Urban Transportation Systems Planning
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Lecture - 52
Land Use and Transportation - II

Welcome to module G lecture 2. In this lecture, we shall continue our discussion about land use and transportation.

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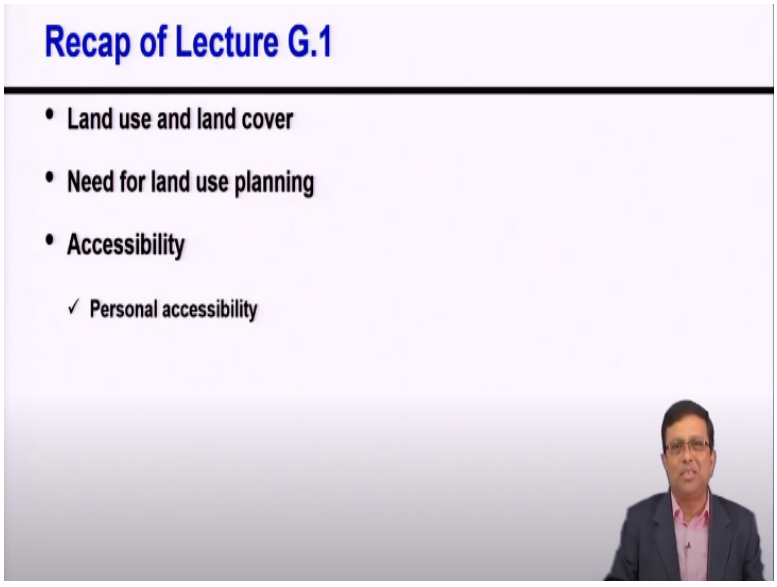

In lecture 1, we explained to you the difference between the land cover and the land use, why we need land use planning and then introduced to you the concept of accessibility. What does it mean, how simply we can, in a very simple way we can measure and then also some kind of refinement to the understanding of accessibility.

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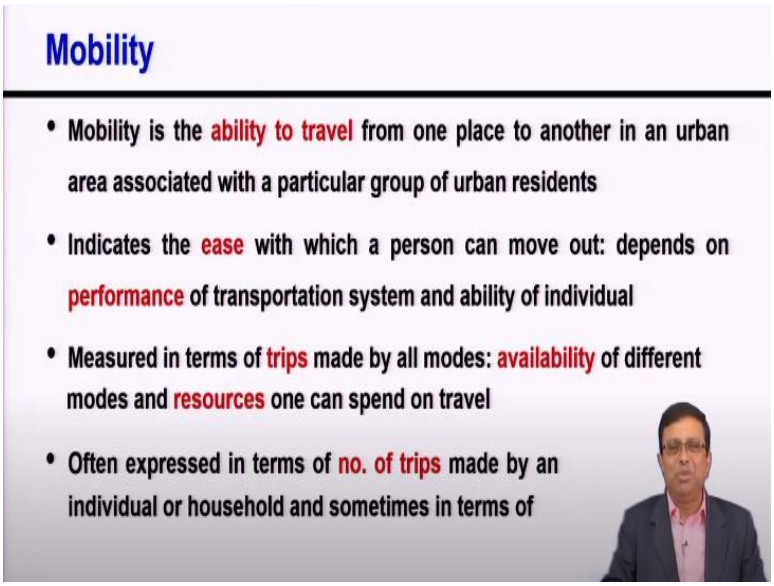

Now in continuation to this discussion now we shall talk about the mobility. Because often the accessibility and mobility both terms go together, used very frequently so you should understand also the concept of mobility to some extent. Again, all these we are not going to discuss in detail. We only discuss it a little bit just to give you some basic ideas. Mobility is actually the ability to travel from one place to another in an urban area associated with a particular group of urban residents.

So, if you consider a particular group of urban residents, it refers to the ability to travel from one place to another in an urban area. Obviously, it indicates the ease with which a person can move out. How easily a person can move out it depends on two things. One is the performance of the transportation system. How easily one can go out depends on how easily one would be able to make a travel it depends on what is the performance of the transportation system;

How well the transportation system is developed, the roads and transport systems are developed and also the ability of individuals. That is what we say different groups of residents. So, how one would be able to go out or to make a travel depends obviously on the performance of the transportation system but also on the ability of the individual because in so many ways the social economic characteristics will really govern that.

Often mobility is measured in terms of trips made by all modes and obviously it will depend on

the availability of different modes, what all modes are available for travel and also will depend on how much resources one can spend on travel. Because traveling is you need to spend some money. So, how much resource one can spend on travel and what is the availability of different modes?

Then only we can measure mobility in terms of the number of trips made by all members. As I said mobility is often expressed in terms of the number of trips made by an individual or a household and also sometimes the aggregate value.

