overlap also, in literature there will be many different ways people have defined in this efficiencies but we are trying to cover some generic efficiencies which can be applicable to all the methods irrespective of which method you talking about. There will be more or less most of the time there will be having the clear picture a clear understanding a clear meaning of those efficiencies otherwise in literature there are their situation where people have defined their efficiencies which are only applicable to those individual systems, so let us look at what are those individual efficiencies.

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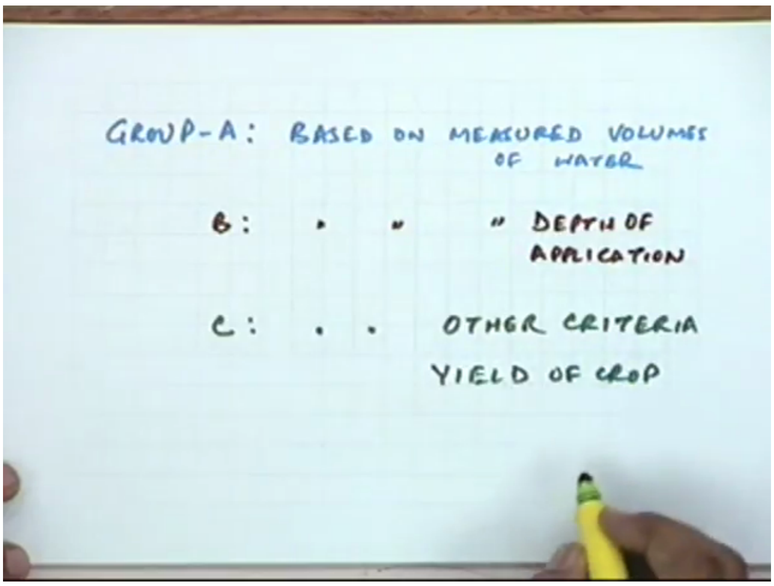

In general they can be categorised in different groups, group A will put those efficiencies which are based on measured volumes then group B will discuss the efficiencies which are based on measured depth of application and group C will discuss some other efficiencies which are based on some other criteria and most of the time this criteria is dependent on or is related to the yield of the crop. Any efficiency you look at, the end interest for the end users or the farmer's interest is in the yield of the crop.

So that is the ultimate thing, so even if you are talking in terms of the water utilisation or you have already seen that the water utilisation is directly related to the yield of the crop. If the water utilisation is reasonable, is optimal then the yield of the crop will also be optimal, so from that angle there are some efficiencies which are defined with respect to the criteria. By looking at the yield of crop how you can evaluate your utilisation of water.

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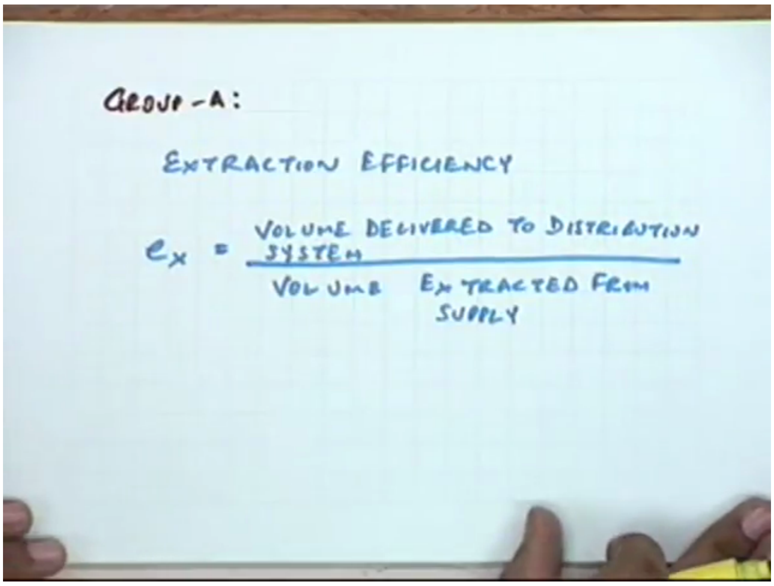

Under group A the various efficiencies which are quite commonly used first one is extraction efficiency, what is the extraction efficiency? It is defined as the ratio of the volume delivered to the distribution system to the volume extracted from the source or the supply. In this case what is reflecting is that how efficiently you are extracting the water which you are going to use or in a way it is also giving you some idea suppose there is a reservoir, now from the reservoir you are releasing some water to be tapped at some lower level where you have the distribution system or at a level which is in the canal, from the reservoir you are having a river or a canal and from the canal water is getting diverted to the distribution system.

