Introduction to Multimodal Urban Transportation System
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Lecture-25
Non-motorized Transportation (NMT) Planning: Alterative Selection through Economic and Financial Analysis

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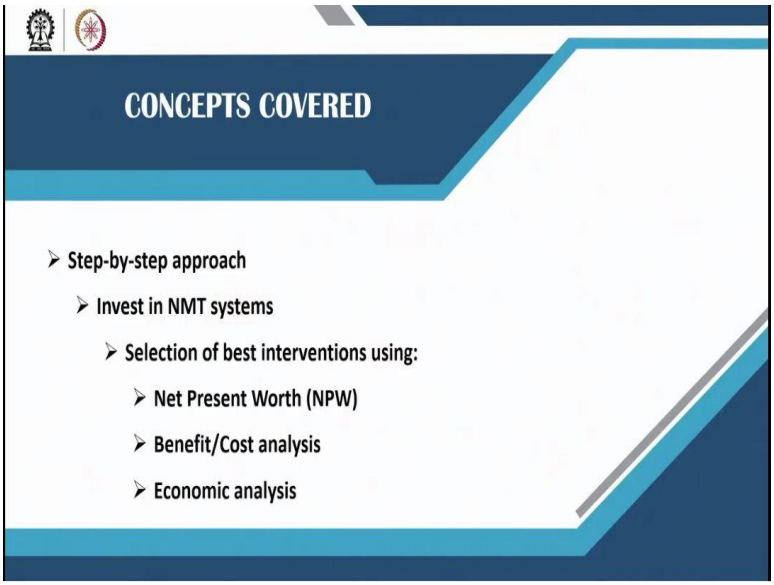

Hello friends, welcome back to the next lecture on NMT planning. In this lecture we are going to take you to the next step in the 5 step planning process, where we will be looking at how to invest in NMT systems. We have looked at how to plan and design in the "planning+designing" steps, we have looked at different criteria selection criteria in the previous lecture. Now we are going to look at how you invest in NMT system. And when you are trying to invest in NMT system, you have to be picking the best alternatives. From the point of view of net present worth or benefit cost analysis or economic analysis. These are the 3 different techniques with which people usually identify which are the best projects to implement or to invest in.

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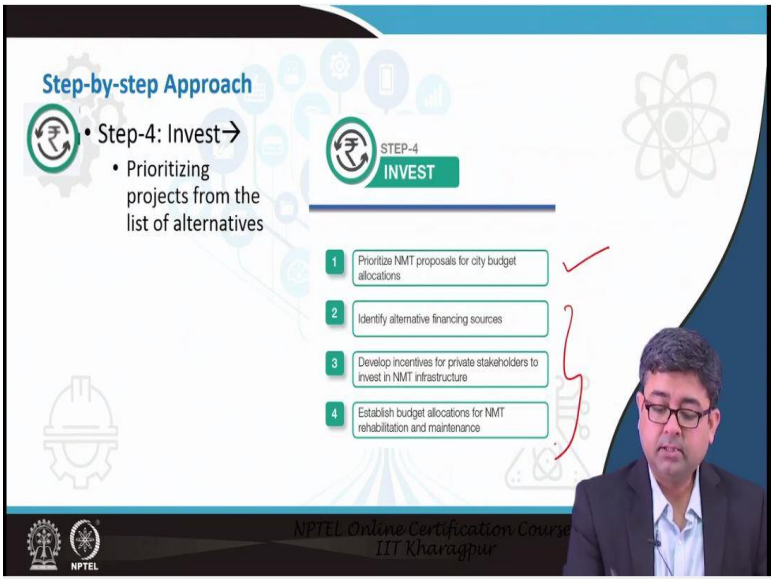

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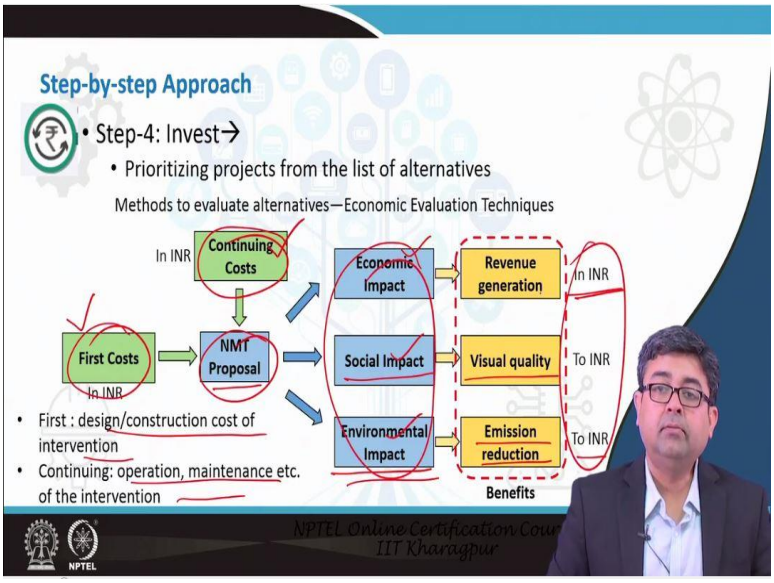

