Urban Transportation Planning
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Module No. # 08
Lecture No. # 34
Transport Related Land-Use Models

This is lecture 34 on urban transportation planning; we will discuss on transport related land use models in this lecture, you may recall that, we completed our discussion on transportation surveys in the previous class. Transportation surveys are intended to collect information under base year condition related to land use as well as travel pattern.

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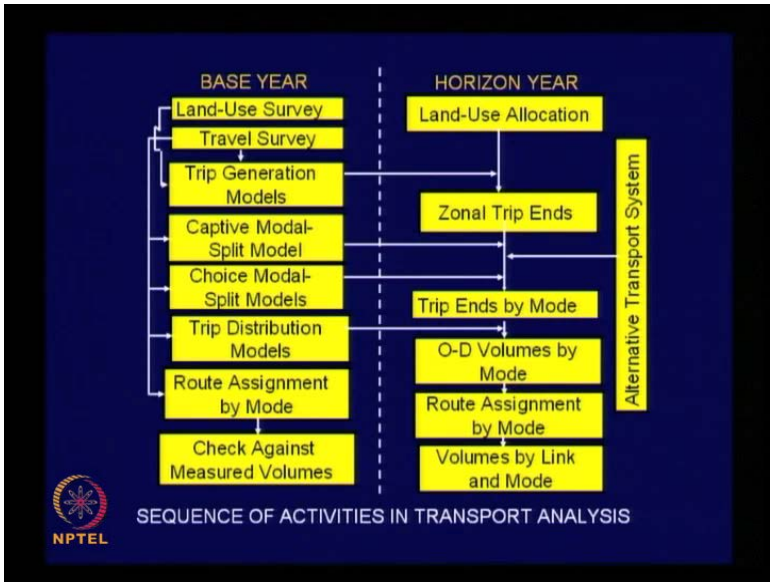

And you can have an idea about the connectivity of transportation survey with the subsequent activities for base year condition by referring to this flow chart. Look at the left hand side, we have completed our discussion an all aspects, listed on the left hand side of the flow chart pertaining to base year condition. This implies that as planners, we are ready with the calibrated models to be used to predict the horizon year travel pattern. Once you go through the process listed in all the boxes on the left hand side, you would be ready with the models for trip generation, mode choice, trip distribution and route assignment, calibrated and ready for use for horizon year condition, how will you use these models for horizon year condition. Let us say in an urban area we have divided the

city or town into 200 traffic zones, and we will have information about the land use, as well as travel pattern for each of the 200 zones for base year condition, we would have collected data and we have the information with us.

Now, we are going to predict the land use as well as travel pattern in the horizon year, or our ultimate objective is, to predict the travel pattern in the horizon year, which might be 20 years beyond the base year or 10 years, depending upon your planning period. To predict the future or horizon year travel pattern, we should have some idea about the possible land use changes in all your 200 zones. Zone one today for base year condition, if it is a residential zone it may have certain number of households with its own characteristics, with regard to average household size, average vehicle ownership, average household income and so on. Now, the question is, will it remain same after 20 years in this particular zone, it is not, it is not going to be same. So, we should be able to visualise, how the household in terms of numbers and their characteristics might change in the horizon year, unless this change is visualised for all different types of land uses that we observed in the base year, we will not be able to get the required data for application of the models that we have already calibrated based on base year data input.

So, we need to get data about the horizon year land use, it could be residential, intuitional, commercial, industrial and so on, we should be able to visualise the future changes, how do we do that, that is what is listed here as land use allocation on the right hand side. Since, we are predicting the future condition, what we practically do is, we allocate land uses based on some guide lines to visualises the changed condition in each of the traffic zones for horizon year, and this process is called land use allocation. So, this is how you need to understand this particular step, and the need for application of a model to allocate land uses. You cannot just do this by random process, there should be a systematic procedure followed for allocating land uses for the traffic zones. We need to make use of some model that is why we are going to study about transport related land use models. Before, getting into the modelling aspect proper, let us get some background information about land uses, and some basic information related to Chicago area transportation study, and the land use plan for that particular city, and then basic information related to transport land use interaction, so that this will form a base for us to understand the modelling process better.

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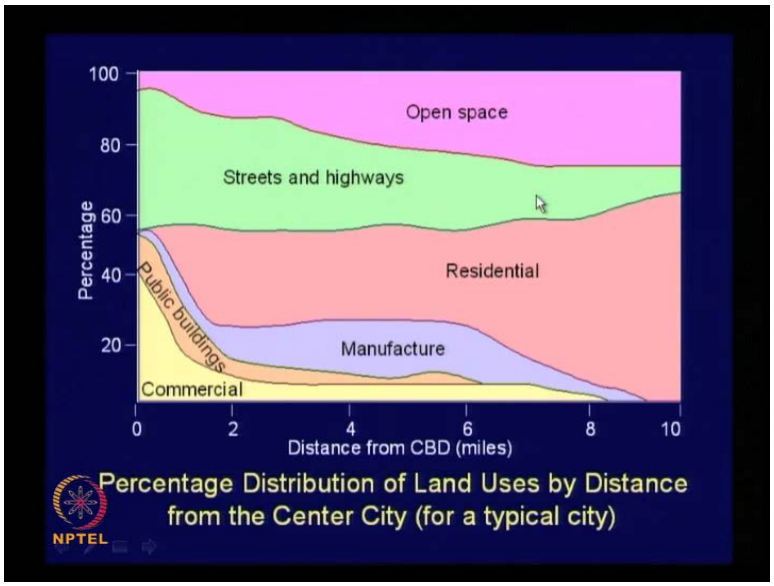

