Water Economics and Governance
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Lecture – 34
Economics of Water Projects: Benefit - Cost Analysis

Hi everyone, in the succession to our previous session, we will be talking about the further financial analysis and in this session we are going to discuss the benefit cost approach for the project analysis. So, the benefit cost analysis as briefly discussed in the previous session as well, there would be a financial benefit cost analysis and there is a economic benefit cost analysis.

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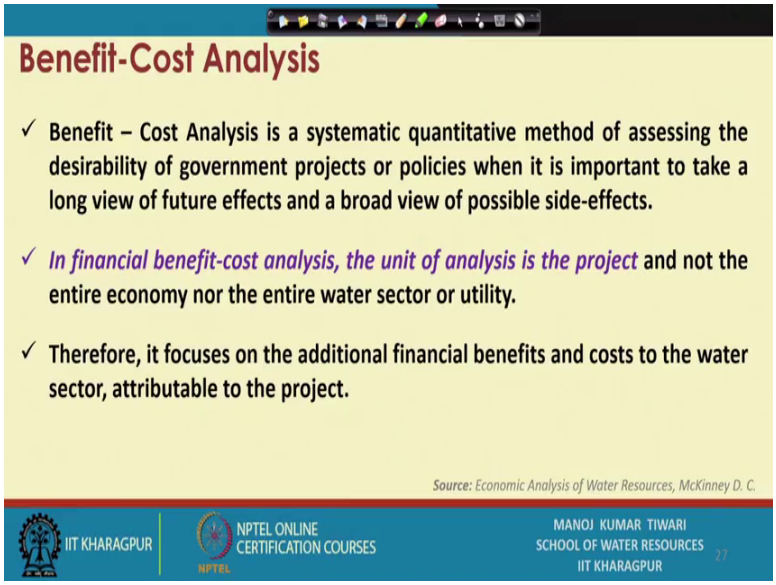

Typically, whatsoever, whenever we consider the benefit cost analysis, it is sort of a systematic quantitative method of assessing the desirability of projects or policies when it is important to take a long view of the future effects and a broad view of the possible side effects, so it is usually done in the beginning. Of course, it can be done while project is in under implementation or what while project has completed, that what benefit it has created and what cost is had it has been associated with.

But, it is usually the project appraisal status it is done in order to foresee what kind of cost it will lead on to the society or environment or in terms of financials and what kind of benefits it is going to create in lieu of that cost. So, the financial benefit cost the unit

of analysis is the project and not the entire economy as in case of economic, the economical benefit cost analysis or the entire water sector or utility.

So, for project appraisal purpose or for project evaluation purpose generally the financial benefit cost analysis is used. So, which sort of focus onto the additional financial benefits and cost to the water sector attributed well to the project in general?

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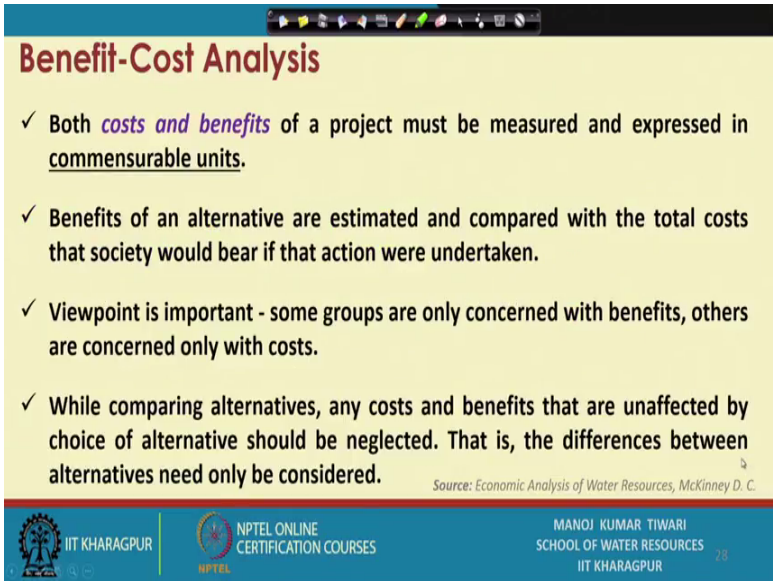

Now, both the benefits as well as cost of a project must be measured and expressed in the quantifiable and comparable units, commensurable units, where it can be quantified precisely and compared like in terms of rupees or dollar or pounds.