So, like we said, this is the fourth step in the 5-step process. And we are basically going to give you an idea about how to prioritize proposals for the city budget allocations. In the previous lecture, we looked at scoring methods, which will allow you to prioritize for designing and planning, now for investing, having the money in the city budget, how do you prioritize these projects? And then we will quickly look at how to identify alternative financing solutions, incentivizing private investment and also developing a budget for rehabilitation and maintenance, which is very important because what we are building, we have to maintain as

well. So, now, any NMT project will always involve costs and will have some direct and indirect benefits associated with it. What are the costs? There will be costs of design construction, etc. And also there will be cost of operations and maintenance. So, there are usually 2 types of costs that have to be considered while you are looking to invest in an NMT proposal. Now, based on the NMT proposal, there are different types of benefits or impacts that it might have. It might have a social impact, it might have an economic impact, or it might have an environmental impact. Now, when you are trying to invest, it is always better, easy and transparent to convert all these impacts into monetary terms. So, economic impact is easy to convert into monetary terms, because you can say that 'x' amount of revenue will be generated as a result of this NMT proposal. So, it might be easy to find, however for social impact, how do you quantify social impact? So, maybe visual quality of the area will increase. So, how do you quantify visual quality, what is visual quality? So, we will look at that. Environmental impact: so, environmental impact is reduction in emissions. So, now, emission reduction, we can quantify. How much carbon dioxide or carbon monoxide reduction is happening? But as a result of that reduction, what is it the benefit cost-wise or monetarily? How is it benefiting the users, so maybe the health of the users is improving? As a result, the cost the health costs are reducing. So that may be a way to monetize the environmental impacts of an NMT proposal. When you are trying to invest in any of the proposals, this is an overall structure of what to identify in that project. You may identify 2 types of costs. You have to identify what are their benefits or impacts, convert them into monetary term.

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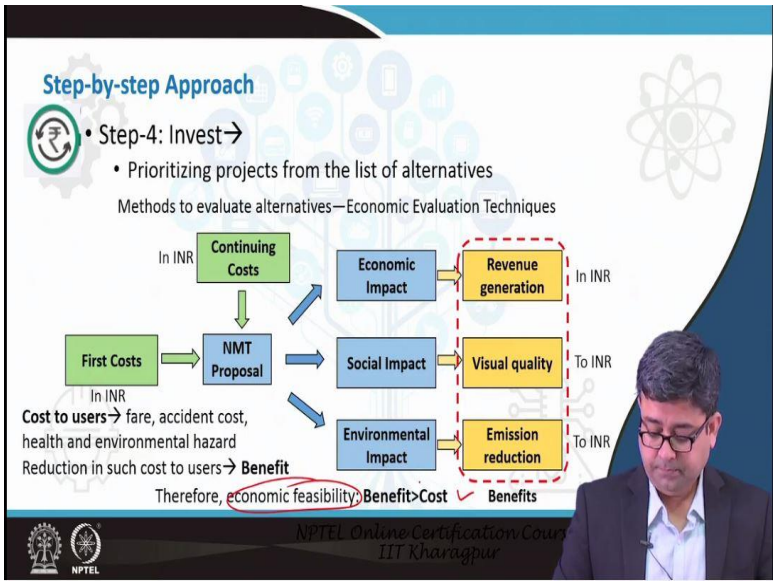

Your project is economically feasible, if the benefits outweigh the costs. So the benefits monetarily are more than the cost that is involved in identifying the project, building the project, then you would say that this project is viable or economically feasible, and we are going to go ahead and invest in this project. Now, what are the different methods in which you will determine the viability or the economic feasibility of a project?

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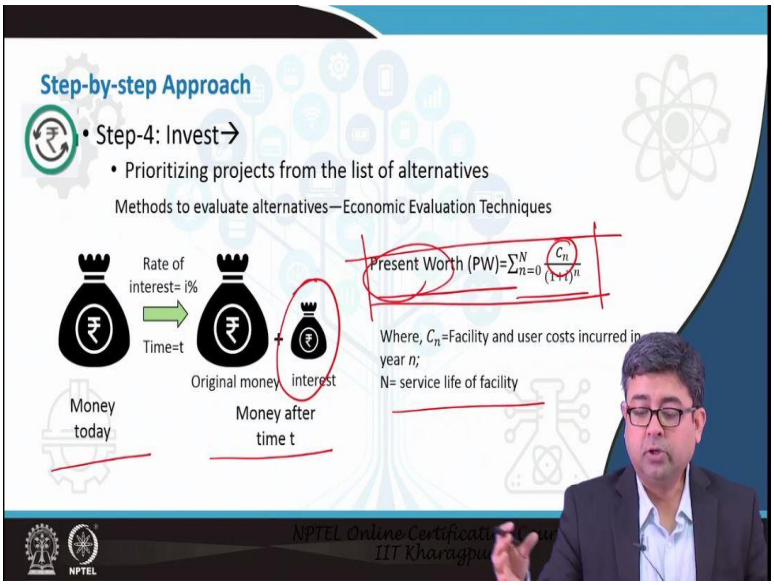

So, the basic principle in any economic analysis is money in hand today is always higher than the value of money tomorrow. Because the value of money tomorrow, you are paying some interest. So, money in hand today is always higher than money tomorrow. So, based on this basic

principle the present worth or the net present worth is calculated of any project. So if you have to invest money in NMT project, that means, you are wanting that whatever money you are investing today in that project, the returns that you will get from that project in the future is higher than the value of the money in the future. I can invest money and get some interest on that money if I put it in a bank. But instead of doing that, what I am doing is I am investing it in NMT infrastructure. So, when I invest in NMT infrastructure, I still want some returns in the future. And those returns have to be of higher value than what I would get from what a bank would give me in return. So that is the primary consideration. Present worth=

$$\sum_{n=0}^{N} \frac{C_n}{(1+i)^n}$$

What the technique or the formula says is that if the facility incurs these costs over its lifespan, or service life, then what is the worth or value of that facility today? So, costs, there will be some initial costs, then there will be maintenance cost and so on and so forth for the entire lifespan of that project. So, if I build this, what is the present worth of that project of that future money?

