Urban Transportation Systems Planning
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Lecture - 53
Land Use and Transportation – III

Welcome to module G lecture 3, in this lecture we shall continue our discussion about land use and transportation.

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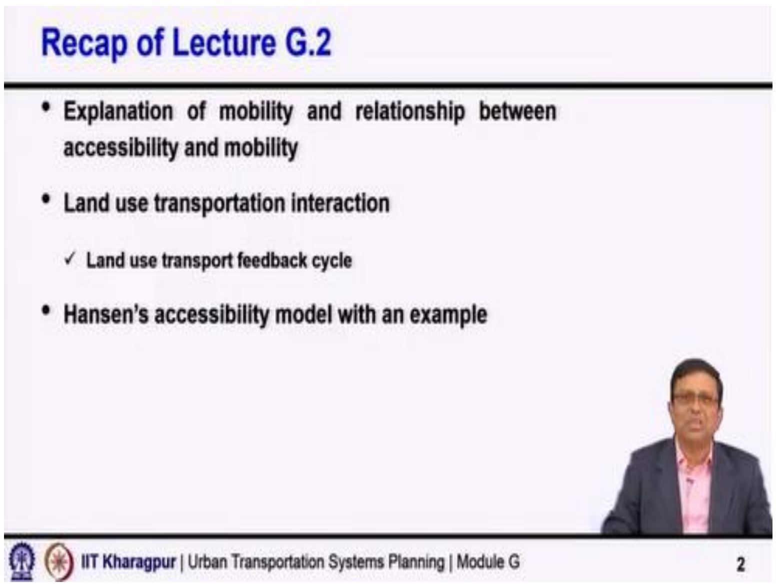

In the previous lecture we explained to you the concept of mobility and the need for accounting both accounting for both accessibility and mobility in the context of transportation planning and how the overall decision to travel depends on both accessibility and mobility, then we explain to you about the land use transportation interaction with some simple cycle or graphical representation.

And, then as I said that we shall not be able to discuss in details about the land use transport models, but some simple models we wanted to show you which are not really advanced model or more recent model rather that early stage model and maybe one model we shall discuss in the next lecture that is intermediate era model you can consider. So, we discussed about Hansen's accessibility model.

How accessibility is defined A ij and then accessibility of a zone i and then how the vacant land or the available land can be considered which is available for potential development. So, holding capacity is considered and then the development potential and how Hansen's accessibility model can be used effectively to find out the residential distribution of residential population in the future. So, now we shall discuss in this lecture about two other modeling approach.

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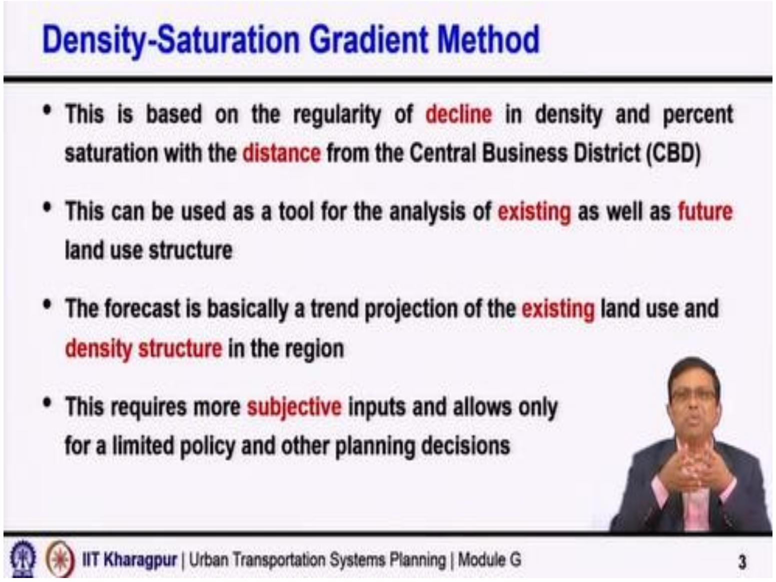

Or, the approach for getting the population distribution the first one is density saturation gradient method. So, this is based on the regulation of decline in density we are saying that density will decline and percentage saturation both will decline the percentage saturation and the density will decline with the distance from the CBD. So, where the maximum density is expected to occur within the CBD?

