Water Management
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Lecture 07
Crop Water Requirements

Let us go back to the same transparency where we had recognised the various processes which are prevalent in this field. Today we will start with looking at what is the requirement of the crop because ultimately that is the major factor which is creating the deficit in the soil. The deficit in the soil which we are going to replenish by the irrigation is going to be created because of the requirement of the crop. So if crop needs more water this particular storage which is available in the root zone depth is going to be depleted faster.

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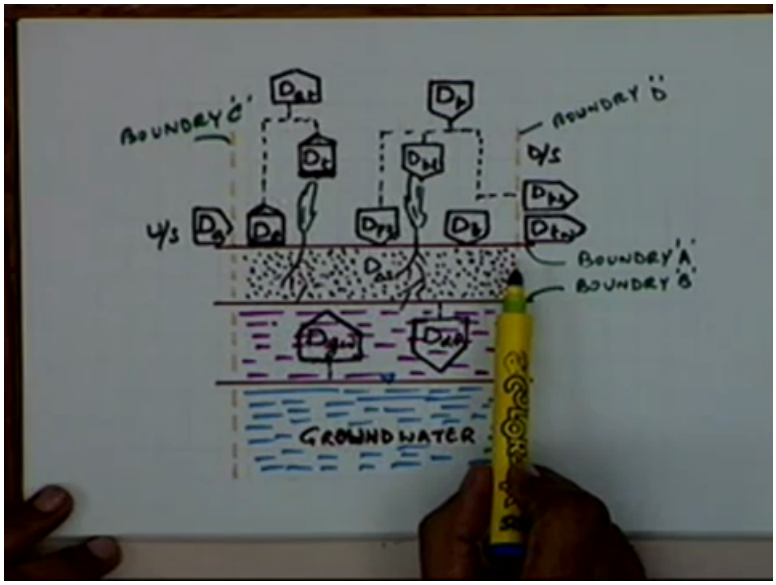

If crop needs less water then the depletion is slow. So in the earlier case when the depletion is faster you might need the irrigation more frequently if natural moisture is not available, if it does not become available in the form of natural rainfall. So that we can only assess if we know what is the demand of the crop? What is the crop requirement? How it varies?

Earlier in the previous years because the irrigation systems are very age old systems, we have been looking at these demands in a very average manner. In a manner which is very approximate and we have been designing, we have been basing our design after irrigation system on those approximate thumb rules. Though they were used we cannot say that there was no method or no computation was used.

There were computations which were made but the science was not the processes or the details of these processes where not very well understood. Because of that reason the demands how they vary in time? How they vary with respect to the climate? How they vary with respect to the different locations? They were not known.

Now if we really want to make the judicial use of this water or we want to manage our waters properly or if we want to ensure that the water is used as much as it is required we must have a proper assessment of these requirements because that is the basic thing which you are catering for. The whole irrigation project is looking at these demands only. They should look at these demands only and only then they should be designed to match these demands in time and quantity.

This is from that angle a very important and the most important aspect before we go in for the actual design of an irrigation system. Let us look at what is the crop water requirement? How it is defined? This is the little definition of the crop water requirement which is put here on this sheet.

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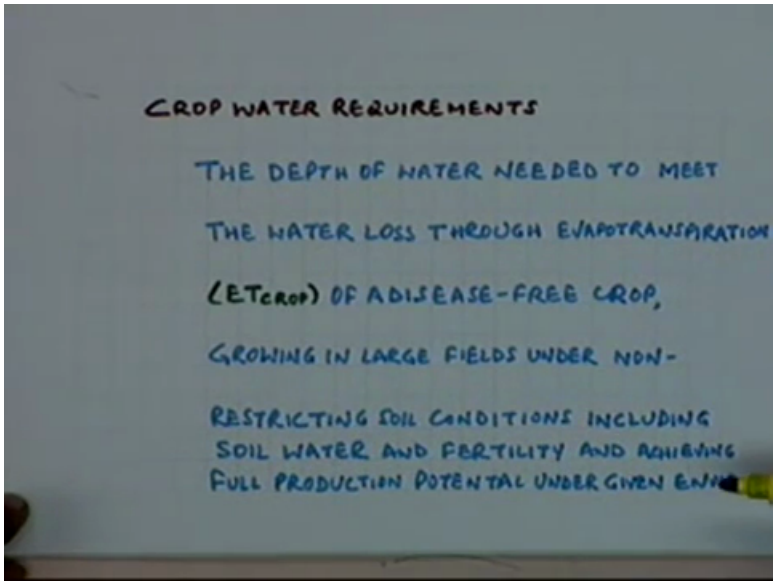

It is the depth of water needed to meet the water loss through evapotranspiration and is termed as ET Crop. That is the term normally used to represent the crop water requirement. ET stands for evapotranspiration and earlier we have been saying the same thing we are representing as consumptive use requirement. So all these nomenclatures they mean the same, of a disease free crop growing in large fields under non restricting soil conditions

including soil, water and fertility and achieving full production potential under given environment.

Now this definition includes many aspects. So we are saying that if the crop is not restricted because of any of these parameters whether it is the environment or whether it is the soil conditions and we should not say that the crop water requirements they will be much different if the soil is shallow soil. If the extent up to which the crop roots can grow we are not allowed to grow. In that case the crop water requirement will be different as where they are saying that the soil conditions should also not be restricted.