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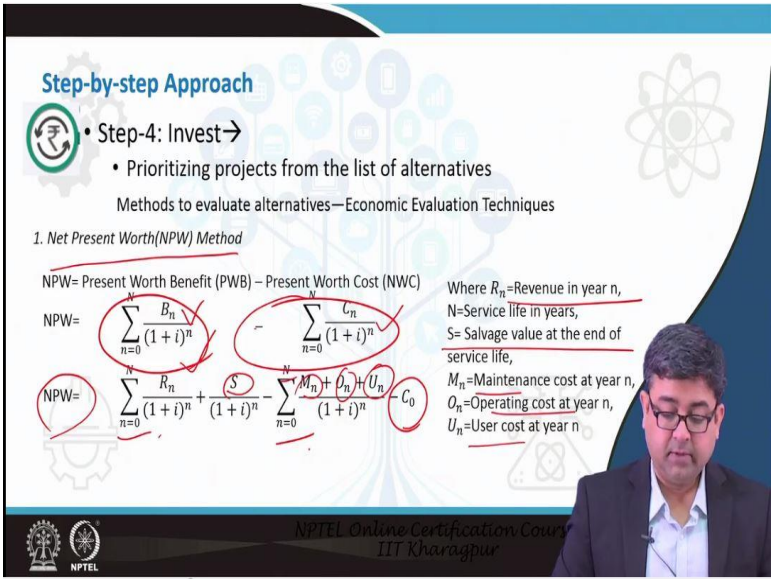

So the net present worth, when we say net, we subtract from it the benefits that are quantified, we looked at different types of benefits and converted into monetary terms. So, all of those benefits minus all of those costs is the net present worth.

$$\sum_{n=0}^{N} \frac{B_n}{(1+i)^n} \quad - \quad \sum_{n=0}^{N} \frac{C_n}{(1+i)^n}$$

So, if the net present worth is greater than 0 that means the benefits are greater than the costs, then you would usually say that it is worth financing or investing in this NMT infrastructure project. So, all the benefits, B_n are all the benefits, the benefits would involve the revenue that is collected from these services over the lifespan and also the salvage value at the end of the service life. So, maybe your infrastructure, when it becomes old, it can be sold as junk, you still get some salvage value out of it. So, that is all the money that will come in from the other result of the project. Whereas you have to subtract some of the costs, ongoing costs, that is maintenance cost M_n operating cost, and user cost U_n. And all of this will be ongoing throughout the life of the project. Whereas there will be one cost that has to be paid upfront for construction. So that is also a negative cost. But that is only a onetime cost. You do not have to do it over the lifespan of the infrastructure.

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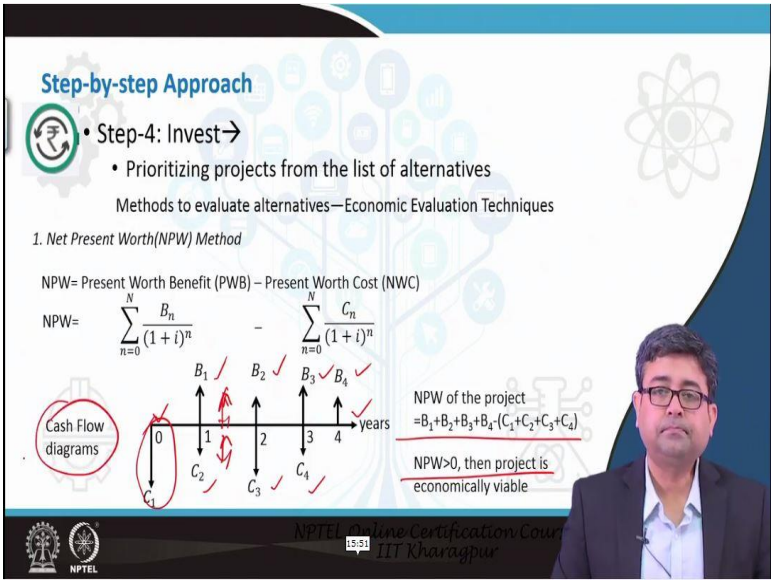

So this is just shown to us on a diagram, so these are the year's lifespan of the project. So they may be the lifespan of the project is 4 years or 4 and half or 5 years, then, in years 0 or currently you have to invest some money for construction, then maybe your operating and maintenance costs goes on. Whereas, you have to start with getting benefits also from year 1, year 2 and year 3. So hopefully, these benefits are higher than this, or cumulatively, they are higher than this. So, if you add this and NPW is greater than 0, then the project is economically viable. This diagram is usually called cash flow diagram.

