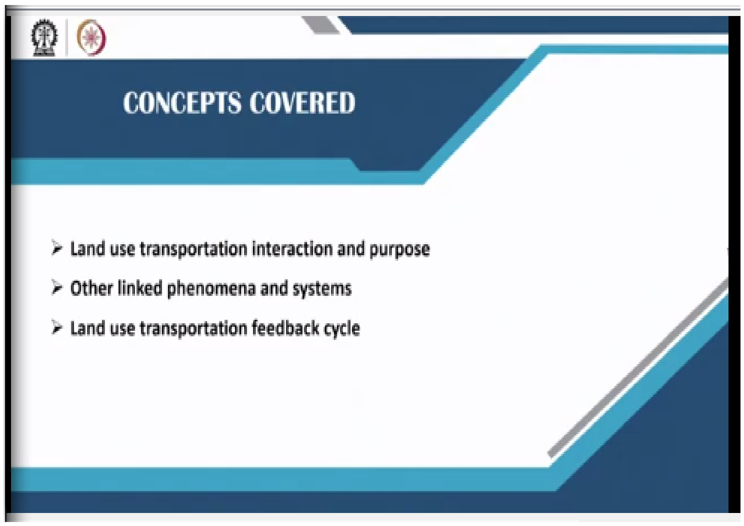
Urban Landuse and Transportation Planning
Prof. Debapratim Pandit
Agricultural and Regional Planning Department
Indian Institute of Technology-Kharagpur

Lecture-05
Landuse Transport Interaction

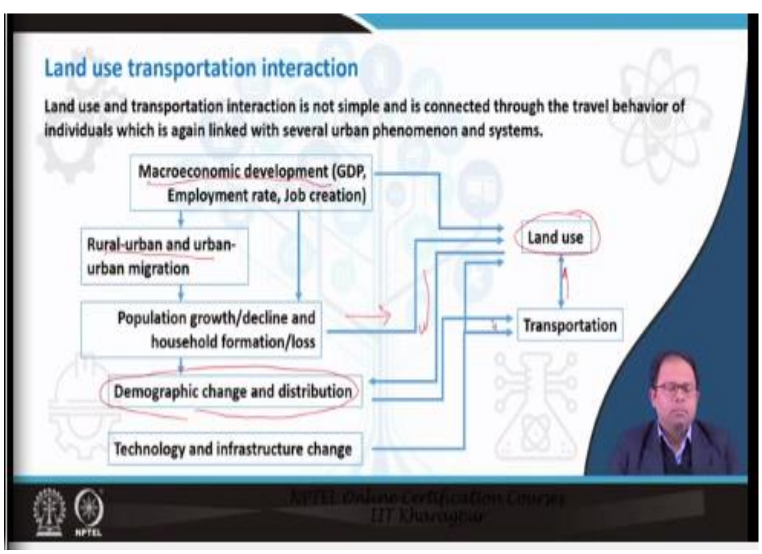
Welcome back. In this lecture we will talk about landuse transportation interaction.

(Refer Slide Time: 00:29)



The topics covered in this particular lecture are landuse transportation interaction and its purpose; other linked phenomena and systems; and landuse transportation feedback cycle. So, these are the 3 concepts that we will understand in this particular lecture.

(Refer Slide Time: 00:49)



Land use transportation interaction

Landuse transport interaction is complex and is connected to the travel behavior of individuals which is again linked with several other urban phenomenon and systems.

