Urban Transportation Planning
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Lecture No. # 07
Conceptual Aspects

This is lecture seven on urban transportation planning. In this lecture, we will continue our discussion on conceptual aspects on the subject matter. Before we proceed further, let us try to recollect the essence of the previous lecture. We may recall that we understood in the previous lecture that the systems engineering process can be applied to study the various steps involved in transportation systems planning process. In that connection, we just listed all the steps involved in the systems engineering process and understood that the problem or set of problems emanate from socio-economic environment.

Then we try to understand the process of problem definition. That regard we try to understand different terminologies in connection with definition of the problem starting from goal, then objectives and then standard. We specifically looked at examples, to understand the concepts of Objective and Standard in the previous lecture. We consider two important examples, one derivative of objectives and standards for a stated goal, community goal of reducing air pollution. We found that there are 11 objectives could be encourage public transport or encourage non motorized most of transport and so on. Then we try to list rated standards for these objectives. To get more specific response from you, I would like just show one or two questions 11 to the previous lecture. The first question is this as recapitulation of lecture six; define the term objective in the context of this particular course, definition of the term objective? Anybody?

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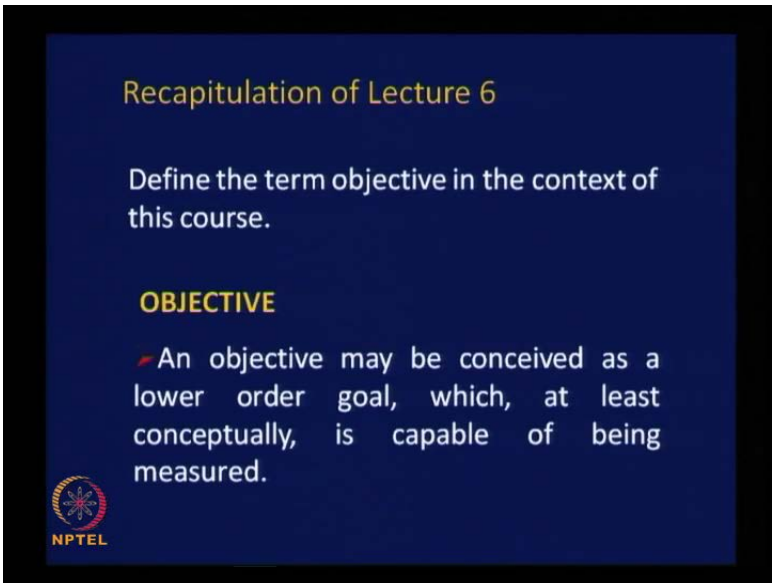

Then I need to give the answer of this question I think, this is a answer, this is a precise definition of the term objective in relation to this particular course of urban transportation systems planning. An objective may be defined or conceived as a lower order goal, at least conceptually, is capable of being measured. Though not quantified very accurately, we can conceptually have a feel of the extent of achievement of any objective. The next question you can guess easily is defined the term standard, the context of this course? Anybody?

Standard is one level more than an objective.

Yes.

Another also it is much more tangible or it is measurable and attainable.

Good, that is a precise definition of standard.

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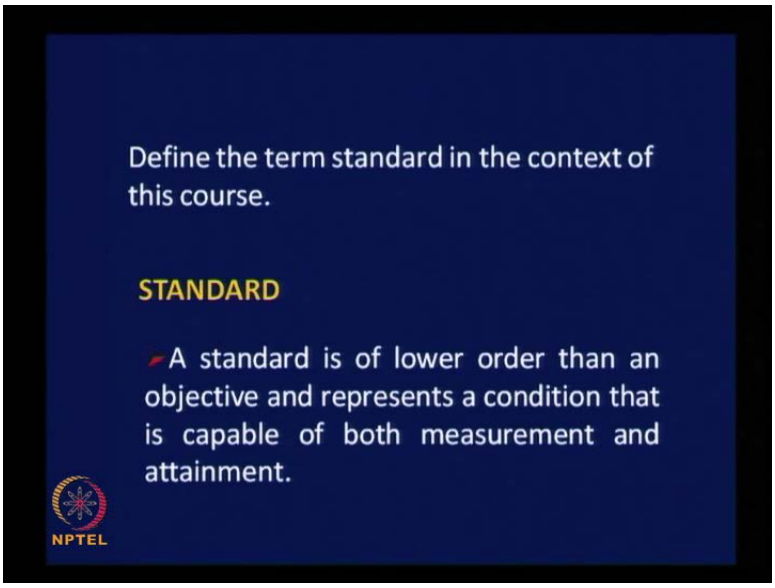

A standard is of lower order than objective obviously, and represents a condition that is capable of both measurement and attainment. That is how we understand the term standard as far as this particular course is concerned.

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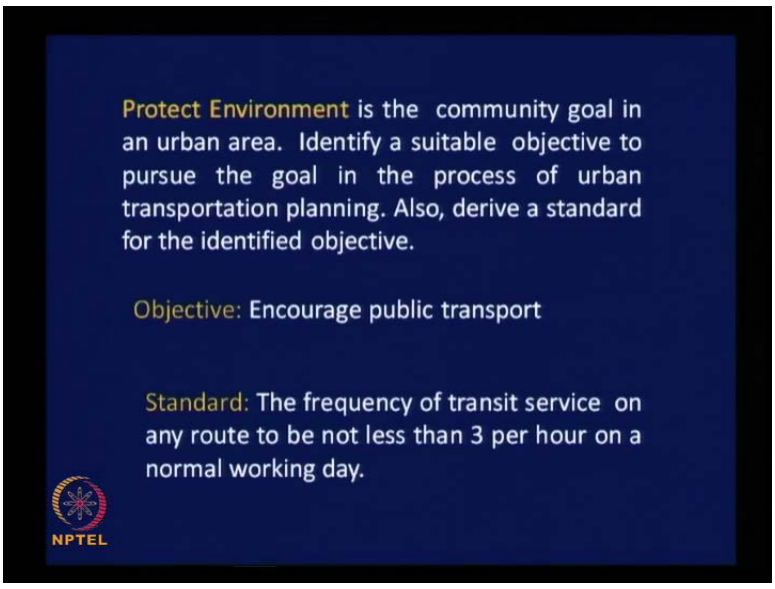

The last question which is rather easier compared to the previous ones, let us say protect environment is community goal in an urban area. We need to identify a suitable objective to pursue this goal in the process of urban transportation planning. Also, derive a standard for the identified objective. So, you need to identify an objective first for this

standard go, and then find out or derive a standard. Yes please. Minimize pollution cannot be an objective in transportation planning process. It can be again a community goal; minimize air pollution from any source including transport system operation. And we are talking about the related objective I have clearly stated here, to pursue the goal in the process of urban transportation planning.

