Micro Irrigation Engineering
Prof. Kamlesh Narayan Tiwari
Department of Agricultural and Food Engineering
Indian Institute of Technology – Kharagpur

Lecture – 57
Economic Analysis of MIS (Part 3)

Hello, participants. Now, we are entering in Lecture 57 of Micro Irrigation Engineering subject. This is on economic analysis of Micro Irrigation System, Part 3. In Part 1, we discussed various terminologies dealing with economic analysis. In Lecture 56, we discussed about optimal flow criteria as well as the critical velocity, maximum velocity criteria. And using the maximum velocity as well as optimal flow criteria, we analyzed how to find out the economic pipe sizes as well as the size of the pump?

Here, the economic analysis in this lecture, we are dealing with in a different way. And then, some of the results which we obtained from our experimental study, those results have been used to analyze the economic value. Cost economics of the product produced which is coming out of the experimental field and how whether system is optimal. Economical as well as optimal that can be used. So, in this particular lecture, we are going to cover economic evaluation considering the optimal spacing of laterals. Economic analysis considering the experimental data which we obtained from our field experiments.

Now, the term which is very important, which we deal in economic analysis is Net Present Value and Benefit Cost Ratio. So, NPV in short form of Net Present Value. It is the difference between the sum of the present value of benefits and that of costs associated with capital and depreciation of MI system components. Now, here, in terms of Net Present Value of micro irrigation system is will be economically viable if the present value of benefit is greater than the present value of the cost which is we are going to incur while we are installing the system while we are doing the cultivation of a particular crop.

So, BCR that is a Benefit Cost Ratio, it is related with the Net Present Value. And, it is obtained by simply dividing the present value of benefits and to that of the cost stream. Now, when we say the Benefit Cost Ratio, so, a Benefit Cost Ratio greater than 1, it implies that the

Net Present Value of the benefit stream is higher than that of the cost stream. And, system that is irrigation system is economical viable. It will be only economically viable when Benefit Cost Ratio is greater than 1.

We need to estimate Net Present Value by using this equation.

$$NPV = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

where,

B_t= benefit in year (t)

C_t= cost in year (t)

t = 1, 2, 3…, n

n = project or expected life of MI components (year)

i = rate of discount (%)

(or opportunity cost of investment)

This expression is very clearly given. That is the benefit at any time t in years minus the cost associated divided by 1 plus the present rate of discount or prevailing bank interest to the power the time period. So, this is the expression which is used to find out the Net Present Value. Then, Benefit Cost Ratio, which was given that benefit in any time period t that is in a year.

$$BCR = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}$$

So, sum of all the years it is estimated divided by the 1 plus i to the power t. And, divided means for that it is that cost associated in a given period. So, this way, the Benefit Cost Ratio is obtained.

The few assumptions which are required in estimation of both cash inflow and outflows for the micro irrigation system to carry out benefit and cost analysis. These assumptions are the life period of micro irrigation system it depends on the type of crop. Mainly, crop there could be some seasonal crop which means seasonal vegetable crop or it can be the crops like Banana, Papaya. Such crops having short duration crop. But, crops like Sapota, Mango, citrus

group, Oranges, Lychee such crops are long duration crops. So, these crops period is also used while we are estimating the cost as well as the benefit when we will be doing. So, income stream from the micro irrigation is uniform and constant. It is we are putting for over the entire life of the crop.

Now, interest rate one has to see that what is the gain which we are getting with various, so, sensitive analysis has to be carried out. So, these interest rates are considered to undertake the sensitivity of investment which we have made. So, these could be 10%, 12%, 15% as the alternative representing the various opportunity cost of the capital. Finally, the crop cultivation technology is assumed to be constant for considering the same group of crops. So, any group long duration as well as short duration crops. So, they are brought under the same category.