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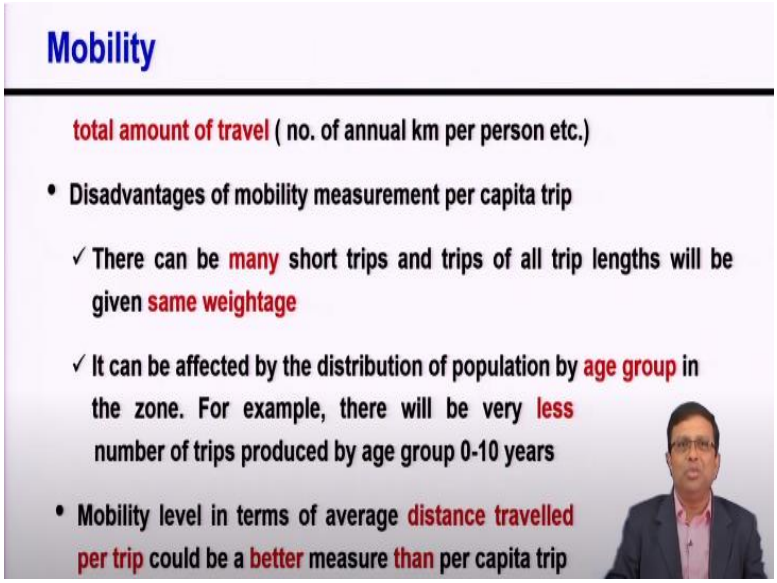

For example total amount of travel, say number of annual kilometres per person, etcetera. Now in many studies or researches have used the; measure of number of trips or number of per capita trips or number of trips per person as a measure of mobility. But then there are two disadvantages or two issues which were faced. Number one is there can be many short trips and since we are saying number of trips, the short trips, long trips all will be given the same weightage.

So, there can be many short trips and trips of all trip lengths will be given the same weightage. But it may not truly represent or may not be completely rational. Because short distance it is easy to make trips. So, long distance trips and short distance trips are considered equal and just I am counting the number that may not be very rational. The second is we are saying trips, number of

trips per capita or per person. So, what we are doing?

Total number of trips made in a zone divided by the number of population. But then zone to zone the distribution of population may be different by age or by age group. For example, we know that there will be very less number of trips made by the age group 0 to 10 years. Similarly older people do not make so much of trouble in Indian scenarios as well. So, if the distribution of population is not the same in different zones.

Then if I am taking the number of trips per person as an indicator and trying to compare that across different zones because the population distribution is different. Only per capita number of trips per person is not a very logical measure to compare across different zones. So, these are the two major issues if we are trying to use the number of trips per person to quantify the mobility. So, people thought that the next idea came that mobility level in terms of average distance travelled per trip could be a better measure than the per capita trip. How much distance?

So, the distance travelled per trip may be taken as an alternative measure. People started working like that.

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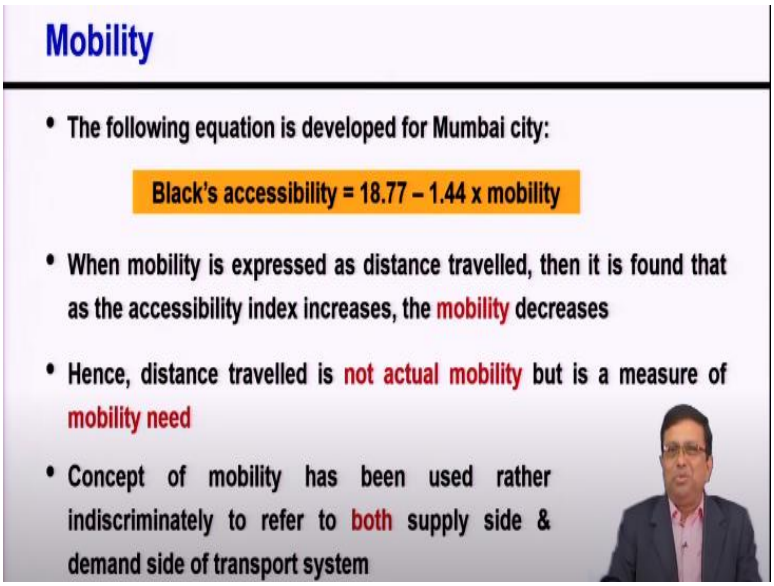

And then a lot of works are there but I would like to show you one small work, very significant work, which was done by a researcher. He actually calculated the Black's accessibility. Of

course, as I said that we have limited opportunities here to go into depth. So, it is a measure of accessibility and in the name of the researcher Black. So, it is called Black's accessibility. So, when this accessibility was measured for the city of Mumbai in India and the relationship came like this.

Accessibility equal to 18.77 - 1.44 into mobility and here the mobility was expressed in terms of as I said earlier slide distance travelled per trip. Distance was taken. So, that is the equation which came up from the real data. This was surprising because what does it indicate? The accessibility improves mobility decreases or mobility improves accessibility decreases. Does it match with your understanding so far whatever you have understood about accessibility and whatever is the basic definition of mobility?