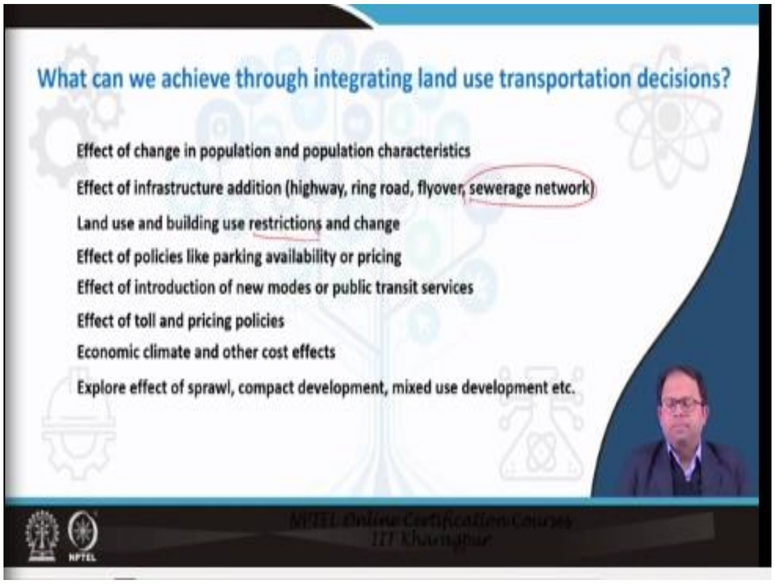
One such urban phenomenon or system is macroeconomic development which relates to change in GDP, employment rate and job creation. Change in macroeconomic environment leads to change in the number of jobs which leads to change in the number of people migrating from rural areas to different urban areas or from urban to another urban area and eventually changes the number of people employed and the total population in an urban area. Thus, macroeconomic development influences population growth or decline and household formation in a particular urban area which eventually leads to change in the demographic characteristics i.e., the number or distribution of the people in a particular urban area.

Similarly, prosperity or economic development brings about a change in the life of individuals. For example, one may decide to start a family or a household may decide to move out from their parents' house to a rental apartment or even buy their own houses. Buying and renting of houses by households increases requirement or demand for buildings in an urban areas. Real-estate developers come forward to supply this demand which again requires provision of new residential land use which has to be decided by the urban planners. Similarly, new jobs require new offices and real-estate developers also supplies new commercial office spaces which also lead to change in the urban landuse. Thus, landuse growth in an urban area is linked with macroeconomic development.

Provision of new office buildings or new housing in certain parts of the city results in changes in demographic patterns and distributions in those areas which also lead to change in the travel behavior in those areas in terms of mode choices, travel distances, travel times etc. Provision of new technology, services and transportation infrastructure for these areas on the other hand, changes the basic structure of the transportation network or the transportation system. This results in change in accessibility and attractiveness of certain areas which can be considered as a reverse or feedback effect on land use.

So, this is how the different systems are linked and the linkages are not only in one direction but have feedback loops as well.

(Refer Slide Time: 06:18)



<u>What can we achieve through integrating landuse and transportation?</u>

Instead of just measuring traffic flows along different roads which is a measure of traffic load and infrastructure adequacy, why do we need to determine the change in the landuse pattern, change in the building use pattern, and change in all the connected systems?

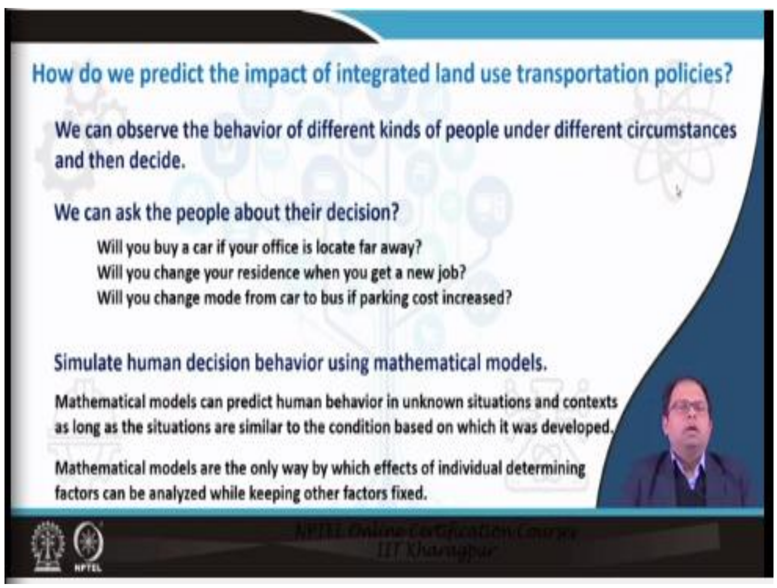
This is required to determine the effect of change in population and demographic characteristics on the different connected urban systems.

We can also determine the effect of addition of a highway or a ring road or a flyover or even a sewerage network in a particular urban area. For example when we add a sewerage network it will increase the carrying capacity of an area or in other words, more number of people can actually live in that area. This also changes the attractiveness or accessibility of that particular area and that this leads to change in the transportation system as well. So, the effect of infrastructure addition is again not straightforward i.e., it may not affect the land use directly or, it may not directly affect the transportation system, but it change the attractiveness and accessibility of that particular area which in turn affects both land use and transportation.