Now, that is one way of making estimation. Here, we are considering that how to reduce the total length of lateral. So, means we need to find out how the water is distributed by using a drip emitter and then accordingly, the spacing between the lateral can be adjusted. So, major limiting factor as we know, it is the drip irrigation system components and where you find that the laterals as well as drippers.

They are these are the major component where cost comes into picture. So, can we reduce the number of drippers? Can we reduce the length of lateral? So, this is only possible in such a way that it should not form run off. The water should not go beyond the root zone depth. And, it should not, we should see that how to adjust the spacing of the lateral. So, this can be, such a study means for finding out the optimal spacing.

This can be done once we have the data related to water advancement or water front movement from the drip emitter and then optimizing the spacing of the lateral. Another one is by considering the crop geometry means planting geometry. And so, we will discuss in detail. So, one is that changing the crop planting geometry such that the total length of the lateral can be reduced. And then, other one is by taking the analysis by considering the field experimental data. So, this 3 types of things which we are going to discuss in this particular presentation.

So, in this presentation which we are taking it is the water front advance under point source drip emitters. That depends on the soil type. What is the soil texture? Because, the water front movement will depend upon the soil texture. What is the dripper discharge? How long dripper is being operated? So, that will be the one component. So, water front advance means this is the advancement in overland surface which will be in a radial direction and then, water front movement or water advancement below the root zone depth that means the downward movement.

So, r and z component of the water distribution is considered. So, larger operation time results larger lateral spacing, but simultaneously result into the deep percolation losses. This is not desired. So, because of the consequential larger vertical movement in water, if you are allowing the larger time that it may go below the root zone depth. That is one part. So, horizontal advancement corresponding to operation duration of the drip emitter that result into vertical advancement equal to the root zone depth. That is important consideration one has to take while we are taking the spacing of the dripper.

So, we carried out this research studies at the experimental level by bringing the soil from the field. So, we have taken different types of soils which are sandy loam in texture which is also black cotton soil. We brought all the way from Maharashtra and then the studies which we were done. So, here, what you are seeing, this is a soil tank model where the water is being distributed from a dripper.

And then, you can see here how the water front it is moving. So, water is moving in the radial direction. This is surface movement of water how it is taking place. And then, at the same time, when we are putting it you can see here how the water is going deeper. So, the time of operation of a particular size of dripper will be depending on the size of the dripper. It will depend upon the particular type of the soil.

So, soil moisture distribution under point source drip emitter in layered soil. Here, it is not only one particular soil, but at certain depth, another soil it exist. That is a common thing

which exists in the field condition. We carried out theoretical studies as well as experimental studies in order to find out the spacing of the laterals.

So, this is one study which has been done for sandy loam soil. Then, the crop was grown Okra. The study has been carried out at Indian Agricultural Research Institute, New Delhi by Dr. Neelam Patel and Dr. TBS Rao Rajput in the year 2001. And, they took study using the drippers of 2 liter, 4 liter and 6 liter per hour capacity. And then, they operated the dripper for 12 hours, 6 hours and 4 hours, respectively.

Means, the volume of water was given same, but the time of operation was different. And then, from their studies, they found that the 4 liter per hour dripper it is giving the optimal length of the lateral as well as the optimal lateral spacing of 92.5 centimeter, but, for Okra crop. So, Okra crop it may need people they give very closer spacing of the lateral. That can be decided depending on the discharge.

And then, another study, this is also carried out in the sandy loam soil for the Okra crop by Jaiswal et al. in 2001. And, what they did, they found that the optimal length of the lateral was 28.76, 59.7, 17.1 meter for the discharge capacity of 4 liter per hour when the drippers is placed in the different spacing. When the drippers were placed, so that way they found out what should be the optimal length of the lateral.

Then, for the same area, they also took the discharge for this similar study for the 8 liter per hour and they determined the optimal length of the lateral. Then, they found from the study that 4 liter per hour dripper for sandy loam type of soil, it is giving better optimal length as compared to 8 liter per hour.

