Introduction to Multimodal Urban Transportation Systems (MUTS)
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Module No # 11
Lecture No # 55
Urban Transportation & Sustainability Park & Ride (P&R) Facility Planning

Welcome back friends so in this last lecture in this series we will be now looking at one specific multimodal facility which is the park and ride.

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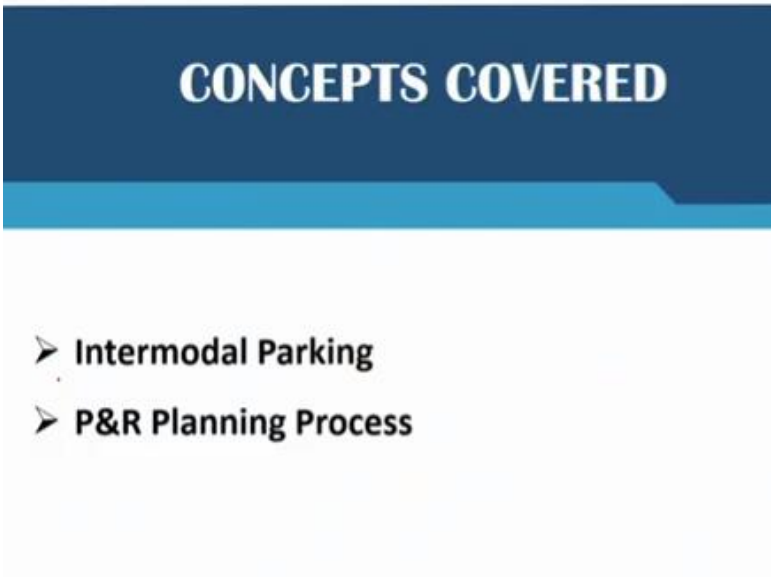

We are going to give you the idea about what is the planning process that goes into establishing a park and ride. Why park and ride are necessary element in multi model urban transportation system. And give you a mathematical way to determine where to locate your park and ride station.

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So there are different types of park and rides and we gave you a little bit of an example in the previous lecture. A park and ride could be a local park and ride that is serving as a collector. For example a transit terminals bus, metro etc. So we told you that even a metro station can be considered as a park and ride station because you can park your vehicle at that metro station and ride the metro ride or ride the BRT. So even if you come by bicycle you can park a bicycle there. If you come by 2 wheelers you can park your 2 wheeler there. So that is a basic type of a park and ride facility. Then it could be a remote park and ride facility which is intercepting automobile trips near origin with express bus, rail service to CBD and the activity centers. So what happens is, may be you have a suburban area and there is a lot of demand for people going to the central business district in morning because majority of them work in that central business district from this suburban area. However the suburban area is a little bit large and you cannot have your express bus or rail service go into all parts of that suburban area. So if you have such a situation, you allow for all of these people in the suburban area to kind of collect themselves at a location that is closer to this express rail or express bus. All of them, come drive there to that place or dropped off at that remote location. And from there they take on the express bus or the express rail so that is kind of the concept of a remote park and ride facility and we will show you pictorially how they are different. And then there is a peripheral kind of a park and ride facility that is on the edge of the CBD or activity centers usually within 2.5 kilometer of the destination. So what happens here is you have park and ride facility at the edge of the CDB itself so may be

the CBD is such an area where the authorities have prohibited the use of single occupancy vehicles or private vehicles. So many of the CBD areas around the world, because they are so heavily polluted, some of the strategies are to avoid single occupancy vehicles from entering into the CBD and encourage the use of only sustainable modes within the CBD that includes public transportation bicycling and walking. So what they do in the periphery of the CBD is that they will allow people to drive till the periphery park and ride lots, park their vehicles there and then they ride either a bicycle sharing system or a metro or a local public transit or whatever it is. So these basically are 3 broad categories of park and ride facilities that we are talking about

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The primary intent or advantage of the park and ride facility is to increase transit, travel. So what happens is public transit, like you know, usually runs on fixed routes, they cannot come to your doorstep. So if they cannot come to your doorstep one of the disadvantages is if your origin or your destination is away from this fixed route. Usually then what happens is people are discouraged from using the public transport system. They feel that well just to access the public transport station I have to go 2 or 3 kilometers, whereas my total journey length in itself is maybe 6 or 7 kilometers. So should I go one third of my trip length and then change a mode and then get to my destination or should I just pick up my vehicle and go to my destination. So that is the choice thought process that goes along when you are talking about accessing public transportation system. So since it is on fixed routes on sometimes even fixed right of way like such as rail, in order to encourage or attract people to using that these park and ride facilities

were first thought of. Since the public transportation cannot come to everyone's home what can be do is we can now provide this kind of remote facilities or this kind of intermediary facilities where you come to that place and from there onwards we will provide you or services. So that was kind of the idea that we by providing park and ride services almost they were giving you the impression that public transport is coming closer to your house than where it was originally because of its fixed route right. So that is the thought process that went into these designing or providing these park and ride facilities. They could reduce urban traffic congestion, so they are likely to increase the public transit mode share they will reduce definitely the use of private vehicles and hence they would reduce traffic congestion. Automobile park and ride lots have been seen to have modest reduction local traffic because if you allow for parking of cars at such park and ride locations so people would then access these locations using that cars rather than using sustainable modes. So automobile park and rides have not been so successful in reducing local traffic however bicycle park and ride lots have greater economic and environmental benefits. So public bicycle sharing system if it is available in your city or if you are looking to bring it to your city then you should have such public bicycle sharing systems share station space with your metro or your larger BRTS whichever you have in your city. So that will definitely give you lot of economic and environmental benefits. Shopping centers adjacent to park and ride facilities tend to benefit the additional shopping. That is why the entire TOD is envisioned in India to have financial benefits for designing such park and ride transfer facilities because otherwise if it is just an open lot where vehicles are parked then it is not the most efficient or economically viable means of space utilization. You have to utilize the space in multiple, fashion in today's environment. You cannot have a single use for one type of facility that becomes unviable during the course of the time.