Quantification still you do not know but what we mean by mobility we know that it is the ability to travel from one place to another and it indicates trying to say that ease of movement. So, does it match with that? It does not match. How? If accessibility improves how the mobility can get reduced? Because accessibility improves means the places are very well connected. One can very well access various opportunities which are there in the surrounding.

And you have also seen to some extent we have discussed that an improvement in the transportation system or the transport network or reduction of travel time, reduction of travel cost will improve the accessibility. Because when we are considering the distance is basically taken for discounting this opportunity. Because longer the distance or longer the travel time lesser value we are adding d ij to the power b in the denominator.

So, does it really match that if accessibility improves the mobility will reduce? Mobility cannot reduce. It does not match with our understanding of accessibility and understanding of mobility. Forget about how we quantify it. But we are sure that if we are trying to quantify mobility by average travel distance per trip or distance travelled per trip then this is not matching with our understanding. Then what it is? What is then the distance travelled per trip?

Distance travelled per trip is actually not the mobility but it indicates the mobility need. Mobility

need and mobility is very different. So, that is why we said when mobility is expressed as distance travelled then it is found that as the accessibility increases the mobility decreases which cannot be true. It does not match with our understanding of accessibility and mobility. So, therefore distance travelled is not actual mobility, but it is a measure of mobility need. Mobility need will reduce.

What happens if a place is very well connected to all other places in that region? Think of two places. One is very well connected to all other places in the surrounding areas and another place which is not so well connected. Accessibility, first case you consider the accessibility of a place is higher, the second case the accessibility is lower. Your mobility need will be lesser in the first case. Opportunity is different but need is again a different thing.

Need will reduce because in all possibilities that place will get developed so well that everything will be available there. If that is the kind of place it is unlikely that a medical facility will not be available there, education facilities will not be available there. So, in all possibilities probably your mobility need will reduce. Not the actual mobility. So, to conclude I would say that the concept of mobility has been used rather indiscriminately to refer to both the supply side and demand side of the transportation system.

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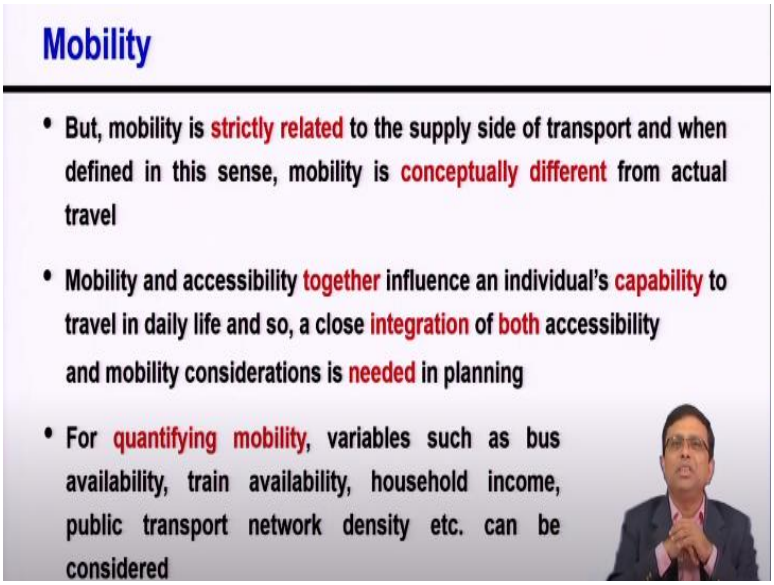

Whereas mobility is actually strictly related to the supply side of the transport system and when

you try to define in this sense the mobility is actually conceptually different from actual travel. So, mobility is important. Mobility accessibility both terminologies are very, very important for us. And without going into further details I would like to say a few important statements that mobility and accessibility together influence an individual's capability to travel in day to day life or in daily life.

Mobility and accessibility together influence an individual's capacity to travel. Accessibility, how well it is connected and mobility will indicate basically the opportunity depending on the social economic group, what kind of opportunity ability and ability to travel. The ability is very important. If you consider the mobility definition what we said? We said first that mobility is the ability to travel from one place to another. So, both are important. And altogether it will decide.

So, mobility and accessibility together influence individual capability to travel in daily life. And if so, therefore a close integration of both accessibility and mobility consideration is needed in transportation planning. We should not consider only accessibility we should not consider only mobility. But what we need is a close integration of both accessibility and mobility. So, that means ideally maybe we should have a quantification of accessibility accounting mobility.

So, the accessibility expression should have consideration of mobility. And when we are trying to quantify mobility, we may take variables such as various variables or aspects such as bus availability, train availability, household income, public transport network density all such kinds of things availability of buses, availability of trains, household income, public transport network density.