So, density and percentage saturation is expected to be highest in the CBD then as we go away from the CBD the distance increases then there will be reduction or a decline in the density and the percentage saturation. This can be used as a tool to analyze the existing as well as future land use structure and the forecast is basically a simple trend projection of the existing land use and the density structure in the region.

Simplified model of course these are all early era model simplified model but when we are learning the subject this models are still very useful and this requires more subjective inputs and allows only for a limited policy and other planning decision of course we do not expect you know the behavioral aspects to be considered in such kind of early era model or simple model but still they are meaningful, they serve certain purpose. So, there are limitations but they are also simplified model and could be used in some situation.

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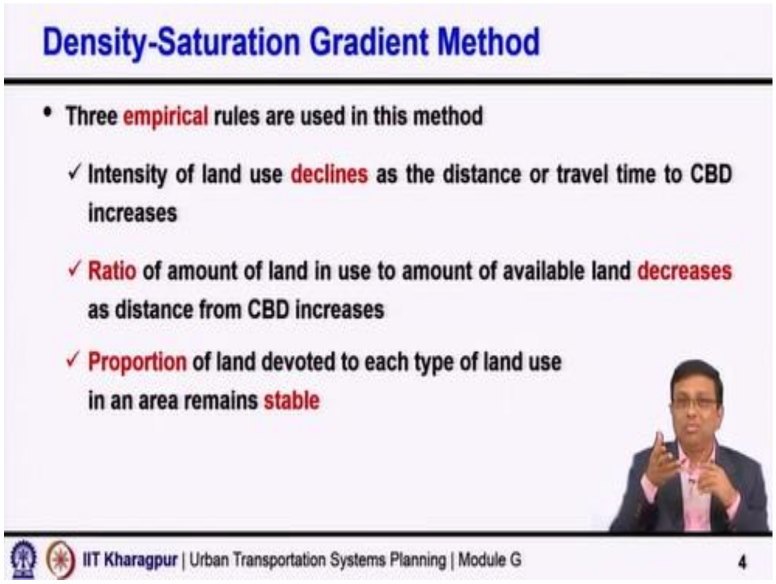

Three empirical rules are considered in this model; you can call them used or call them also considered in this model. One is intensity of land use declines we are talking about intensity of land use declines as the distance or travel time to CBD increases. So, as you go away from the CBD the travel time increases distance increases and as the distance and travel time increases the intensity of land use declines very logical.

That is what you see from any city center if you go away radially outside we see that as we are away from the CBD the intensity of land use declines. Second, the ratio of land use land in use the ratio of amount of land in use to amount of land available, out of the complete land partly land is already used and part of the land is available for future development. So, ratio of amount of land in use and or to the amount of land available that ratio decreases as the distance from CBD increases.

Again, quite logical again quite of logical the more percentage of land is available higher and higher percentage of land is available as you go away further development can take place. Third, is again an important consideration it says that proportion of land devoted to each side of land use in an area remains stable, this actually indirectly indicates the interdependency of different types of land use.

If certain, if more residential population is there you need more school, more you know medical facilities, more services. So, the proportion of land devoted to each type of land use in an area remains stable a very again, a very logical consideration. So, if you say the empirical rules are generally logical may be relook at the things will show you still there are many potential many things such kind of models cannot do we also know this limitations.

So, more and more behavioral based models are being used these days and people use micro simulation behavioral based model and there are you know very detailed and used transport models which are coming up but they are also very data hungry, these are very simple model use very simple concept.

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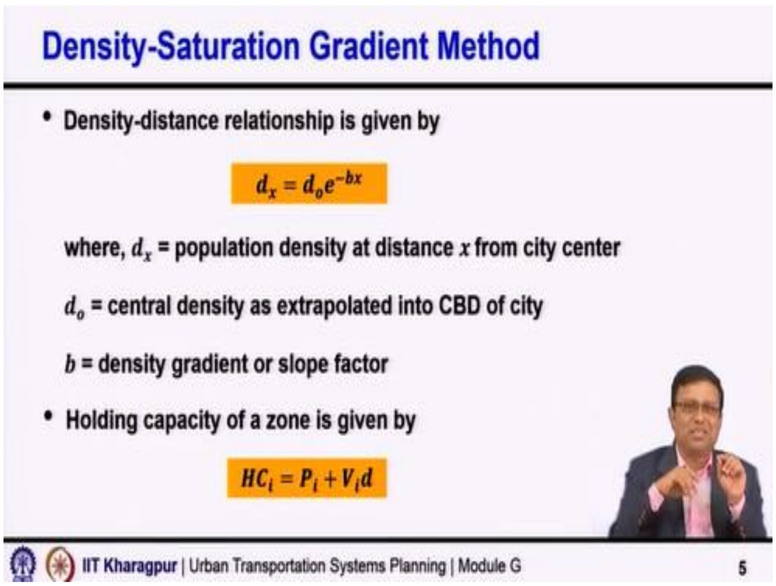