Similarly the water conditions should not be restricted. If you supply less amount of water it will affect its requirement. If the moisture availability is not there then the usage of water will also be reduced. But that will affect the yield. So this definition when we define this crop water requirement we are saying that all the conditions are preferable conditions, they are the normal conditions, under normal conditions.

The depth of water which is needed to meet the water loss through evapotranspiration is the crop water requirement and is termed as ET Crop. Earlier there have been so many because this was a very vital factor, there were so many formulations which have been put forward by the researchers all over the world and there are many methods which have been used.

The variation of these methods is because of the fact that one major factor is the data availability because if your data which is required to represent various factors which are affecting the crop water usage on the moisture usage by the crops, if those data are not available then you will tend to use some method which are more approximate methods, which are needing less amount of data.

There are some methods which have come into existence because of those factors because you cannot stop designing your projects if the data is not there. You might still go ahead with some approximate data with whatsoever data is available. So from those angles some of the methods are methods which use minimal data. There are some methods which are more accurate, which are more data demanding.

They are in a position to take care of all the changing conditions and all those methods have been used in the past but somewhere around two decades ago it was realised that even after having all those methods available in literature there are many problems when you start

looking at the crop water requirements because of the fact that there are the factors which are affecting the crop water requirements.

There are many factors and all those factors are very difficult to delineate the effect of those factors. Then around in 1977 the Food and Agriculture Organisation which is the UN body, they came out with some recommended procedures which should be used for computing the crop water requirements and that is available in the form of irrigation and drainage paper which is paper number 24 on crop water requirements.

That is the one which is giving all these methodologies and the various terminologies. They have recommended some procedures which we are going to look at and those procedures are the ones which they have tried to pick up from the existing methods and they have improved upon those existing methods and recommended the procedures which are modified procedures.

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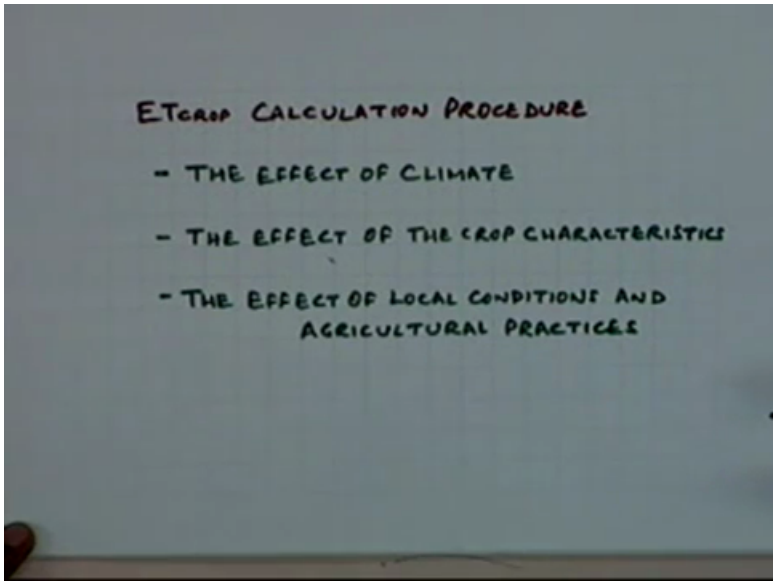

But the major problem which was coming was that when you are looking at the ET Crop there are the effects which are prevalent, they are basically because of the climate. The climate is one of the major effects which is governing what is the crop water requirement. The other factor is the effect of the crop characteristics. There are also influences what is the amount of crop water requirement which is needed for that crop to grow.

Now it was very difficult to delineate these two effects so FAO recommended a procedure in which you can delineate these two major effects and then the third effect is the effect of local

conditions and agricultural practices which can be taken care of. This is not a very major thing but the first two are the major parameters or the major influencing factors.

If we can delineate these two then the problem can be simplified and with this idea the FAO recommended a way to do this and they defined reference crop evapotranspiration which is termed as ET 0 or ET not or ET O. You can give any name to this.

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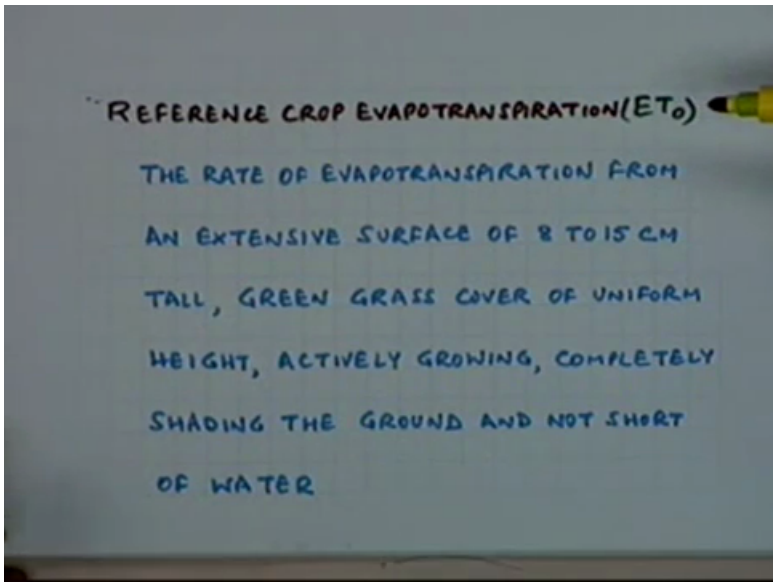

It is defined as the rate of evapotranspiration from an extensive surface of 8 to 15 centimetres tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water. So that is the definition of reference crop evapotranspiration. Now let us have a look at why this was needed? We have just said that it was very essential to delineate the effect of climate on the crop water requirement from the impact of the crop characteristics on the crop water requirement.