Because public transport network density will show that how closely we can access to the bus stop. So, walking distance to the bus stop or the last mile connectivity to the bus stop all these will come. So, there are further developments which are reported in the literature but I will have to stop there and with this concluding statement that a close integration of both accessibility and mobility consideration is needed in transportation planning.

So, a lot of subsequent research has happened based on these directions or based on this kind of

conclusion. And there are measures of accessibility which is accounting also mobility. That means quantification of accessibility and accessibility measures include many things and out of those many considerations one component is also the mobility. So, together we need to consider them and for the transportation planning purpose.

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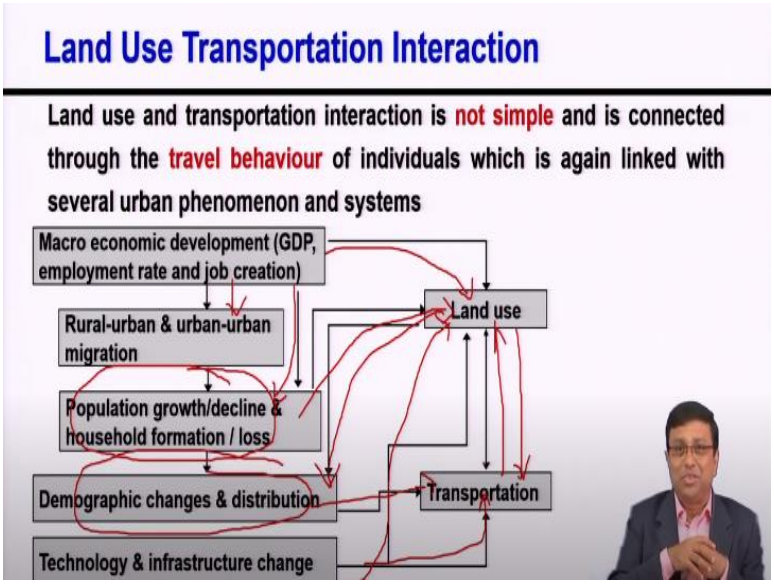

Now I go to a different topic. When we talked about the accessibility itself we said that the land use and transport are not separate identities. We sometimes consider land use planning separate, transport planning separate. The outcome of land use planning is fitting as input to the transport planning process. We do it for our simplicity and as I said, every modeling approach will have some kind of limitation or is based on certain assumptions.

We need to improve further to make it even more realistic or more practical. But actually the transport and the land use are very closely related. And this land use transport interaction is not simple and is connected through the travel behaviour of individuals, which is again linked with the several urban phenomenon's or systems. For example, let us try to see this simple flow chart. I do not know whether it is simple but we try to represent it in a simple manner.

If you look at this somewhere some macroeconomic development is happening or changes are happening. Rather I should say it can go on the positive side, it can go on the negative side. GDP may grow, GDP may come down. Employment opportunities may be created employment

opportunities may be lost or so. I mean going down during a recession or something. So, change in the macro economic status what will it mean?

The moment it is changing it will immediately directly impact the land use. So, this connection is it may impact the land use. Let me take the pen. So, this way directly impacts land use. That is why this is shown. Now once this macroeconomic development or some changes is happening, it will cause also migration. Maybe rural-urban, urban-urban, more job opportunities you create people may come from rural to urban areas or loss in opportunity people may go back.

People may also shift back to their own cities because there are no jobs so they do not stay there. You create more opportunity more people may come even from rural areas or from other urban areas and all these will mean some kind of change in the population. It may grow, it may decline. Even directly also we can say that change in macroeconomic development in a positive or negative sense may also directly have an impact on this population growth or change in the population.

Now once the; population growth or decline happens and household formation may happen, loss also may happen, people may shift also. So, there will be change in the demography. So, demographic changes and distributions will happen. The moment demographic change and distribution will happen if we are, say creating more jobs, think of a positive side. So, more people may come or more people will start remaining, there will be more demand. That will have an impact on the transport.

Now; that also, if you think when the population growth or household formation happens that will also impact the land use. The moment the land use changes that will also impact the demographics. You develop technology, develop infrastructure, build more roads, build more housing, whatever you say, any change in the technology, any change in the infrastructure that will impact also the land use.

That will also impact the transport. And the land use will then impact on the transport; transport also will impact the land use. So, all actually if you see this they are all interconnected. So, land

use and transport are interdependent. Land use will influence transportation, transportation will influence land use and not only that through several other processes as I have said any change in economic development, migration, housing opportunities, growth of population, demographic changes.

Technology or infrastructure changes, all actually will somewhere or other impact both land use and transport. See it is very difficult to actually segregate one. That is I want to take out transport and consider them separately. It is difficult. And also this interaction is not so simple. So, there are dedicated courses as I am offering a 12 week course. You will find there are similar courses available which are specifically focusing on this land use transport modeling.