The benefit of an alternative are estimated and compared with the total cost that society would bear if that action was undertaken, the viewpoint is important because some groups will only consider benefits, some groups will only consider the cost it depends on the whosoever is doing that analysis. If I am an industry person and I am proposing a project, I would of course, give more emphasis to the benefits in order to highlight that my project is likely to create this, this, this benefits for the society, I may overlook certain costs or I may overlook lot of negative impacts that it is going to create, because if I highlight those negative impacts, probably my project may not get passed.

So, in order to avoid that a industrial representative is likely to focus more on to the benefits if he is proposing the project, a civil society or civic body which is kind of

opposing let us say any plan we have had many examples, for let us take an example of dams. So, when the dams are proposed the government or the body that is proposing the dam highlights all the benefits if the dam is constructed this is going to be the advantage, it will be utilized for irrigation sector, there will be development of infrastructure, development of livelihood and comes with n number of positive externalities.

While, if NGO or civil society, which is opposing the dam will probably overlook the benefits and will more emphasize on to the cost or losses, that it is going to create this harm, there needs to be replacement of people and there will be reduced flow in the downstream. So, there will be n number of costs what we can say will be cited against the process; on the other hand, there could be n number of benefits cited against the project for the project. So, that way these viewpoints are very important, whosoever is proposing the activity, what groups are concerned with benefits? What groups are concerned with cost? Needs to be seen and if the analyzer can go as holistic as possible, he will be as accurate; he will be very accurate in measuring the outcomes.

So, while comparing the alternatives, any cost and benefits which are not affecting the choice of alternatives should be neglected. If, let us say we are comparing 2 alternatives and we are like the example that we took in the previous session, where the net benefits were same, so we excluded the benefits we just incorporated the cost.

So, similarly when there are different components of benefit and cost and if one is comparing. So, all those components which are leading to the similar benefits or similar cost can be excluded and we can only highlight or we can only consider those benefits or cost elements which are different in nature. So, like if we are putting a irrigation project, whether we are putting irrigation through pipeline or canal system if it is serving the same objective, so then we are not interested in computing, taking the objective into the consideration we are more interested in, what is the expenses and how it is? What are the additional effect of a canal, if canal is being laid?

It is likely to be conduct some additional benefits because it will provide an open surface source of water or additional cost because if there is a water theft or what are stealing, how it is going to affect the other aspect. So, there could be additional cost and additional benefits of a element as opposed to the other and that needs to be considered, when we go for a benefit cost analysis of the system.

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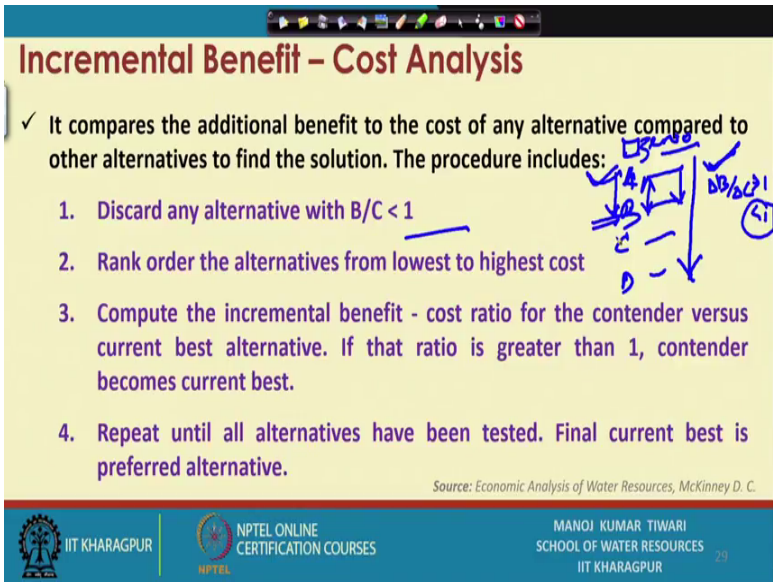