If that can be done then the ease with which you can compute the crop water requirement or varying crops can be achieved in a much better manner. So can you now imagine what is the rule of this picking up the grass as the crop? Can you see that point? And I ask you that question why it was grass which was picked up? (())(15:12) No, that is not the reason, covering the entire area is not the major reason that why the grass has been taken as the crop. (())(15:28) Not even the surface area, pardon. (())(15:33)

No, even that is not the reason. When we are saying that we are trying to delineate the two can you just imagine that what happens if you are assuming that the climate remains similar or effect of the climate is taken care of. If it is only the crop which is responsible for defining

the crop water requirements. You know that the crop has its own growth period. It has its growth period.

The stages of the crops are we have just considered they are different, okay. If you look at the variation of the requirement, the variation of the requirement is something like this which is only because of the crop characteristics, okay.

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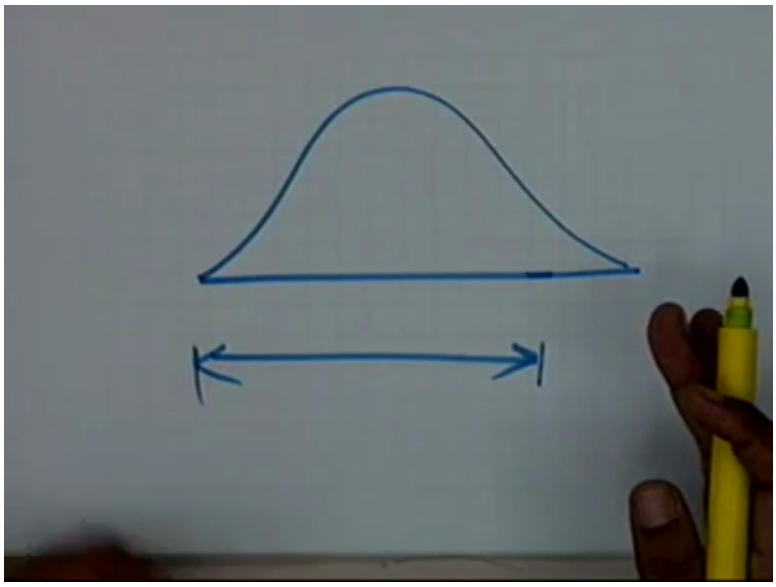

In the beginning when the plants are small you are having a (vari) requirement which is much less. Somewhere in the second period which is the crop growth period, the moisture requirement of the crop increases. It might touches the peak and then towards the ripening period. But again it will come down. So this will be a typical moisture requirement.

If I say that this is the moisture requirement. It is a typical most requirement over the growth period of the crop if this is the total growth period. Now if I pick up a crop for which this requirement remains constant then I must ensure that I pick up a crop which does not grow much, it does not vary much over its growth period, is a crop which is having the same requirements with respect to its own characteristics. So in the case of grass since its size remains same, the requirements because of the crop characteristics they do not change.

That is the reason that the grass has been taken as reference crop which will be used to define reference crop evapotranspiration which will be a yardstick with which you can compare the other or with respect to which you can compare the other requirements of the other crops. If you do that what is the advantage? That now you can look at what is the impact of the climate only, is not it?

Now with this assumption that the requirement of grass does not change with respect to its own characteristics, whatsoever you are getting the impact, whatsoever requirement is being defined is mainly because of the climate change. That is the major reason that why this concept of reference crop evapotranspiration has been introduced because now it will be much easier.

You can find out what is the evapotranspiration requirement of the grass which becomes the reference, you can use that reference for all the crops and then use another factor which defines the crop characteristics and putting these two things together you can find out the requirements of the individual crops. That is how the effect of the crop characteristics can be taken. The crop coefficients are defined which are termed as k c. These crop coefficients are dependent or function of the crop specie.

They also vary with the crop stages. They vary with the soil moisture conditions and also vary with climate. Now that is the problem that the variation is with respect to the crop. Within the crop, the crop stages, the climate, soil moisture condition which means that you cannot generalize these coefficients. For the same crop which is being grown in the different areas in different environment you cannot assume that their crop coefficients will be similar, they might vary.

And that is the reason that there is lot of research which is needed to be conducted by the local authorities or by the local institutions or the local universities so as to ensure that the local crop coefficients are known for all the crops which you are growing in that area.

Those crop coefficients have to be evaluated which is a very big job and people and the researchers in the agricultural universities they are still indulging in all these evaluations of crop coefficients and it is a very lengthy procedure because you have to have the actual observations. You have to use the lysimeters which are expensive instruments and is the time consuming job.