The complete course like urban transportation systems planning, the complete course is on land use transport interaction and land use transport modeling. So, it is really a big area. But here we will not be able to, that is not our intention and plan also to discuss everything in detail. We cannot do that. But we want you to give the basic context as I say that four stage urban transportation planning we are discussing what is the context of land use?

How we are taking it. We are taking it as external input. But then also you want to tell you a little bit that it is not really separate. That is what is our assumption for this kind of modeling approach and there are advanced models which actually consider them together. So, the whole land use transport interactions, there were early generation models then middle era models and the recent model of the latest development is much more complex.

So, many considerations are there, so many complex models are there and those models are also most cases very data hungry. So, much data is required then only the model details anything. Any model you develop in more detailed form you want to develop you need to input more data. So, really it is an interesting area. Those who are interested please take up other courses, specific courses on land use transport interaction and land use transport model.

In this course we give only some general understanding and some introductory material to you. So, this clearly shows how the interaction takes place and how the land use and transport, their

interdependencies explained and we say that it is not so simple. It is a complex one.

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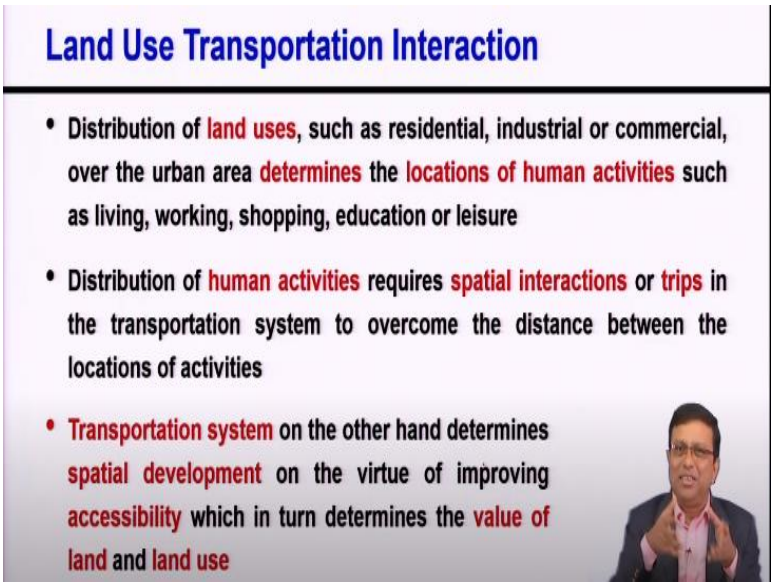

Now the land use transport interaction you can also think of it like that the distribution of land use is there. So, residential locations, industrial, commercial all these are located in different places. So, distribution of land use determines the location of human activities and where people want to live, where they will work or the shopping opportunities are available, where, education is available, so and so.

And distribution of human activities needs special interactions of trips because they have to be connected. How they can be connected through trips? So, that is where the travel part comes. In the transportation system to overcome this distance people want to travel and the transportation system then comes into picture. And transportation system on the other hand is where the land use brings the transport context. On the other hand the transport system determines the special development on the virtue of improving accessibility.

Because the moment you improve transport you are actually changing the accessibility and which in turn will change the value of land and the whole land use will change. So, that will again impact the land use. So, transport will impact the land use in this manner and the land use will impact transport as I said in the first two points.

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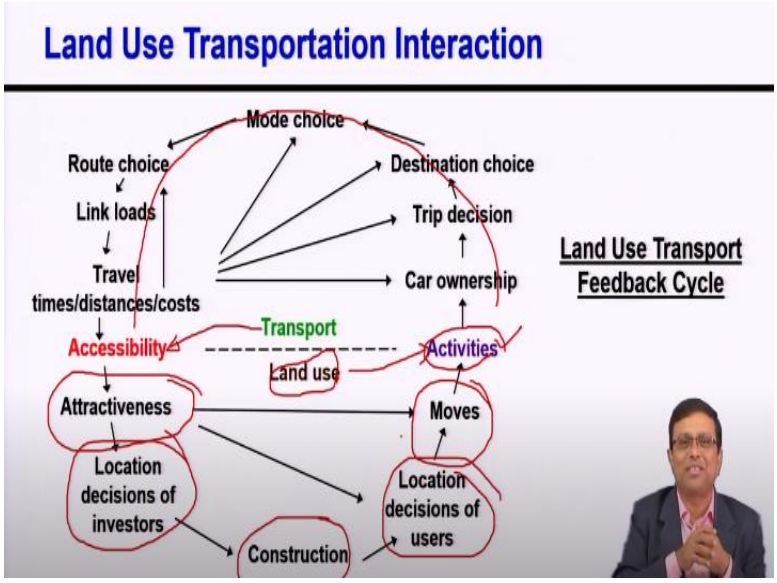

This is shown here in this one. So, you consider the land use and the land use actually will generate activities. The moment the activities are generated then the whole transport process will come. And every decision will get linked. The moment you want to travel then how to travel, the car ownership will come, the transport system characteristics will come, the trip decision, destination choice will come, more choice will come, route choice will come.