Floor Area Ratio (FAR) is increased to achieve compact development or transit oriented development of certain zones in the city. This will result in a cascading effect in both the landuse, transportation and many other urban systems which will also affect each other. Similarly, policies related to parking availability or parking price, in central areas are linked to people choosing public transit system. This will probably increase the demand for new buses and will also increase the requirement for parking area in the terminal or we may be even required to provide a new terminal facility. This is actually a feedback to the land use which can only be predicted by integrating land use and transportation.

Similarly, the effects of introduction of new modes of public transit services, toll on certain roads, pricing policies, change in land price in a particular locality can also be determined. Land price is one of the factor which determines if people are going to buy buildings in a particular locality or a particular TAZ. The effect of sprawl, compact development, and mixed use development can also be measured when we have an integrated landuse transportation model.

(Refer Slide Time: 09:35)



<u>How do we predict the impact of integrated landuse transportation policies?</u>

The 4 stage transportation model has already been briefly introduced in an earlier lecture. Models are used to represent the urban transportation system in a comprehensive development plan. However, all processes or decisions does not require a model or are too difficult to represent using a model. This is because, we may not be aware of all the variables that are required to develop a particular model.

On the other hand, we need to understand or rather predict the impact of an integrated land use transportation plan. This can be achieved by observing the behavior of different kinds of people under different circumstances and then decide on the impact or the effect. For example, survey of a group of people along a particular corridor may reveal that,50% of them chooses public transit,25% chooses personal car and the rest other modes. So, this survey result can be applied to predict the modal choices of people along another corridor of the city which is more or less similar. However, the result may be right or wrong since there would be certain changes from one corridor to another corridor which may not be apparent. However, we can still depend on this technique in situations where it is more or less similar.

Next, if the effect of introducing a new mode along this corridor needs to be ascertained, the previous survey technique is inadequate and people are required to be asked about their choice to change mode. Similarly, people may be asked, about their choice to shift to bus from car if parking cost is increased.

Thus, while we observe the behavior of different kinds of people and then comment on/determine their choice we call this revealed preference. Whereas, when we ask people to state their choice, this is called stated preference.

In case of hypothetical scenarios, people state their choices based on their perception at that point of time. But eventually, when the time comes to take a decision it may be significantly different than what was stated earlier. While, these discrepancies will remain, we can base our decision based on the broad feedback given by the people.

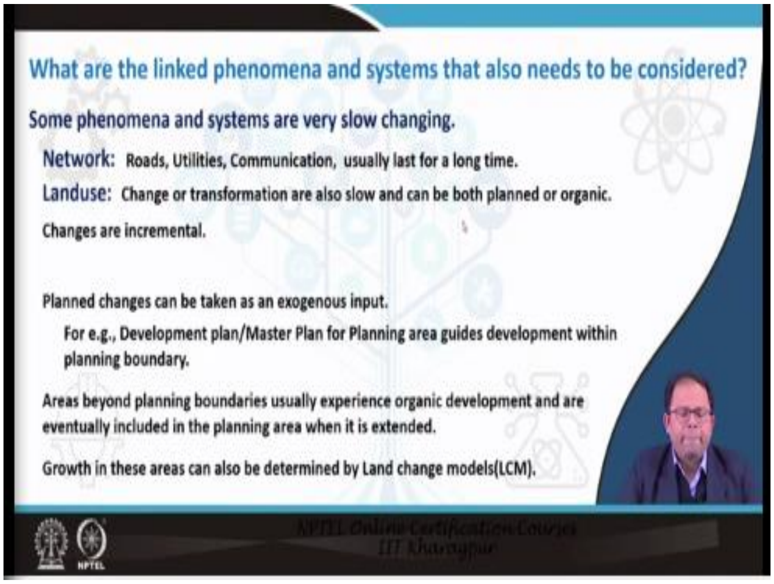
The feedback from one instance is also difficult to impose on another situation. For example, the feedback from one corridor cannot explain the final outcome on another corridor. This also does not allow us to determine the impact of a particular policy on the choice that a person makes. Thus, there is a need to develop mathematical models.