Now, when we compare the additional benefits to the cost of any alternative compared to other alternatives to find a solution we need to follow certain procedure. So, there are, the procedure has various step the first one is, one needs to basically discard any alternative which is having a benefit cost ratio less than 1. So, if a alternative is showing the benefit to cost ratio less than 1, that means, the cost or the net costs are going to be higher than the expected benefits and that is why that option or that project or that alternative should be discarded right away, should not be considered at all.

Then, we should rank other alternatives from the lowest to highest cost. So, if I have 1, 2, 3, 4 different alternatives, so how the cost is my I like from lowest to highest cost I should rank these alternatives and then compute the incremental benefit cost ratio for the contenders versus the current best alternative, if that ratio is greater than 1, the contender becomes the current best.

So, I have let us say ABCD different alternatives, of course, there is always a scenario that no project is being done, so there is always a 0 scenario. So, one can compare A with 0 and if the benefit cost ratio for A is higher, we can accept A is fine and then, we can see that what if we move from A to B increment. So, then we compare the additional cost required for moving from A to B and additional benefits that B is generating as compared to A and take a ratio of additional benefits by additional cost, If this is greater than 1, so my current choice becomes B and not A.

While if this is less than 1, my current choice still remains A, and not B. So, that way the analysis is done and it is repeated until all alternatives have been tested and final current best final best preferred alternative is selected. So, that is how it is done, which is basically called incremental benefit cost analysis because the benefit costs are being estimated based on the incremental benefits and incremental cost for any alternatives.

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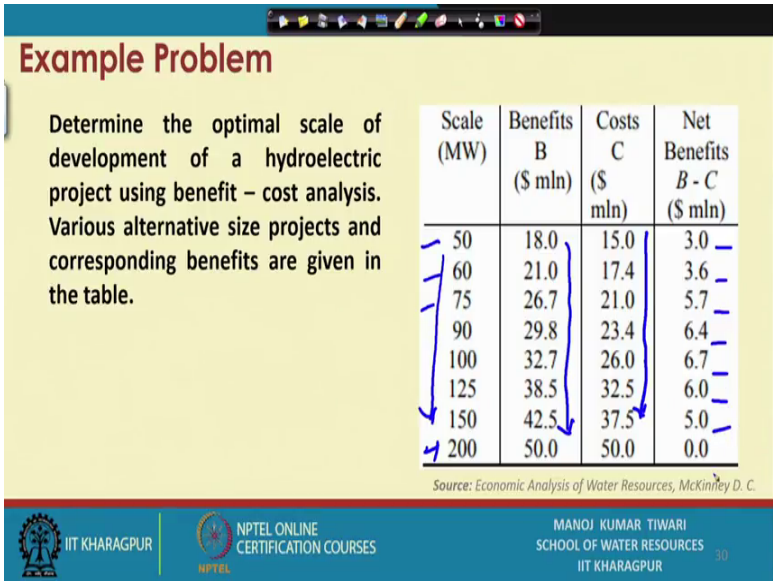

So, this will be more clear with a practice problem. So, let us say that, we need to figure out the optimum scale of development of a hydroelectric project using this incremental benefit cost analysis, there are various alternative sized projects and the corresponding benefits and costs are as under if one sees here. So, there is a different scale starting from 50 megawatt to 60 megawatts so up to 200 megawatt. So, we have the benefit and cost available for different projects over here.