And once you know the route and how the people and the assignment and how the equilibrium is happening then the link load will come then the travel time or the congestion effect or the cost will be determined. And all this will improve the accessibility. So, one end activity that is the land use part basically. So, connecting to activity in a way and then transport is actually finally influencing with the input from land use and activity and all the trips and mode and route and destination.

All are getting linked actually. And then this influences accessibility. The moment the accessibility then comes the lower part you can think. So, accessibility changes the attractiveness. If a place's accessibility is improved attractiveness will also improve. People would love to stay there. So, given an opinion or given a choice all of us would love to stay in a place which is where the accessibility is very high, in a zone or in a location where the accessibility is high.

So, the attractiveness will increase. The moment the attractiveness increases that will influence the decision of the investor. Wherever the demand will be there builders also promoters also will come. They will start developing infrastructure they will try to sell those properties. So, the construction will happen and that itself now there are so many flats, so many office areas, buildings are available. So, that will start influencing location decisions of users.

Finally, movement will also take place, people may shift, relocate all this. That again will impact the land use. So, now the moment the land use is impacted the activity pattern gets changed. So, you can see this whole land use transport feedback cycle how it works and that tells you how complex those interactions are.

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Quickly now we will talk about one accessibility model which was proposed by Hansen. And Hansen's demonstrated that location with good accessibility had a higher chance of being developed, as I stated also earlier, developed at a higher density than remote locations. So, it was designed or the model was designed to predict location of population considering employment as the predominant factor in determining location.

So, how the population finally will get distributed, that is a key thing that we try to get. And he suggested to use an accessibility just like this. A ij equal to E to the power E j divided by discounting. So, opportunity is here, whatever we said as earlier. Opportunity is here,

employment is taken as the basis. So, people are employed somewhere then you try to decide where you want to locate your residence.

So, employment is taken as the key consideration at the starting point in a sense for this kind. So, A ij equal to E j divided by d ij to the power b.

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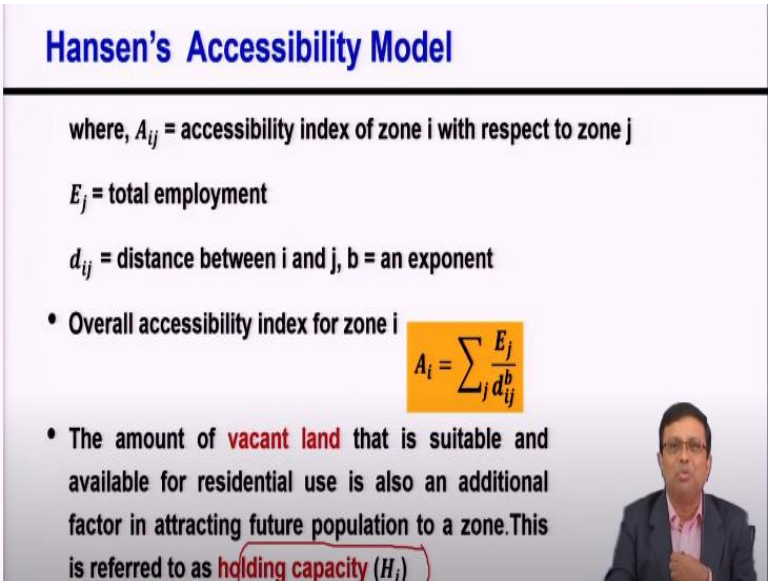

Here A ij is the accessibility index of zone i with respect to zone j and E j is the total employment. d ij is the distance between i and j. b is an exponent or a constant you can say. So, overall accessibility of a zone is how much? It is said accessibility of zone i with respect to zone j. Now there are many j's around. So, sum over all j, all zones together will decide how is the accessibility of one zone.

So, A i is basically sum over j or you can say sum over j E j divided by d i j to the power b. Discounting is happening through this distance or time or whatever you say. Now interestingly, this is the accessibility in terms of connections, in terms of travel distance accessing to various opportunities like this but now how fast it will get developed. Let us try to think. Now the amount of vacant land is really an important consideration here.

The amount of vacant land that is suitable and available for residential use is also an additional factor in attracting future populations to a zone. And this is referred to as in this case as holding

capacity. So, how much vacant land is there? Vacant land will give the opportunity for further development. So, the holding capacity is known.