This is how the different types of land uses change in the case of a single CBD urban area, or single nucleolus urban area. Land uses have been broadly classified into open space, streets on highways, residential land uses, manufacturing and whole sale, generally it is designated as manufacture, public buildings or institutional land use and then commercial land uses. On x axis you can see the distance from CBD in miles, of course it is from American literature that is why miles is indicated here, we have just taken as available in the literature, and this is the percentage proportion of different types of land uses with respect to distance from CBD. At CBD proper, you can see very high percentage of commercial land use, nearly forty percent of the land space available is only for commercial activity, and quite a few public buildings amounting to about fifteen percent of the total space, and then manufacturing etcetera will be negligible in the CBD area very small percentage.

And streets and highways form the chunk of the land use, because once the land use is very intensive you need to have access, so you have lot of streets lanes and bi lanes, to access each and every building in the heavily built up area. That's how the space allocated for roads, becomes very high near the CBD, and open space obviously is going to be relatively less. As you move away from CBD towards the fringe areas, you can see there is a decrease in commercial land, and there is relatively lesser decrease in institutional land uses. And increase in manufacturing land use, and increase in residential land use only beyond a certain distance; say about 6 kilometres and beyond

off course, after an initial increase immediately after the CBD. And streets on highways get reduced, express as percentage of the total space available when land use becomes scattered when you move away from CBD, obviously the road network will have less number of links leading to lesser percentage of road space. And open space obviously will increase. This is general understanding of the land use pattern and its relative proportion in any urban area, in a typical urban area, that is what is written here; percentage distribution of land uses by distance from the centre of city for a typical city.

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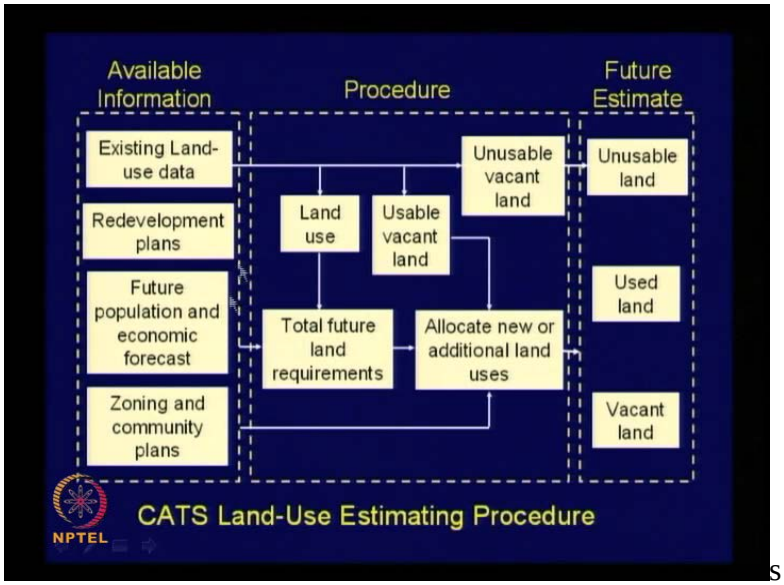

And then if you look at, how the land use allocation was done for Chicago area transportation study, CATS study; they first looked at the available information with regard to land use, existing land use data was available to them. Then, they had information about redevelopment plans, what do you understand by redevelopment plans. Nothing, but plans leading to land use changes, there may be dilapidated buildings in certain areas or they might plan to change a part of residential area into purely commercial area, or introduce some institutional areas in your residential location. These are called redevelopment plans that will be known in the base year itself, and then future population and economic forecast. This was also available to the Chicago area transportation ready planner's, because different departments would have worked on it and they would have developed some plans for future demographic and economic scenarios, that is available in the base year itself.

And then zoning and community plans, what do you understand by zoning and community plans. This zoning is different from the traffic zones that we discussed about; this zoning is related to master plan zoning. Any urban area will have a master plan, and master plan first identifies the different parts of the urban area, for different types of land uses. Certain areas are identified as residential zones, and certain areas only industrial zones, certain areas only commercial, certain areas may be to be kept as open space, to maintain certain percentage of greeneries, and some other areas for major public activities and so on, this is already prefixed in the master plan. Master plan is a document which gives you some information about the different types of land use allocation for the whole of the urban area for the future, at least for 20 years ahead.

And this division is called again zoning, and the community plans are nothing, but incorporation of the desire of the people, different communities in the urban area into the master plan, and master plan is a document which will be prepared by involving all the stack holders; business community, industrialists experts, administrators, nongovernmental organisations, all these agencies will be involved in finalising the master plan and this will be a very important, sacred document which should not be altered frequently. You can take enough time, sufficient time to prepare the master plan, then it has to be at the (( )), and this is also available in the base year, or all these information was available in the case of Chicago at the base year condition itself.

Then the procedure followed is as shown here, from the existing land use data, you can get information about, the actual space which has been used land use, then useable vacant land, because you are dividing the whole urban area into number of zones, you would have included certain open space, which can be used for development, and then unusable vacant land. You cannot alter the land use in certain cases huge water bodies, helix and so on, so these are unusable vacant lands. So, this category session, the exact extant can be worked out for base year condition. So, this is what was done in this particular case also. Then knowing the future population and economic forecast, and knowing the current land use. You can get information about total future land requirement, can you not get, present land use is known to us, and prediction of future socio economic activities is known demography as well as other related information, so we can easily predict the total requirement for the horizon year condition.