So, it should be related to the planning process.

An objective could be the increased use of public transport.

Increased use of public transport, fine. So that is how we must look at the goal and connected or related objective. So, we can say simply encourage public transport is the relevant objective. And I hope that you will be able to easily derive a standard for this objective, any volunteers to give the standard for this objective? Standard. I will give the standard for this objective; the frequency of transport service of on any route to be not less than 3 per hour on a normal working day. This is related to encouragement to be provided for public transport, but it is easily quantifiable and attainable. That is how you need to understand the term standard related to the planning process, clear.

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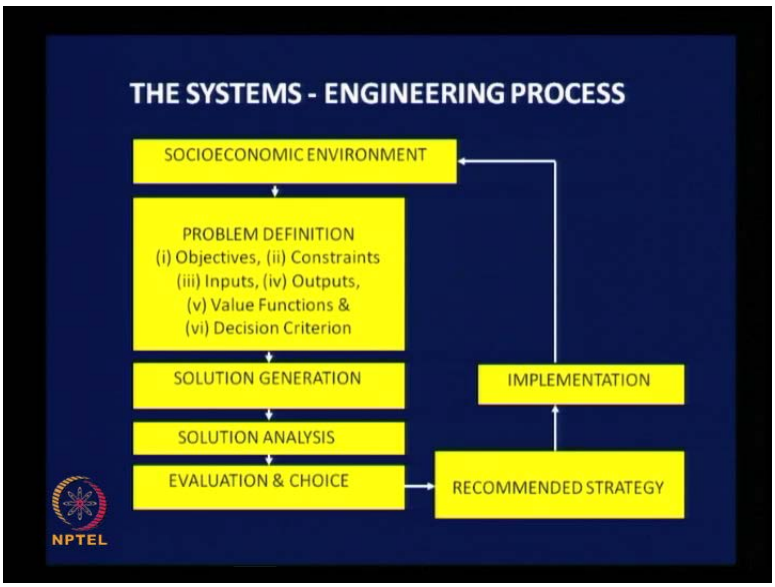

Let us go further, on understanding the conceptual aspects related to the systems engineering process. This box is already known to you and discussed detail, then the second step is problem definition, third solution generation, fourth solution analysis, fifth

evaluation and choice, sixth recommended strategy, seventh and last implementation. Let us try to understand, where we are now discussion in the flow chart. We are in the discussion of problem definition stage of the engineering process. And we have completed our discussion about only one listed aspect namely objectives, we did not discussed the term objective as listed here. We had one term of higher order of the objective namely Goal, and another term lower order to objective namely Standard.

We discussed about three terminologies related to one term listed here as objective in the flow chart. And we are yet to discuss about other five important terminologies starting from constrains, inputs, outputs, value function, and decision criteria. We will go further and discuss about each of these terms in detail.

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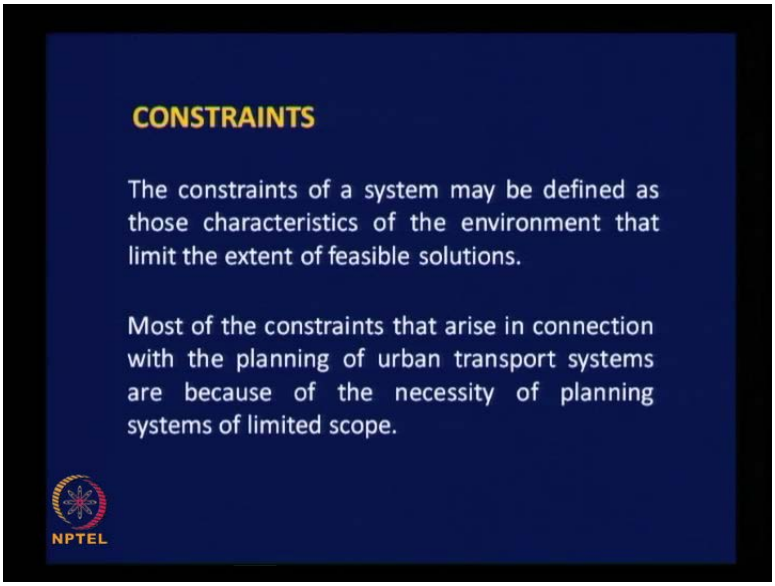

Constraints; the constraints of a system may be defined as those characteristics of the environment that limit the extent of feasible solution. So, they are nothing but the characteristics of the environment; what is environment for the system here? You may recall that is indicated to you that the socio-economic characteristics of the urban travelers provide the environment for the transportation system, is it not? With this understanding, could it be possible for us to identify the characteristics of the environment? That limit the extent of feasible solution. (No audio from 09:31 to 09:37) Most of the constrains that arise in connection with the planning of urban transportation

systems or because of the necessity of planning systems of limited scope, that is a implication of constrain.

When there is no constraint, we can plan for a system without any limitation the scope of the design construction as well as the operation of the systems. When we have constraints, we have to limit the scope of the system that we are planning to introduce in a particular urban area. What were the specific constraints that might limit the scope of systems, any idea? For any project, yes please. Land availability yes, one possible constraint, cost yes, very important point.

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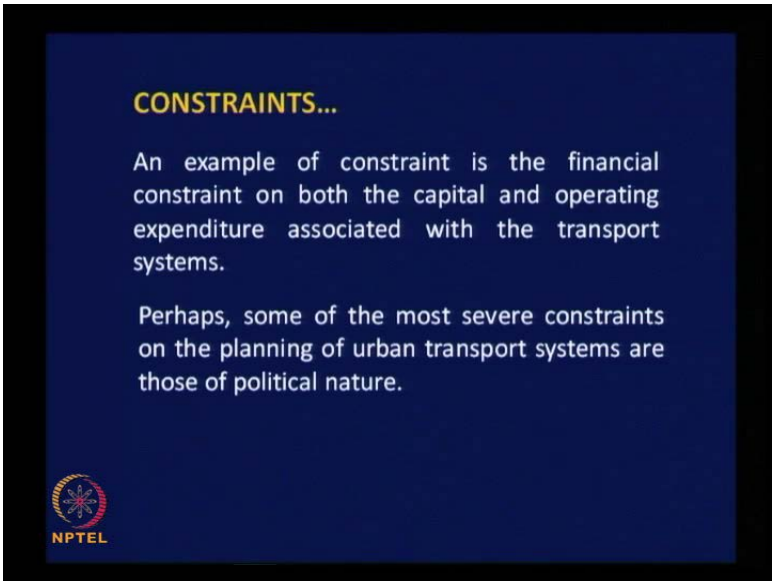

Let us try to formally list the constraints in a systematic way, one example of constrain is the financial constrains as we mentioned related to cost. On both capital as well as operation expenditure, the cost of construction and then operation both together associated with the transport system. It is a very important point to be kept in mind; this is a constraint of the environment, financial constraint. How do we understand the environment, in this particular case? You may perceive that most transport system providing mass transit facility is normally constructed and operated by government particularly, in developing countries. So, here the financial constraint is specifically related to the financial constraints of the government itself. Government we have limited resources, but there could be competing demands for various sectors starting from

housing, food, education, health, transportation and so on. So, they have to apportion the available resource to all this completing sectors.