So the extraction efficiency will be the water which you have delivered to the distribution system and the water which was released from the reservoir, so if there is a loss in between then you are having the extraction efficiency in that case can be reduced.

Student: (())(21:44) conveyance efficiency.

Conveyance in that segment, yes is part of the ins in some cases people are combining the 2 efficiencies, the conveyance within the system and the conveyance above the distribution system, so if you separate them out there can be some conveyance loss above the distribution system, there can be some conveyance loss within the distribution system, so this is the conveyance loss above the distribution system and that is why it is called extraction efficiency. It is a terms which is now being used more often just to differentiate the 2 that is their problem because these things all these efficiencies, they are also to be used to for the purpose of diagnostic analysis.

If you want to diagnose the inefficiencies in your system you do not know how to start with that, you do not know if you look at only the overall yield you know that the yields are low, you know that that is because of the fact that if everything else is all right, if you are done if your manure is fine, if your soil is fertile everything else is okay there is some problem with the water utilisation, so where is the problem. You want to isolate the those actual situations or isolate those segments of the irrigation system where the problems are so that is what is the diagnostic analysis and for isolating those segments these efficiencies will help you because you are trying to…through these efficiency you are trying to synthesise the whole system, you are trying to look at the various segments of the system and wherever you find that the efficiency, relevant efficiency is very low you can try to plug those loopholes.

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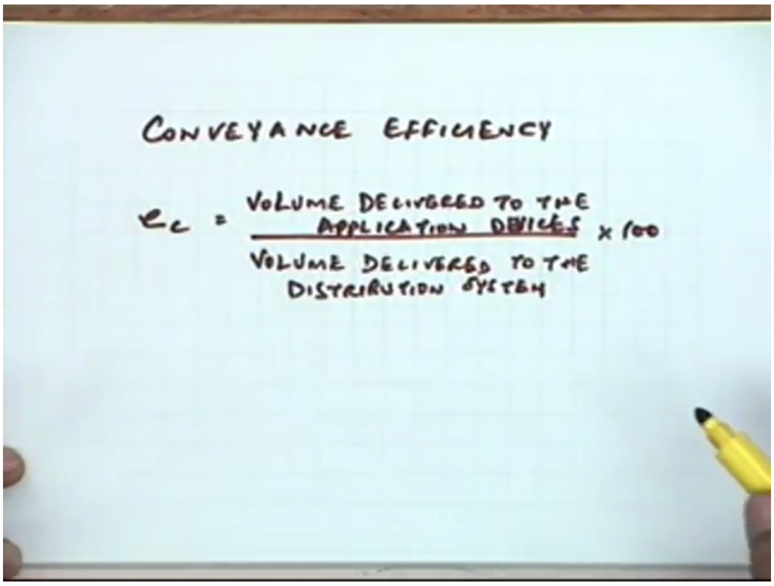

So the next one is as she has pointed out that this is part of the conveyance efficiency, the extraction efficiency, the next one is the conveyance efficiency, let us call it e c this is also something similar to the previous extraction efficiency but for a different segment. This is defined as volume delivered to the application device to the application devices by the volume delivered to the distribution system into 100 because you express these efficiencies in terms of percentage, all these efficiencies are expressed in terms of percentage, so in this case now the volume which is delivered to the application devices.

Now application devices is a general term used intentionally here, these application devices can be in some cases in the case of the systems which are using the gravity flow, it can be some of the dead sheet cell or it can be in some case the perforations available in the channel which are giving the input to the farrows or it can be some other device but if you look at the sprinkler system the device can be…the nozzle itself the nozzle of the sprinkler systems, so this term give you the indication that it is the volume which is going to be delivered through these devices onto the fields, so any loss which is taking place in between that level and the distribution level, the place where water has been received for distribution that is going to give you the conveyance loss, okay.