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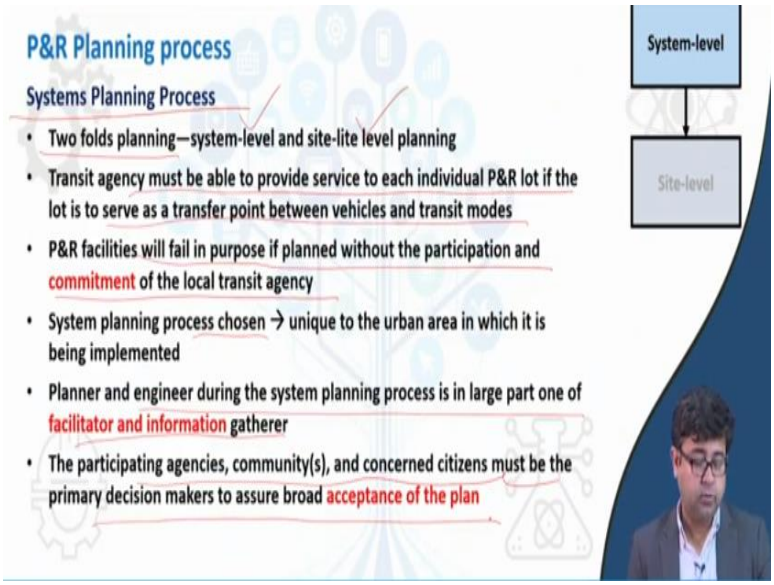

Park and ride planning process adopts something called the systems planning process. They are twofold, one is the system level and the other is the site level. So you have to look at a park and ride facility from the point of view of the urban transport system. As a whole connect all the park and ride lots appropriately and then you have to have some site specific planning for each of the park and ride lots. For example a transit agency must be able to provide services to each individual park and ride lot if it serves at as a transfer point between vehicles and transit modes. Park and ride facilities will fail in the purpose if planned without the participation and commitment of the local transit agency. You have to definitely partner with your transit agency because this facilities are meant to enhance the transit usage. The role of planners and engineers during the system planning process are in large part of facilitators and information gatherers. So you have to have lot of information that has to be exchanged between transit agents, the transit operators and the park and ride operators. If you do not have lot of information that is exchanged then these things will start to fail because now if I as a potential user of the transit system do not know if this park and ride lot is full. There may be a scenario in the morning when there is a morning rush hour a park and ride lot gets full. If that information is not available to me prior then I go to this park and ride lot and find that, well it is full and then I am already in my car. So that will encourage me to just take my car and drive to my destination and not make that trip on transit. So that is a loss of one transit trip and similarly if 100 people lose and have not information about the parking availability they would again start driving. So this is a very

important aspect in the case of park and ride facilities. That information has to be gathered and disseminated to the users. Of course participation of agencies, communities and concerned citizens must be the primary decision makers. Several stake holders have to be always consulted prior to planning or setting up any kind of a system.

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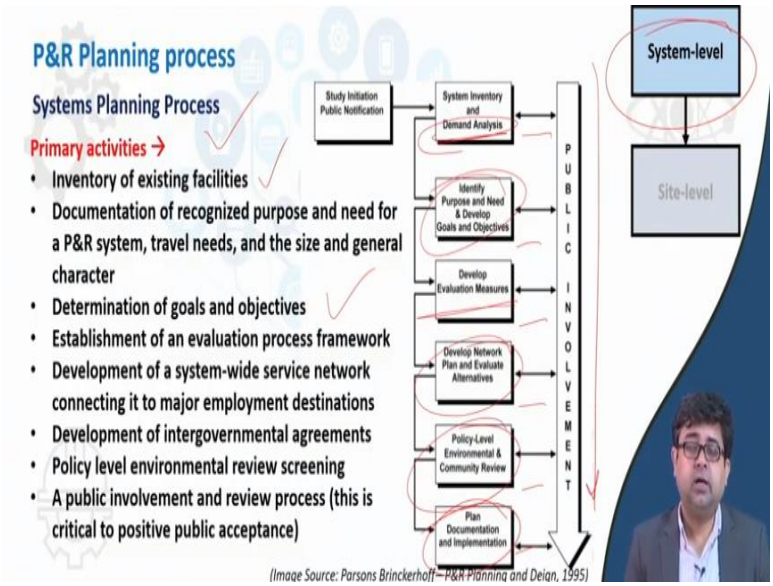

So the primary activity in this and rest of all the activities and you would see that public involvement is there in each of these steps. All of these activities are a pretty generic in nature but they have to be followed needless so as to develop these park and ride at a system level otherwise you would see that they are working good at individual level but they are not working very well at a system level. So you have to have first an inventory of course then you have to have a demand analysis. You have to know how many people actually would want to park at that station and take the metro. If you do not know the demand then you would not be able to provide for so many parking spaces. Then the situation arises where people would come and get no parking spot and then they would just have to drive away in their vehicles. Obviously you have to set up some goals. The goals could be that transit ridership would increase by 5% if I have a good network of park and ride lots. Because remember the intent of park and ride lots is to increase the ridership of public transport system. So if you work with that goal in mind, that today the public transportation ridership in my city is 10% which is very low and we want to increase that. In order to increase that we want to now put in our park and ride lots. Now the goal of this park and ride lot system would be to increase the ridership by 2% maybe. If you have that