Now, if you see the benefit for different megawatts will obviously, if you increase the power production the benefits is likely to increase; similarly, if the cost is also likely to increase. So, we will see that the cost is also increasing and we can get the net benefit in terms of benefit minus cost. So, one can see that net benefit over here is these values, the interesting point is that scale of investment is different, so the cost here is different.

Ideally, this unit which is the 100 megawatt unit is giving the highest benefit to cost difference. If you see the benefit to cost are increasing up till this point and then it is

actually it has started decreasing further. So, this probably is the optimum benefit to cost ratio, so if you plot this data that can be clearly seen.

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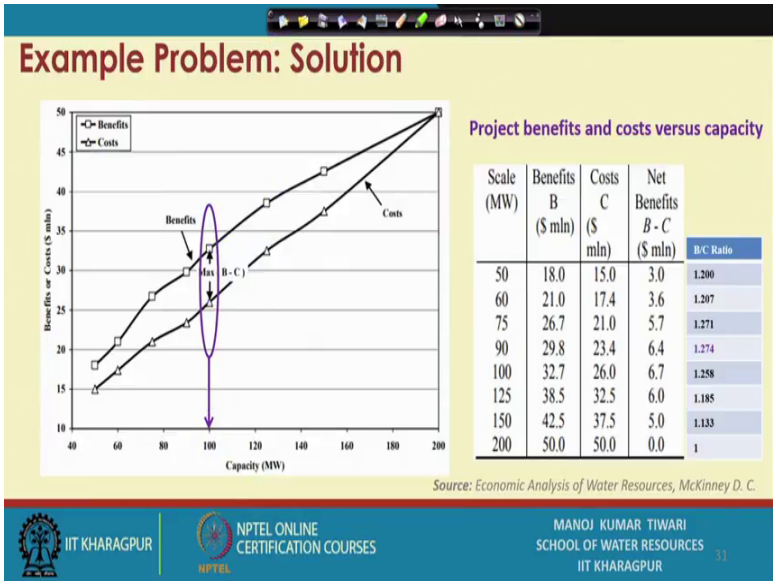

Scale (MW)	Benefits B ($ mln)	Costs C ($ mln)	Net Benefits B - C ($ mln)	B/C Ratio
50	18.0	15.0	3.0	1.200
60	21.0	17.4	3.6	1.207
75	26.7	21.0	5.7	1.271
90	29.8	23.4	6.4	1.274
100	32.7	26.0	6.7	1.258
125	38.5	32.5	6.0	1.185
150	42.5	37.5	5.0	1.133
200	50.0	50.0	0.0	1

This is the scale of capacity and this is the benefit or cost. So, the upper one is these square ones are the benefits and the triangular ones are the cost. Now, if you see the as the capacity is increasing, the benefit is increasing, the cost is also increasing, but the difference is maximum here at 100 megawatt. So, this 100 megawatt is giving the highest difference in benefit and cost. However, if you see the benefit cost ratio, which is one other parameter which is typically used for the analysis purpose.

So, if you see the benefit cost ratio thing over here, it is evident to see that benefit cost ratio for different alternatives is, here if you see the highest benefit cost ratio is actually for the 90 megawatt. So, the benefits onto the unit investment if you see, is highest for 90 megawatt. So, there are some experts, which suggest that one should go for an option which gives the highest return on to unit investment, if I am investing 1 rupees, how much return I am getting onto that. So, if my 1 rupee is on let us say if I am investing 100 rupees and my 100 rupees is becoming 110 rupees. So, there I am getting the 10 rupees of investment that is better because my gain is 10 percent as opposed to I am spending 200 rupees and getting a benefit of 15 rupees.

So, there my net benefit is higher, my net benefit is 15 rupees, but my net investment is also higher and if I see the gain per unit investment it is higher for the 10 rupees benefit

on a scale of 100. So, that philosophy suggest, that one should directly go for the benefit cost ratio; however, in terms of particularly water projects or this.