So, if there is a basic constrain in the availability of resources itself then this is going to be a major constraint in restricting the scope of our system in the planning process. And perhaps, somehow the most severe constraints on the planning of urban transport systems or those a political nature not only financial, there could be some political constraints. For example, in a particular case, it may be necessary to subsidize public transport services, what do you understand by subsidizing? Providing financial assistance operators of a transport service, to meet the expenditure later to the operation. If this assistance is not provided, system may not be able to be operated in an economically viable condition. That is how we need to understand the subsidize in this particular case.

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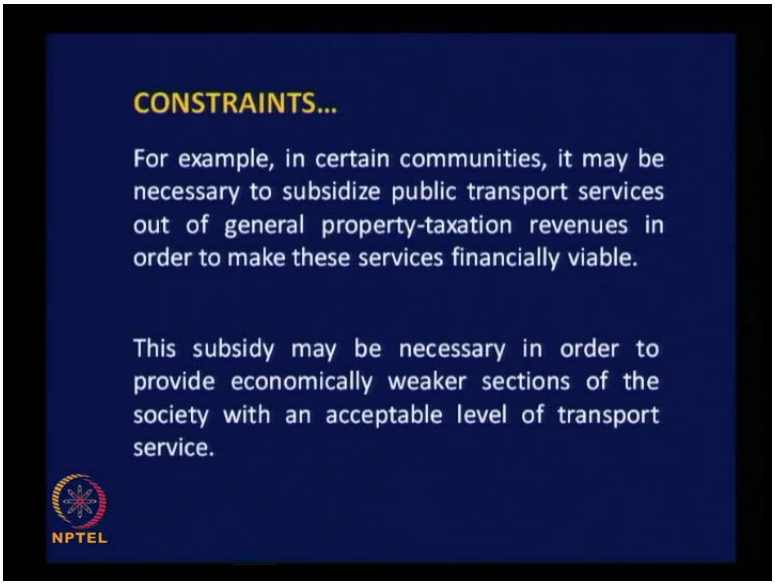

Out of general property taxation, revenues in order to make these services financially viable, why the problem of subsidize arises the operation of transits services? Why? Yes please.

Sir, basically our transits services cannot be made over armatures I mean you would ideally like to have an air condition service or fast service and efficient service.

Yes.

For all that cost money and the money be count of money be common will have to portend will have to, will increase our period of time as in a continuous subsidize, it is not a onetime subsidize of a construction. So that is why we have to have to go and for a which is a practical solution other than ideal solution.

Fine, the point here is we have to get back the money invested in construction and operation of the system from the users. When the users are unable to pay for the cost of construction operation maintenance, then the question of subsidize comes. Normally, transit users are middle class and lower middle class of the population, there paying capabilities limited and transport operation is looked at a kind of social service by the government particularly, transit system operation. So, when the users are unable to pay for the cost of operation as well as construction the systems the question of subsidize arises. That is how the government as to divert some money from the general tax revenue.

And this is a political decision, how much money has to be given to the transit operation as subsidy or the tax payers may feel that too much of money is given to the transit operators and subsidy. And which affects their basic welfare measures, which are to be taking care of by the government. You may recall some standards that we considered example earlier, 15 percent of the cost of travel by private transport could be the maximum cost of travel by transit. How this 15 percent is survived it? Based on the possibilities of taking away some money from the tax revenue and giving, that amount of money as subsidy to transit operators.

Now, the 15 percent may be questioned, why 15 percent give or make it as 20 percent so that subsidy gets reduced, is it not? So, on this questions were arise and it should be a political decision finally to fix the subsidy to provide to transit service operators. This subsidy may be necessary in order to provide economically weaker sections of the society; we can acceptable level of transport service is it not? It is an social issue, which has to be sorted out by the government. So, these are these shows which me to some constraint in the planning for transportation system.

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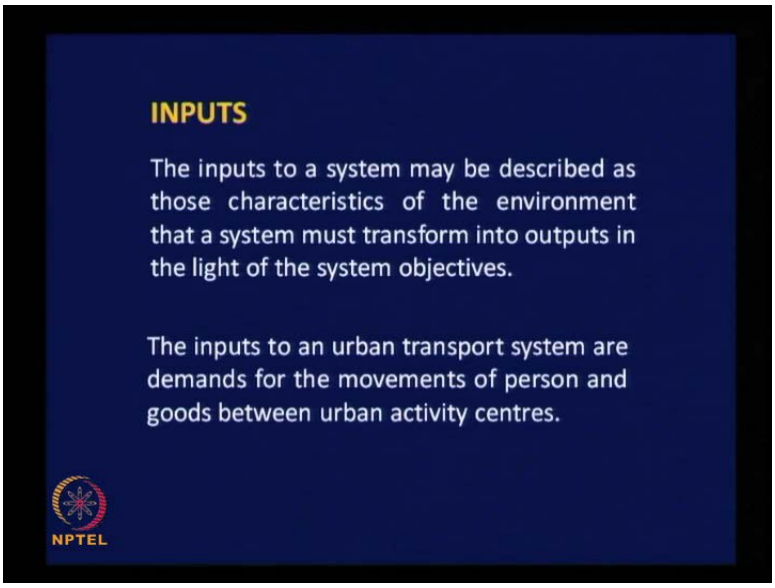

Next important definition of a term which should make very clear is inputs. Inputs to a system may be described as those characteristics of the environment that the system must transform into out puts in the light the system objectives. Based on this explanation, would you be able to identify the input to the system is nothing but characteristics of the environment that is system must transform into outputs. Any suggestion? In general terms you can say that, the input to an urban transport system are nothing but demands for the movements or person and goods between urban activity centers.