The study carried out at IIT Kharagpur by my group of students in the year 1997 for Banana crop. And, we took this study where we have taken different planting geometry. Planting geometry here it means that we are putting normally you may find that the Banana when we are giving water, there are clusters of the group of the Banana plant automatically it comes from the same one mother plant. And then, there will be several suckers which will be

coming. So, in the same manner, we saw that this is coming by natural way, why can we not have the study so that we can reduce the length of lateral.

So, what we did, we have taken 1 plant, 2 plants, 3 plants and 4 plants adjacent to each other and by considering the plant to plant and row to row spacing, different spacing we have given. By taking the area under each plant is 4 square meter. That is 2 meter by 2 meter. Then, we gave irrigation amount of water by using estimating from the weather data, climatic data by using the modified Penman method and estimated the evapotranspiration requirement of the crop. And then, the study which was carried out, we found out that what should be the cost of cultivation per hectare. So, the per hectare class it came as a 26,300 rupees during the prevailing market price of 1994, 95, 96 by 96.

So, this is the way you can see here, how the planting it has been done. This is one of the planting system. So, this is one of the planting system what we have given that you can see here. There is means the spacing between the lateral is 6 meter. A typical spacing is 2 meter by 2 meter. So, every 2 meter, there will be but here we have taken 6 meter. And then, there are 3 plants side by side. So, this is smaller dots which we see. These are the plantation and then, the plant to plant is spacing is 2 meter. So, this is the one way of putting the plantation where number of plants per hectare area is 2,500, number of laterals which we used as 34.

The layout of the field which you see here it is 98 meter wide and 102 meter long. And then, this is the one we have combination. Another geometry which we have taken, means the spacing between the lateral is 8 meter. Means, purpose is that how to reduce the length of lateral. And then, planting it is done. That is, between 2 meter by 2 meter. But, there are 4 plants adjacent to each other. So, number of lateral, here, you are seeing here, it is 34 whereas it is reduced to 26. And then, total length of the lateral in this case it was 1,632. And here, it is 1,222. And then, we took such observation and then yield data were recorded.

So, altogether, there were 16 planting geometry which we have considered. And, what we found that 2 meter by 2 meter spacing it is giving best response where other as from the length point of view what we are finding that length of the lateral in the different planting geometry it varied from 1,222 meter to 4,900 meter. 4,900 meter was for 2 meter by 2 meter

spacing. Whereas, this one just now which I was showing you that where the 4 plants were and then lateral spacing was 8 meter. So, this way and then the data as well as from the length point of view what we found that this is giving best response. That is 1.33 meter is the plant to plant spacing and 3 meter is row to row spacing which require 3,290 meter length of the lateral with the Benefit Cost Ratio of 3.09.

So, what we find that the plant to plant spacing of 1.33 meter, keeping 1 plant in each pit and row to row spacing of 3 meter is recommended for the dwarf Cavendish variety of the Banana cultivation to minimize the cost of this system. That is one study. Then, similar study we carried out for the Okra crop at IIT Kharagpur by my group. They have done work. And, what they found that the planting geometry for the Okra, it should be done at 30 centimeter by 30 centimeter and lateral spacing of 2.4 meter. It is giving best response in terms of the yield. That is 14.89 tons per hectare with the Benefit Cost Ratio of 2.18. And then, the yield per millimeter of water used is 22.39 kilogram per hectare. This is the water use efficiency. So, this is another study considering the planting geometry.

Now, some of the experimental trial and the results which came from the trial this study is taken up in a different angle that if the drip system is adopted for some of these crops, horticultural crops, how those results are beneficial and then from the benefit cost analysis which particular crop which is giving best results as compared to the conventional method of irrigation.