Then the density distance relationship is given by such kind of equation d x equal to d 0 e to the power minus b x, so d x is the population density at a distance x from the CBD or from the center and d 0 is the density in the centre. So, central density has extrapolated into CBD of city and b is the density gradient or slope factor people call and you can clearly see as we go away from the city center or the CBD naturally this equation shows how the density will reduce with increasing distance.

The second is this approach or method also use holding capacity but holding capacity is defined in a slightly different manner here the holding capacity of a zone is in terms of the population. There we considered in earlier case Hansen's accessibility model and when we extended and used it for to calculate the development potential then holding capacity you just consider the vacant land but here the holding capacity is the population.

How much population it can accommodate, so tell me simply how much population an area can accommodate how much are existing how many are population is already there the number of population presently in this zone that is p i plus the amount of vacant land that is there and at what intensity of development is permitted for those land, parts per square meter or square kilometer or whatever you need to say per unit area.

How many population we can have that depends on the rules and regulations of the city how much development is allowed what kind of development is permissible in which zone all such kind of rules and regulations will govern this, so H C holding capacity of zone A i H C i equal to P i + V i into d.

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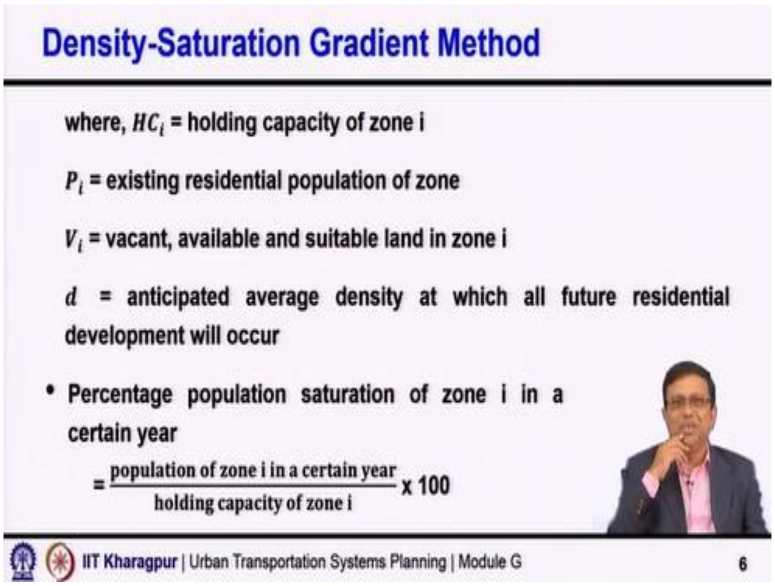

As I said, H C i is the holding capacity of zone i, P i is the existing population they are any how there so what is the capacity present population plus what is the amount of vacant land available and suitable for a particular purpose multiplied by d what is the d, d is the anticipated average density at which all future residential development will occur future what density will be permitted that also may change over time the government regulation changes.

The housing regulations will change that is again also become dynamic, you can see that cities earlier mostly having one or two storage building then having g + 3, g + 4 then even higher and now in the big city especially in metros you will find that g + 30, g + 40 kind of development people are talking. So, it depends on anticipated average density at which all future residential development will occur.

If you want to consider is same as the present one you can do that you want to take a different value you can do that, so you can calculate the holding capacity. What will be the holding capacity in the future, then present population saturation of a zone i how much is the holding capacity? Compared to that what is the amount of population that is presently living in zone i that shows the level of saturation.

So, percentage population saturation of zone can be collected can be calculated easily equal to the population of zone in a certain year divided by what is the holding capacity of a zone into 100, 100 means we want to express it in percentage.