That is the input to be system that is demand for movement of people and goods between activity centers that goes as input to the system that you are operating. This demand is nothing but one of the characteristics of the socio-economic aspects of the people and the goods transport requirement of the dwellers, is it not? So, we can clearly understand this as one of the characteristics of the environment.

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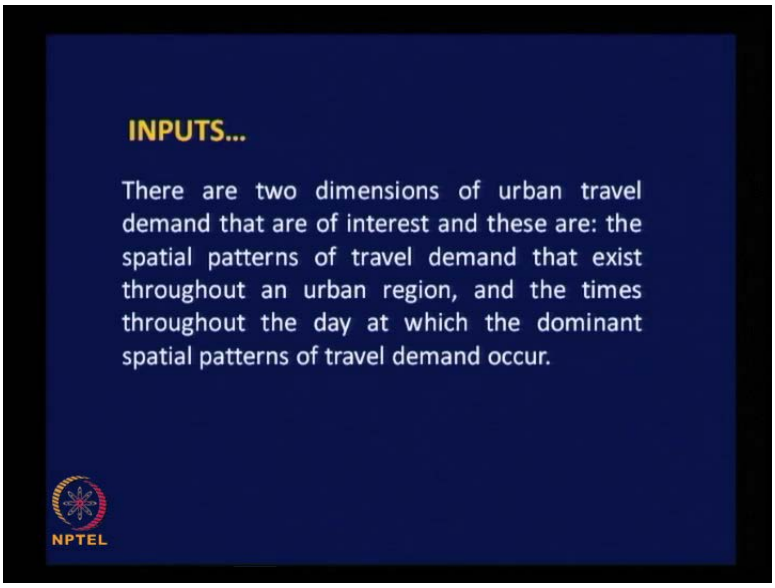

And this is an interesting aspect to be understood very clearly, in connection with inputs. It is not that you can quantify the total input and workout or derive the output of the system. Input is spread over space as well as time. The quantum of demand for movement from zone A to zone B is going to be totally different from the level of demand for movement from C to D. So, it is spatially varying and even if it take the demand between A and B, it is going to be different in the morning period and different it the non pick periods and again different during evening periods. So, it is varying spatially as well as temporarily that is how assessing the demand itself is the challenge, and then we need to transform the demand into system output.

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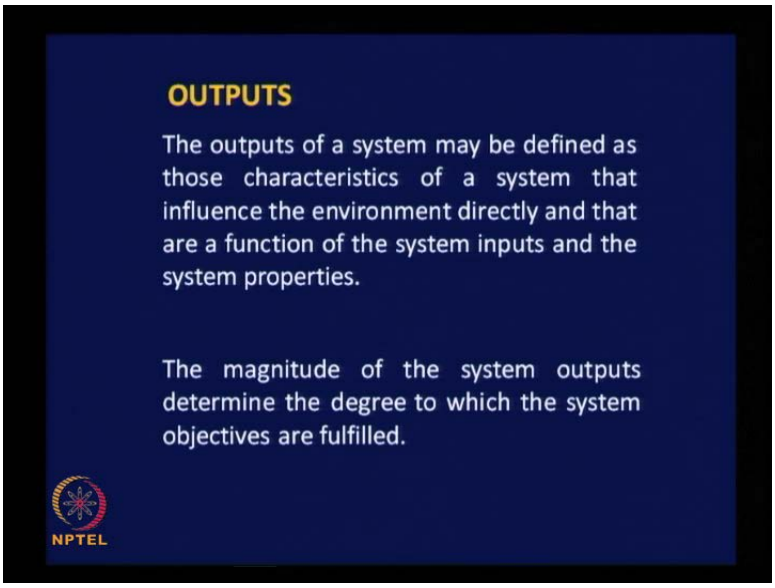

The outputs of the system may be defined as those characteristics of a system that influence the environment directly; and that are a function of the system inputs and the system properties. The point to be understood very clearly here is the characteristics of a system that influence the environment directly. So, what are the characteristics of the system that influence the environment directly? As I mentioned environment is nothing but the system users and their socio-economic characteristics that provides the environment. What are the characteristics of the system that directly influence the environment? Let us say we are planning to metro rail system alone a corridor in urban area.

What are the characteristics of the metro rail system which may influence the uses of for the likely uses of the system? We look at system characteristics in terms of it speed, how fast it will take me from one point to another. Then another important point about which we think is a cost, how expense it is going to be. And those who are concerned about safety, they will also think about the level of safety available in that particular more and so on. So, these are all the characteristics are influence the system namely the uses and the socio-economic characteristics. So, the magnitude of the system outputs determine the degree to which the system objectives are fulfilled. System outputs as we know could be speed level of safety are cost implication and so on. The magnitude of the system outputs, determine the degree to which the system objectives are fulfilled.

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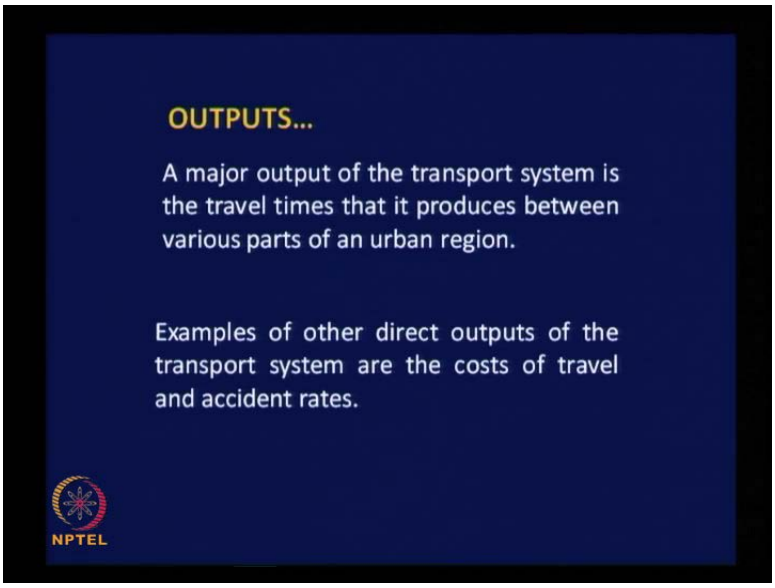

As we discussed a major output of the transport system is a travel times that it produces between various parts of an urban area. And other important outputs are of the transport system or the cost of travel and accident rates. And several other outputs can be considered for example, level of comfort available in a mode of transport in a system that we are planning to introduce. Or sometimes the level of convenience that is system can provide to a particular set of uses, all these things come under system outputs.