This concept may not always be applied because the benefit cost ratio is for; if I am having an alternate options of investment, I can invest this money over the other place, if I save the money here if I am investing just 100 rupees only here and getting 10 on that. So, remaining 100, if I am having a pool of let us say 200 rupees or 500 rupees, so out of that 500, the remaining 100 I can spend on to some other activity, where again I will be getting a return of possibly let us say 7 percent 8 percent or 10 percent. So, that my net return is higher as opposed to spending 200 rupees and getting 15 rupees of return.

However, for the government projects because the objective of government is not to basically earn interest or not to earn larger profits on to the money, it is rather how much maximum social benefits I can get without having the financial burdens on me. So, without going for any additional cost issues, if I can gain the maximum social benefits for whatever cost that is the ideal case for a government project.

So, in such case if you see this incremental benefit cost ratio becomes more valuable because the benefit cost ratio would suggest you here that one can go for 90 megawatt production, which is giving the highest benefit to cost ratio, but if you see that benefit cost margins. So, if government invest this 32.7 million dollars as opposed to 29.8 million dollars, which is additional 2.9 million dollars. So, if I invest that additional 2.9 million dollars I will get additional benefit of 0.3 million dollars that is fine. So, my net benefit is going to be 6.7 million dollars.

So, for that, even that additional expenditure I am getting certain benefits, still I am getting certain benefits. So, it has to be seen on a prospective that I am spending 2.9 million dollars more here from for moving from 90 to 100 and I am actually getting a return of, I am getting a return of from 23.4 to 26. So, 2.6 of the return I am getting on to that, so we will see this thing which is, which will be more clear, when we go for the analysis that way.

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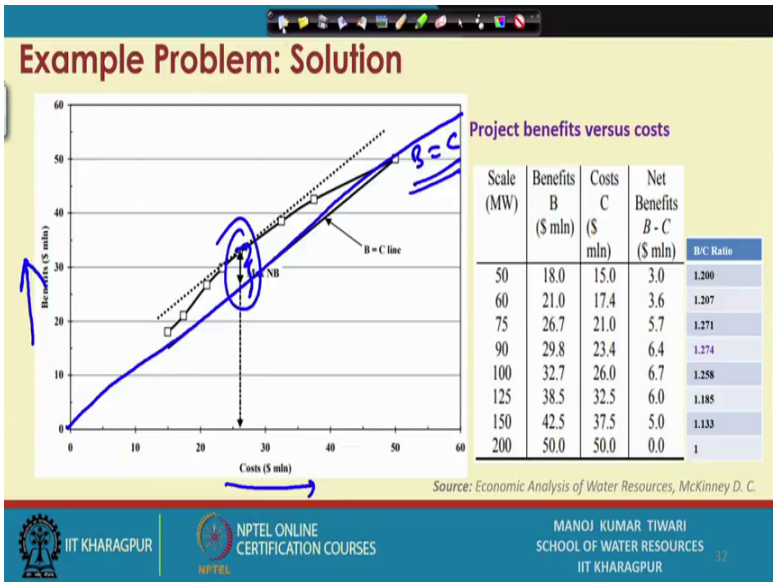

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100	32.7	26.0	6.7	1.258
125	38.5	32.5	6.0	1.185
150	42.5	37.5	5.0	1.133
200	50.0	50.0	0.0	1

However, from the gap itself it can be seen that the 6.7 is the gap or if you see that maximum benefit over here, so it can be seen when one compares the benefit to costs. So, if my cost scale is here and benefit scale is here, the of course, the 45 line or 0 line is going to be my benefit is equal to cost or cost is equal to benefit line. So, if benefits are over this line, I am getting benefit on to that and any line parallel to this it can be seeing that the point giving the maximum benefit over here can be selected. So, that kind of analysis could be helpful, it can be incremental benefit cost analysis can also be very helpful over here.