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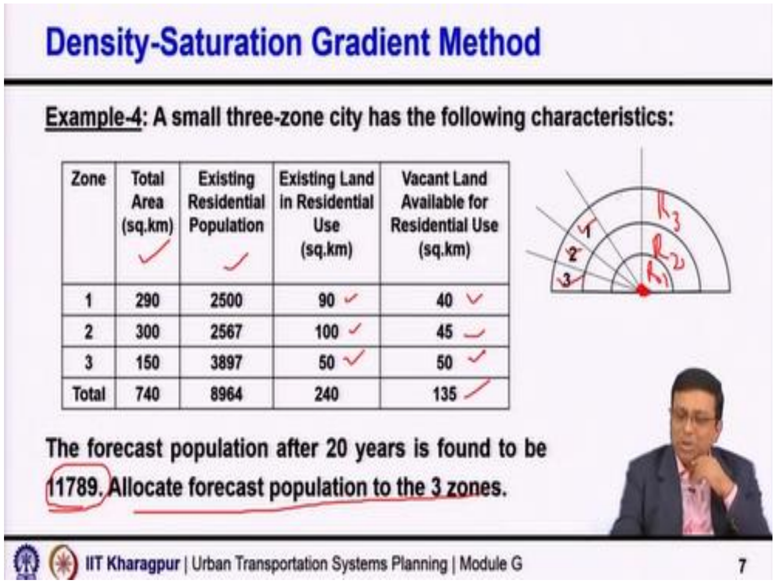

Let us take a small example; let us say the small three zone city has the following characteristics but we want to make it little bit simple. So, look at the figure on the right side here the first ring suppose this is the city centre that is what is tower city center and this is ring R 1 this is ring R 2 this is ring R 3 and let us assume that the residential this density what we said earlier the density the density changes density gradient.

That density gradient is valid when we are moving from R 1 to R 2 to R 3 we are going away from the city but when we consider a particular ring we can assume within that ring because all are we can assume from equal distance in just there in one ring. So, if something some zones or multiple zones are located in R 3 all these zones are from equal distance from the CBD. So, this density in all these zones permissible density will be same.

Because so this density distance density relationship will not apply, so we took intentionally in this example three zones which are just in wondering to explain that we shall not apply this density distance relationship, so this relationship we are not going to apply, they are not applicable because we are considering that our all these three zone you can see this is zone 1, zone 2 and zone 3 all these zones are in ring 3.

So, they are all from equal distance from the CBD and CBD is this one, so that equation we are not going to apply but we are going to show you the simple application of this holding capacity part. So, that is what is the total area which is available existing residential population in all the three zones are given, existing land in residential use how much land is presently used in residential that are given and the vacant land available for residential use are also given.

Now, remember that every authority will planning authority will save something not the whole area will be available for residential use only. So, we are considering here of course our focus is all on residential use so the existing total area completely will not go for residential use, different land uses are there remember that rule 3, this one proportion of land devoted to each type of land use in the area remains stable.

So, note that everything will come only for one particular land use different types of use also will be there. So, for example; 290 square kilometer is available in zone 1, 90 square kilometer is used presently for having residential population and another 40 square kilometer may be made available, the remaining for other purposes. Now what is saying the forecast population after 20 years is given as 11,789.

And, whatever to do as we have been doing for every example that we have to allocate forecast population in three zones. So, we have shown one approach how using the accessibility model you can do it, now we are showing density saturation gradient method Hansen's accessibility model which we showed how you can use that to get this population distribution in the future. Now, we want to show you how density saturation gradient method overall in a growth sense can be utilized to get this allocated population in the future.

But, we are considering that all these three zones are in one ring. So, we are not directly considering the change in density gradient that we are not considering.