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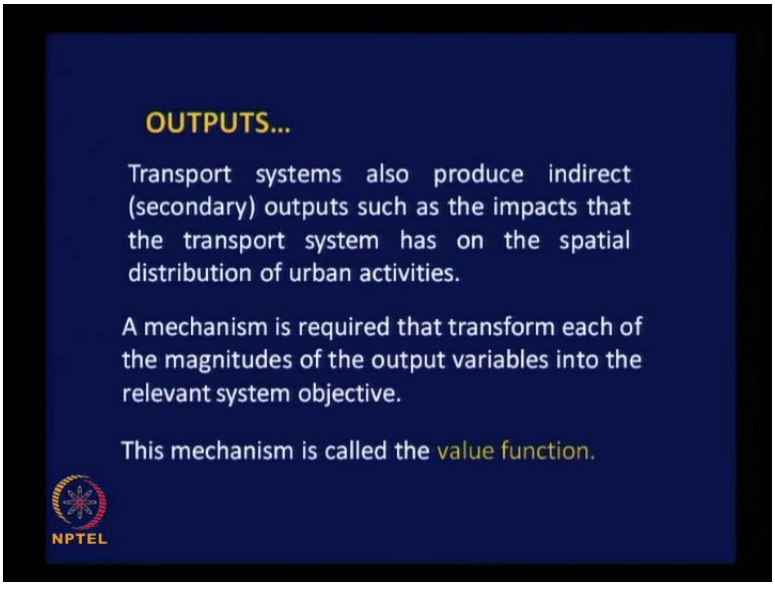

Transport system may also provide some indirect outputs. One example given here is impacts that the transport system has on spatial distribution of urban activities. What do you understand these particular by this particular statement impacts that the transport system has on the spatial distribution of urban activities. Can a transport system make an impact on the spatial distribution of urban activities, what are the major urban activities? We have already classified the urban land use and activities are related to the different type of land uses.

So, we can understand activities in this context as housing for industrial activity, institutional activity, recreational activity and so on. Now, point made here is there could be indirect impacts created by a transportation system in the form of spatial distribution, changes in spatial distribution of urban activities. This is very much true the context of developing countries, developing countries experience the process of transport system induced land use pattern. Land is pattern itself is induced by transportation system. Ideally speaking, we must provide transport system to suit or max land use pattern.

But what happens in the developing countries is that we introduced some transportation system, and we find over a period of time there are different kinds of land uses developing on both sides of the transport corridor. So, this is what a mean by transport system induced to land use development which is not desirable, but it happens mainly because we have very poor transport infrastructure; wherever there is some infrastructure facility available there is a faster growth of land use of different kinds along such corridors.

That is what is indicated here that could be indirect impact or effect of introducing transport system. Now, what we need is the understanding of the requirement of a mechanism that transform each of the magnitudes of the output variables into the relevant system objectives, it is very loaded complex sentence. We should be able to transform each of the magnitudes of the output variables of the system into the relevant system objective; that means first we should fix a magnitude or unit of measurement for system objective. And then probably, we should try to quantify the output of the transport system and then compare the transformed output of the system will be system objective.

Let us say the system objective; one of the objectives says to minimize travel time and second objective, let us say is to minimize accident rate. These are the two objectives already identified for development of the system. Now, after planning for a particular system one will be able to perceive the travel time implication on a system that we are planning. And we will be able to quantify the travel times savings, because of the new system that we are planning to compare to the old system. Once you are able to quantify the travel time savings, it should be possible for us to convert the travel time savings into a comparable unit.

Is it possible to convert travel time savings into money value? It is possible provided all of us agreed that time is precise commodity and it carries money value. And of course, the money value of time of individuals might vary depending upon were individual characteristics any capability age, their monthly income and so on. But still each individual's time is valuable. So, when travelers save some amount of time than time is going to be used productively by them for some other activity. So, it results in some additional productivity if there is a saving in travel time. And it is possible to work out the money value of time of individuals. Wherever basis available and statistics are available and it is possible to estimate the average money value of travel time of different categories of urban travelers.

Once we are convinced about it, then you can say that it is possible to quantify the time saving involved in the particular system and aggregate the total time saved and get some money value for the time saved. Similarly, it should be possible for us to quantify the money value of accidents, provided all of us agree that every individual is contributing for the productivity of a country. It is to some way or other each one of us or contributing for the overall GDP growth of our country. If that is the assumption, then obviously if life of an individual is lost, there is a loss to the productivity of a nation. If this argument is accepted, then we can say that every accident cause money to the society as well as the whole nation. On this basis it is possible to quantify the money value of different types of accident, fertilities, major injuries, minor injuries, property damage and so on.

When a person gets major injury, what happens? The productivity of that individual gets reduced little; there is some loss of productivity. And we have lot of data available to quantify the loss of productivity due to various reasons like fertility, major injury, minor injury and so on. And it is possible to assign many values for all these aspects and

aggregate the total money value in terms of a money value of reduction and accidents after introduction of a new system. Now, if this is a basis then it is possible to accept this statement. A mechanism can be developed definitely transform each of the magnitude of the output variables into the relevant system objective. This mechanism is called value function, getting some value for any objective as well as the output values of transportation systems.

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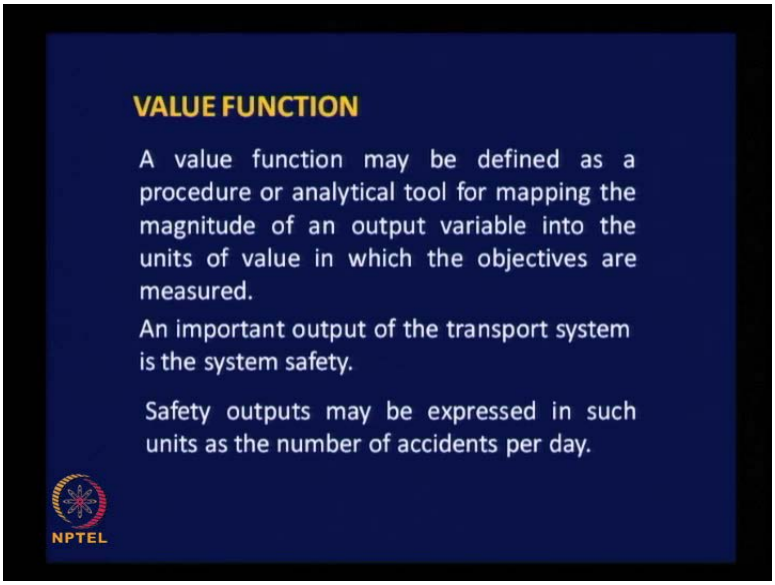

So, we can define value function as a procedure or analytical tool for mapping the magnitude of an output variable into units of value in which objectives are measured. An important output of transport system is a system safety, just to given example. And let us see how to develop value function to quantify system safety and assign money value. Safety inputs may be expressed in such units as a number of accidents per day in cities and terms is quite common, basis of understanding the level of safety in urban travel. Number of accidents per day, accidents of all kinds, as I indicated accidents of minor injury, major injury, fertilities are only property damage and so on.