So, that is what was done in CATS study, and having known the future requirement, you can allocate new or additional land uses by taking input from these sources; zoning and communicating plans refer to master plan, and look at the useable vacant land, and look at this total future land requirements. All these 3 will give input for this output, namely allocation of new or additional land uses. Why it is allocation, because you are just creating land use for the horizon year condition, which is not existing now, so your allocating land uses that is why it is called land use allocation, and this step only requires modelling process, that is what we are interested in.

Once, you have allocate land use for the horizon year condition, you can get the clear picture of the future, land use estimate for the urban area, giving information about unusable land obviously, whichever is unusable for the basic condition is going to remain as unusable land for your horizon year also, and then used land based on the future requirement and a vacant land that may be available in the horizon year in the future. So, this is a basic frame work for land use planning, for the purpose of transportation planning. So, our focus will be on allocation of new or additional land uses. All other things are simply getting information from various records.

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And to have some background information for modelling purpose, let us look into the general aspects of land use transport interaction. Anybody who can comment on land use transport interaction in general, whatever thoughts are coming to you, land use transport

interaction; any responses. Of, course I think all of you agree that, there is a closer interaction between land use and transport, how land use creates activities, activities needs transportation and transportation creates accessibility to land, again land use gets developed and so on. There is a closer interaction between land use and transport, to give a formal statement on this particular aspect, you can say land development generates travel, and travel generates the need for new facilities, activity centres let us say, which intern increases accessibility and attracts further development.

And the related statement is this, the question of whether transportation influences land use, which also means development, or whether land use dictates transportation, has been a matter of ongoing concern among transportation professionals. This is the question which has not been answered satisfactorily even today. Whether transport is catalyst for land use or land use is catalyst for transport, is a question. There is no clear cut answer probably the general acceptable answer is; it is both, that is how we can understand the possible reaction for this particular question.

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Thus, the connection between transportation and land use is a fundamental concept, which needs to be understood very clearly, in transportation planning as transportation and land use are inexorably connected, inseparably connected, clear understanding of this connectivity is the basic requirement to proceed further. So, everything that happens to land use has transportation implications, without mobility there is no land use. So,

everything that is happening to land use will have its own transportation implications, and every transportation action affects land uses. If we develop a new kind of transport link, for example immediately we will find some changes in the land use pattern in that particular area.

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And transportation's most significant impact on land development occurs, when access is provided to land that is a pre requisite. You must have accessibility to land then transportation is able to impact the land use significantly. Please, understand accessibility and transports are little different aspects. Accessibility is a kind of administrative or policy decision to provide access to land uses. Once access is available then transport systems comes into play and make changes in the land use pattern. Increased access to land raises the potential for development obviously, and more development generates additional travel. Just some statements related to land use transport interaction.

Once access has been provided and land patterns begin to change over a period of time. The results of these changes are for the most part irreversible that is the most important thing. Transportation system changes land uses and these changes are going to be irreversible mostly, very rarely there are changes made in land uses, it is very difficult to change land uses in the future. So, that is why we have to be very careful while providing access to different types of land uses and developing transport system to provide mobility for people.

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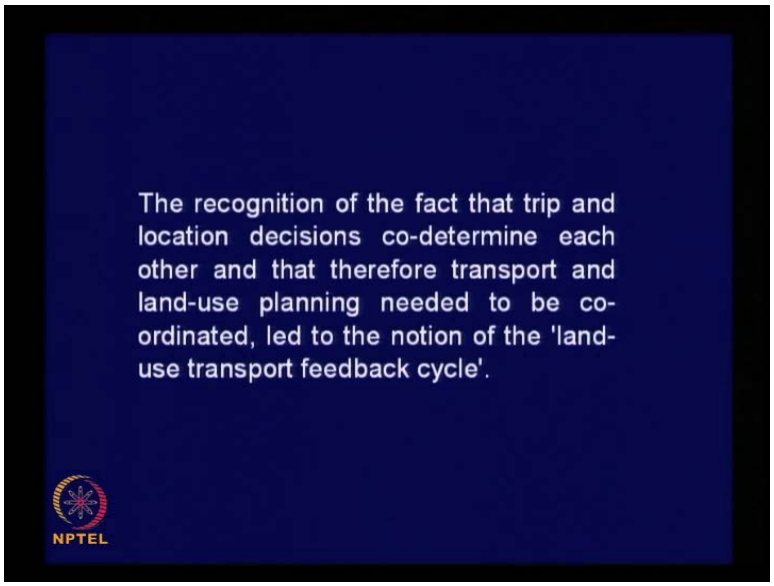

Now, the recognition of the fact that trip and location decisions or transport and land use decisions, both are same trip and location decisions, co determine each other, one is influencing the other, co determine each other and that, therefore transport and land use planning to be coordinated, most important statement, is to be coordinated this led to the notion of land use transport feedback cycle. The understanding that there should be a co ordination between the land use planning and transport planning led to the notion, or concept of land use transport feedback cycle, may be let us have a look at the feedback cycle itself.