Human behavior and decisions can be simulated using mathematical models and that is why we require the 4 stage travel demand model or a modeling system for urban landuse and transport integration. These simulation models can be used to predict the impact of different policies and interventions using the data that we have collected from existing situations.

Next, as long as the situations are more or less similar, we can use the same model. For example, model developed using the data collected from surveys along a bus corridor on mode choice between bus and personal car or taxi, can be used to predict mode choices in another corridor in the urban area. So summarizing this, we can say that, mathematical models can predict human behavior in unknown situations and contexts as long as the situations are similar to the condition based on which it was developed. This also means that, if a model is developed for a city in India, probably that model cannot be applied directly to a city in America or any other developed country. The variables or other characteristics of the system that are used to develop the model may remain same or maybe there are certain changes in form of addition of a few more variables, but the model needs to be calibrated separately for that other place or situation. Thus, we cannot use the same model but we can use a variation of the model by calibrating it thus saving time and survey cost.

If a model is developed to predict mode choice assuming that, cost, time and the comfort level of a particular mode influences the choice, the model will be also able to estimate the effect of cost increase on the choice of that particular mode in that particular corridor if everything else remains constant. This also helps to determine the factors that could be changed to improve a particular outcome on mode choice in a particular corridor. Thus, mathematical models are always helpful in determining policies which will help us to decide on future changes for an urban area and to also evaluate the outcome of those policies.

(Refer Slide Time: 16:41)



Linked phenomena and systems

Several linked phenomena and systems are considered in determining landuse and transport interaction. These phenomena can be categorized into four types. The first one is very slow changing systems or phenomena, then slow changing systems and phenomena, then fast changing systems and phenomena and very fast changing systems and phenomena.

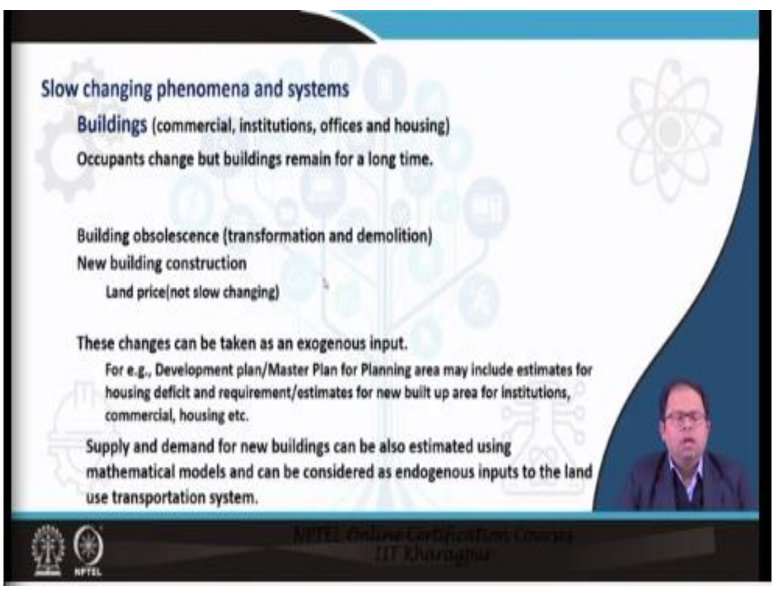
Slow changing systems

Urban networks and the urban landuse are very slow changing systems where changes happen over a period of time. While some changes can be observed after a 5 year period, probably significant change can be observed after a 20 year period. Thus the timeframe is important. Similarly, road, utilities and communication networks don't change rapidly but there is a continuous accumulation of incremental changes. For example, a road may be widened within a period of 5 years or may get extended by another kilometer. Similarly for land use, at the end of 5 year period residential land use percentage may change from 25 to 27 percent. Thus, only incremental changes happen.

Considering the modeling process, there is also a need to identify slow and fast changing systems. When the changes in a system are very slow considering a planning period, we can take that input as exogenous. Thus, the total number of new industries that can come to a planning area may be taken as an exogenous input since it is both slow and it is difficult to determine how many numbers of industries will grow in an urban area over a 30 year period. Instead city planners can set up a target in terms of investment and types and number of industries for the planning period and this could be taken as an exogenous input in the modeling process of landuse transport interaction. These targets could be also adopted from suggestions given in the development plan. This is how, very, very slow changing phenomena and systems can be considered in urban land use and transportation interaction models.