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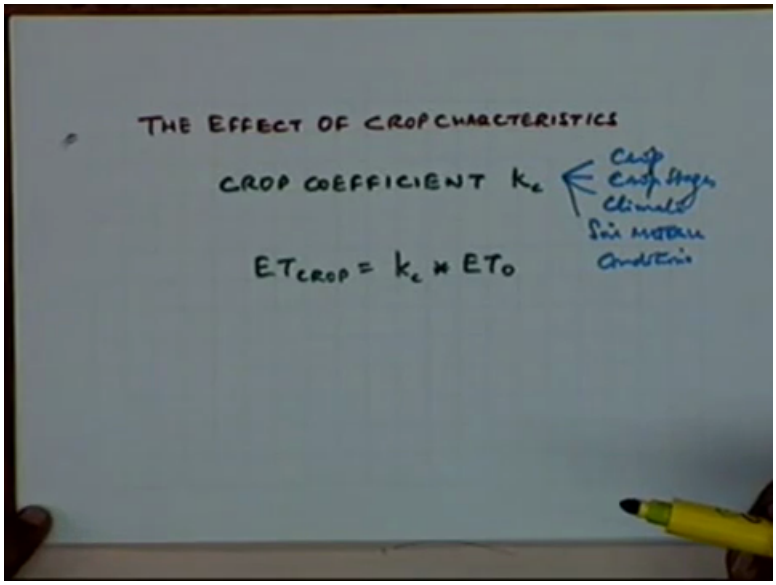

But as a methodology once you know the value of crop coefficient and you know the reference crop evapotranspiration you can find out the crop water requirement which is ET Crop, okay. And this k c can be either for the crop stage or you can even have it available for different months. This is entirely dependent on what is the duration of the computation which you are using. Then lastly the effect of local conditions and agricultural practices.

Once you have found out the ET Crop now up to that level you are making the assumption that all the conditions which we have used they are the optimum conditions where it is in the form of the soil profile or whether it is the availability of moisture. All those things up to this level where you are trying to find out the ET Crop, up to this level you have so far assumed that all the prevailing conditions were the optimum conditions. They may not be so.

So, to take that into consideration the effects of local conditions and agricultural practices can be incorporated and those who will be only the local effects. They have to be looked into in a manner which can only be done at the local level. So these things cannot be generalized. You have to look at whether what is the soil water availability? What would be the impact of the decrease in soil water availability? Then what is the optimum level? Whether the salinity conditions are prevailing?

That will have its own impact. What is the method of irrigation which you are using? Those things will have their own impact and the cultivation methods. All those things the local impacts have to be taken care of.

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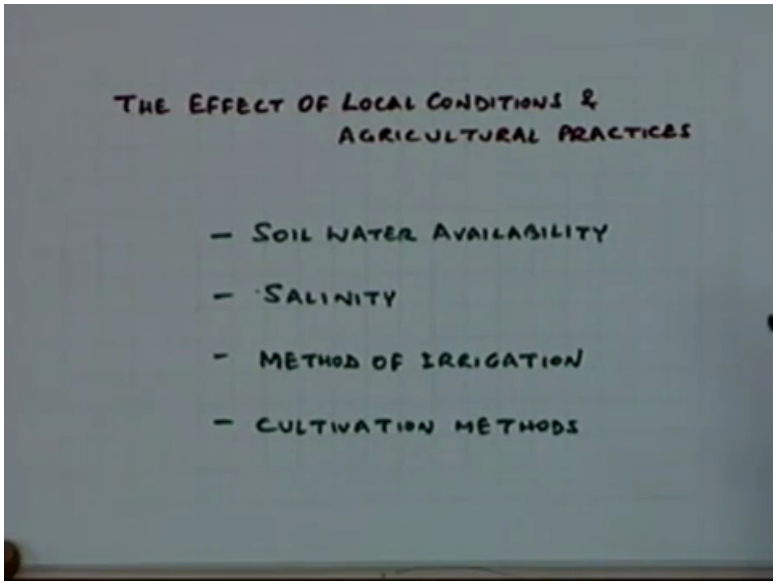

That is essential if you want to find out what are the actual crop water requirements within the constraints. Now with this background and with this methodology which the FAO thought of adopting they came out with the various computational procedures which should be adopted and they selected these four methods Blaney Criddle method.

These are the methods which were existing methods but not in the same form in which they have been recommended by FAO now, the radiation method, penman method, pan evaporation method. Now these four methods have been recommended by FAO and why these four methods have been recommended because so that the user can pick up one of these methods depending on the availability of data.

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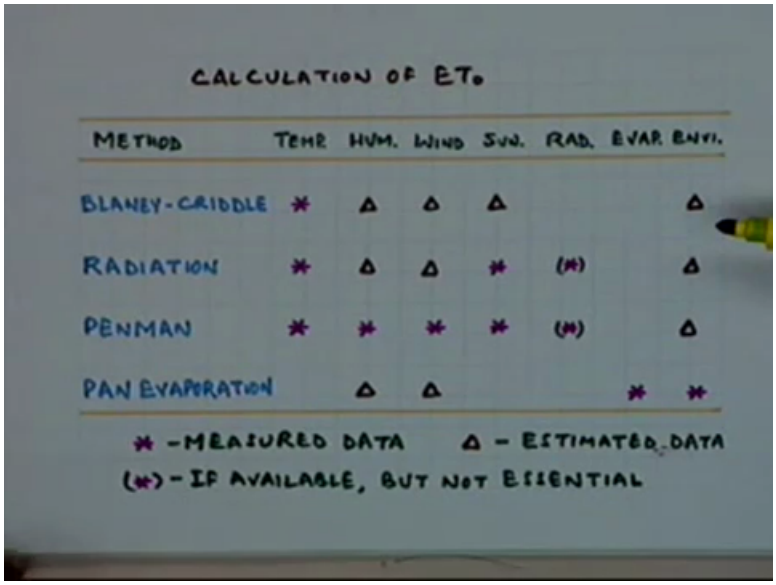

And this chart shows the requirement of data for these methods. The Blaney Criddle method it basically can be used when you have the data on temperature only available. The computer data can be or estimated data can be used for all these other quantities. This is the temperature, this is humidity, wind, sunshine hours, the radiation, evaporation and the data on environment.