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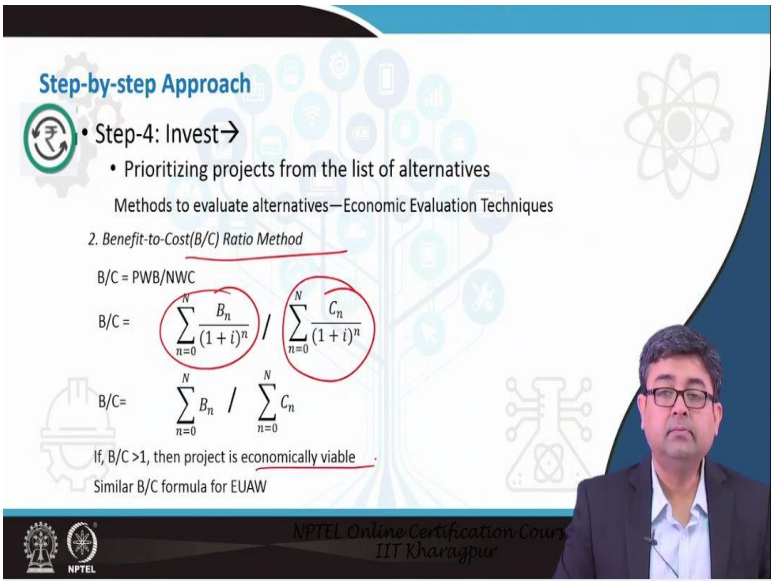

The other method in which people usually find out whether a NMT project is viable, is called the benefit to cost ratio.

$$\sum_{n=0}^{N} \frac{B_n}{(1+i)^n} \quad / \quad \sum_{n=0}^{N} \frac{C_n}{(1+i)^n}$$

Benefit to cost ratio again is very similar to the terms to what we have already looked at all the benefits divided by all the costs. If the ratio is greater than 1 then it is economically viable. So, now let us explain this using an example so that it is helpful to you.

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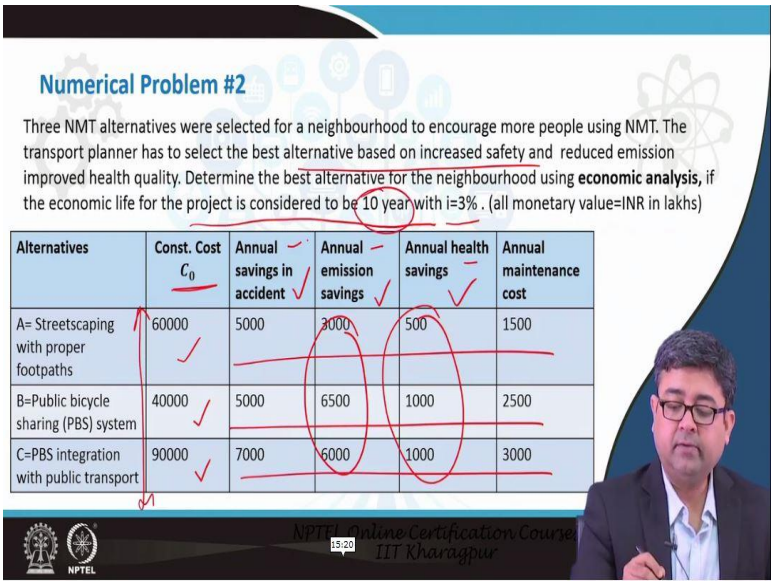

There are 3 NMT alternatives. This was selected to encourage people to use NMT. These are the same examples that were used in the last lecture as well. Streetscaping with proper footpaths, public bicycle sharing system and PBS integration with public transport, I guess the third one is different. Now, the transport planner has to select the best alternative based on increased safety and reduced emissions and improved health quality. So now, the criteria on which the transport planner has to select the best alternative are savings from accident, increased safety, savings from emissions because of reduced emissions. There are savings and annual health savings as well so maybe reduced safety plus higher exercise because of good facilities are resulting in annual health savings. So, based on all these three, how do you determine which is the most viable project and it is also said that the economic life of the project considered to be 10 years with an interest rate of 3 percent. So, all of these terms are already, for simplicity sake, converted into monetary terms or it will take some effort if you are doing it for the first time to convert health savings and emission savings into monetary terms. So, what we see here is there is always an upfront cost of constructing these things and then these are annual costs. So, these are annual and over 10 years we have to calculate this.

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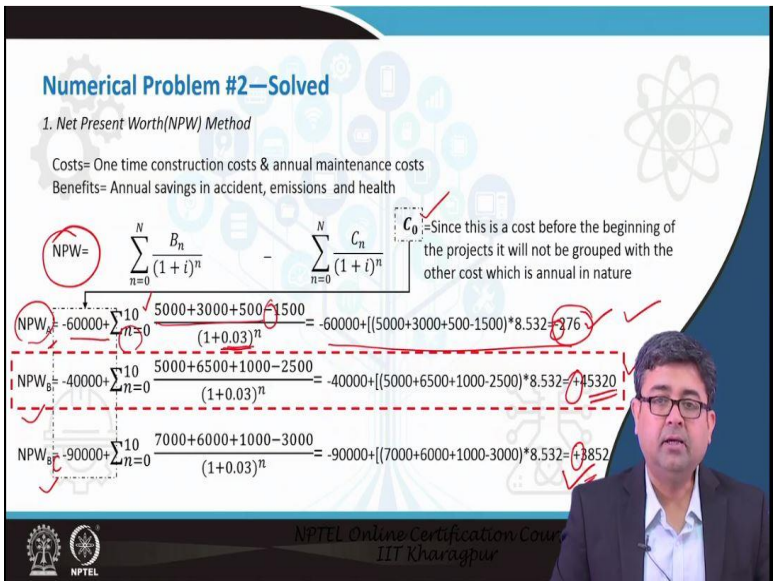