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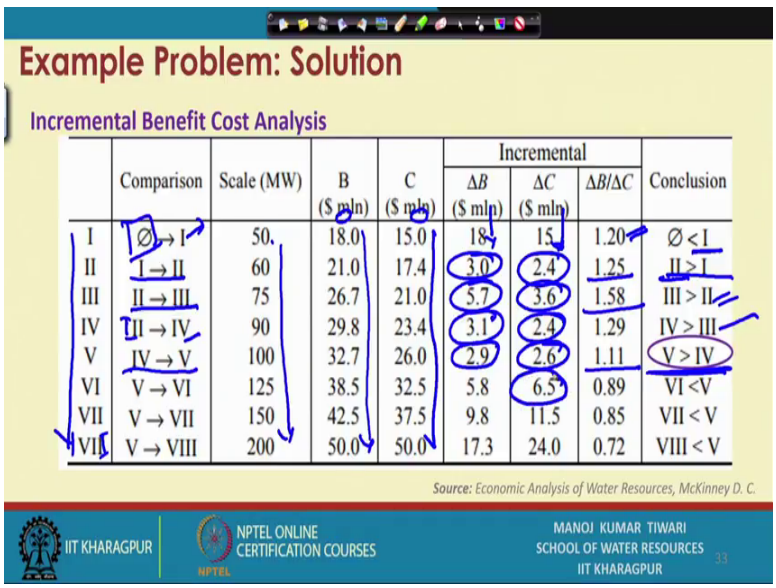

	Comparison	Scale (MW)	B ($ mln)	C ($ mln)	Incremental ΔB ($ mln)	Incremental ΔC ($ mln)	ΔB/ΔC	Conclusion
I	Ø → I	50	18.0	15.0	18	15	1.20	Ø < I
II	I → II	60	21.0	17.4	3.0	2.4	1.25	II > I
III	II → III	75	26.7	21.0	5.7	3.6	1.58	III > II
IV	III → IV	90	29.8	23.4	3.1	2.4	1.29	IV > III
V	IV → V	100	32.7	26.0	2.9	2.6	1.11	V > IV
VI	V → VI	125	38.5	32.5	5.8	6.5	0.89	VI < V
VII	V → VII	150	42.5	37.5	9.8	11.5	0.85	VII < V
VIII	V → VIII	200	50.0	50.0	17.3	24.0	0.72	VIII < V

So, as we were discussing the concept of incremental benefit cost analysis, we have various options here starting from 50 to 200 megawatt and accordingly we can name the options from 1 to 8, this would be option 8, so from 1 to option 8 we can have this idea. Now, as if you recall the methodology this has to be listed in terms of the cost from lower to higher and then associated, but what are the associated benefits and then we compare these alternatives of course, the first one is going to be compared with a no project alternative when nothing is being done.

So, when nothing is being done your total cost is 0 and total benefits is also 0. So, when you look for the delta B incremental, so you basically increment a cost of 15 from 0 and you get a benefit of 18 from nil or your baseline and the ratio of this gives you a incremental benefit to cost ratio, which is going to be the same as benefit cost ratio for case 1. Now, since it is greater than 1, so we will say that the alternative 1 or the proposal 1 is superior then doing nothing.

So, we will compare the next low cost alternative which is now the option 2. So, we will compare 1 with 2. So, for 2 we have to spend additional 2.4 million dollars and we are getting 3 million dollars of additional benefit, giving a benefit cost ratio of 1.25. Since, this is greater than 1, so we can say that option 2 or alternative 2 is superior to alternative 1 and we can move comparing alternative 2 and 3 in similar fashion.

So, for comparing alternative 2 and 3, we see that over us 3.6 million dollar investment we get an additional benefit of 5.7 million dollar giving a benefit cost ratio of 1.58, which says that alternative 3 would be better than alternative 2. Similarly, we compare now alternative 3 to alternative 4 and we see that additional benefit of 2.4 million dollars leading to sorry, additional cost of 2.4 million dollars leading to a benefit of 3.1 million dollars and that is suggesting that alternative 4 is better than alternative 3.