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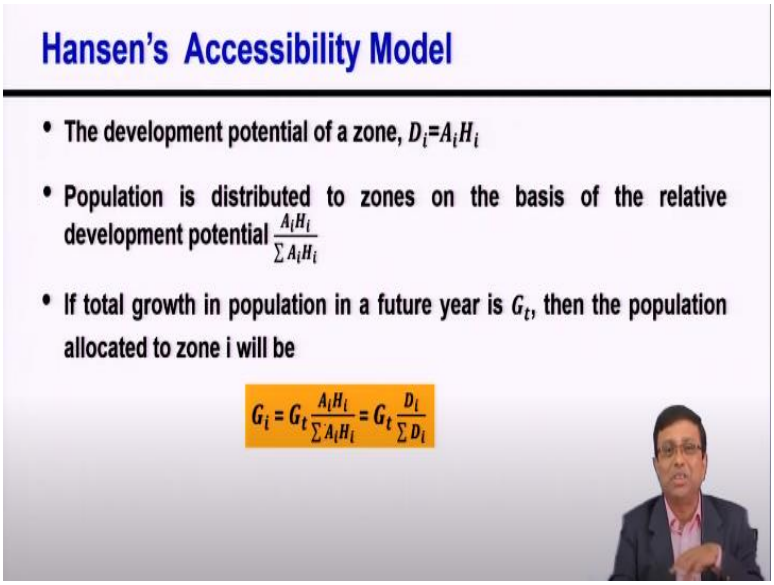

Now once the holding capacity is known and the accessibility is known then the development potential of a zone will be A i into H i. Then what is the accessibility? Higher accessibility higher holding capacity for the scope of development that will mean that the zone will have higher potential to develop to a higher density or further development. So, like that you can have every zone will have some development potential based on consideration of accessibility and holding capacity.

Now how relatively the zones will likely to develop with the future as per relative development potential? That is what is shown here. A i H i divided by sum over A i H i. And then the future population will get distributed as per relating to developing potential. If I know in the future so many people are going to come up, how they are likely to then the population, how they are going to get distributed as per the development potential.

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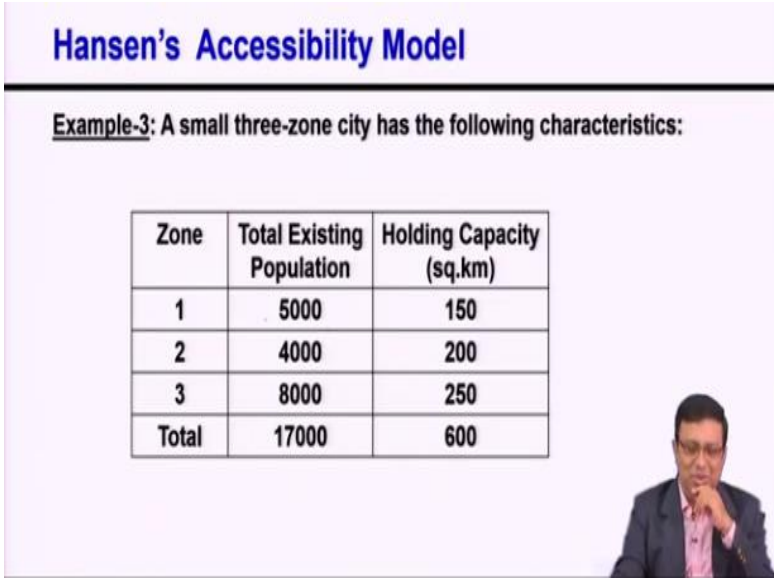

Now I have taken here a small example. There are three zones, existing population, you can assume the employment is proportional to population and the holding capacity are given.

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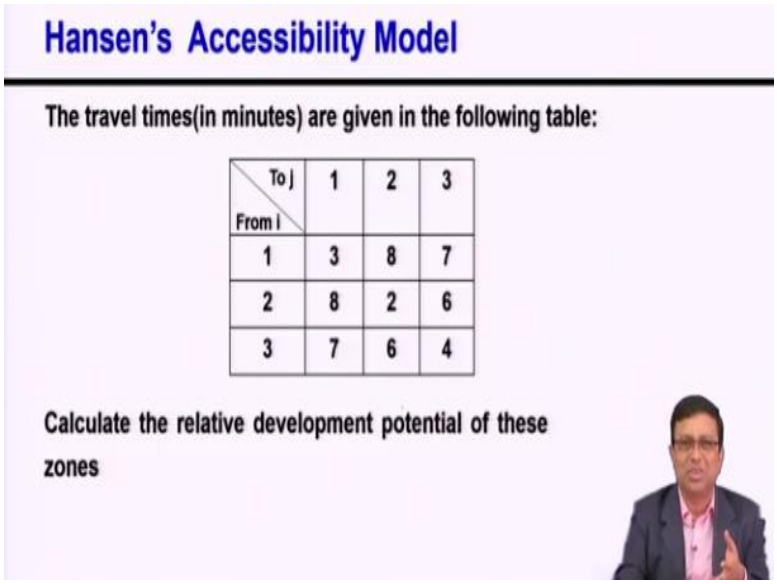

And the travel times are also given. 1 to 1, 1 to 2, 1 to 3 like that and calculate the relative development potential of these zones.