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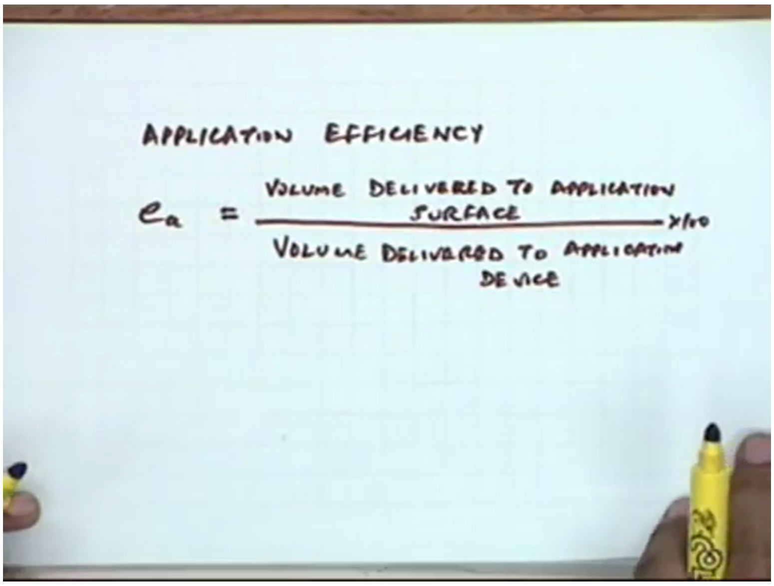

Then we have application efficiency, the application efficiency is defined as the volume delivered to application surface by the volume delivered to application device. It may happen that you have brought the water to the level of the application device whatever device you are using, now between that device and that device is going to deliver the water on the surface of the field, now between this process there can be some losses and the losses can vary from method to method, if you assume that you are using a sprinkler irrigation system.

So the moment you are leaving, the water is leaving the sprinkler head will find that the there can be some loss, a considerable loss if the wind is blowing at a very high-speed because most of the water which is coming out of the nozzle it might get drifted before it reaches the surface on which is intended to come, so in that case the application efficiency can be very low whereas the chances of the water getting applied onto the surface using the conventional surface irrigation method where you are using the gravity flow, the level of application efficiency can be comparatively higher, okay. So this will give you an idea that between that levels of the application device and the level of application surface or the field, what is the amount of loss which is taking place?

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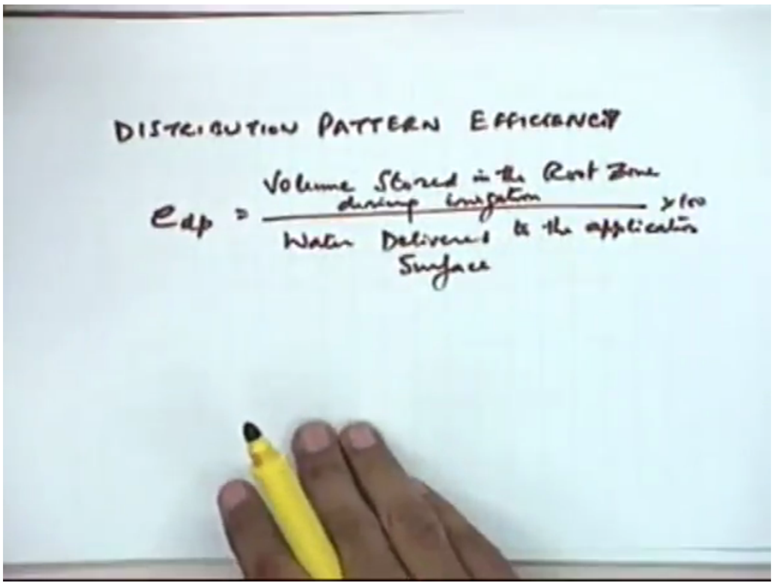