So, using this formula for NPW we look at what is the net present worth of project A? So project A has an initial cost. Which has to be subtracted so that is a negative 60,000. Then it has annual costs or annual benefits of 5000. In the first one savings are: 5000 in annual savings, 3000 annual savings, annual health savings of 500 and maintenance cost of 1500. So, the maintenance cost has to be then subtracted. The interest rate here is 3 percent. So, if you do the math, then it comes out that the net present worth of this project A is coming out to be negative. The value is not much important, but the sign is of importance here. So it is coming out to be less than 0, which tells us that the project may not be the most economically viable project. Remember from the previous class, if you are scoring these projects, to find out the best alternative using the simple scoring method, then this rated very high, whereas, now, when you are trying to actually invest in this project, you are finding out that the net present worth of this project is negative. Similarly, if you do it for project B and project C *(correction: B should be C in the slide)* what you will find out is that project B has the highest net present worth. Both of them are viable, both of them are in the positive. But once both of them are in the positive, which is the higher one? It is the project B. So you can select project B for investment purposes. So you would be confident that if I implement project B, I would get maximum returns on my investment.

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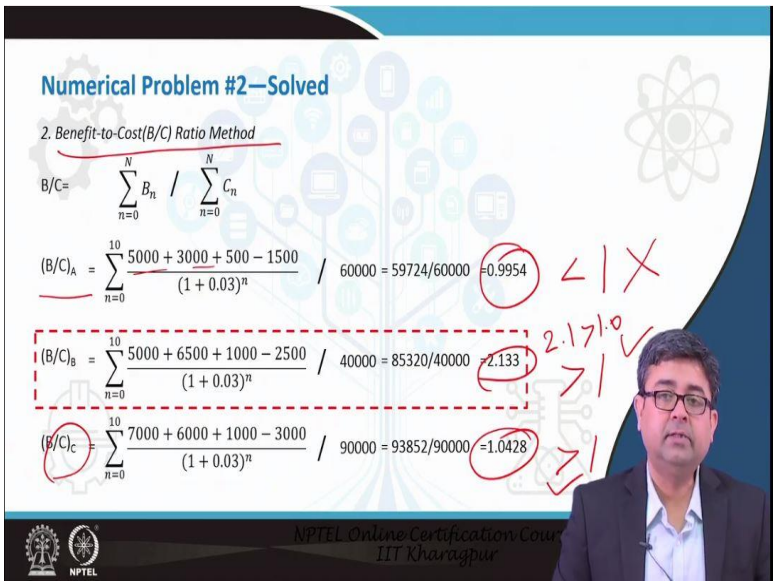

Similarly, for the same problem, if you use the benefit to cost ratio, you will see that project A has a benefit to cost ratio of 0.99 which is again less than 1, project B has a benefit to cost ratio of 2.13. The terms are all very similar that we have already used, which is greater than 1 and project C also has a benefit to cost ratio greater than 1. So, it tells you again this project A is not economically feasible whereas, both of these projects are economically feasible. However, this is more feasible because 2.1 is greater than 1.0. So, using both of these methods, net present worth as well as benefit to cost ratio, we are finding out that project B is the most viable, economically feasible project.

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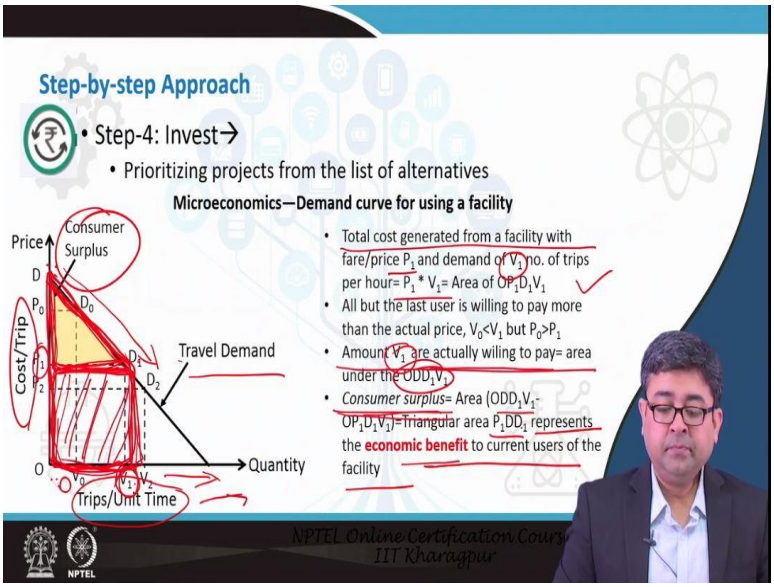

Now, the other method of finding out which is the best feasible project is to look at it from the point of view of purely the users. So, from the point of the users and the user benefits, you can determine which of the projects is economically viable. So, in order to do that, there is a concept called consumer surplus which determines the economic benefits to current users. What it says is that if you have cost per trip on Y-axis and trips per unit time on X-axis, then you say that if the cost is high, very few trips will take place. Whereas if the cost of any type of transportation facility decreases the number of trips will increase. Number of trips is nothing but the number of people who will avail those NMT services and more number of people use facility then there is more number of trips. So, if the price is high, then very few people will use it; alternately if the price gets down, if the price decreases, the number of people using it will increase. So, your travel demand curve is an inverse curve, but for simplicity's sake, it is shown as a straight line. So, what it says is this, i.e. what this consumer surplus concept says is that the total costs generated from a facility, total cost generated or revenue generated from a facility with a price P_1 and demand of V_1 So, total revenue= P_1 times V_1 or the area $P_1D_1V_1O$ or $OP_1D_1V_1$.