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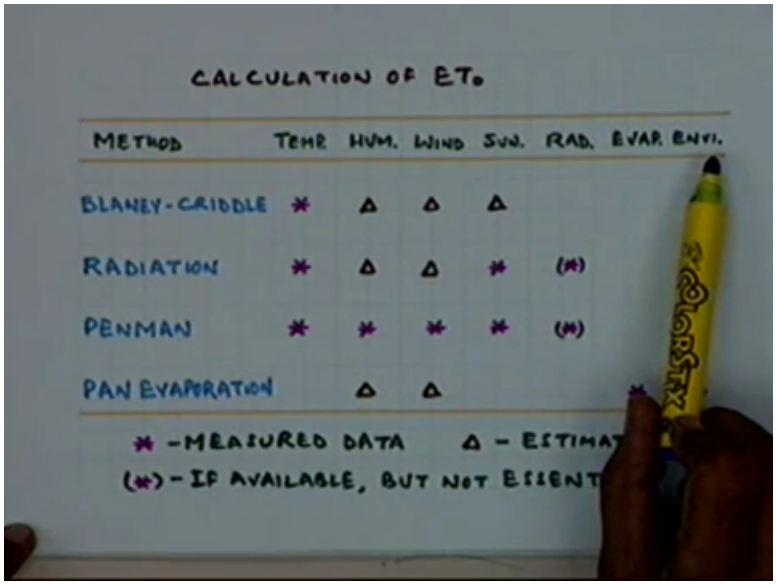

These are the various quantities which have been depicted here. In the case of radiation method you need the data on temperature, sunshine and radiation if available. If it is not available still you can use the method. If you look at this chart the penman method is the one which is more data intensive. Its requirement in terms of data is very excessive in comparison with other methods. So if you have all these elements available then you can use the penman method.

In terms of the accuracy the penman method is the most accurate out of these methods which has been suggested here. Pan evaporation is basically in the observatories you are having evaporation measurement which is a very regular feature and in most of the places wherever the meteorological observatories tare there you will find that the pan data is invariably available and that data can also be used for computing the crop water requirements.

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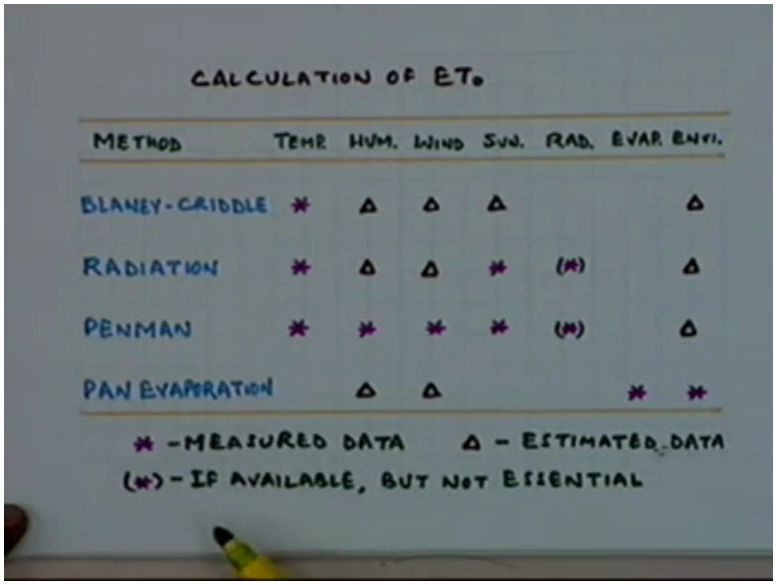

Let us start looking at these methods one by one. The first method which is the method which was proposed around 1950 and this method is the one which has the data requirement the minimum. It just requires the data on temperature which is the data which is to be observed. Though it requires the value of p which is a parameter on which the data is available and is a known data.

And this is the original form of the equation which was used for finding out the consumptive use requirement on the monthly basis and K is the coefficient which is equivalent to crop coefficient and this factor f was composed of this part p into T divided by 100 and the temperature in this particular case was in Fahrenheit and p was the percentage of the annual sunshine hours in the month.