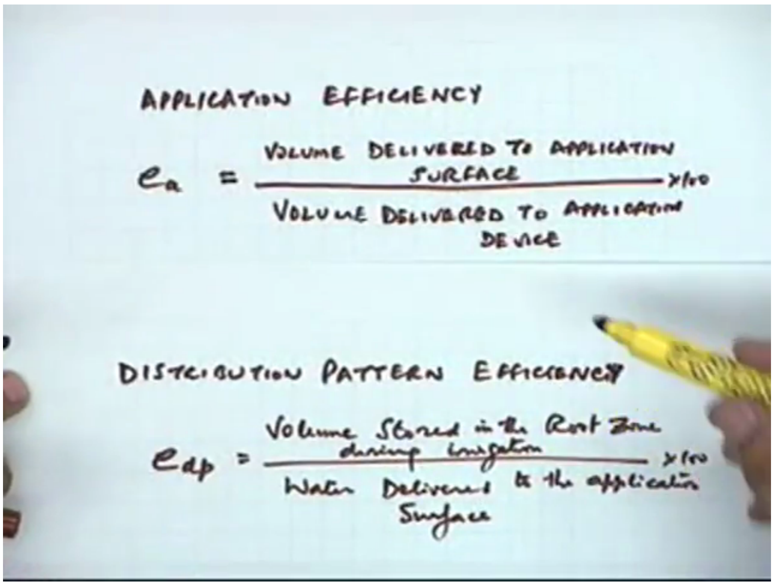

Then there is another efficiency which is called distribution pattern efficiency, I will call it e dp and is defined as volume stored in the root zone during the irrigation to the water delivered to the application surface, again in normal practices you will find that these 2 application efficiencies, the one which we have mentioned earlier the application efficiency and the distribution pattern efficiency they are clubbed together. Invariably you will talk in terms of how much is the volume which has been delivered to the application surface and how much is the volume of water which is stored in the root zone.

So these 2 are taken as the application efficiency in general but if you want to divide the 2 and look at how much is the impact of the things like distribution pattern which will be quite apparent in the case of sprinkler systems where the losses can be quite high, you will find that this this differentiation between the 2 parts as we have seen in the case of previous case where the conveyance efficiency was divided into 2 components. Similarly in this case also you are dividing the application efficiency into 2 parts 1 is what is the difference between what has been supplied and what has been received and then subsequently out of the received, how much has been strode into the soil?

Because out of the received quantity there can be some loss may be because of (())(33:45) it can be lost because of deep percolation, so all those things can be taken care of if you take these 2 in combination, okay. But in general if you club the 2 still you will be getting only the application efficiency, the overall application efficiency and that will be the ratio of the volume delivered to the…or the volume stored in the root zone because this and this will be the cancelled and it will be the ratio between the volume stored in the root zone to the volume delivered to the application device, is that clear? And that is the reason precisely that why they are so many of efficiencies because it is dependent on the conceptions used by the users or the designers which are the aspects which they want to look into how minute they want to go into these aspects and accordingly they have to define those quantities and come out with some indicators which can be used.

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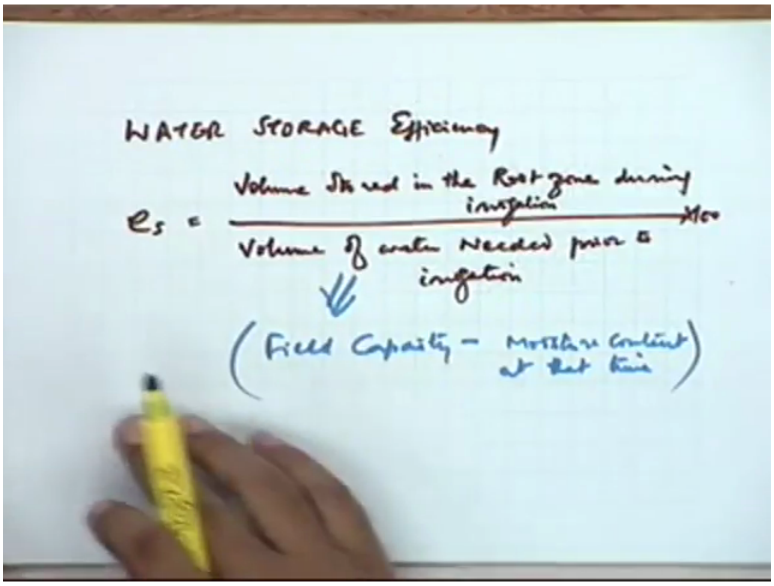

Then we have water storage efficiency, water storage efficiency is the ratio between volumes stored in the root zone during irrigation to the volume of water needed prior to irrigation. This efficiency is defined to find out how effectively you have been able to remove the deficit which was there in the root zone, the volume of water needed prior to irrigation, how you will find out? It will be basically the field capacity minus the moisture content at that time, at that time when you are…so this component the volume of water needed prior to irrigation, you want to bring the water to the soil moisture to the field capacity level, so the deficit is the difference between that level and the moisture content at that instant.