Areas beyond planning boundaries, like peri-urban areas or gram panchayats, usually experience organic development and are eventually included in the planning area when they are extended. However, master plans or development plans do not predict change in these areas. So, certain outlying areas which are included in the master plans can be taken as exogenous input while modeling the changes in the urban land use and transportation. If required, Land change models (LCM) can be used to predict the organic development in the surrounding areas.

(Refer Slide Time: 21:31)

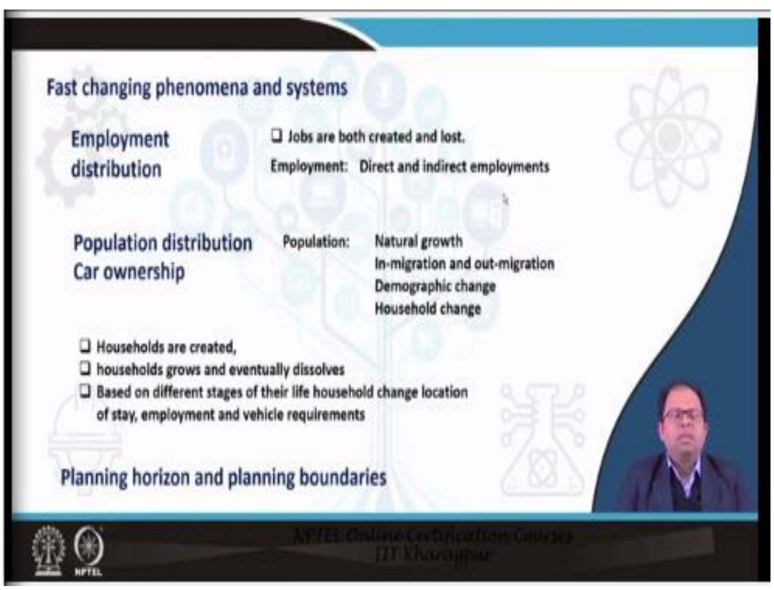


Slow changing phenomena and systems

Buildings (commercial, institutional or residential) last for 50 to 100 years but building use is considered as a slow changing phenomena. This is because within a 50 year period a residential building is most likely to have multiple occupants. A building may change hands i.e., a new family may buy that building or different families may rent that building. Similarly, in case of a commercial building, many offices or firms may take up the building on rent. Thus, buildings are not modeled in plans where the planning horizon is very small and are taken as an exogenous input from development plans and accordingly, we can develop our landuse transportation interaction modeling system. Usually in an urban area, new building construction happens when buildings are either demolished or they are transformed. For example a G + 2 storey building may be transformed to a G + 4 storey apartment building. Even though a building is not that old, it may face obsolescence and needs to be demolished. So, broad estimates of buildings being constructed and demolished and the areas where they need to be constructed can be taken from the development plan. On the other hand, land prices are not slow changing, they fall with increase in building supply and vice versa.

Thus, we can take housing supply as an exogenous input either from the master plan or based on housing deficits that we estimate for a particular urban area. However, for a longer planning period of 20 years we can develop models to predict both supply and demand for new buildings i.e., we consider housing supply and demand as endogenous to the landuse transportation modeling system.

(Refer Slide Time: 25:33)



Fast changing phenomena and systems

New jobs are created and lost in an urban area. Similarly, when new population is added or new households are formed, population distribution of an area changes. These are fast changing phenomena and these have to be modeled in an urban landuse transportation modeling system.

In regards to population, both natural growth and the in migration and outmigration of population to that urban area is considered. However, migration data can be taken as an exogenous input. A demographic and household change that takes place in every area or TAZ in an urban area is modeled using a population distribution model and population location model. The likelihood of a population group or a household to own a car is predicted using a car ownership models.