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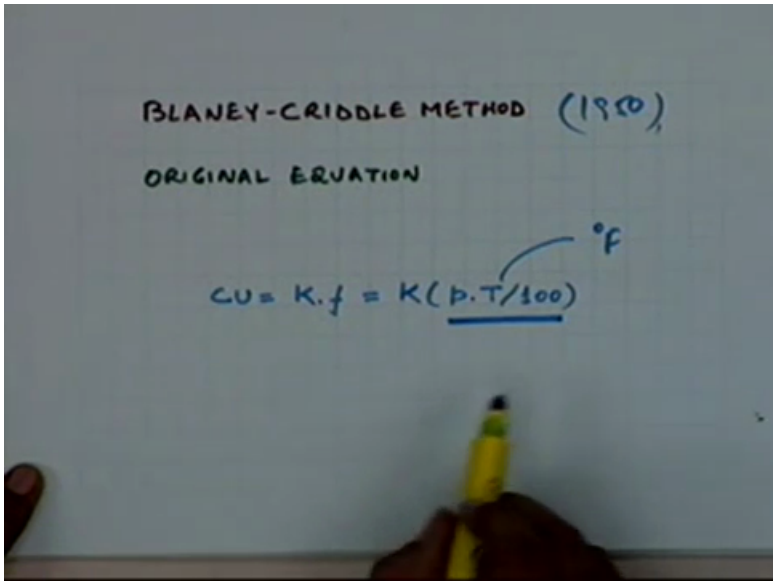

So what it used to use was the temperature and the expected percentage hours of sunshine in that particular month or that duration. And you can use it for different durations also which is the value which is known value, because if your location is fixed then the percentage of possible sunshine hours are also fixed.

So only dependent on the temperature which used to give the crop coefficient or the consumptive use requirements of the crop, it was found that the method was not very accurate because of the fact that just the temperature is not sufficient to define how to account for the variations which are actually taking place and which are influencing the crop water requirements.

So the recommended relationship which has been given by the FAO or choosing the Blaney Criddle formula this is a recommended relationship in which the ET not in millimetres per day is based on the same parameters. The value of p is the mean daily percentage of total annual data in hours for given month and latitude. And T is in degree centigrade. It is the mean daily temperature in degree centigrade. So as far as this part is concerned this is still the same. Still those are the two parameters which are being used.

The main difference is being made by the factor C which is the adjustment factor which has been used in addition to the previous parameters which were existing parameters in the Blaney Criddle formula.

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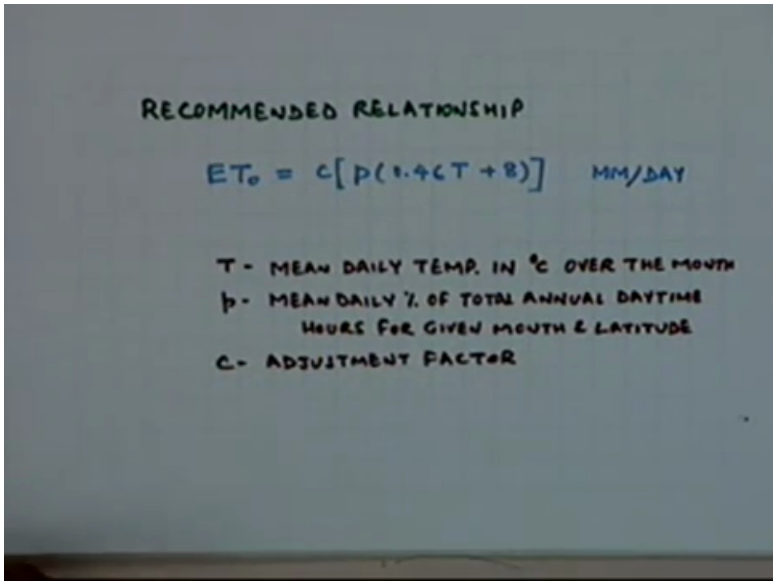

Now this adjustment factor is taken into account the prevailing conditions in the area and the three factors which have been included which are supposed to be influencing the crop water requirements the most they have been taken into account and those factors are the relative humidity, sunshine hours and the wind conditions.

When you say (sunshi) sunshine hours the actual sunshine hours, not the (possi) maximum possible or which has been considered already in p. Over and above that it will make lot of difference whether the conditions are cloudy or there are clear skies there.

So that has been taken into consideration, instead of using the elaborate data what has been done is that if you know the general conditions of your area which is quite possible because in almost every area you have the local meteorological office, they come out with the weather reviews and they give the general conditions prevailing over the week or over the biweekly period or over the month.

So those things are quite often they are available. So if you can make use of those along with the temperature which is normally available which is the only (observa) observable data here which is being used then you can find out reference crop evapotranspiration value which is more accurate than the previous Blaney Criddle formula was giving. This is the table which is showing the mean daily percentage of annual data in hours for different latitudes and this table can you see this now.

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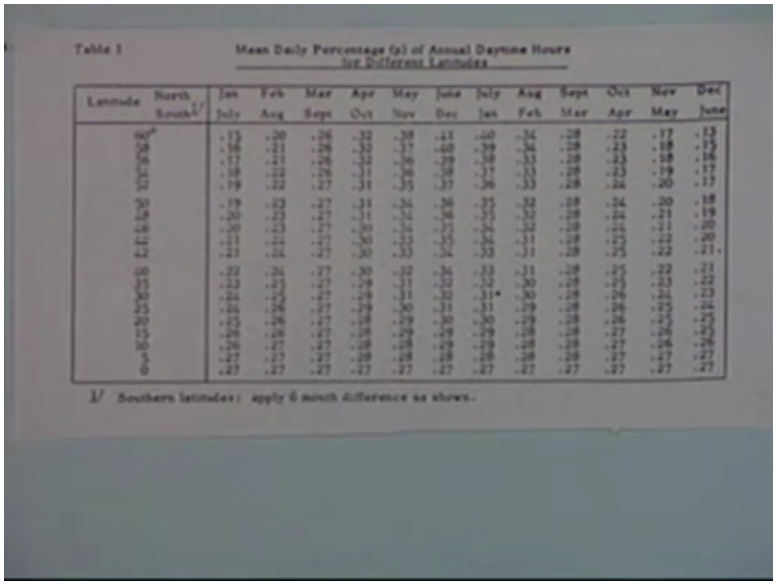

Anyway this is the standard table which is giving for different latitudes. What is the p value for different months and the northern and southern hemispheres the values are same but they are shifted by 6 months difference. So all these values are given here and even if you look at FAO 24, this table has been taken from there.