goal in mind then you can work towards achieving that to goal. There always has to be goals and objectives that have to be set otherwise you are just working aimlessly. You would not have any goal or aim towards working. So setup your goals and objectives, develop metrics will always measure whether you are working towards your objectives or goal or not. It is very important that these measures are monitored at specific time intervals, not only at the end of the year or when somebody higher up has asked for an answer. It is always a good practice to have continuous monitoring using these measures of how your system is working. Or develop network plan and evaluate alternatives. Maybe there has to be a plan B if your current network of park and ride lots are not working. Then what is the alternative? You have to maybe tweak the design of the park and ride lot. Maybe you have to reduce the parking cost of that lot. Maybe you have to subsidize the ticket cost of the transit line for people who you are using the park and ride lots. So there are many strategies that you can develop in order to attract more transit ridership and have at least 1 or 2 alternatives in place. A policy level environmental and community review of course has to happen from time to time whether sometimes people queuing up at these park and ride lots to enter or leave may make such areas into environmental hot spot. Suddenly all these cold engines are starting up in the evening when people are returning from work and now everybody wants to exit the park and ride lot. So that whole area becomes environmental hotspot and if there is a lot of residential building surrounded. People may object to it. So how do you plan environmentally for such situations? You have to have some review plans and monitor it often or periodically in order to have mitigation plans, etc. So these are generic steps that need to be followed in developing a system level park and ride facility.

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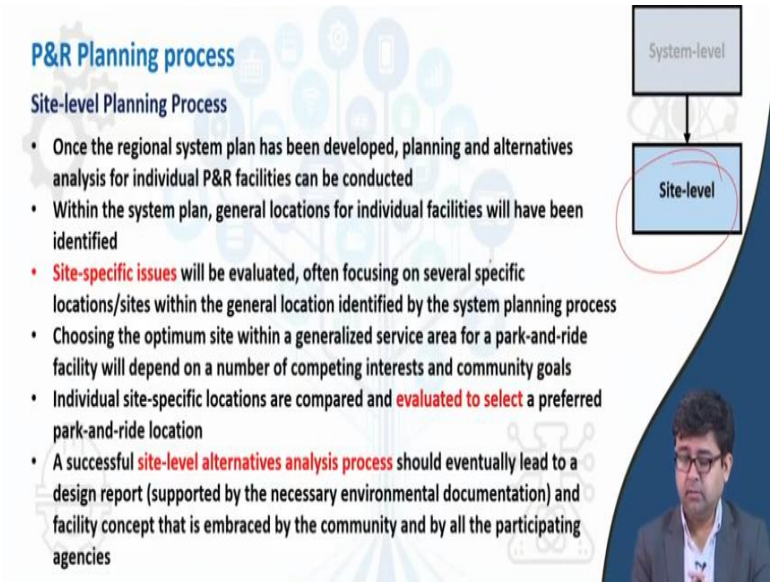

Then when we are talking about site level planning process, which site to pick for your park and ride facility becomes very important consideration. Because the site should not be become an environmental hotspot such that it is inconveniencing the people who live around it. The cost of the land becomes an issue because now you have a parking structure in the middle of a big residential or commercial area and that may play a role in picking which site you would develop your park and ride lot. The connectivity to the transit line is of course one criteria. You have to have the site well connected to the existing metro or BRT line. It cannot be such that there is a 200 meter distance from your park and ride lot to the station then that extra 200 meter is something, which becomes an inconvenience for the person who is parking at this lot and has to walk. Then you have to provide shelters for walking, maybe during the rain it becomes a problem. So when you are picking a site there are multiple considerations that you have to take into account based on which you have to design for.

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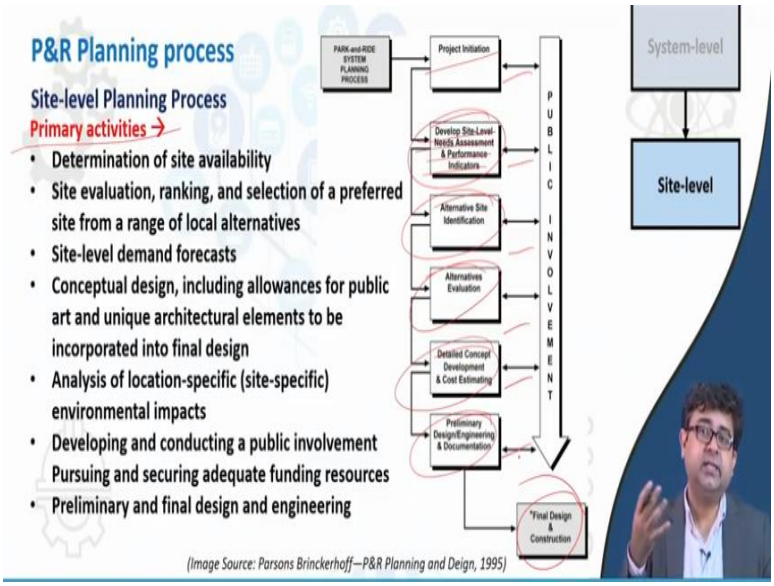

And what we will be going through today is letting you develop this site analysis or this site picking process. We will show you a mathematical way in which you can pick from alternative sites that you have. Again if you, want to have a check list of all the processes to know whether you have followed all the processes in the site planning process. After you initiate the project you develop a site level needs assessment and performance indicators. Again you have to have certain performance indicators performance measures just like we had it in system levels. Now site specific alternative identification always has alternatives against which you are ranking or rating. So do not always put your money on one site you can put your money once you have decided from an existing pool of alternatives. You evaluate all these alternatives and then you come down to detail concept level development and cost estimating for one site which you have now thoroughly evaluated and said that this is the best possible site for my park and ride facility. After that comes your regular preliminary engineering, design, documentation and construction. So these are site level planning process which is pretty generic for any project that you want to take up. But in this case this is a park and ride facility and we will take you through this process in a mathematical concept and allow you to understand how to pick a site for your park and ride facility. Again you see that public involvement in every step. Do not ever leave the public out from your planning process because that will eventually come back to bite you, since these very public are the ones that will be using the system. And if you do not take them into confidence while building the system then they may not use it once you have built it. And then all the money

that you have put in the planning design and construction process goes to waste or you have to revisit your construction design. And then you put in a lot of money to change it and the process becomes very expensive.