Further, analysis for alternative 4 to alternative 5 moving from alternative 4 to alternative 5, we see that additional cost of 2.6 million dollars is leading to additional benefit of 2.9 million dollars. So, here again we get a benefit to cost ratio as 1.11 and we will say that alternative 5 is actually better than alternative 4. We will compare the 6th one with 5 and here we see that for an additional investment of 6.5 million dollars we are getting the benefits of 5.8 million dollars.

So, this additional investment is not justified because it is the investment is more and return is less. So, this is not justified and that is why it we are getting a benefit cost ratio less than 1, this is not justified and we will see no our alternative 5 is still better than alternative 6 and we will compare the alternative 7 again with not alternative 6, but alternative 5 because we have dropped the alternative 6.

So, for alternative again 7, we will see that a additional investment of 11.5 million dollars leading to benefits of 9.8 million dollar, again benefit cost ratio less than 1. So, we will say that we will drop alternative 7 also, till this point alternative 5 is still the best. We will compare 5 with 8 at the end, which is the last one and we will see that additional investment of 24 million dollars leading to benefit of just 17.3 million dollars, which is again not justified and benefit cost ratio is less than 1 and that way we will see that alternative 5 still remains the better choice alternatives.

So, with this kind of analysis also we can say that which is the best solution and which one is to be adopted. So, this entire incremental analysis again suggest us that the alternative 5, which is the production of 100 megawatt power appears to be the best for a government project; although, please remember that if you see that your net gain on per unit investment it is not highest for 5, it is for the 4th and not for the 5. So, that kind of analysis helps us, let us take another quick example of similar fashion.

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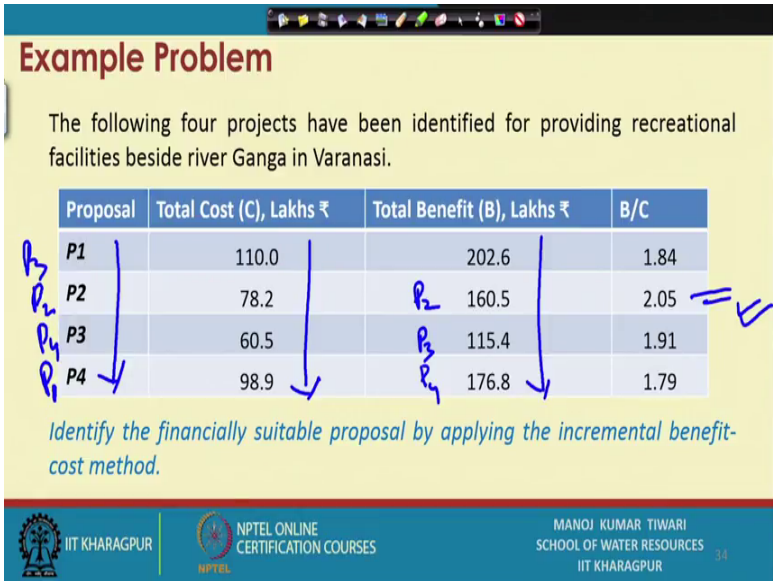

So, we are having let us say 4 projects identified for providing recreational facilities beside river Ganga in the Varanasi, let us the projects are listed as P1, P2, P3, P 4 we have their total cost in lakhs of the rupees, their total benefits and their benefit cost ratio. If one sees the benefit cost ratio accepted, the proposal 2 is giving the best benefit cost ratio a little over 2, so should be accepted. There I will get the maximum return or maximum benefits on the unit cost, unit amount of expenditure.

However, let us see again the same analysis from the concept of incremental benefit cost method. Now, incremental benefit cost method we see that the lowest cost here is for P3 and then for P2 and then for P4 and then for P1. So, we will list the alternatives based on the lowest cost. So, the alternatives would be listed as P3, then alternatives will be listed as P3, then we have P2 which is the 2nd lowest, then P4 and at last P1.

So, we will list these alternatives over that fashion and let us see how this turns out to be.