The frequency at which a person changes a job or buys a car can be called fast changing relative to construction of buildings or change in land use of an urban area. Thus, we need to develop models to simulate the creation of households, their growth through several stages and final dissolution. Households grow when, a single person family becomes a two person family after marriage, and when arrival of a child makes it a three member family. Then, the child grows up and leaves the household thus making it a two member family. With death, eventually this becomes a one member family and then the household eventually dissolves. This transition process needs to be traced. Based on the different stages of their life, households also change the location of their stay, individuals change their employment location which again change their vehicle requirements and influence car ownership. Thus all these phenomenon and systems needs to be predicted and based on the planning horizon and the planning boundaries we need to decide what should be included in our modeling process.

(Refer Slide Time: 28:45)

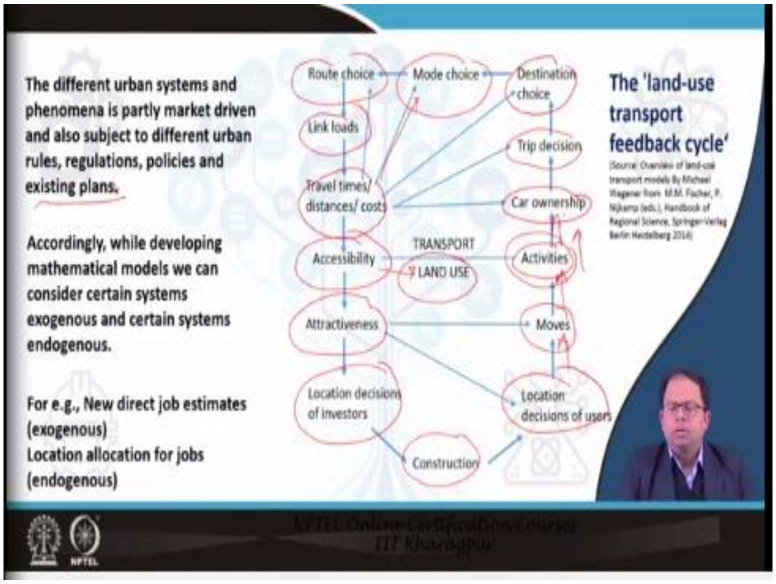
Immediately changing phenomena and systems

Some phenomena changes very fast and even daily. For example, when fare changes for a particular transit system then people may change their mode. When a person buys a transit pass for a particular corridor which is valid for a short period, he is likely to use transit during this period. Similarly in regards to perceptions, a person's perception about a city's transit system or a neighborhood doesn't change overnight, but still, it can be changed through provision of a new infrastructure or provision of a new service.

There are also very short term and dynamic changes that needs to be considered in land use transportation systems. For example, time, congestion, congestion pricing, parking availability, transit crowding are all dynamic phenomena which can influence landuse transportation choices. For example, if a bus is crowded during a particular hour, a person will avoid bus usage during that particular hour but he may use it during other hours, or, if he sees a bus coming which is filled to the brim, he will not get on that particular bus. Similarly, if a person uses a mobile application to check parking availability and finds that parking is unavailable, he may not take his vehicle on that particular day. Using Google traffic data, one can immediately decide to change the route or even the mode to avoid congestion. These are dynamic changes that can happen and should be captured using a landuse transportation model.

Finally, when we consider urban environment, there are certain effects which are immediately felt, like noise and air pollution along an urban corridor if there is lot of traffic. Land use structure may result in long term impacts like water and soil contamination and these choices also need to be modeled in a landuse transportation system. Interestingly, as a feedback the environment also impacts location choices. If an area's environment is not that good, people will not choose to locate to that area either for job or for residences.

(Refer Slide Time: 32:06)



Land use transportation interaction

The entire landuse transportation interaction process includes a comprehensive list of systems, phenomena and actions. This is illustrated using the famous image titled 'the landuse transport feedback cycle' developed by Michael Wagner.