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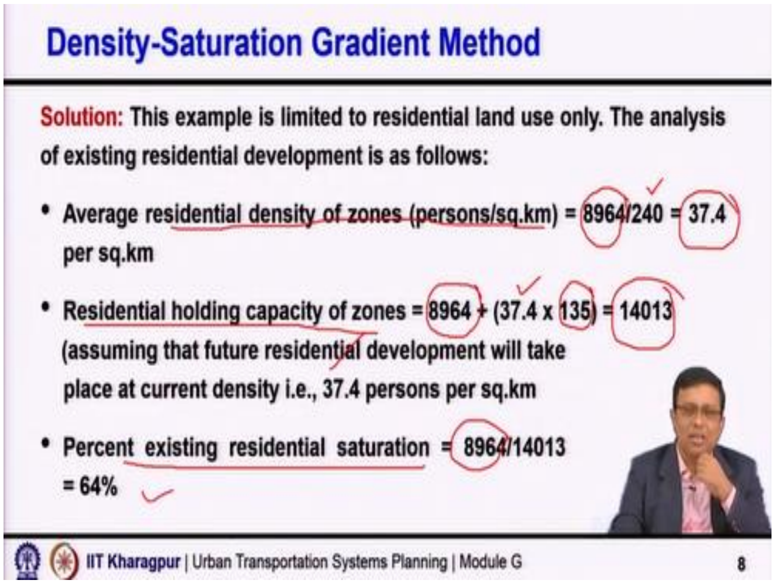

So, what we are trying to get? We can get that average residential density of all the zones we are calculating, we know that presently 8964 people are staying this is the 8964 existing population and divided by the 240 square meter kilometer that is the present existing land which is used and we are not distinguishing so all together we are considering because it is just in one ring so this gradient or change had it been one is located in R 1 band another in R 2 another in R 3.

Then, we would have considered the change in the gradient but here we are not considering. So, divided by 240 so you know that 37.4 persons per square kilo meter and let us assume in this case that in future also we will allow the similar kind of development you may allow a different value your policy may be now it is 37.4, I will use a higher value it is quite possible and understand that this numbers do not mean anything, it is just for example purpose.

We have taken some number to show you how the calculations can be done. So, it could be higher but in this case we consider them as same. So, we are saying how we can calculate then the residential holding capacity 8964 people are already presently staying there 135 square kilometer is the total available vacant land that is what you can say available vacant land for residential use and at what density the development will take place 37.4 person?

So, multiplied by 37.4; so, we get that holding capacity is 14013 whereas presently how many people are there 8964. So, what is the percentage existing for existing residential saturation what is the percentage saturation now 8964 present population divided by holding capacity. So, you can get it 64% saturation that is there today.

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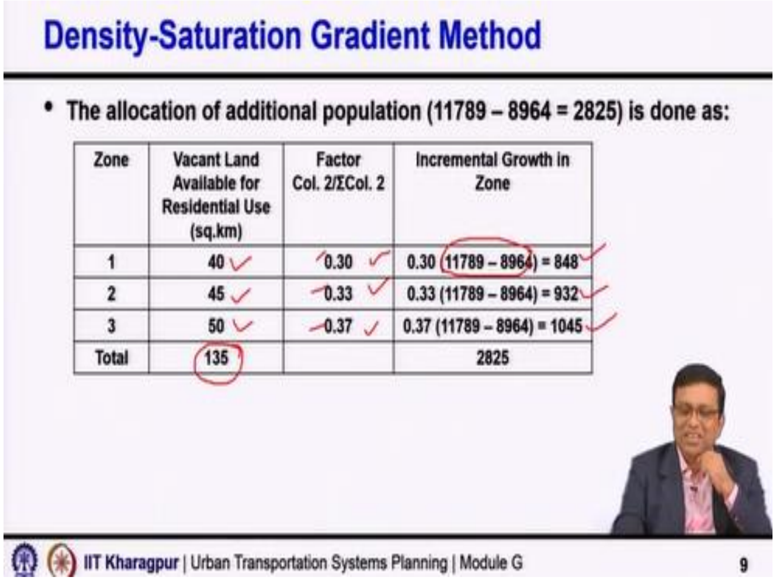

And then we know how much is the vacant land in each zone so total vacant land is 135 square kilometer which was used also there and then we say what is the proportion of vacant land available in different zones it is only like 40 by 135, 45 by 135, 50 by 135 that is what these three values are calculated and then how much it will accommodate the total difference is how much present 8964 and we want 11789.

So, 11789 - 8964 that is the additional population to be taken and it will get distributed in proportion, so point 30% will go to zone 1, 33% will go to zone 2 and 37% will go to zone 3. So, like that we can say that how this remaining population will get distributed.