So, this area, if you can calculate the area in that graph, it will tell you how much cost this facility can generate or how much revenue it can generate. Whereas, you can also find out how many people are actually willing to pay for this service. So, some people may not be willing to pay. What is willingness to pay is some people pay out of compulsion, whereas some people are actually happily willing to pay for this service. So the amount V_1 these are the number of people trips meaning number of people making these trips. The V_1 are actually willing to pay and is equal to the area, this big area, which is the area that V_1 people are willing to pay. So, the area is ODD_1V_1. So, this is the area that they are in. Now, if a project is economically beneficial to the users, you determine that economic benefit that is determined by what is called the consumer surplus, so that consumer surplus is this yellow shaded area right there. So all you have to do is you know the entire area, you know the revenues generated or cost. So the profit generated essentially is cost minus the revenue generated. So the net if you subtract this square or rectangle from this trapezoid you will get the triangle and that triangle is the consumer surplus, which represents the economic benefit to the current users of that facility. So, you can quantify the economic benefits of that particular NMT facility. So, that areas again it has given us the entire area ODD_1V_1 minus this area $OP_1D_1V_1$ will give you this consumer surplus this upper triangle which is P_1DD_1.

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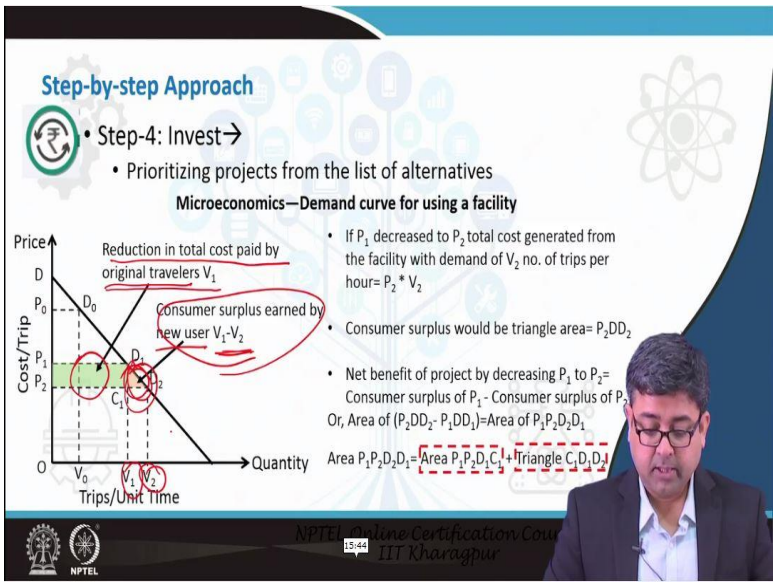

Now, the next thing is to know what the benefits to the users are when the cost is reduced from P_1 to P_2 and demand increases. What happens is sometimes in an existing facility, you may not have enough users, for eg., there is an existing bicycle lane, but to avail that bicycle lane, you have to maybe use the public bicycle sharing system, which costs a certain amount of money. And hence, you are seeing that you have put out these lanes, but nobody is using these lanes and nobody is using the public bicycle sharing system because of the price. So in order to improve or increase the demand or increase the number of people using these trips, so that you get revenue out of it, you actually reduce the price for the user. So when you reduce the price for the user, how does the benefits change and how do you quantify those benefits? So what it tells again, step by step, if you say that, if P_1 decreased to P_2 total cost generated from the facility, with demand V_2. So, now the demand. So, if original prices P_1, now it reduced to P_2 and for P_2 the demand is V_2 or demand as in the number of trips per unit time number of people using it is V_2. So, now, since the price has reduced what is the new demand, it is P_2 times V_2 or the consumer surplus would be the triangle. Now, the consumer surplus was this triangle initially as we saw, now, it will be this bigger triangle, P_2DD_2. So the consumer surplus has increased, that means the economic benefit has increased and maybe there will be more people using it. So, what happens to the net benefit of the project, by decreasing the price from P_1 to P_2? It is consumer surplus of P_1 minus the consumer surplus of P_2 or it is the area P_2DD_2 - P_1DD_1 which gives you this shaded

area. So, this grey shaded area gives you the benefits to users when the cost is reduced from P_1 to P_2 the demand increases from D_1 to D_2.

Now, this trapezoid again has a rectangle in it and also has a triangle in it. So, what does the rectangle rectangular area determine? It determines the reduction in total cost paid by the original travelers V_1. Now, since the price has been reduced from P_1 to P_2 what happens is the original users which are only V_1 they are also going to pay less whereas, the new users which are V_2 which did not use the facility when the price was P_1, they are now going to earn some consumer surplus, which are the new users. So, which is given by this triangle $D_1C_1D_2$. So, again, understand the benefits are both to the existing original travelers as well as to the new users. So, by reducing the price, you are not only benefiting the existing users, but also attracting new users and they are getting a consumer surplus of this. Again, you just need to determine the area of these two in order to quantify. How do you quantify the consumer surplus or quantify the economic benefit? This is a very simplistic way of estimating consumer surplus. Otherwise, as an economic theory you can have classes on it for hours, but this is a very simplistic way of telling you how to determine in economics feasibility of any project in this case we are looking at NMT projects and from the point of view of user benefits and in this project.