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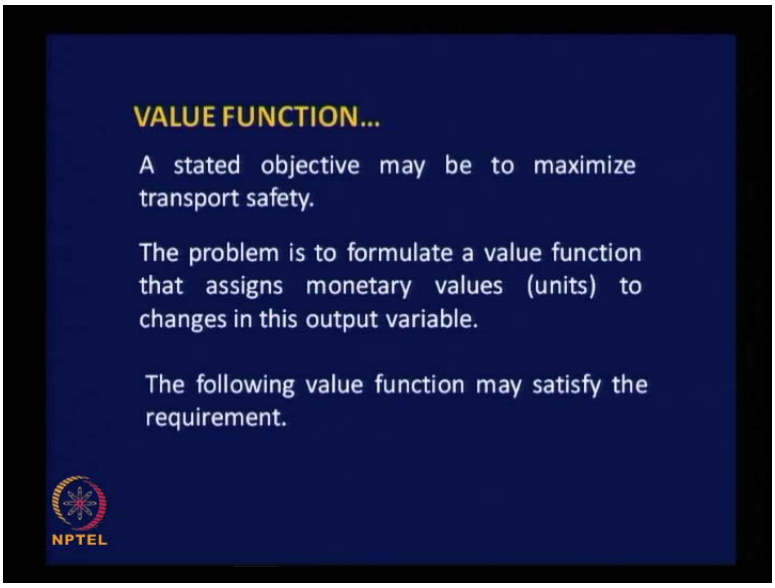

Now, a stated objective may be to maximize transport safety. The problem is to formulate a value functions that assigns monitory values, units to changes in this output variables. How to assign money values for changes in this particular output variable, particular in this case level of safety? The following value function may satisfy the requirement for example.

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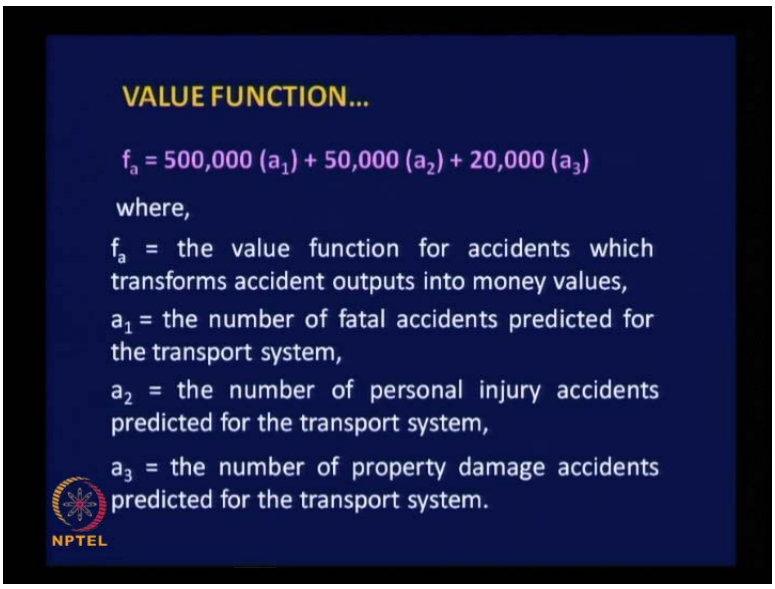

This is an example of a value function f a is equal to 500,000 a 1 plus 50,000 a 2 plus 20,000 a 3, where f a is equal to the value function for accidents which transforms

accident outputs into money values, a 1 the number of fettle accidents predicted for the transport system, a 2 the number of personal injury accidents predicted for the transport system, a 3 the number of property damage accidents predicted for the transport system. For this purpose, we have classified the accidents into three broad categories fettle, involving injuries both minor and major and property damage. These costs indicate just average cost based on or the available, later you can easily workout the average cost of each of these types of accidents.

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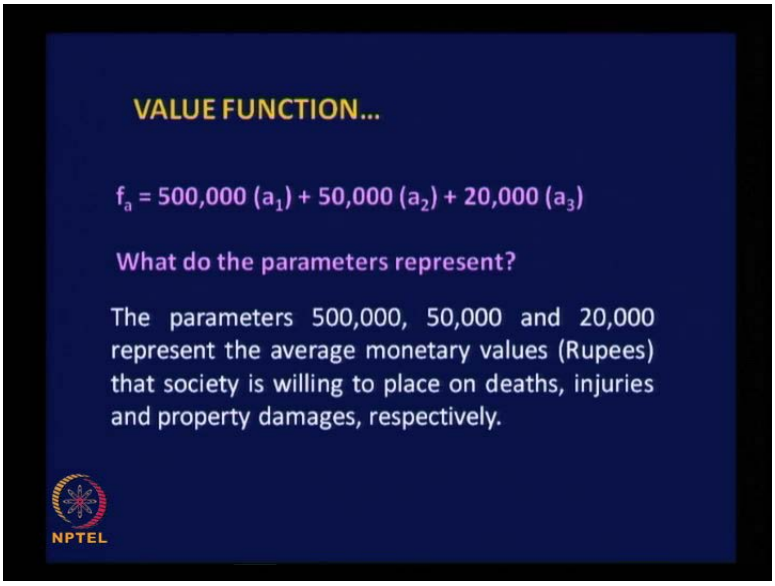

Now, what do the parameters represent in this equation? The parameter value 500,000 50,000 and 20,000 represent the average monitory values in rupees that society is willing to place on deaths, injuries and property damages respectively. Why society's willingness is brought into this context? You would have heard about accident compensation being awarded by course. When accidents occur, court is awarding the compensation. What is the basis on which aha court decisions are taken? It is based on the money value attached to the life of an individual buy the society.