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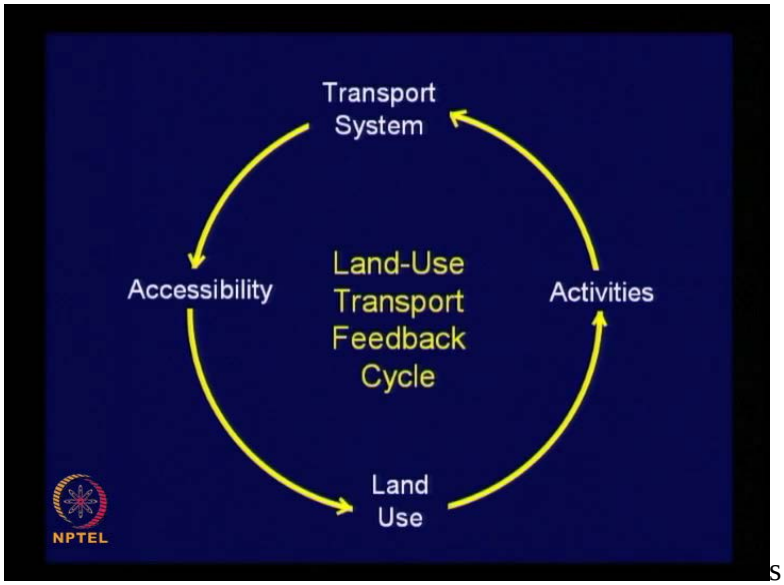

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This is the cycle, let us say there is some kind of land use shown at the bottom, land use generates lot of activities, activities means more transportation activity, more intense transportation leading to transport system development. And once you have transport possibility of a mobility, demand for access to additional land uses increases, it leads to more accessibility. Once you have accessibility there is increase in land use. So, land use generates activities. Activities generates demand for transportation and transportation system generates more access and so on, and this is what we call as a land use transport feedback cycle. So, this cycle is a basis for land use, land use transport interaction and then the modelling process.

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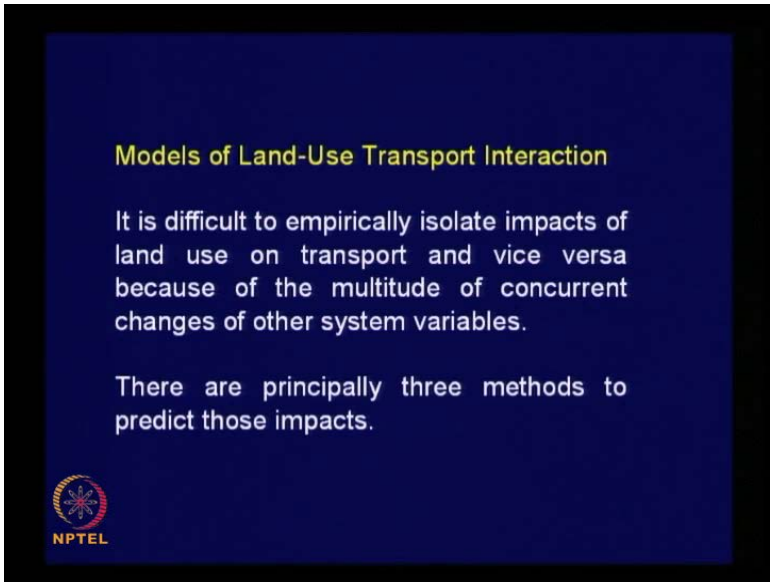

Models of land use transport interaction can be developed following different methodologies, in general it is difficult to empirically isolate impacts of land use on transport, what do you understand by isolating impacts of land use on transport and vice versa, are isolating impacts of the other thing, impacts of land use in transport or transport on land use. What do you understand by this statement, it is difficult to empirically isolate empirically means based on observed data, it is difficult to empirically isolate impacts of land use on transport and vice versa, because of the multitude of concurrent changes of other system variables, if you take urban system, it comprises several other subsystems. It is not just land uses and transport system, there are several other systems like; water supply electricity, sewerage, and network of socio economic activities and there connectivity's and so on. So, the whole system is

simultaneously changing, so it is not possible to just look at land use in transport in isolation and study the impact of one on the other based on certain observed data. So, while you try to model this fact has to be understood very clearly, and off course there are principally three methods to predict these impacts, its only prediction, still we need to do something to predict the land use changes for the horizon year condition, there are three possibilities.

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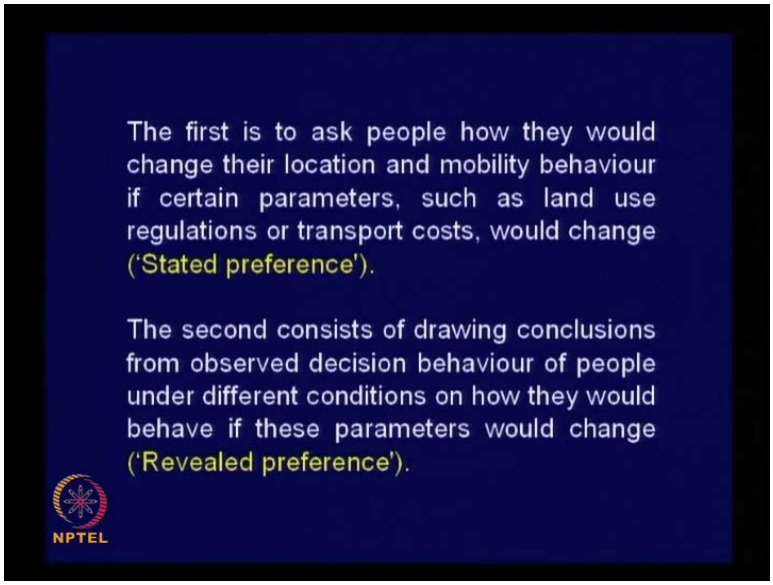