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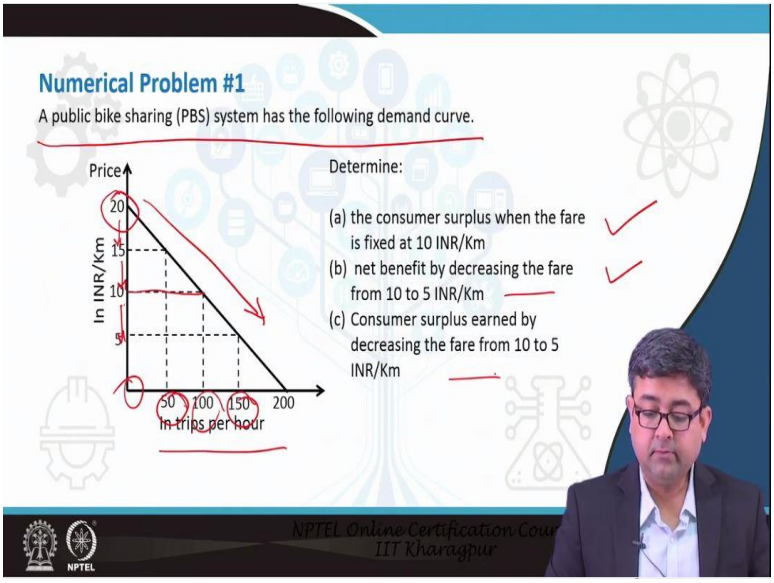

So again, as we did in the previous lecture, we are going to give you an example of how to calculate these economic benefits, say, a new public bicycle sharing system has the following demand curve, or an existing public bicycle system has a following demand curve. So, what it

says is that, if the price of the public bicycle sharing system is 20 rupees per kilometer, nobody is going to use it, there are no trips per hour. Whereas, if it reduces to 15, then you will have 50 trips per hour, reduced it to 10 there will be 100 trips per hour. And if you reduce it to 5, they are 200 and so on and so forth. So, this again it is a simplistic linear curve, but usually demand curves are not linear. So, what can we determine? (a) Can we determine the consumer surplus when the fare is fixed at 10 rupees per kilometer? (b) What is the net benefit by decreasing the fare from 10 to 5? What is the net benefit and what is the consumer surplus earned by decreasing the fare from 10 to 5. So, what is the net benefit by decreasing and what is the consumer surplus by decreasing? So, let us look at the first one which is the consumer surplus when the fair is 10 rupees per kilometer.

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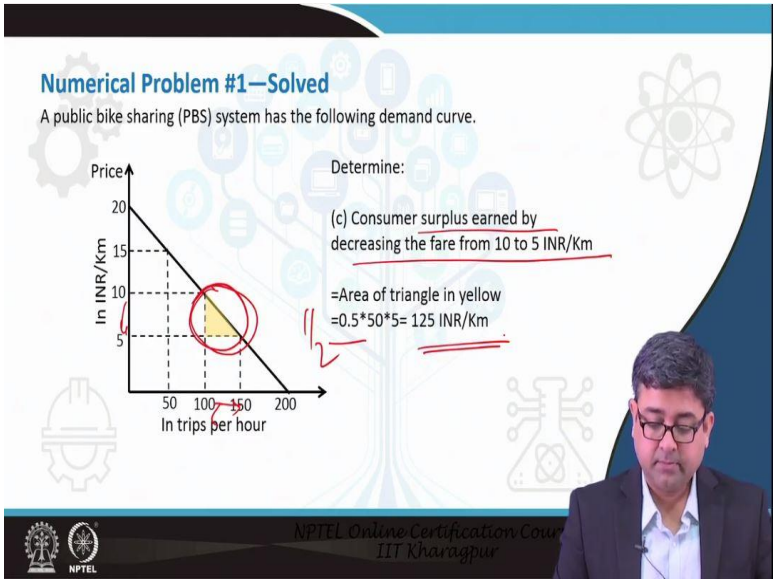

So, when is 10 rupees per kilometer we already saw that the consumer surplus is the area of that triangle. So, the area of the triangle is 0.5 as in (1 / 2 * 100 * 10). So, it is 500 rupees per kilometer is the consumer surplus or the economic benefit to the users or the economic benefit as a result of users using this system, it is an economic benefit, so 500 rupees per kilometer, so, if you have a bicycle sharing system for our net worth which has 20 kilometer net worth. So, every kilometer you are getting a benefit of 500 rupees when there are 100 trips per hour at the cost of 10 rupees per kilometer. Next, what is the net benefit for decreasing the fare from 10 to 5 rupees? So, net benefit is the entire trapezoid between 10 and 5 and till 150, at 5 rupees there are 150 trips per hour, so, we just calculate the area of trapezoid. You can see that there is a net benefit of

625 rupees per kilometer, if you reduce the price from 10 to 5. So, net benefit also includes all the costs that are usually associated in construction in maintenance and operating. Usually, we think that by reducing we may not be reducing the cost or reducing the price we not may not be able to cover for operating our maintenance costs. But, if you calculate it properly, you are actually benefiting more, which can be again, put back into the maintenance and operating costs. Finally, what is the consumer surplus earned by decreasing the fare. So, the consumer surplus earned for the new users? All the existing users have the consumer surplus, but the new users now have this additional consumer surplus, which is the triangular area again (1/2 *50*5). So, that is the new consumer surplus that is simple enough. This consumer surplus method allows you to quantify in a very simplistic term, what are the economic benefits from implementing any kind of project.