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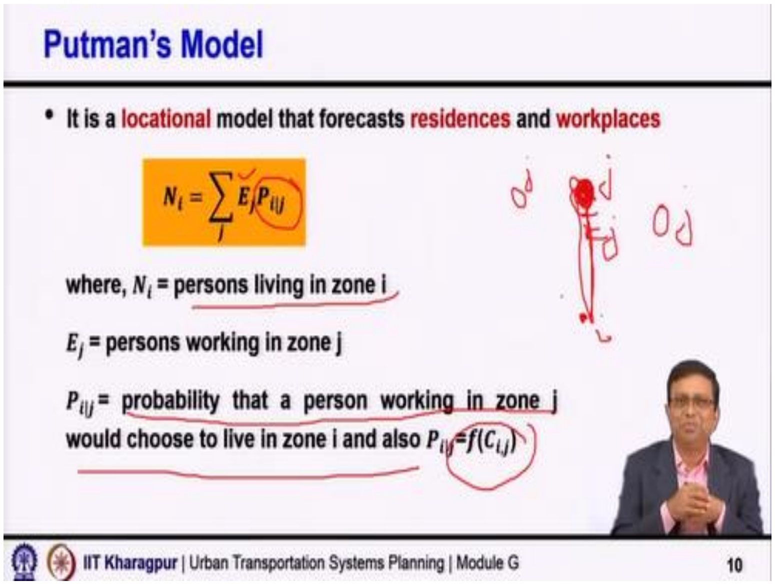

Now, we go to another model which is known as Putman's model. It is also an operational land use model which is used it is a locational model also which is used to forecast residences and workplaces again I would say it is residences only given the workplaces. So, it starts again with the employment so employment distribution is known then how the residential population will get distributed.

According to this model N i number of people who will are expected to live in zone i where from they will come there are different employment centers these are all j, j equal to 1, j equal to 2, j equal to 3 like that and people are working there, employment in this each zone is E j, so a fraction of E j people who are working there in E j they can decide to stay residential location could be any of these zones.

So, how much fraction will come to a particular zone i, will depend on what is the employment in zone j E j multiplied by what is the probability that a person working in zone j would choose to live in zone that is what so how many people are working in or employed in zone j E j? How much will come to zone i multiplied by the probability that a person working in zone j would choose to leave to zone i.

So, that probability how we can calculate it will be obviously a function of the C ij you can again the C ij is the generalized representation of cost, it could be time, it could be distance, it could be the actual cost, it could be the generalized cost. So, obviously this probability is a function of the C ij does it depend only on this particular i and particular j the answer is no what you expect here all i's are competing for to get that share from j, j amount of people employment are there in j.

So, that E j number of people all together they will locate in any of these zones so that all are employed in zone j. So, who are competing to get that those people in terms of to have their residential location in zone i, all the i are competing; all the i are competing. In this case j is fixed because employment is in j. So, E j people are working in zone j who are competing to get them all the i? Everybody says come and stay here in my area, another residential zone is saying okay you come and stay here.

Now, obviously people will get distributed will get distributed based on what the relative C ij value relative cost, function of cost.

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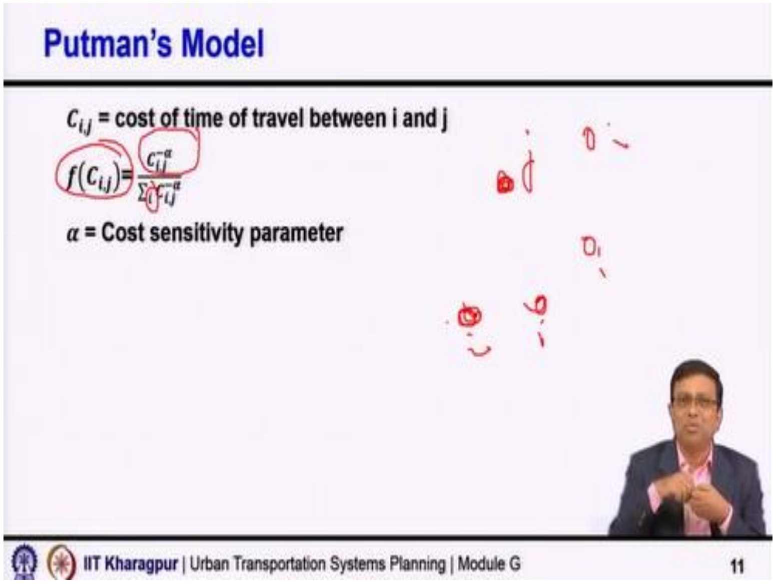

So, the relative value is how much you can say C ij to the power minus alpha because as the cost increases there will be more deterrence less attraction, so the power will be minus because it is ideally the C ij should be denominator but we are using it as a as a multiplier. So, C ij to the power minus alpha that is what divided by this is one j this is one i so different i's are competing now every i is competing to get a fraction of this e j this is all i, i is 1, i is 2, i is 3.