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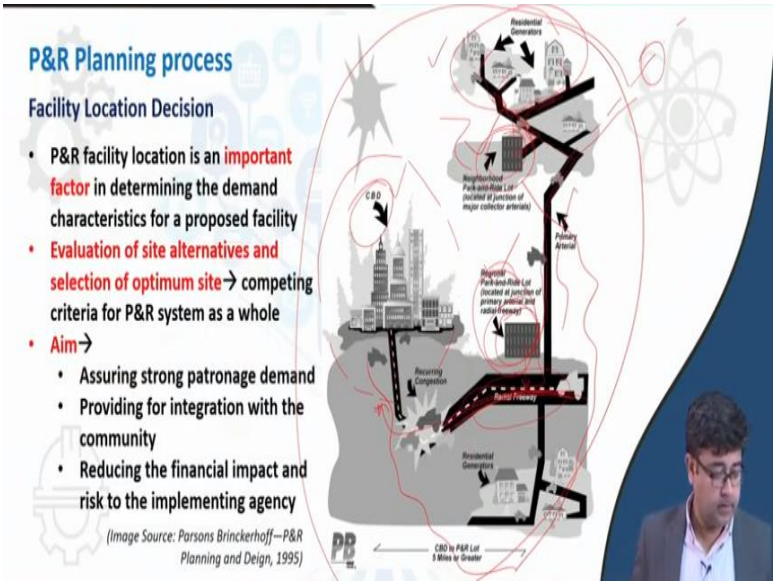

If you look at the entire eco system of a park and ride facility, this is what I was talking about in the first slide when I showed that there are 3 different categories of park and ride lots. So maybe here are your residential generators from where you would want to go to your CBD. This is here and this is maybe the entire road network that is available to you. So you could have your neighborhood park and ride lots right here where you take your individual cars and come to this point. And from here everybody parks their own cars and you all get into one person's car maybe. So that is carpooling. There is no transit that takes you from here. This is what is called an automobile park and ride lot. So in an automobile park and lot what happens is if your 5 friends who would want to ride together to your CBD because all of your offices are very close to each other in CBD. So rather than that, one friend can go to each and everybody's house to pick others up or each of them rides to this lot. And then maybe take turns. So on Monday you go with friend A's car and Tuesday you go in the friends B's car the all the other cars are parked there. You get dropped off. Maybe you do not even park there, maybe a family member drops you off at that location because it is close enough to your home. So that is kind of a neighborhood or a local park and ride lot. The other one is your regional park and ride lot. Now you are coming out of your collector roads or your residential roads. And you are now on your

primary arterial, now this primary arterial maybe connected to different residential areas. And now that you have a situation where there are 5 people in a car there may be other situations where all of them coming to this regional park and ride lot. Now this because is a regional park and ride lot, it is well connected to the freeway on which there may be your high speed bus service or maybe metro service. So now you can again park your car here and have access to your mass rapid transit. So you see there could be 2 tiers of a local park and ride lots and a regional park and ride lots which can then provide you access to your mass rapid transit line which is generally along your freeways or highways or even sometimes they are on your arterials. But in this case it is shown on your highways. This is the entire understanding of your travel from your residential areas to your CBDs. Sometimes the other ones are you have your perimeter park and ride lot right around your CBD area where you come. You are still driving but you come here and then from this point onwards you take your public transportation. But for periphery park and ride lots you would see that you would have already driven the majority portion of your trip. So they are not that effective in reducing congestion or in reducing emissions.

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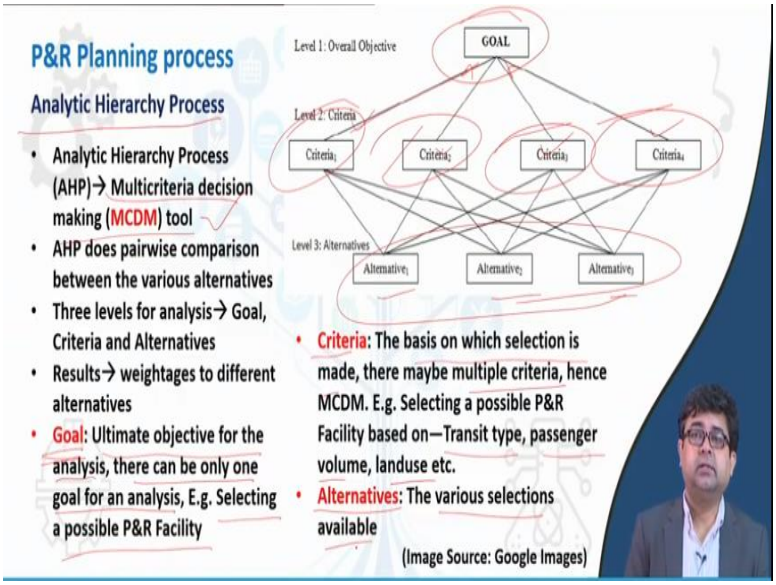

So now we will quickly take you through a mathematical formulation of how to decide which site you want to locate your park and ride station. The process that we are going to take you through is called the analytical hierarchy process. It is a multi-criteria decision making tool essentially that allows you to achieve your goal by solving for different criteria for different

alternatives. So you may have 2-3 different alternative sites for your park and ride lot and each of those sites are characterized by different characteristics. Solving for those characteristics or criteria you can then achieve the goal of picking one site from these 3 alternatives. So that is the entire idea of how analytical hierarchy process works. Your ultimate objective is to achieve the goal. The ultimate objective for the analysis that can be only one goal and for this analysis that is selection of a possible park and ride facility. So that is your goal that you have to reach criteria the basis on which the selection is made. There may be multiple criteria. Hence for this MCDM (multi criteria decision making) tool the different criteria may be the transit type the passenger volume, land use etc., And the alternatives of course is the various locations that are available to you in order to set up this park and ride lot. So since the siting of a location would be based on different criteria it will not be only be based on the land price. It will not be only based on how close is it to the metro service. It will not be only based on what is the pricing that I can charge for parking. So there will not only be based on individual single criteria but they will be based on multiple criteria. So a solution is reached by optimally solving from these multiple criteria which will allow you to develop or pick a site with much confidence rather than just picking a site arbitrarily.