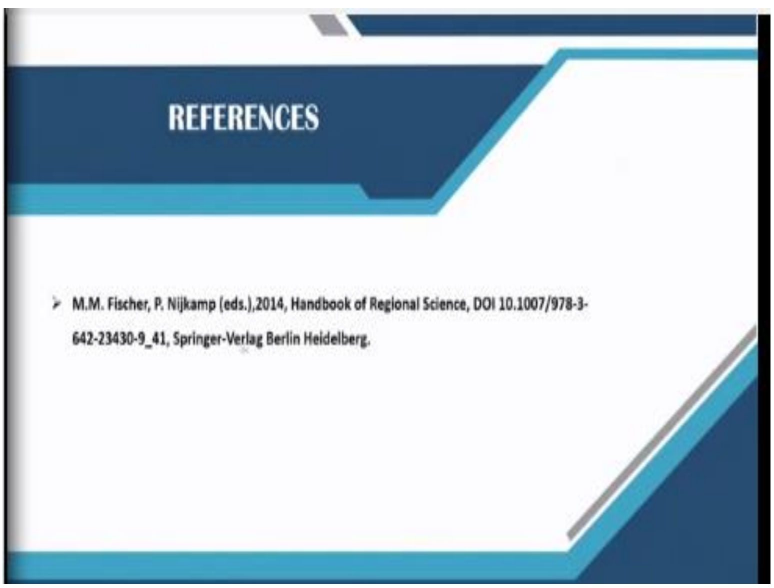
A particular instance of landuse and transport leads to certain activities that a person does in a particular day. Activities refer to going to school, work, restaurant or staying back at residence etc. This setting of landuse and transportation determines his car ownership. Once a person buys a car it influences his/her mode choice to reach a destination. Once a mode choice is made, decision is taken on the route. Depending on the route, the travel time and cost will be different which again influences his/her mode choice. Choice of a route may also change his/her trip decision. For example, the person may decide dynamically to either not travel or change destination for watching a movie in case he/she finds the network/route to be congested. These short term changes in individual choices, in the long term, changes accessibility which is a fundamental characteristic related to landuse.

Change in accessibility changes land attractiveness of an area which is essential for real estate developers to undertake construction or a person to buy a house in that area. This will again lead to household movement to a new area and this starts the chain of activity which we have already described. This is the landuse transportation feedback cycle and this also summarizes the relationship and the linkages between the different urban phenomena and systems.

While some of these phenomena are driven by market forces, some of them are guided by urban rules, regulations, policies and existing plans like development plans which are already in place. For example, a master plan shows areas reserved for residential land use thus making residential choices more restricted.

Thus, a land use transportation plan determines the available choices for a particular activity or a particular location choice. While developing these plans, certain systems are considered exogenous and are taken as fixed inputs from existing plans and other documents whereas, certain systems are considered endogenous and models are developed for these particular systems and the interactions in-between these systems.

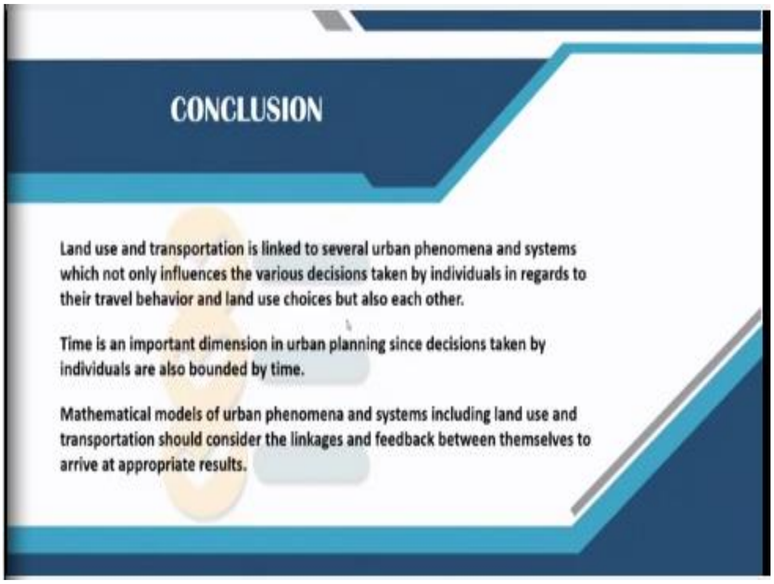
(Refer Slide Time: 36:50)



Reference

Handbook of Regional Science.

(Refer Slide Time: 37:04)



Conclusion

Landuse and transportation is linked to several urban phenomena and systems which not only influences the various decisions taken by individuals in regards to the travel behavior and landuse choices but also each other.

All urban phenomena, for example, residential location choice and real estate development are linked.

Time is an important dimension in urban planning since decisions taken by individuals are also bounded by time.

Mathematical models of urban phenomena and systems, including landuse and transportation, should consider the linkages and feedback between themselves to arrive at appropriate results.

Thank you.