Now out of this deficit how much of the deficit has been removed that is what is shown by the water storage efficiency. It can also be said that there is something which is dependent on the management, how you are…you might not be willing to bring the level to the field capacity level all the time, you might be intentionally reducing the moisture up to a particular level or the moisture deficit up to a particular level and you are not intentionally going to bring the moisture content to the field capacity level.

So in that situation the water storage efficiency is not reflecting what you what you want to get, so this water storage efficiency subject to the situation where you are trying to bring it to the field capacity level but it is not coming to the field capacity level because of some other reasons or you want to find out how effectively the storage has been made in the process of irrigation in the root zone with the assumption that you want to bring it to the field capacity level.

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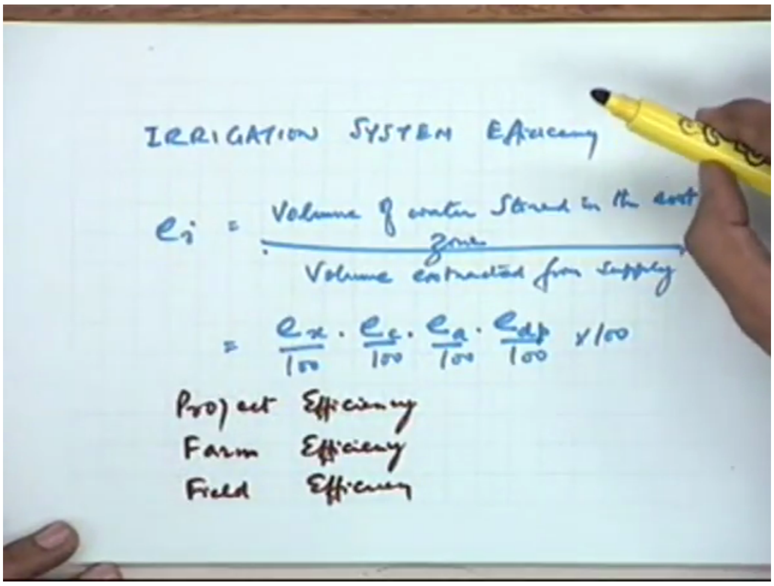

You also sometimes want to know the irrigation system efficiency, now irrigation system efficiency is basically the overall efficiency, you have seen all the individual efficiencies which the system can be divided into when you have you have intentionally divided the total system into different components and we have tried to look at various components and assigned those efficiencies or defined those efficiencies in those segments but if you want to look at how the how the overall system is performing then you can define this irrigation system efficiency which is nothing but it gives you is the volume of water stored in the root zone which is your ultimate aim to the volume extracted from the supply or the source.

So this ratio in other words there is nothing but is the…if you combine all the efficiencies the extraction efficiency, conveyance efficiency, application efficiency and the distribution pattern efficiency and since these are in percentages you can bring into the factions and multiplied by 100 that is what will be your irrigation system efficiency. But irrigation system versions again many a times you can you can switch or you can change your point of interest, if your point of interest is the source itself then it will be the project efficiency and in that case it will be termed as…that means if I am considering this volume extracted from the source then sometimes it is called either the irrigation system efficiency or the project efficiency.

If I bring down this level of interest if I am only interested at what happens after the farm, there is a farm (())(41:45), so in that case it will be called farm irrigation efficiency that means I take in the case of farm efficiency it will be the volume of water stored in the root zone to the volume of water delivered to the farm (())(42:06). So what is my input level, if I shifted my input level accordingly the in that case what I am considering is I am considering the conveyance beyond that farm or within that farm, what is the conveyance losses? I am considering the application losses within the farm, all the other losses but my point of interest is brought down to the farm level so it will be called the same thing the irrigation system efficiency will be called in that case, the farm irrigation efficiency.

If I bring it to the field level then it will be termed as field irrigation efficiency, so is a question of which level am talking about accordingly the irrigation system efficiency can be defined and it will include all those… It will be an overall efficiency from that point onwards or with respect to that point of your interest, okay. Now so far we have seen all those efficiencies which are concerned with the volume of water only that you are checking how much volume has been delivered and how much has been consumed inside the field ultimately but you have not looked at how this volume is being distributed?