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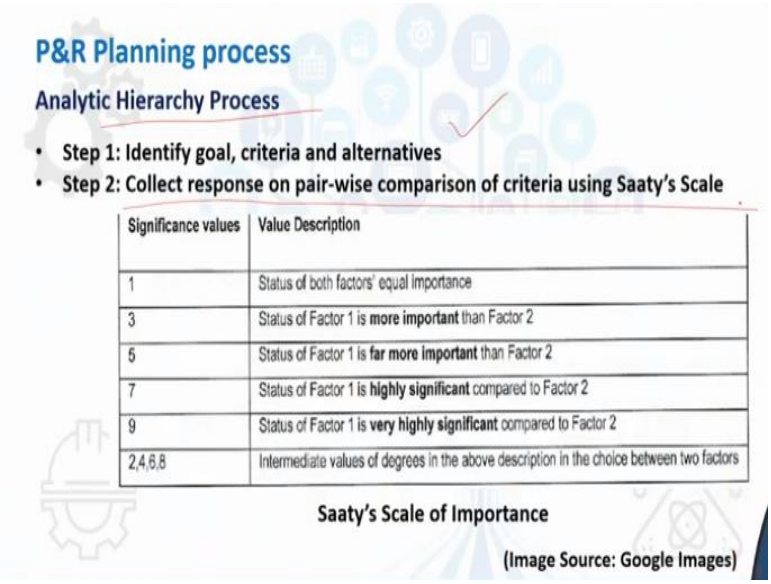

So for example in step 1 of this AHP process you have already identified your goals, criteria, and alternatives. So you know you have 3 sites from among which you have to choose one and there are these criteria that are common to some sites. And these are specific to some sites. You have

developed all your criteria. And then you know obviously the goal is to pick one site. Next, what you do is? You collect responses on pairwise comparison of the criteria. On a certain 5 point or 7 point or 10 point scale you rate each of those criteria. So, think about this as a when you are trying to pick a phone for example. When you trying to buy a mobile phone the different criteria in your head is, how good is the camera? How good is the battery life? How good is the looks of the phone? So, for each of those criteria there scores. Similarly think of these as rating for picking a transit location. Now, maybe some experts will give one set of ratings maybe some users will give some other set of ratings. Multiples stake holders who are involved in this would give these ratings. Now you would work with these ratings and then coming to a solution of picking a site.

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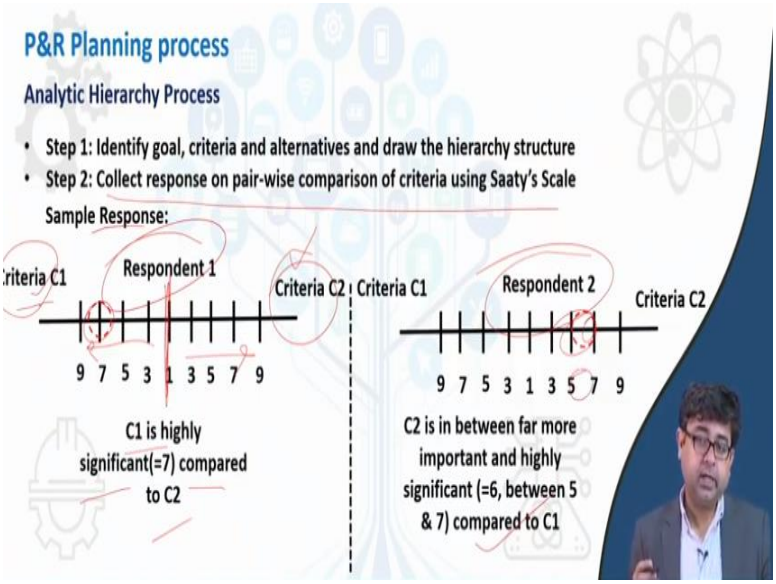

So for example one responded may say that criteria 1 are highly significant as compared to criteria 2. So whatever maybe the criteria he may give criteria 1 a higher rating. So this one if we give the rating of 1 meaning both criteria are equally important, for this person. If we go this way on the scale, criteria 1 is more important and if we goes this way criteria 2 is more. So that is the entire step 2 formulation of data collection. It is to have responses collected from various stakeholders on where to provide these facilities. So this is another example of a different respondent providing a different answer. So he or she picks a number in between. So you would have interpolate that understanding.

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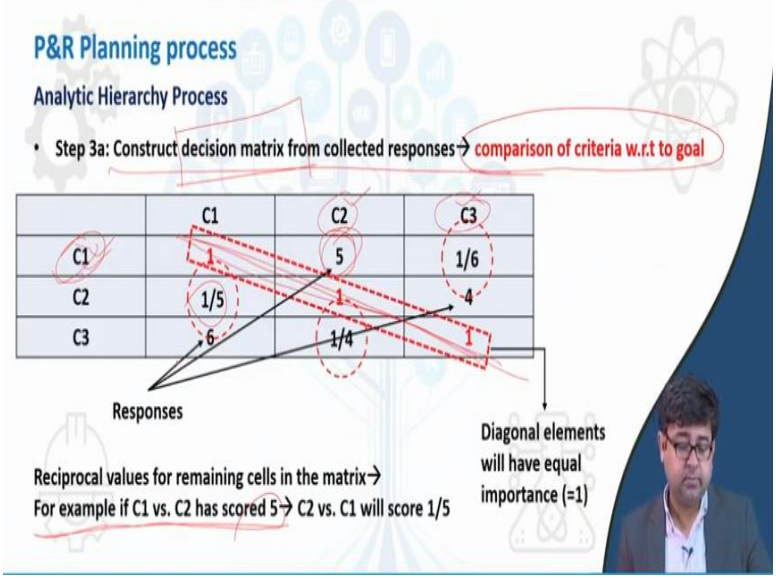