So, there is a one agency which funded the project of Precision Farming Development. This is a Ministry of Agriculture, Government of India funded project. That is National Committee on Plasticulture Applications in Horticulture that is Ministry of Agriculture and Farmers Welfare. That is the agency where large number of crop experiments were taken on the fruits crop, vegetable crops and there are many other flowers etcetera we took study.
We recorded the observations on the biometric response. That is yield as well as there are other parameters, biometric observations, the date of emergence of flower and the response with respect to different methods of irrigation. That is a ring basin or check basin or furrow irrigation method. That is a conventional irrigation and then these data which we obtained

were compared with the drip irrigation system and then the economic analysis has been carried out.

So, economic analysis, when we carried out, it involves certain steps. So, these steps are stated here. So, we assume that the life of the drip system, that is your micro irrigation system, it varies from 7 years to 10 years. In fact, based on my personal experience, whatever the systems we installed in our field, these are as old and is still these components are functional.

Considering the life of the systems and components, we are estimating the depreciation cost. If you remember, we discussed about the, these life of the components. So, in the previous class, when we were doing the economic analysis, we have already given a table. And that table can be used to find out the life of the system components. So, here, the depreciation cost is obtained considering if it is linear, we can consider that every year how much it will be, bringing down the price. And then, prevailing bank rate interest particularly for agriculture, it is a lower rate interest that should be used to calculate the interest rate. And then, the annual repair and maintenance cost, it is considered as 1% of the annual cost. And then, total cost of the system is the sum of the depreciation cost sum of the interest and then annual repair maintenance. So, this will be coming as a total cost.

And then, this is a variable cost which will be changing year to year. Of course, some of the cost it is once a long duration crop. So, planting material, seed, if it is a long duration, if it is a means short duration seasonal crop, then it can be seedlings, planting, intercultural operation, cost of fertilizers, manures, plant protection chemicals. These are some considered as operating cost or cost of operation. So, total cost will be having the cost of cultivation plus the total cost which we calculated in the Step 1 which is as 1e plus the item to this one which we are talking about. Then, determine the amount of water supplied through this system, how much amount of water, which we estimated by using the Penman Monteith equation or FAO56 equation. So, here, we will be estimating what is the amount of water which was used when we are giving water through drip system and when we are giving through conventional system.

But, what happened? When we are giving water through drip system here, we are not flooding the entire or we are not wetting the entire area allocated to each plant. So, wetting is the wetting factor or wetting made by the dripper is considered while we are giving water through drip system. So, it is in case of horticultural fruit crops, this value it is bearing from 30% to 60% or 0.3 to 0.6 or 0.65 maximum it is taken. But, in case of close growing crop, it varies from 0.65. That is at initial stage. And, it goes up to 100%. Sometimes, we take 90%. So, that value is used to find out the total water requirement. The procedure has already been stated in previous class.

So, we will be finding out that what is the, because we are we have conducted experiments. So, we find out what is the yield under drip system. And also, with the conventional system, then, we will find out the prevailing market selling price. So, whatever the drip means response which we are getting we multiply and we will find out what is the total value. Means, we will find out, how much is the total income which we are getting. Only thing here one can see the quality of produce which can be also it will aid because quality of produce done by the drip system. Here, we are giving appropriate quantity of water. We are giving fertilizers. So, that way the quality of produce is better. And then, selling price will be different.

But, for the comparison purpose, we are taking the same selling price here. So, then what we will do, we will find out the net seasonal income. Means, we will subtract the drip system and conventional system. That is the item 7 minus 3 that 3 is your total seasonal cost. Total seasonal cost is subtracted from the total net income.

Now, estimating the additional area when we are giving water through drip system, we are saving considerable amount of water. So, that saving in the water if it is used for cultivation that has been calculated and then if we are considering the same selling price and the additional produce which we are getting that can be utilized. So, additional income due to the additional area that can be found out and the additional net income can be found out. So, we will find out the gross cost of the production. We will find out the gross income. And, we will work out the Benefit Cost Ratio. So, Benefit Cost Ratio due to drip, Benefit Cost Ratio due to conventional irrigation system, we can also find out, how much is the net profit when per

millimeter of water? Because, we have already used drip systems so, per millimeter of water. And then, determine the yield per millimeter of water used. So, this is a water use efficiency term that can be also estimated.