So, in this particular case, the society is attaching the value of 500,000, 500,000 is it not? To the life of an individual on the average. And the money value attached to the injuries is just 50,000 rupees on the average; and for property damage 20,000 rupees per incident involving for per accident involving property damage. Another related question is how do we get this equation? You can get this kind of equation using regression analysis, if

we have sufficient data on different types of accidents pertaining to a particular city. It is nothing but a simple linear regression equation, relating the money value total money value of different types of accidents and then the weightages given for different categories of accidents.

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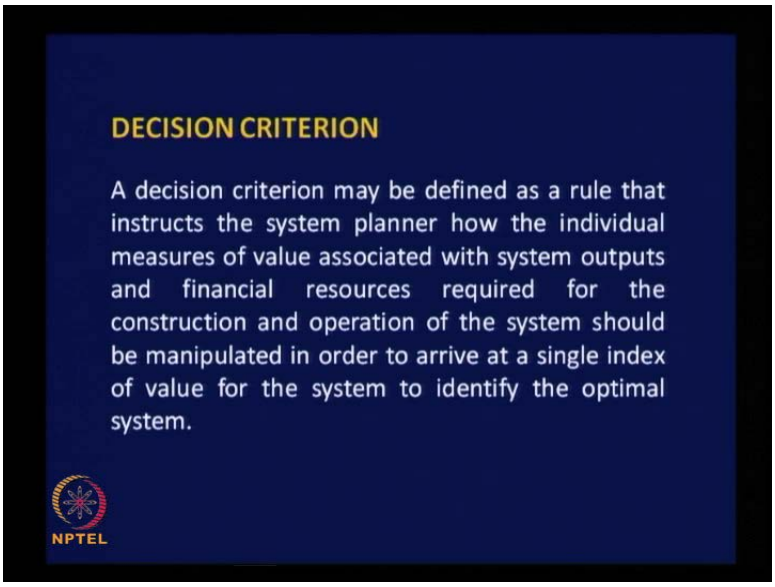

Next decision criterion; we need to take decision, we fix a objectives and then we just propose different alternative transport systems. And study the operative characteristics of different system and quantify the outputs of the different alternative, the form of reduction in travel time, travel cost and then possible reduction in the accidents. After quantifying each of these characteristic we are transforming these characteristics into money value. This implies that we are measuring the level of obtainment of objective in terms of money; minimize travel time means to what extent we are going to minimize? To answer this question, you must have some data about the cost implication at present involved in urban travel. Then if you introduce a new system, what is going to be the reduction in cost over all cost of travel after introducing that particular system?

So, once you know that it indirectly implies that you are able to quantify your objective in terms of money value. So that is how we need to understand the possibility of transforming system characteristics, system outputs into money value as well as the objectives into equal money value and comparing both. And decision criterion will be based on this comparison. So, we can understand in decision criterion or define the term

decision criterion as a rule, that in strikes the system planner. How the individual measures of value associated with system outputs by travel time accidents and so on. And financial resources required for the construction and the operation of the system should be manipulated in order to arrive at a single index of value for the system to identify the optimal system.

Let us say we have three alternative systems as per our plan and want to identify the one which is more optimal and economically viable. Only basis is to quantify a total benefit occurring out of the systems construction and operation as well as the cost implication for developing the system in the form of constructions cost and maintains cost and operating cost.

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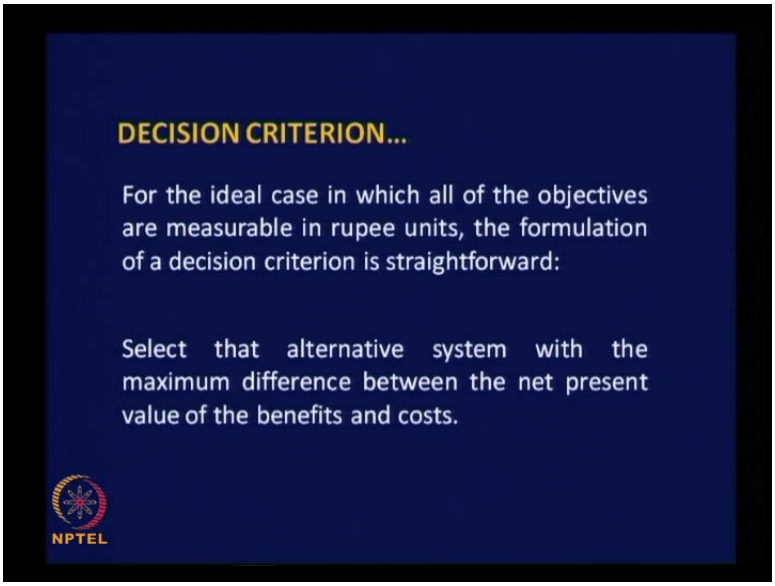

For the ideal case and which all of the objectives or measurable in rupee units, the formulation of a decision criterion is straight forward. To quantify the total benefit, quantify the total cost and compare the benefiting cost in each of the alternatives and choose the alternative which gives a maximum different between the benefit and cost. It is very simple and straight forward, if a whole decision process is based on only cost and benefits. Is it always based on cost benefit analysis? It can be based on only costs benefit analysis provided, we are able to quantify all possible benefits and assign money value. Quantification of cost aspect is very easy, because we do estimates for cost of

construction, cost of maintenance and cost of operations. We can accurately quantify the cost implication.

Quantifying the benefit is not that easy, you can quantify benefits like reduction in travel time, reduction in accident rate and so on. Beyond that there are number of benefits that will be enjoyed by the travelers by a particular system. The level of comfort how to quantify, the difference in comfort level assign money value, the level of convenience or the level of general trip satisfaction. There is another concept which is very much appreciated in the developed countries, general satisfaction of trip making using a particular mode.

So, these are all highly qualitative, it is extremely difficult to assign money value. But still you must consider these aspects also before taking a decision. Our decisions finally, should not be based only on cost benefit calculations, should also be based on other qualitative aspects. Now, the question is how to take into account these qualitative aspects? Any suggestion? Let us go further probably we will get some clue. So, as I said if it is based on cost benefit analysis, you can select the alternative system with the maximum difference between the net present value of the benefits and cost. What do you understand by net present value of the benefits and cost, why worrying about net present value?

Because, money has some value in the for example, if we invest the money we may get some interest on that.

Yes.

However, in the future, if you want to estimate we do not know the present value of the future investment you need to give. So, we are expecting it in the net present.

Good, good, the reason is the understanding money earns money over a period of time. If you have 100 rupees, it is going to multiply into several hundred in course of time. And if you are expected to get several 100 rupees in the future, the present value of that money is going to be much less. We need to accept an economics that money earns money over a period of time. Based on this understanding, we need to understand this particular statement, net present value of the benefits and cost.