Once you do that then you construct what is called as a decision matrix. So this is the comparison of all the different criteria's with respect to the goal. So now you have to develop this decision matrix so when compared to criteria 1, criteria 5 is more important. So for example criteria 1 versus the criteria 2 has scored 5. So criteria 5 and criteria 2 is more important when compared to criteria 1 whereas criteria 3 is less important when compared to criteria 1. So this is how you develop a decision matrix from all the data that you have gathered. You would see that obviously your diagonal would be 1 because you are not comparing criteria 1 against criteria 1. So all the diagonal value is 1 and in this matrix you would have all the values on the diagonal side is reciprocal of the value on the other side. So that is how you develop the decision matrix for the criteria's so this is a comparison in the criteria with respect to the goal.

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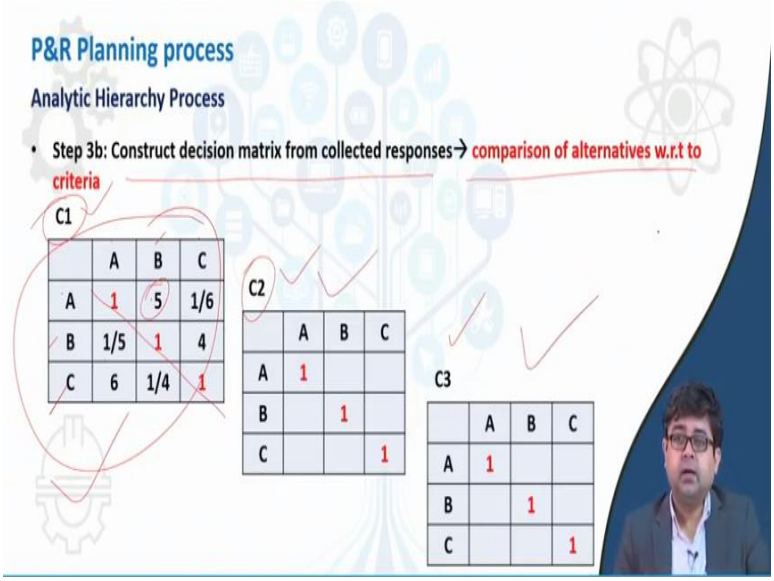

Similarly what you do is you construct decision matrix for each of those criteria and comparing it with the alternatives. Now you have to do a decision matrix for each criteria against the 3 alternative sites. Just as you have done it for the criteria's against the goal which is this. You have to develop a decision matrix using the same responses that you have got from all the stakeholders. Again your diagonal is 1 and the elements are inverse of each other across the diagonal. You develop it for each of these. How many other criteria you have? In this case you have 3 criteria. In the next step what you do essentially is to normalize. Now you have a matrix how do you normalize a matrix? All you do is the matrix that you originally had from the criteria you add up the columns and then you divide individual cells with the sum. So after you divide individual cells with the sum what you do is you develop a weighted average for the rows. So you add these 3 and divide it by 3 because there are 3 of these and you get these values. First you develop a normalized matrix from the existing decision making matrix. Then you develop these additional column of the row averages. Then you do similar calculations for all the alternatives with respect to the criteria. So if this is a criteria's with respect to the goals, you do similar things for each of these decision matrix. Convert them into normalized matrix and then develop the row averages.

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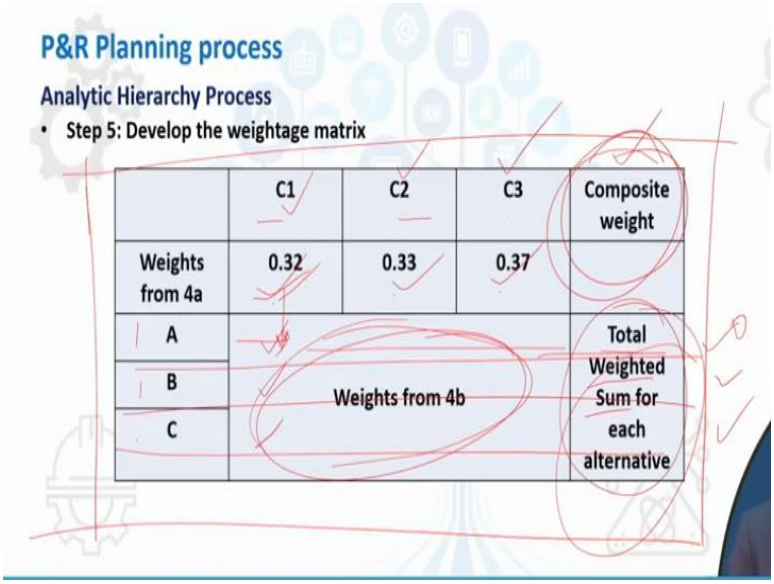

Eventually you will have this large matrix that will have each of the criteria weights as columns and each of the alternatives as rows. And all the weights that you would have developed would fit right in here. And the additional column that you will have here is the total weighted sum. So you just multiply that with whatever values here and you sum across the rows and the weighted sum will give you the composite weight. Now this composite weight consists of weights of criteria against the goal and also the weights of alternative against the criteria. So this is the composite weight score and this will tell you which alternative A, B or C is the site that you want to pick. So the higher the value the better is the site for our case.