This table you can have a look, pick up the p value depending on the latitude which you are which is the prevalent latitude and you can easily find out what is the p in question? So having known the temperature and the p value which can be picked up from the table then you want to evaluate the C. The factor C or the adjustment factor which you have used in the equation that factor has to be evaluated. This figure is a combination of the various parameters.

You can see that these three blocks in these three columns they are showing the blocks which are for different range of relative humidity. It is the low relative humidity which is less than 20 percent. If you have relative humidity which is between 20 percent to 50 percent which is termed as medium relative humidity. You can use this scale or you can use the third one if the relative humidity is more than 50 percent.

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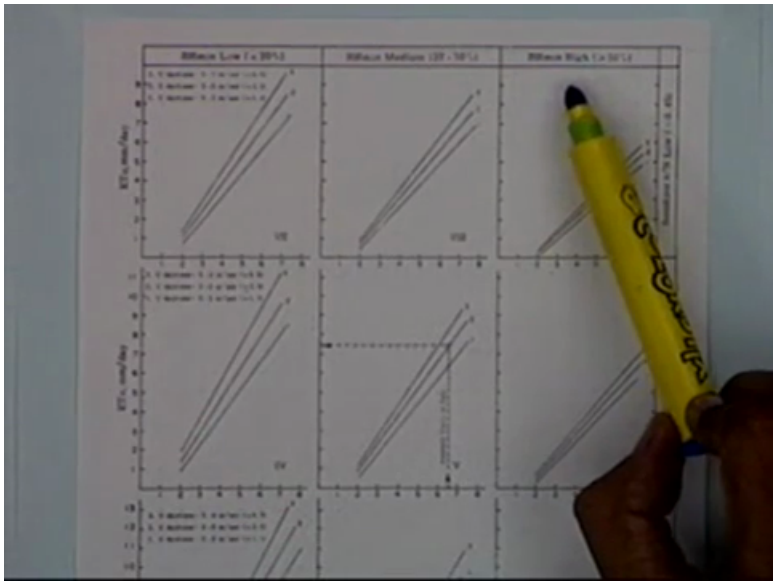

So here knowing the relative humidity you can select which of these columns have to be used. The ratio of actual sunshine hours to the maximum possible sunshine hours that is given in these rows.

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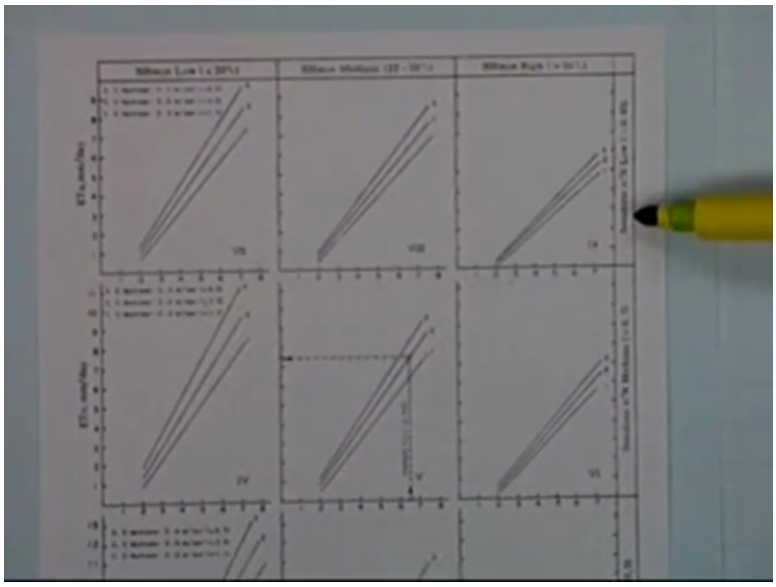

If you look at this, this is for the low sunshine hours, this is less than point 45. If you have sunshine hours prevalent in your area of range which is medium then you can use this row. If the sunshine hours is high then you use one of these figures. So depending on the two values, the relative humidity and the sunshine hours you can select which one of these nine will be the one which should be used.

Then the third factor which we have said that the daytime wind velocity or the daytime wind velocity is these three velocities have been used. When the velocity is between 0 to 2 metres per second then this is number one curve in this particular case. Then the number 2 curve is when (velo) the daytime wind speed is 2 to 5 metres per second, you can use number two. The third curve can be used when the daytime wind speed is 5 to 8 metres per second.