Cost is incurred presently; we construct the facility, maintain the facility on at the base A condition and operate the facility. Whereas, benefits are going to approve over a period of time over the next 10 years, 20 years, 30 years, 40 years and so on, but our interest is, what is the real value of all those benefits to the basal condition? So that we will be able to compare the cost and benefit and find out which is more. So, this process of converting the future benefits to the current value is called discounting procedure. So that is how we should be concerned about the present value of the benefits, and then cost for comparison purpose.

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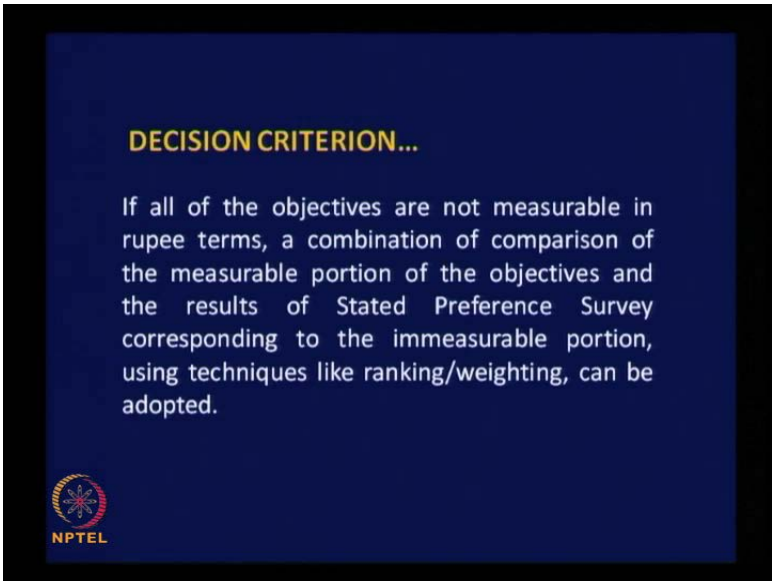

And to continue our discussion on decision criterion, if all of the objectives are not measurable in rupee terms as I mentioned, a combination of comparison of the measurable portion of the objectives; and the results of stated preference survey, corresponding to the immeasurable portion using techniques like ranking, weighting, can be adopted. What do you understand by stated preference approach? As the name implies it is the preference stated by the potential uses of the system. Let us see, you have three alternatives with very well known cost benefit ratios. You have to go to the potential users and explain to them about the operating characteristics and the cost implications of each of these alternatives, and then get the response with regard to their choice; based on other aspects, which are not quantifiable like comfort, convenient and so on.

So, you must approach all categories of users, different socio-economic stator, get response from all kinds of users and then aggregate the response. While aggregating we must resort to the process of ranking waiting and so on. What do you understand the ranking process? It is a response given by the potential uses. When you have three alternatives, if you ask them to choose the best one, they must choose or you can give them the option of ranking in terms of comfort, how do you rank these three alternatives, Number 1, number 2, number 3? Their own perception, they will give ranking for these three alternatives, get this information from all types of uses.

Then there are methods available to give weightage for the ranking process to finally, get some number, aggregate number indicating the preference of different alternatives by the users. And include this information also into a cost benefit analysis and then finally, come to a conclusion about implementation or choice of a particular alternative. So that is how final decision with regard to the particular alternative to be implemented is taken.

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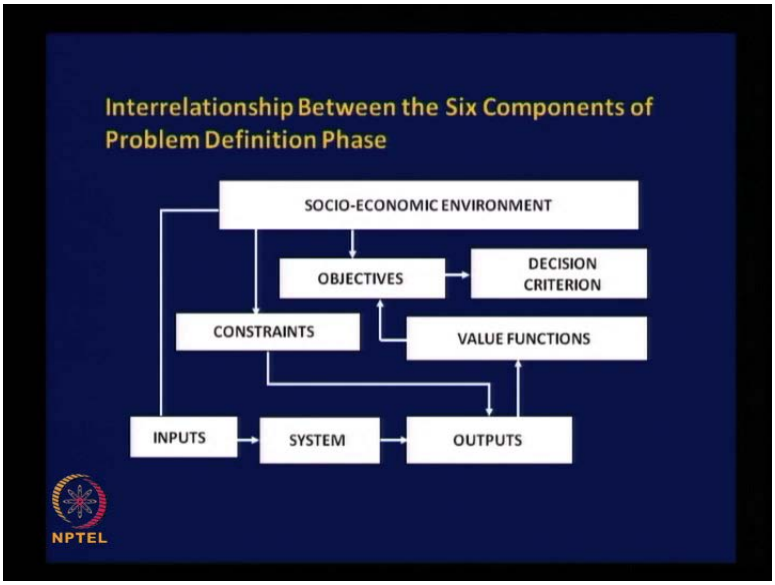

And let us try to understand now, the inter connection between the different concepts that we are discussed so far in problem definition phase. We started our discussion with the understanding of socio-economic environment, is it not? And there are free important aspects that emanate from socio-economic environment in the problem definition process. What are the three aspects that emanate from socio-economic environment?

May be I will give the first one; inputs to the system come from socio-economic environment, is it not?

Input the system provided by the socio-economic environment, anything else? System constraints also emanate from socio-economic environment, is it not? If the society is very rich they may not mind having a very expensive system. Society is poor you must think of take this constraints into account and design systems of limited scope. Then objectives as he pointed out objectives emanate from socio-economic environment. These are the three important term aspect related to problem definition that directly emanate from socio-economic environment. And we discussed about other aspects related to problem definition, which are directly related to the system namely system output.

And constraints decide the system output. If you are able to spend more money and introduce a metro system and there is no constrain, then output you know, what will be the output? If there is a constraint output will be different. So, there is an implication of constraint on the output of the system. Then value function, we want to transform the outputs into money value for comparison purpose to check to what extend we are able to achieve the objective by this particular alternative, is it not? Value function and then you use the value function to check the extent of achievement of the objective. So, this is how the various components of problem definition phase or interrelated. This understanding is also important, we cannot just understand these aspects in isolation, the inter connectivity is also very important. Finally, decision criterion it is obvious, decision criterion is based on the objective or understanding the objective of the planning process that is initially said.

So, we will complete our discussion with this, and continue with the rest of the aspects related to transport system, engineering process in next class. To summarize in this lecture, we continued our discussion after defining objectives and standards. To understand other aspects like input, output, constraints, decision criterion and so on. And finally, understood the inter relationship between all the aspects related to decision making process. But this we will close our discussion for today; we will continue our lecture in the next class.