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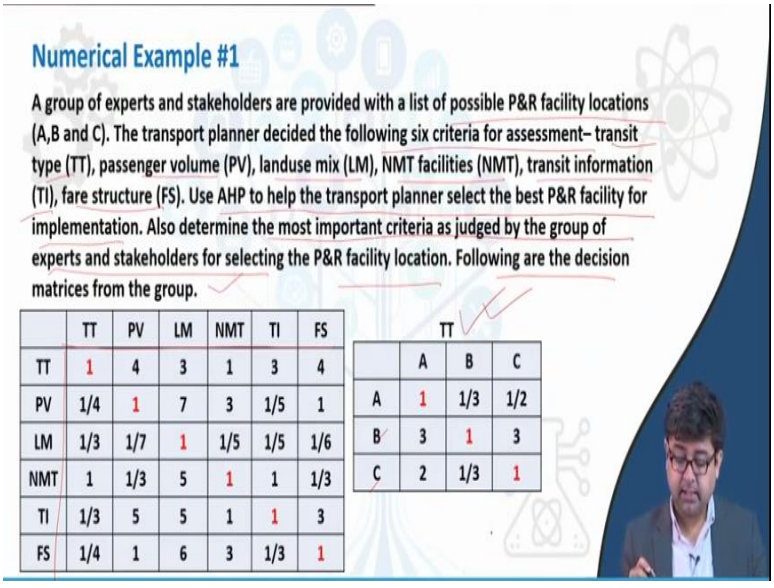

	TT	PV	LM	NMT	TI	FS
TT	1	4	3	1	3	4
PV	1/4	1	7	3	1/5	1
LM	1/3	1/7	1	1/5	1/5	1/6
NMT	1	1/3	5	1	1	1/3
TI	1/3	5	5	1	1	3
FS	1/4	1	6	3	1/3	1

TT

	A	B	C
A	1	1/3	1/2
B	3	1	3
C	2	1/3	1

So if we take an example of that and say that a group of experts and stakeholders are provided with the list of possible park and ride facility locations A, B and C. Again we have 3 locations. The transport planer decided the following 6 criteria for assessment. So instead of 3 criteria that we have looked at here now we saw that the transport planner has looked at 6 criteria. The first criteria is transit type, the second is passenger volume, third is land use mix, forth is NMT facilities, fifth is transit information, and last one is fare structure. There are 6 criteria against which each of these sites have to be evaluated and the responses have to be taken from the various stakeholders. On this, using AHP the transport planner needs to select the park and ride facility for implementation. Also determine the most important criteria as judged by the group of experts and stakeholders for this selection. Following are the decision matrices. So for simplicity we have already developed the decision matrix for you for example this is the decision matrix for criteria against goal. All the criteria's are in here. And then you have the matrix with respect to criteria since you have 6 different criteria. So for each, criteria against the alternatives there is one decision matrix like this. So this is the decision matrix for transit type.

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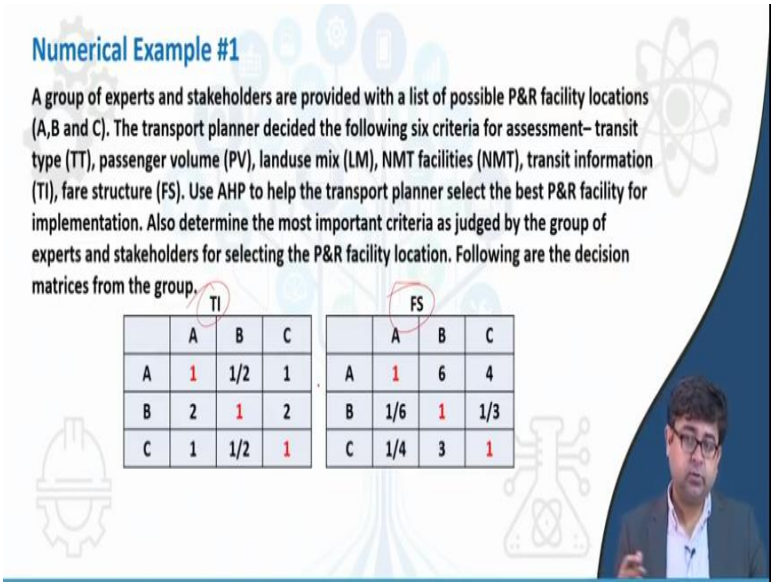

Similarly for passenger volume, for land use, for NMT, for transit information, and for fare structure. So all of these have been given to you for simplicity sake but these have to be developed from the questionnaire survey that you have done with the experts and the stakeholders.

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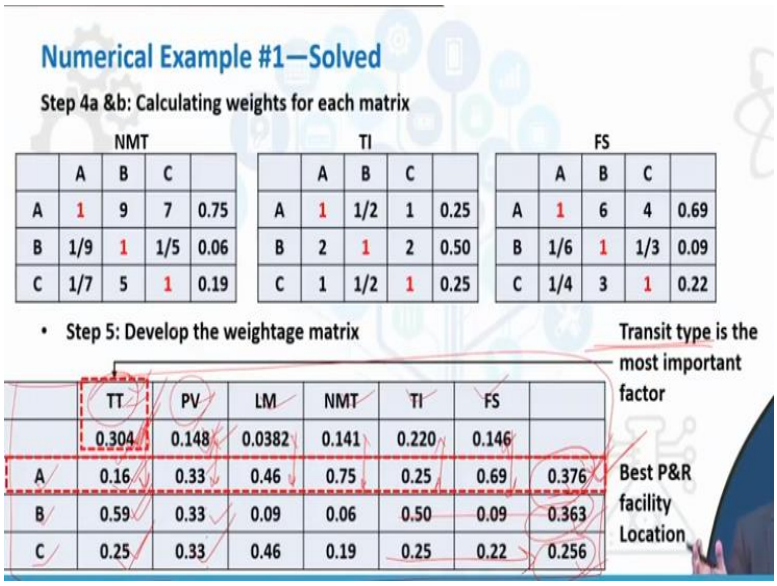