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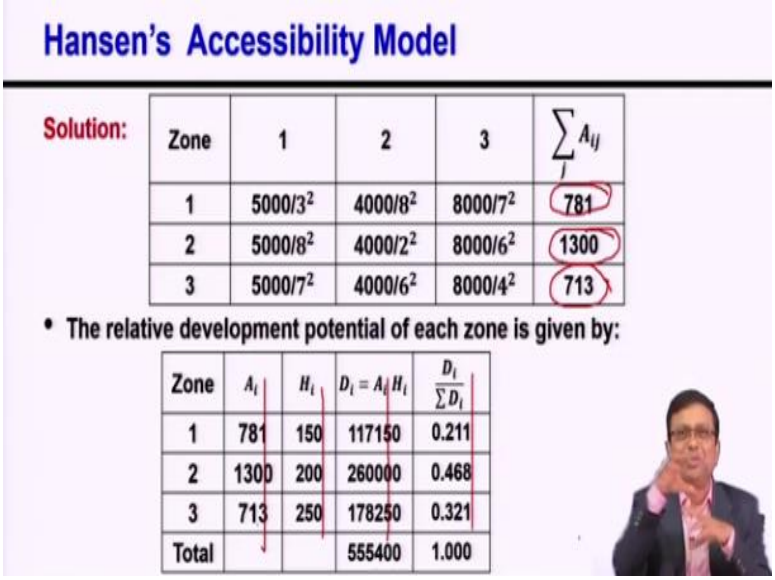

So, what we can do? We can take an exponent of 2 here. The b is d ij to the power will be the is taken as 2. So, you calculate A 11, A 12, A 13, A 21, A 22, A 23, A 31, A 32, A 33, 1 to 1, 1 to 2, 1 to 3, 2 to 1, 2 to 2, 2 to 3. You can calculate like this then you take a zone and sum it over all j you can get the accessibility of zone i as 781, accessibility of zone two as 1300, accessibility of zone three as 713. Then once you know the accessibility these are the values here.

Then you know the holding capacities given so you can calculate the development potential and you can calculate the relative development potential. And now if I tell you what will be the future population and how the future population will get distributed to all these three zones, you will simply distribute it as per this relative development potential of these zones.

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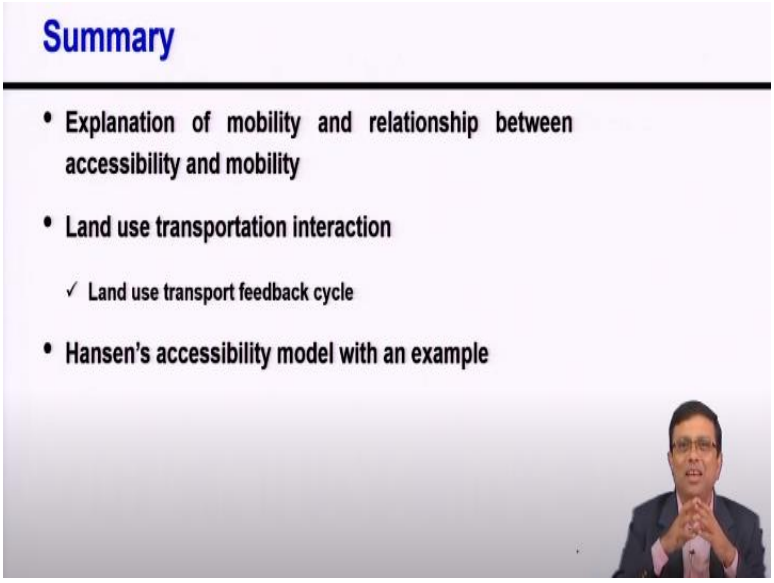

So, what we discussed in this lecture in summary we explained to you what is mobility and different ways of quantifying mobility. And we said that what are the; issues with different measurements and then justified or explained you little bit the need for considering both accessibility and mobility together. And as a set also there are accessibility measures which also account for mobility in the quantification of accessibility, so, accessibility accounting mobility.

Then we explained to you the land use transport interaction in a very simple way we try to say. And there are so many models. We say that really in this course we shall not be able to tell you any advanced model or so. But few things we want to discuss and the first model what is discussed here is Hansen's accessibility model by taking the employment and then we said that how the residential population will get distributed.

So, we defined what is accessibility. A ij accessibility of zone i with respect to zone j then how we define the accessibility of a zone sum it over all j. And then accessibility is better than the vacant land is also important that relates to the holding capacity. And the accessibility and holding capacity together will decide the development potential of the zone and then the future population likely to get distributed as per the relative development potential of different things.

Then with a simple example we tried to or I tried to tell you how you can apply this Hansen's accessibility model to get the future distribution of residential population. So, we close it here.

Thank you so much.