The first possibility is this, which some of you might have heard about, to ask people how they would change their location and mobility behaviour, if certain parameters such as land use regulations or transport costs would change. You just ask or conduct a survey, getting the opinion of a different sections of the people as to how they will change their residence, based on the likely changes in land use as well as transport related issues, may be transportation costs or transportation mode and so on. To get this opinion you must generate future scenarios, and you explain the future scenarios very clearly to the respondents. You must give them clear options, if this is the possible change what will be your decision, if this is going to happen, how will you decide about your residence, will you move out of this place or still continue to stay here, things like that, that is our interest, because we are interested in visualising the possible changes. So, the question here preparation, is a tedious and difficult job for this particular approach. You have to clearly explain the future conditions and then get the response from the respondents.

Since, you are collecting some statements as preferences of the respondents, this method of getting the future scenario is called stated preference approach, or stated preference method of conducting survey to get some information about the possible future land use scenario. Why we need to do this, because we expect changes in the land use pattern in the horizon year, and you just anticipate all possible changes and then get the response from the residents. We see in practice in citizen towns people living in one place are shifting to another location for various reasons. Maybe to be nearer to your school for their children, or to be still closer to their employment location, or may be the rent is very high in a particular location and they move on to a location where the rent is little less, or a medical facility is not that good in location they want to move on to if they are elderly people they move closer to good health facilities. There are various possible reasons for movement of people within an urban area; this is what we want to know for horizon year condition. Similarly, industries they may be located in one place today in the base year, they might change over to another location for a want of space. They may have their own expansion programmes; they would like to have another branch somewhere else and so on. Commercial activities, it is not that we are not going to talk to only the residents and get possible scenarios for shift of residences; it is for all kinds of land uses. You must get this information from these stake holders of different kinds of land users, and this is what is known as stated preference approach.

The second approach consists of drawing conclusions from observed decision behaviour of people under different conditions on how they would behave if these parameters would change. You just observe people moving from place to place for residential activity, or observe shoppers opening branches or moving the shops from one location to another, observed other industrial activities and any other related activity in urban area. Just observe over the past, may be you would have record of changes over the past, and since we have observed the changes that can form provide the basis for predicting the future possible changes in the land uses, because these changes are revealed by the users of different types of land uses, they have already changed. This changed pattern can be the basis to predict the future changes, and this is what is called revealed preference approach, because they are revealing their preference by actually changing.

And what is the problem with these two approaches; in the first case you’re just explaining the future scenario to the respondent. It’s not that they are going to actually

change, if it is a real change situation, we may not know how they will react. So, they perceive some scenario based on your explanation and give their response. If you ask a respondent that if the transportation cost from your home to your work place is increasing by 200 percent, would you like to change and move closer to work place. They may for basic condition say still I will manage I will not change, but when it comes to the actual situation, their decision might be different. So, it is all based on perceptions.

So, it is likely to be erroneous, the error could be significant. So, we have to be very careful choose the right type of respondents and try to get accurate information. This type of survey is not only applicable for predicting values pattern. This type of survey is used for various other purposes. Planning of transport systems and their components, stated preference and revealed preference surveys are quite common. In the case of revealed preference survey the data base is very strong, because you are observing something happening and collecting the actual data. Only problem with this information is that the horizon year condition may not be similar to the conditions under which these people have changed locations. They have changed locations based on the prevailing conditions at that time. The conditions in the horizon year might be different and the rate of change need not necessarily be same as we have observed in the past. These are all the problems related to these two approaches we should be aware of it.

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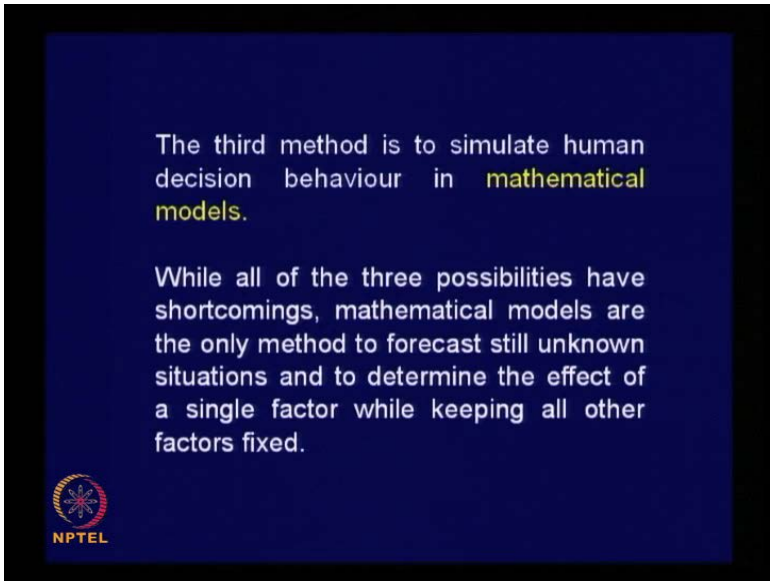

And the third possibility is, to simulate human decision behaviour in mathematical models. You develop mathematical relationship based on empirical observations and use these models to predict the possible future changes. Now, the question is which one is to be used finally, for our purpose while all of the three possibilities have short comings, what is the short coming of mathematical model then. You will not be able to incorporate all the randomness involved in the decision making process. You have to make approximations and provide constraints, so that you get some closed form solution in mathematical models; that mean mathematical models need not necessarily reflect the whole of the reality, there will be assumptions and approximations.