NMT	A	B	C	
A	1	9	7	0.75
B	1/9	1	1/5	0.06
C	1/7	5	1	0.19

TI	A	B	C	
A	1	1/2	1	0.25
B	2	1	2	0.50
C	1	1/2	1	0.25

FS	A	B	C	
A	1	6	4	0.69
B	1/6	1	1/3	0.09
C	1/4	3	1	0.22

	TT	PV	LM	NMT	TI	FS	
	0.304	0.148	0.0382	0.141	0.220	0.146	
A	0.16	0.33	0.46	0.75	0.25	0.69	0.376
B	0.59	0.33	0.09	0.06	0.50	0.09	0.363
C	0.25	0.33	0.46	0.19	0.25	0.22	0.256

So once you have developed these now know that the goal is to select the best park and ride location. You have 6 criteria and your alternatives are 3 sites that you have with you. So what do you do? You directly go into step 4A and 4B where you have determine the normalized matrix. After normalizing you have to determine the weights for each of the criteria against the goal. So what you do is you have each of these so you have to sum it up. Once you sum it up you divide this by this sum. Then you add up all that and divide it by 6. Because you 6 criteria here and that will give you 0.304. Similarly all of these numbers can be calculated. Do the same thing for all the matrixes each of the criteria versus the alternatives. Similarly develop weightages for them. Once you have this individual weightages and once you have the weightages for the criteria you will develop this massive matrix that I had shown you earlier. It has all the criteria on columns and alternatives on the rows. Where did we get this 0.304 from? Right from here because that is for the travel time criteria that is the normalized weighted average. So you have 0.304 here. 0.148 comes from and here so on and so forth. For the criteria travel time alternative A had weightage of 0.16, alternative B had 0.59. C has 0.25. Similarly you insert all of these from the individual matrixes or weightages that you have developed. And now you would see that you would get this value. Just as you weighted sum of each of these alternative. So, weighted sum meaning you multiply each of these with each other and you sum it. If you multiply each other and sum this you will get this. You multiply these with this and then sum you get that. Multiply this with this and sum you get this. So what this allows you to say is now you can rank them and

you see that alternative A gets the highest composite weightage. So alternative A has got the highest composite weight, B has the second highest composite weight. Whereas C has the lowest. You pick this as your site for your park and ride lot. Another question that is asked is which the most important criteria is and you can see that among all the criteria, 0.304 is the highest. So travel time or transit type is the most important criteria that goes into the selection of a park and ride lot. So for example may be if your transit is a metro line versus your transit type is the BRT then the location of a park and ride lot would differ in those 2 cases. So that becomes the most important criteria from the point of view of all the stakeholders from whom you have surveyed. So this is an example or a mathematical method of MCDM that will allow you to pick the site for your park and ride lot.

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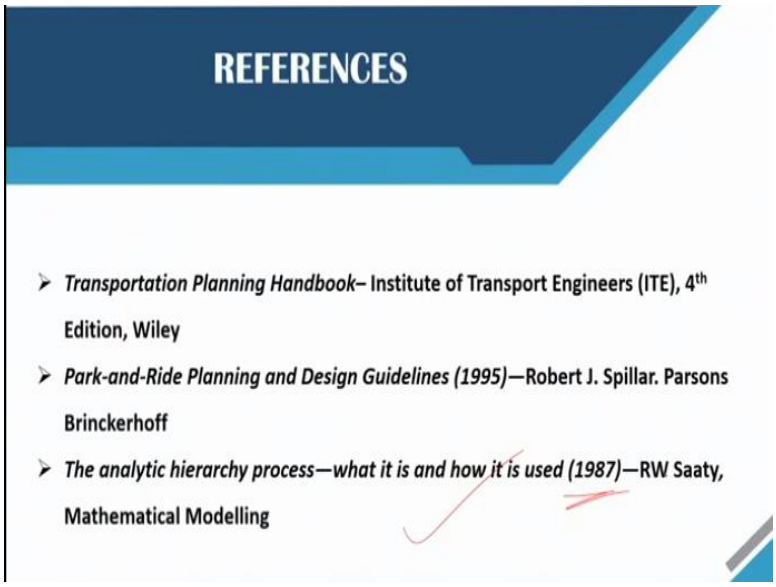

I hope you have followed through with the example as well as the explanation that we have provide. Again this is the AHP process if anybody wants to read. It is an old book but it is very easy to understand. AHP is used in various other researches as well so it is a good technique to know about.

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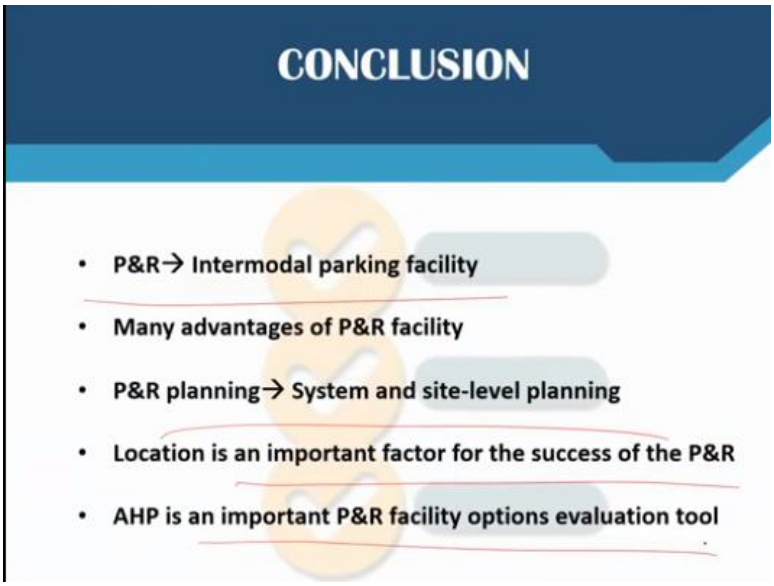

So in conclusion what we have looked at in today's lecture is, what is park and ride facility? Why is it important? What are the different types of park and ride facilities? How do you plan for it? System planning versus site level planning. And why location is an important factor in it and how you actually use a mathematical formulation, which is AHP, to determine the location of park and ride facility. Thank you very much for your attention.