So, this is one example which has been reported by A S Rao. And, it is given in the particular manual. The study data collected from Maharashtra and in case of the Pomegranate field that particular thing, it is given. If the Pomegranate it is cultivated then cost of the drip system involved is 18,000 rupees. Life is considered as a 5 years. So, this is a low life is given. But, it can be of more life also. So, the annual cost will come down considerably. So, this is depreciation 3,600 and then considering the bank interest rate, it is estimated repair maintenance, this is 1% which I told you. So, that way it will be calculated and total cost is obtained.

Now, total cost of cultivation has been worked out and then amount of water which has been given. Whereas, when we are taking conventional system, this particular part is nil in case of conventional irrigation system. And then, the cost of cultivation, it is in case of drip because it is using the soluble fertilizer some of the more components. So, this is also more than the conventional system. Water used by the crop because we are using the drip system. So, it is 785 millimeter. Here, it is 1,440.

Yield, it is 109 into 10 is to power 3. This is 75. So, this is the actual field data recorded based on the interview done or the experimental studies carried out in Maharashtra. And then, selling price also it is very low price. It has been given. Means, it is old data. So, this is 1000 rupee means 1 rupee per piece. This is for just example we are giving it. You can see here the how the income is estimated. So, income is from the produce is item 4, 5 that yield multiplied by the selling price this means giving the income. And then, this is for the income due to conventional irrigation system.

Now, net seasonal income it has been estimated. So, there is a difference you are getting. And then, additional area due to saving in water. So, here 0.8 because this is the saving in water we are bringing. So, that way, all these components which I explained in the steps these are here, explained here also. And, we can see here that net extra income due to implementation

of the drip system. It is coming 1, 40,628 from 1 hectare area. So, net profit per millimeter of water used is 110.14. This is a 10.42. Water use efficiency is also very high as compared to the other methods. So, this is you can see that how this is giving response. And, main thing is that you can see here Benefit Cost Ratio. So, Benefit Cost Ratio is 4.84 when we are using drip system. This is 2.2. So, this way, it is shows that when somebody is using drip system for cultivation of Pomegranate crop, one can derive this benefit.

Similar studies has been carried out at IIT Kharagpur with the support from Ministry of Agriculture and Farmers Welfare through the project. So, we carried out work for Banana crop, Guava crop and Pineapple, Mango, Sapota. So, these are the fruit crops. And, you can see here the, these are the actual results we got from our study. Much better results afterword's, these are not very high yield. But, whatever yield we have got, we are just showing you here how the Benefit Cost Ratio it is giving on water use efficiency. So, this you can see. There is a considerable improvement in the yield as well as Benefit Cost Ratio when we are using.

Similarly, for the Turmeric, Potato, Okra, Tomato, Cabbage, and Capsicum all these are vegetable crops. And then, these studies have been carried out. And then, for this, the yield, water applied, these data are useful for you people when you are referring that you can refer these things that fixed cost water use efficiency and then benefit cost analysis has been carried out. So, we can see that these are all the results which based on the long term research work carried out for more than 2 decades. And then, these data have been obtained based on that such studies are useful for taking up research studies, taking up the trials, taking up such crop cultivation in the farmers field and farmers as such they are adopting these things based on the data available.

So, in this lecture, we have covered the economic evaluation considering the soil moisture movement. We have discussed about the economic evaluation considering the planting geometry. Means, 1 plant, 2 plant, 3 plant, 4 plants of the Banana and optimize the length of lateral. Then, we also did experimental field research work and evaluated the economics of the fruit crops vegetable crops. So, this we did study.

In the forthcoming lecture, we will be working out numerical problem on economics of micro irrigation system in Tutorial 11. You can refer these references which are there quite a good number of references are there, these can be used. Thank you very much.