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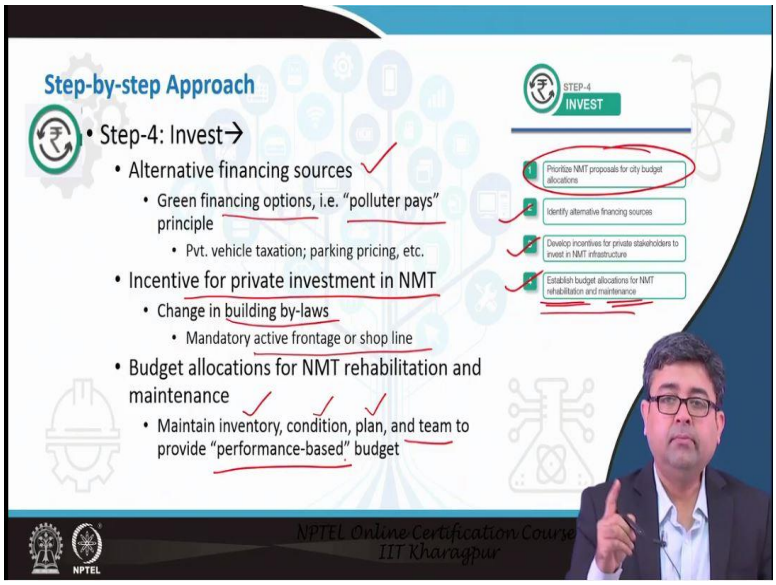

Finally, let us look at briefly look at the other 3 steps that are involved in in the fourth step of 5 step process, which is invest. We have already looked at prioritising NMT proposals. The next step in it is the finding of alternative financing sources. As we had mentioned before, money for NMT projects are always lumped with other projects, other highway projects or other mass rapid transit projects. So, you have to always be ready to find alternative ways of financing your NMT projects. So one option currently that are being explored are called as 'green financing'. Options that employs "polluter pays"—the concept of "polluter pays". So if you have vehicles you need to be taxed more. Or if you have if you want to park your motorised vehicle, you need to pay a

higher parking fee. So those all work on the principle that the person who is polluting the environment is paying more. So that are called greener financing options. The other the next thing to look at is developing incentive for private investment, which should not always depend upon public money to come in. Although these are all public infrastructure, but private investment is very, very essential in these cases. And they can be done by small things, but they all accumulate up into a larger network. For example, if you just amend some of the building bylaws and make it mandatory to have active frontage along the front of your building, active frontage meaning active facilities, active meaning bicycle tracks or sidewalks or whatever. So, when you are having a frontage on a main road or a collector road or something like that, you have to have a footpath in front of it or a bicycle track in front of it. Similarly if you have commercial building coming up, you have to have a sidewalk in front of your shop or so on and so forth. So that is a private investment, i.e. the builder who is building it or the shop owner who is who owns the shop, needs to take care of the frontage of their shop or building. Finally, the last thing to remember while you are investing is to also have some budget allocations for maintenance and rehabilitation. It is not only important to build new NMT facilities, but also to rehabilitate them from time to time and also maintain them from time period to time period. In order to have a budget, you always have to maintain inventory of your NMT systems, you have to always have some periodic condition checks of your inventory. You have to have a plan. So this you have to know that the sidewalk will last for ‘n’ number of years. A Street light will last for ‘y’ number of years. If you know the life cycle then you can have a plan for when to rehabilitate and when to replace them. And also you have to have a specialised team, you cannot just ask the designer or the construction person to rehabilitate and maintain. So you have to have your own team that will allow you to monitor the performance of your infrastructure and you can have a budget that is performance based for maintenance and rehab.

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So, that concludes our lecture, where we have looked at different ways of financing NMT infrastructure and how you do investments, how do you quantify or prioritise your investment priorities. Again, the guidance documents are given here.

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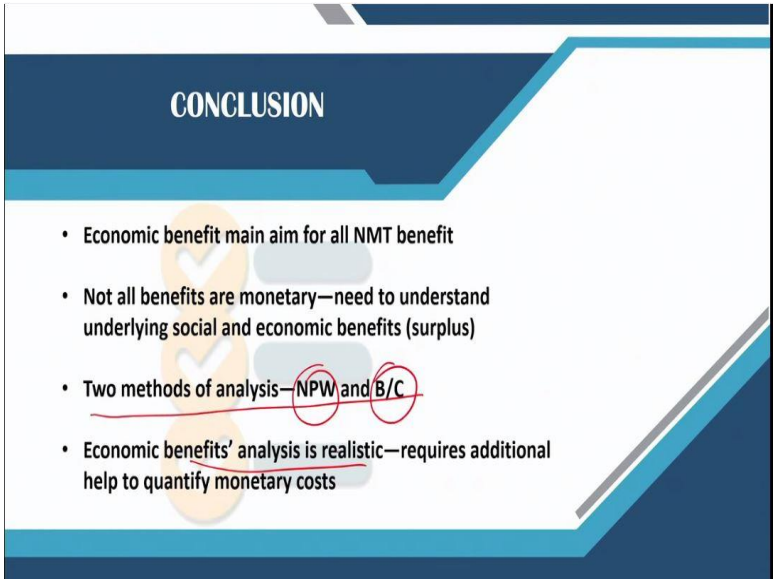

And we have exposed you to 2 different types of methods to determine financial feasibility and economic benefit analysis, net present worth benefit cost analysis as well as consumer surplus. Thank you.