So, one particular zone i how much i will get? C ij to the power minus alpha divided by sum over C ij to the power minus alpha but sum over all i please understand that some over all i who are competing these i's are competing to get. You know in one place 500 people are employed, now this 500 people can stay anywhere in this zones any of these i zones, so everybody is saying ok, how much we want to attract maximum of this 500?

How much one can attract one zone conductor depending on what is the C ij, C ij to the power minus alpha divided by sum over C ij to the power minus alpha sum over all i because all i s are competing to get a share from j that is all.

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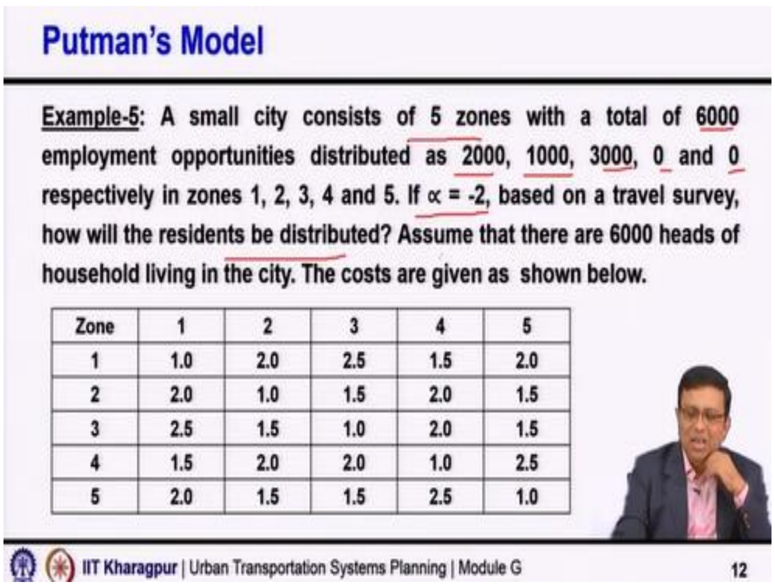

Zone	1	2	3	4	5
1	1.0	2.0	2.5	1.5	2.0
2	2.0	1.0	1.5	2.0	1.5
3	2.5	1.5	1.0	2.0	1.5
4	1.5	2.0	2.0	1.0	2.5
5	2.0	1.5	1.5	2.5	1.0

The remaining is a simple example of it is application. So, let us consider a small city which consisting of 5 zones with a total of 6000 employment opportunities distributed as 2000, 1000, 3000, 0, 0. So, zone 4 and zone 5 no employment. Alpha is - 2 based on a travel survey then we want how will this residence be distributed let us call that as 6000 employment to 6000 residents. Assuming that, there will be 6000 heads of households living in the city.

The costs are given below, so the cost matrix is given 5 zones 1 to 5, i is 1 to 5, j is also 1 to 5 so this cost matrix is given.

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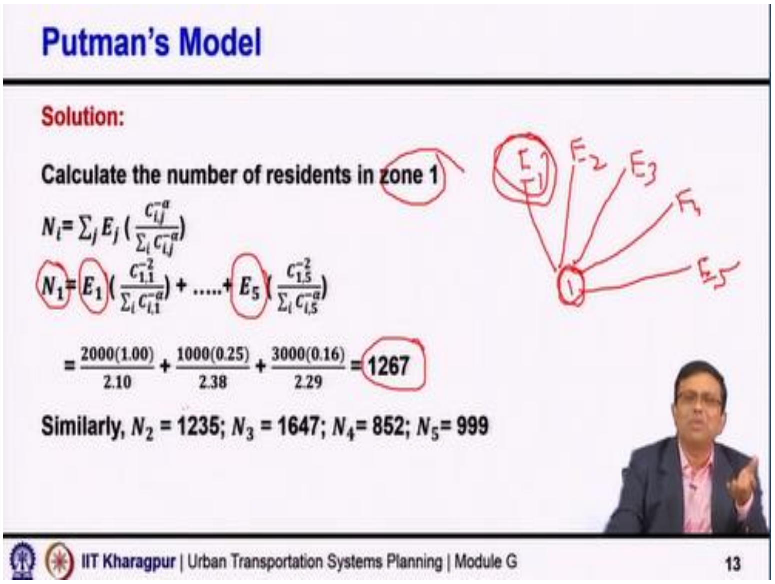