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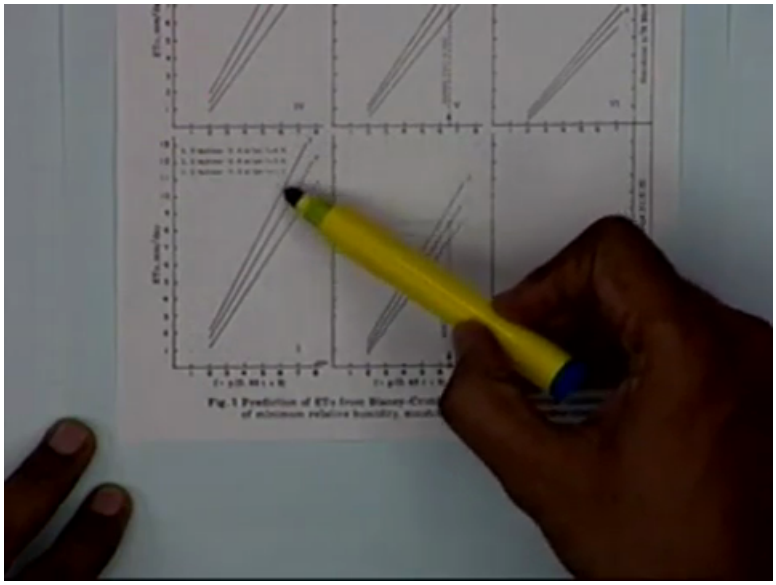

So if you know these three factors you can select the proper figure and it can be used to find out what is the value of C. So having known the F value this plot is between F which is equal to p into point 46 times temperature plus 8 which gives you the F. So knowing the F value the C is taken care of by this figure and you can use that in this particular example for chi row they are found that in that particular month the sunshine hours was of the nature high.

It was more than this ratio. N by n was more than point 9. So this particular row has been used. The relative humidity was medium, this column has been used and then the daytime wind velocity was between 2 to 5 so number two curve has been used.

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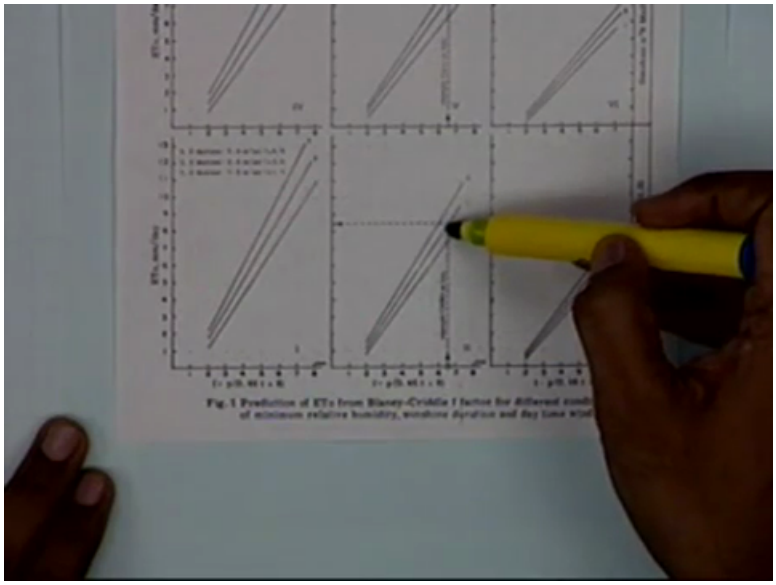

So once you know this then you find out what is the ET not. What is the value of reference evapotranspiration? This is result of work which has been done on some experimental catchments. The data has been taken from the experimental catchments. Then the stepwise regression analysis has been done to first find out which are the most important factors which should be considered.

That is how these three factors have been taken into account. And then these relationships have been evaluated and that is how this has been recommended after all that study. And this variation now it accounts for all these changes which are taking place in a particular area and you are accounting for those factors to find out what is the reference crop evapotranspiration using this particular method.

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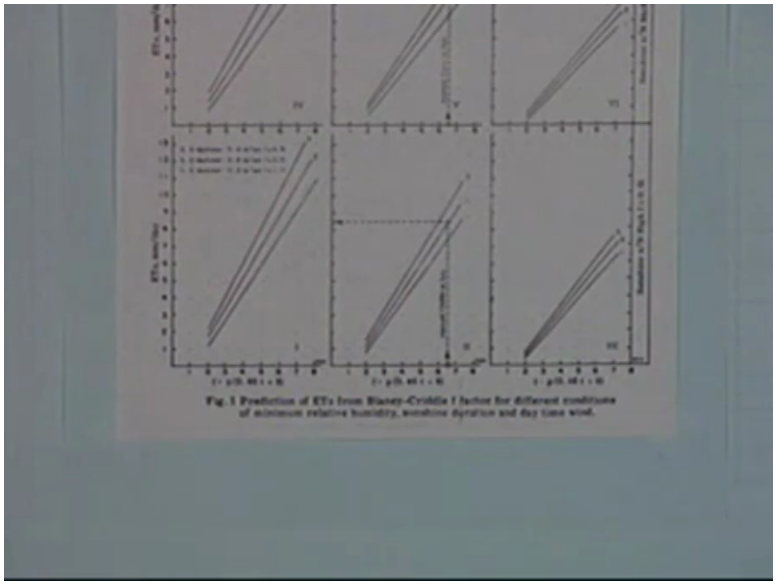

So with this procedure and with this chart things are quite simple and straightforward. You can use them. Still there will be some inaccuracies. You cannot say that if you are using this method the inaccuracies have been reduced but not completely taken care of because of the fact that you are using approximate data. Again you are using the ranges, you are not using the exact. Within the range how much it is, it is not known. It is not being taken care of, okay. Any question? Thank you.