So that is why it is stated that while all of the three possibilities have short comings. Mathematical models are the only method to forecast still unknown situations, and to determine the effect of a single factor while keeping all other factors fixed, that might be our interest, if this is the policy decision taken for the horizon year what will happen. If, some other decision is taken, how the land uses will change. All these possibilities are possible once you have a model; mathematical model. You can hold one and change a parameter and see what will be the effect. That is how models are better suited to predict the future scenarios.

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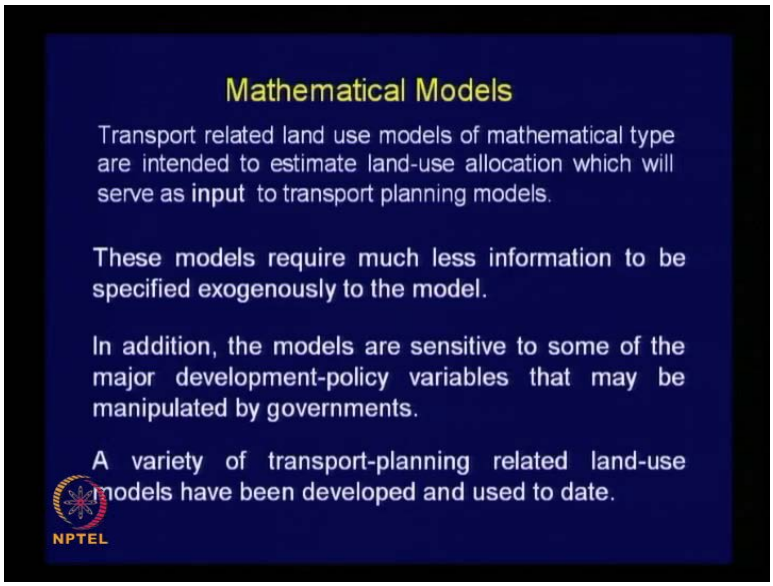

And we will continue on few other aspects related to mathematical models. Transport related land use models of mathematical type, are intended basically to estimate land use

allocation that is your ultimate objective to estimate land use allocation, which will serve as input to transport planning models. What are transport planning models, land use allocation is going to serve as input for our planning models. The planning models are the models related to the four major steps; trip generation, mode choice, trip distribution and route assignment, unless you allocate the land use you will not be able to use the models for horizon year condition. So, this provides the input for all the four models. These models require much less information to be specified exogenously to the model.

What do you understand by specified exogenously, from outside the model structure, most of the information is generated internally. Once you give some input the model internally generates the possible changes. These models require much less information, off course still we give information exogenously, but it is relatively less to be specified exogenously to the model.

In addition, the models are sensitive to some of the major development policy variables that may be manipulated by governments, that is the most important aspect. There may be major policy decisions taken by government. Those scenarios should be possible to be incorporated in the modelling process. What are the likely possible likely policy decisions by the government with regard to land use changes. They might possible plan to introduce some new mode of transportation, covering a number of traffic zones in a particular area, in a city or town. That is a major policy decision introduction of metro rail system, monorail system. It is going to change the land use structure significantly or due to some reason they might change, open space or agricultural land into industrial land use, because of demand for more industries to be accommodated in an urban area. These are all major policy changes decisions taken, and those changes are to be accommodated in our modelling process, so that the model can realistically predict the future land use scenarios. A variety of transport planning related land use models have been developed and used to date about twenty, twenty one models so far have been developed and used for land use prediction.

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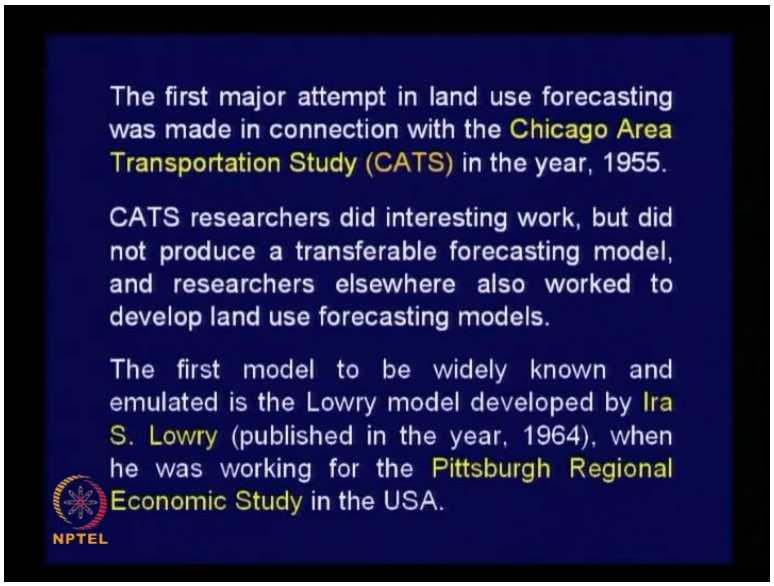

The first major attempt in land use forecasting was made in connection with the Chicago area transportation study CATS in the year 1955. This was the first systematic attempt made to forecast the future land use in an urban area, in the USA, about which I have shown you a flow chart also earlier. And CATS researchers, basically planners did interesting work, but did not produce a transferable forecasting model, what is a transferable forecasting model. The model which can be used for other urban areas, the model was specific to only Chicago area. They had incorporated several variables each will become unrealistic when is this model is used for another city, and of course other researchers elsewhere also worked to develop land use forecasting models. They have made lot of attempts made in fifties and sixties to develop land use forecasting models.