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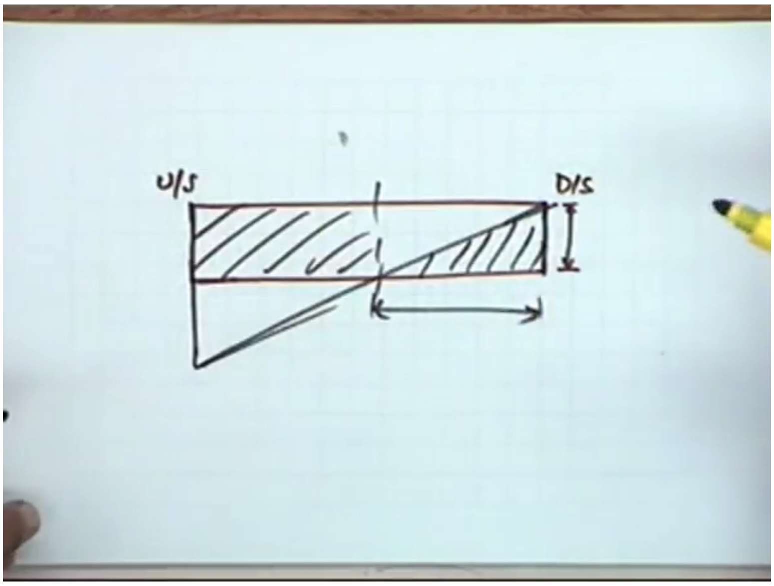

It can be I can I can give you a situation that you have your end product was your end result of the interest was that you have this field where you are using a surface irrigation method for distribution of water. There is the upstream level of the field and this is the downstream level and you knew that this was the requirement this much depth of water was needed throughout the field.

So this is the deficit which is created you want to satisfy this deficit and in order to satisfy this deficit you know the total volume requirement but if you say that you have provided that volume at this upstream level how this volume of water has been distributed in to this total length of the field unless it gets distributed in a way that you have minimum variation unless that happens is not of much use because if I try to divide the water in such a way that I have I have this much water here this much water here, the volume is same the volume is same only problem is that in this part of the field the amount of moisture which is available is much less than this much part of the field is has got all the required quantity of water and this was the requirement and it has received all the required quantity up to this level but in this particular case the required was this much but it has received only this much.

So there is a deficit which is still prevailing and this deficit has not been taken care of though you have you have supplied the total volume which was desirable which you have which you wanted to deliver to this field, so if you look at the efficiency which is defining that segment which is the application efficiency, it will give you application efficiency which is very close to 100 percent which is very good because you are looking only at the volume but in fact you are not doing the right thing because the deficit has not been taken care of uniformly throughout the field.

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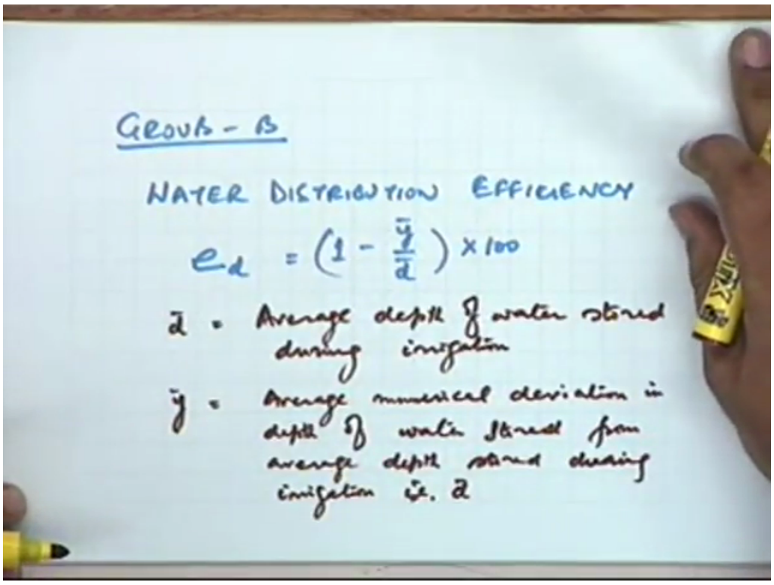

So to look at those aspects you have to define some more…and this is which can which can throw some light on those aspects of distribution of water and to do that it is what we had said that group B efficiencies will look at the distribution aspect or the depths of water and the efficiency which is used to do that is known as water distribution, water distribution efficiency. Let us call it e d, it is defined as 1 minus y bar by d bar where d bar is the average depth of water stored during irrigation and y bar is the average numerical deviation in depth of water stored from average, depth stored during irrigation which is nothing but d bar.