What we will do? Calculate the number of residents in zone 1. So, zone 1 will get what zone 1 will get from each of these zones 1 to n as j each of this case each of this zone will have some employment opportunity and from each zone a small fraction will come to zone 1. So, if I consider zone 1 how many will get attracted zone 1 will attract something from E 1 something from E 2 something from E 3 like that there are 5 zones, so something from E 5 as well.

So, all the 5 zones so it will try to attract from all the 5 zones E 1, E 2, E 3, E 4, E 5 you can call it as E 1, similarly it is E 2. So, like this it will take a fraction of all this is E 3, E 4, E 5. So, E 1 fraction of that E 2 a fraction of that E 3 fraction of that E 4 is fraction of that E 5 fraction of that, now how much but E 1 how much fraction will go to 1 will depend on C 1 1 to the power minus two divided by C i 1 to the power - 2 or minus alpha sum over all i.

Because whenever we are considering as how much employment will come to zone 1 it is not that zone 1 is only trying to compete all the i zones are competing. So, it is sum over i and how much will come to one will depend on numerator will be C 1 1 to the power minus two divided by sum over i, C i 1 to the power minus 2. I have written generally as alpha, alpha is you know 2 - 2 - alpha, alpha is 2 in this case.

So, like that you calculate N 1. Similarly, how much zone two will attract, zone three will attract, zone four will attack. So, you can find out N 2, N 3, N 4 and N 5, so that will tell you that if my total 6000 people said employment opportunities are there in zone one 2000, zone two 1000, zone three 3000 and then how the residential how these households are going to get distributed. If my travel time matrix are like this and alpha is - 2 and if we assume that the Putman's model is applicable. So, you can get this, how the residential population will get distributed.

So, far we discussed three approaches we discussed about the Hansen's accessibility that you can use to decide how the residential population will get distributed, we also discussed here in this lecture density saturation gradient method, how that can be utilized to get the distribution of residential population and then again we said how you can use Putman's model to get that distribution of residential population and, each case we explained you with an example problem simple example problem.

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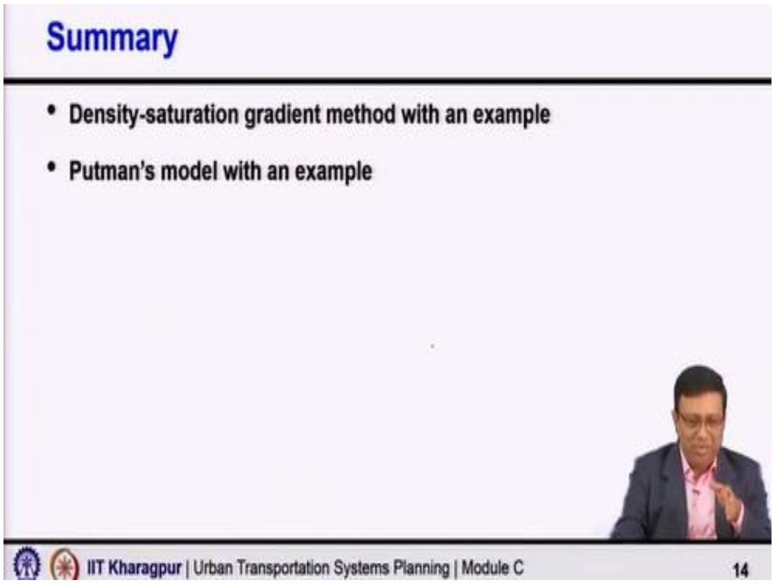

So, what we discussed specifically in this lecture about two methods density saturation gradient method and we explained how it can work with a very simple example and then we also told you about another model what is called an operational model called Putman's model. Again, to say given employment distribution and the transport network, the travel time cost all this. How you will get the distribution of residential population in different zone that also explained you with an example. So, we close this lecture with this.