The first model to be widely known and emulated known and it is readily adopted by most of the researchers, emulated is the Lowry model developed by Ira S Lowry, published in the year 1964. He published the whole model and modelling process in 1964 and when he was working for the Pittsburgh regional economic study in the USA. And Lowry's model is acceptable even today for land use prediction purpose. All other models are mostly based on the frame work of Lowry's model.

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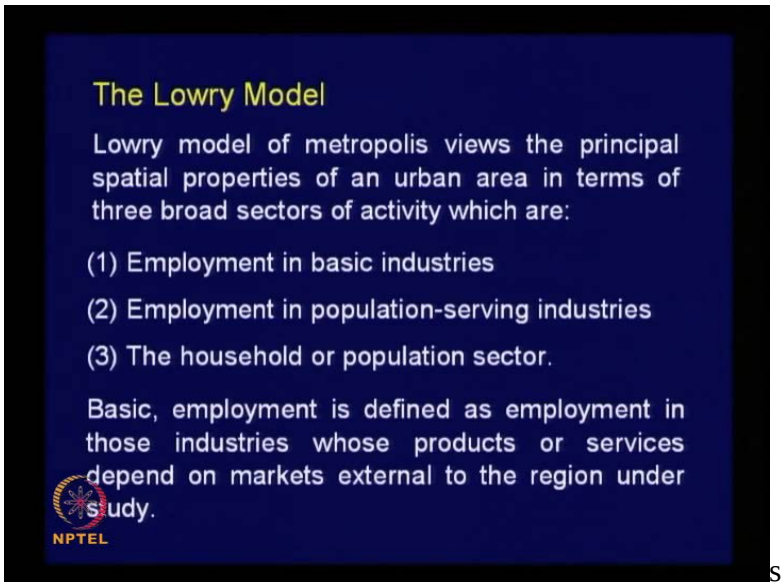

So, we will discuss more about the Lowry model of land use, which covers the basic frame work involved in land use prediction. Lowry model of metropolis, vast urban area is metropolis views the principal spatial properties of an urban area, principle spatial proprieties of an urban area, in terms of three broad sectors of activity. Lowry is dividing the spatial pattern or land use into three broad sectors, and the first one is employment in basic industries, or in other words it is related to the location of basic industries in urban land space, when we say employment indicates the intensity of activities in these particular, activity pattern namely basic industries. Then employment in population serving industries, later on we will see what is really meant by basic industries in population serving industries by Lowry himself. He is defining later these terminologies. Then, household or population sector, so basically all activities are put under these three heads, basic industry, population serving industry, households or total population itself, you can express people in terms of population or number of households. Basic employment is defined as employment in those industries, whose products or services depend on markets, external to the region under study. There, are industries in urban areas that their markets are not confined to that urban area, they extend beyond the urban area in which they are located.

Can you think of basic industry for this city, whose market is not confined to this city extends beyond the limits of the city, automobile manufacture; yes automobile manufacturing industry, car manufacturing industry, motorized two wheeler

manufacturing industry. They are not selling all their products within Chennai city, it goes foreign wide. So, these categories of industries will come under basic industries. Other institutions, let us say for example, IIT madras, how do you account for this institution under these three categories, will it come under population serving industry or basic industry, even though it is serving people, how would its market, think about it, and government department offices, secretariat of the state government or a reserve bank of India branch office here in Chennai city. My question is; are they closely related to the location of the households in the city. Location of IIT, location of secretariat, location of reserve bank office, are they closely linked to the location of people in the city, location of households, no definitely. And these institutions and their activities are not confined to only Chennai city. So, this kind of land uses also will come under basic industries category that is the point we should not assume that it is only industries that will come under basic industries. All activities whose frame work extends beyond the urban area, in which they are situated, will come under first category that is the point to be understood.

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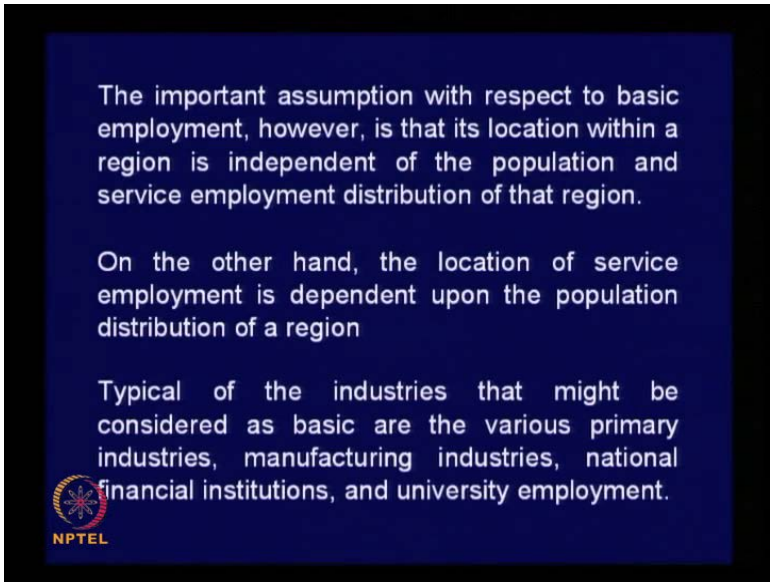

And the important assumption with respect to basic employment, however that its location within a region, is independent of the population and service employment distribution of that region, it is totally independent, it is not related to the population distribution. IIT is located here not, because we have lot of students around IIT to make use of the institution, it is totally independent of the population spread of this region. On the other hand, the location of service employment is dependent upon the population

distribution of a region. Now, you can think of the different types of service employment institutions. All the retail shopping facilities are dependent on the population distribution.