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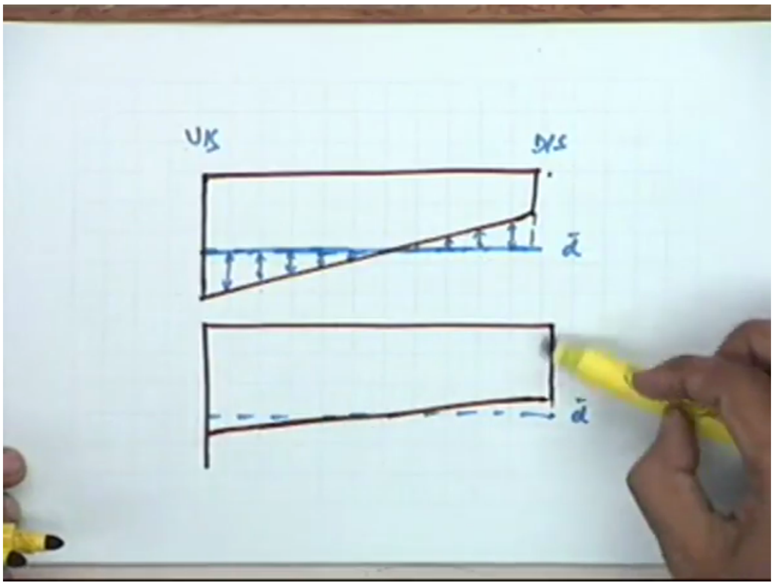

Let us look at the symptoms of let say that suppose at that application, this is the way the depth has been applied because in normal situation whenever you use the gravity irrigation methods you will find that the upstream will be getting as comparatively higher amount of moisture than the downstream areas. So suppose this is the this is the depth from upstream and to the downstream end this is the depth which you have applied, what is the average depth? This will be the average depth of application.

So this is nothing but this is d bar and the y bar will be depending on how many…suppose if you take many sections if you take many sections, the more the number of sections you take it will accordingly the valuable remain same but the accuracy will increase, so if you take a sections at this interval you will find that the deviation of the actual depth from the average depth will be these ones, these are the deviations and if you take the average of these deviations. If this will be close to the for example if we draw another situation, now if the actual application is this, in this case this is the average depth d bar and the deviation are now much smaller.

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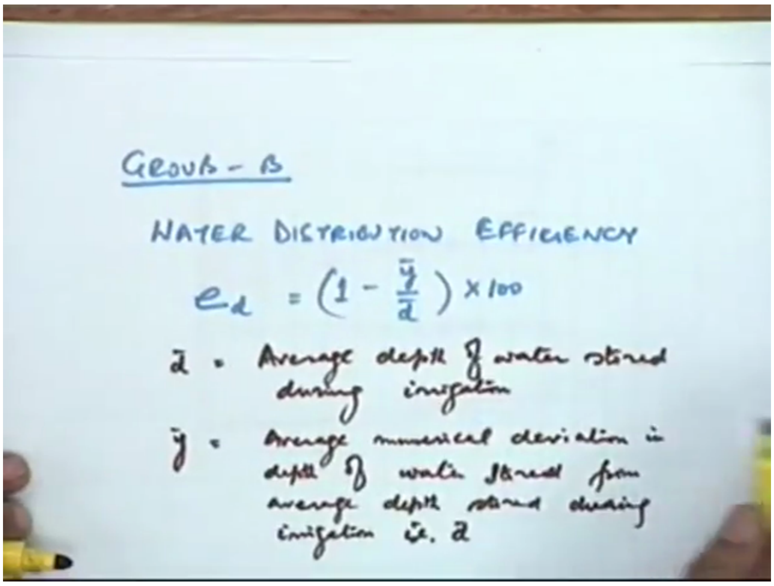

So in a situation where the deviations a more you will get a value for this part you have a value which will be a very small value and the distribution efficiency will be very high if the deviations are very small. Larger the deviations the larger will be the components on this side or this is y bar by d bar it will be more than it will be (())(52:20) which would be a larger and the water distribution efficiency will be lowest, so that is how we will see that the water distribution efficiency will give you index of the uniformity of the depth which you have applied onto the fields, okay. Any questions? We are left with less time so we will not be able to finish this the group C, so we will stop here and we will take this in the next class. Thank you.