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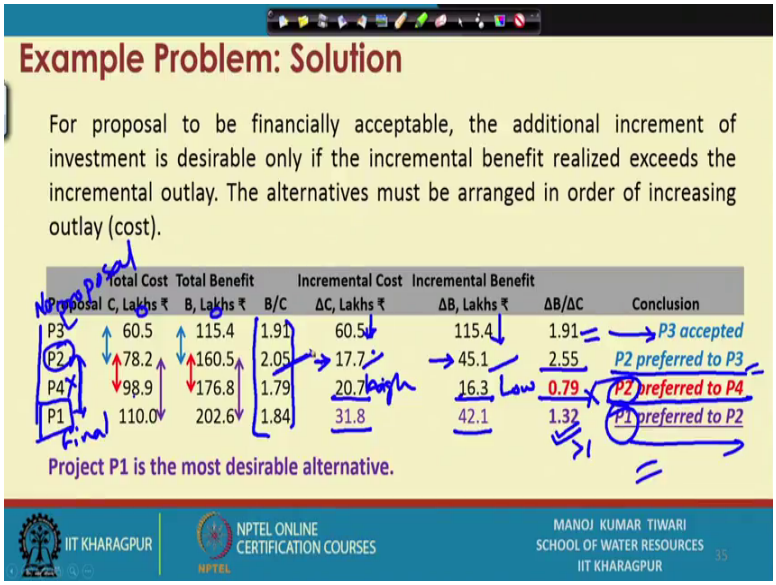

Now, this is how we have listed our alternatives P3, P2, P4 and P1, the total cost and the total benefits is given to us, the benefit cost ratio is also known, although it is of no use when we are computing the incremental benefit cost ratio straightforward, but let us see. So, at first we will compare the lowest investment as opposed to 0 case scenario, when nothing is existing. So, in that case the delta C, the net investment is 60.5 lakh rupees, that is here and the net benefit delta B is 11.5.

So, this is basically compared from a 0 case scenario, which is actually no project, no recreational facility when we do, when we are not having any proposal and this gives us a benefit cost ratio of 1.91 which is of course, going to be the same and we can conclude that the project 3 can be accepted. So, it is better to have at least project 3, when we compare that no project is recommended that kind of scenario.

So, we will compare the next low cost alternative which is project 2. So, we will compare the P3 versus P2 over here and see that here additional investment or additional cost of 17.7 lakh rupees is needed and that is going to lead to the additional benefits of 45.1 lakh rupees, the benefits can be subtracted that will give 45.1 and the cost can be subtracted that will give 17.7. This giving me an incremental benefit cost ratio of 2.55 and since it is higher than 1, we can say that P2 is preferred to P3.

So, now, our best option becomes P2. So, we will compare the next low cost alternative which is P4 with the P2 and we will see that here we need a further investment of 20.7 lakh rupees and we are getting of more benefit of 16.3 lakh rupees as compared to option P2.

Now, you see the cost here, the additional cost here is high and the benefit are relatively low. That is giving a benefit cost ratio which is less than 1 and is not accepted, so we will say no. P2 is still preferred to P4, so my choice is still remains P2. I have discarded P4 as an option, P4 cannot be taken as choice and then I will compare P2 with P1 and then I will see a additional investment needed is 31.8 lakhs and additional benefits that I am getting is 41.1 lakh of rupees, which is giving me further a benefit cost ratio of 1.32 which is greater than 1 and P1 can be further accepted and that will be preferred to P2.

So, this way, we can say that the P1 is going to be my final recommendation. So, project P1 is going to be the most desirable in such scenario accounting for this. So, by going to the benefit cost ratio as P2 would have been selected, but when we do this analysis we figure out that P1 is going to be the more rewarding in terms of the government investment, we are not talking here about the net in gain on to the unit investment, but on the overall investment this project is relatively more rewarding as compared to other alternatives.

So, that is how the incremental benefit cost ratio; benefit cost ratio method is used for the analysis of the various alternatives in terms of water related project or the allocation

practices. So, we will end this session here and we will continue discussing the basics; some more basics of how the water allocation is done based on the financial principles and these aspects in the next and concluding session of this week.

Thank you.