How the Velachery the neighbourhood is developing, developing into a high intense commercial area, it is mainly, because of the spread of population. Typical of the industries that might be considered as basic are the various primary industries, manufacturing industries, national industries financial institutions and university employment and so on. These are not dependent on the local population spread, what are primary industries, any examples for primary industries, what do you understand by primary industries. Primary industries are linked to the natural geographic features of an area.

As far as the Chennai city is concerned, you can say fishing or fisheries is a primary industry, because it is a coastal city, and the port itself is a primary industry, because since it is a coastal city there is a possibility of having a sea port here, because of the natural resources available in the area, these industries are developing. So such industries are primary industries, agricultural for example, in some other urban area, I said Tiruchirappalli is basically agricultural city, agriculture is primary industry, because of its natural wealth available in that location, that industry is flourishing. And manufacturing, of course you know, and national financial institutions and university employment. These are all examples; you can include a set of other possible types of institutions under this category.

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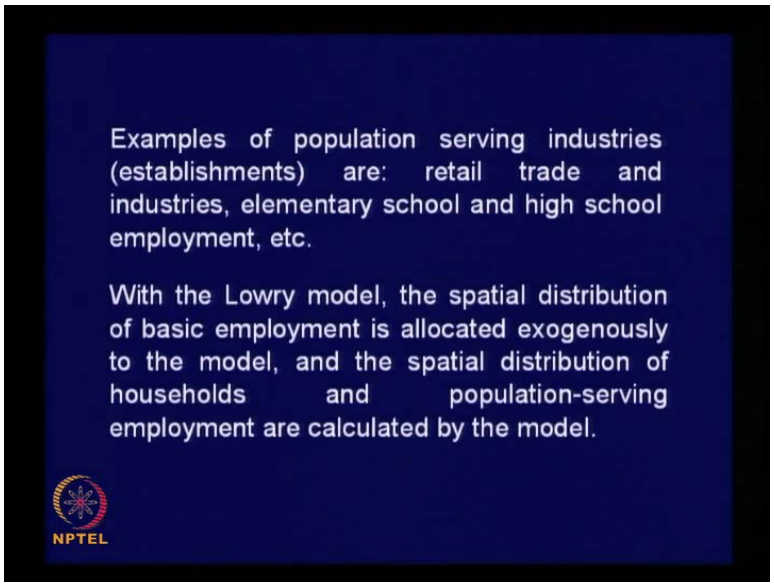

Examples of population serving industries or establishments are; retail trade and industries, do we have retail industries. Can you give examples for retail industries, shall we say a mechanic shop is a retail industry. It is not retail industry, but it is a retail service related industry, then what are retail industries. There will be fabrication of small consumer items here and there, based on the demand in the local area, which we may not be aware, there will be so many the cottage industry kind of manufacturing of items which are needed by the local population. We may think that when we buy something in the shop it is really manufactured somewhere else and we are buying certain items, its not necessary.

Elementary school, high school employment and all those things are very much related to the population spread. And all other similar institutions will come under population serving employment; particularly medium size hospitals, clinics all these things will be coming under population serving employment, not major health facilities like Apollo hospital. There market extends beyond a city, but medium size smaller clinics and doctors' consulting rooms, all these things will come under this category. With the Lowry model, the special distribution of basic employment, please understand clearly, the special distribution of basic employment, is allocated exogenously. That means your fixing the location of basic industries yourself prior to application of the model, you are fixing the location of all the institutions coming under basic industry for horizon year condition. Based on the master plan and other inputs that you are getting, you are going

to fix the location of all the institutions coming under basic industries category; that will be fixed, that will be the input to your model, allocated exogenously outside the model, to the model, and the spatial distribution of households and population serving employment are calculated by the model. The model adjusts the distribution of population and population serving employment, or population serving institutions.

That is very important, that is the main factor which will influence most of the trips made in an urban area. So, that is how Lowry's model is considered to be very useful in predicting the future land use pattern, we will stop here. And to summarise what we have discuss today, we understood first the important of the land use allocation for horizon year condition, because that is the basic input needed for using your transport planning models; for trip generation, mode choice, trip distribution and route assignment. And we tried to understand the intricacies involved in land use transport interaction, and also we learnt a bit about the process of land use allocation for Chicago area transportation study.

And there are three possibilities for predicting future land use pattern; one is by stated preference approach, the other one is by revealed preference approach, and third using mathematical models, even though all the three approaches have their own weaknesses strengths and weakness the mathematical model is better, because this can be used to predict the effect of different policy decisions, holding certain set of variables constant, and among the mathematical models the Lowry's model of land use is recognised to be the most important well accepted model. And we know now as far Lowry's concept the entire land use pattern is put under three categories namely; employment in basic industries, employment in population service industries, and households or population of the urban area, and finally we tried to understand what is really meant by these three categories. We will stop here and continue our discussion in the next class.