Modelling analytics for supply chain management
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Lecture-16
Warehouse location models - I

Welcome to module 4 of modelling of analytics for supply chain management.

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In module 1 you have learned like the basis of supply chain and it is modelling. Now, in module 2 you have learned about we showed a supply chain diagram and we said the supply chain starts with demand forecasting and once we have forecasted the actual demand. Then you have to select your suppliers if you start with the supply chain you visualise a diagram and we say that you first have to forecast what will be your demand for the product accordingly you go and select your suppliers, the supplier selection modelling we have already done we have already completed. Now, once the suppliers are selected then the quantity that the suppliers will supply has to be transported to your production system or to your warehouses that was the transportation modelling which again we have completed.

Now, once you have finished of with transportation the products have to restore in your warehouse house for some time this for the raw material and after some time they goes into the production shop or the machine shops. Now, what is that sometime? For some organization who follows a just in time system of production that sometimes maybe a few hours or maybe one day or maybe one and half days. Certain products you need to store for

more time. For example, seasonal products or for example, some products which you have to buy in bulk to avail of cheaper transportation rates.

So, raw material storing though it is a cost centric activity and we would have love to avoid raw material storing, but still raw material storing happens and is continuing to happen in supply chain. So, warehouse location where to store your raw material is one question that we will have to answer that is point number 1, point number 2 is. Now, once you have produced your finished product once the finish products are ready they have to be sent all out into the market, now your market maybe the entire country plus the adjoining countries and your market maybe the entire world, for fashion products, for your winter jackets, for your laptops.

So, market maybe the entire world, so your finished product distribution also, to a great extend requires warehouses. Finish product distribution, warehouses are required for another reason and the primary reason is see production happens in bulk, but end consumer demand happens in bits and pieces. For example, look at the winter jackets that are being manufactured when it is being manufactured 10000 pieces of jackets are being manufactured in one production run, but you and I we are ordering only single piece of jacket.

So, production happens in bulk and demand happen in a staggered manner end consumer demand. So, where will you store you need to store the products. So, that is why the finish products warehouse comes in, so warehousing in supply chain is of 2 parts one is the incoming raw material storing warehouse and the outgoing finished product storing warehouse in earlier systems to distinguish between these 2 that is the incoming raw material warehouse and the outgoing finished product warehouse. In earlier system we would classify the place where incoming raw materials are kept as a store and the outgoing finish product where there kept was called as a Warehouse.

So, income raw material store outgoing raw material warehouse why we are not using the word store now a days. Because now, the word store some time means retail outlets or the retail stores. So, somewhere we are saying incoming raw material warehouse and outgoing raw material warehouse we do not use the word store right now in that sense in supply chain, but the word store still remains, if you go to a factory, if you go to manufacturing unit they will say bring this from the store. So, to them the internally the word store remains but then when we are speaking of supply chain in that sense of the term we are using the word

incoming warehouse and outgoing warehouse or incoming raw material warehouse or outgoing raw materials warehouse.

Now, that is point number one, what is point number two, we will love to store nothing in the warehouse which we just mentioned we will love to store nothing in the warehouse we will love to have the system where there is no warehouse at all because warehouse is a cost centre what are the cost in the warehouse let us look at the cost, fixed cost, the fix cost in the warehouse will be a rent it will be a electricity, it will be the cost of the support staff everything and that cost runs into some hundreds of thousands and imagine a company which is spread across our country to the length and breadth of a country and adjoining countries you can imagine the total number of warehouses and as such the total amount of fixed cost is incurred in running this warehouses, so, we will love to have a situation when there a no warehouses because warehouse is the cost centre.

But we cannot avoid as we have mention. So, what is our objective? Our objective for mathematical modelling is we would try to have as minimum number of warehouses as possible because that will reduce my fix cost and we will model the location of the warehouses in a such a manner that my transportation cost from these warehouses to the market are again minimum. So, number one we will have as minimum number of warehouse as possible. So, that my fix cost comes down and we will have location of these warehouses in such area from where the total transportation cost of moving the product into the warehouse as well as from warehouse to the market that total transportation cost that is a variable cost is minimum.

So, from mathematical point of view warehousing problem or warehouse location problems is a minimization problem that is minimize cost problem remember in supplier selection right at beginning we have given you some idea about linear programming similarly in transportation modelling also you have got an exposure to application of linear programming for transportation. In warehouse location modules we will use linear programming and we will also introduce integer programming for warehouse location decision.

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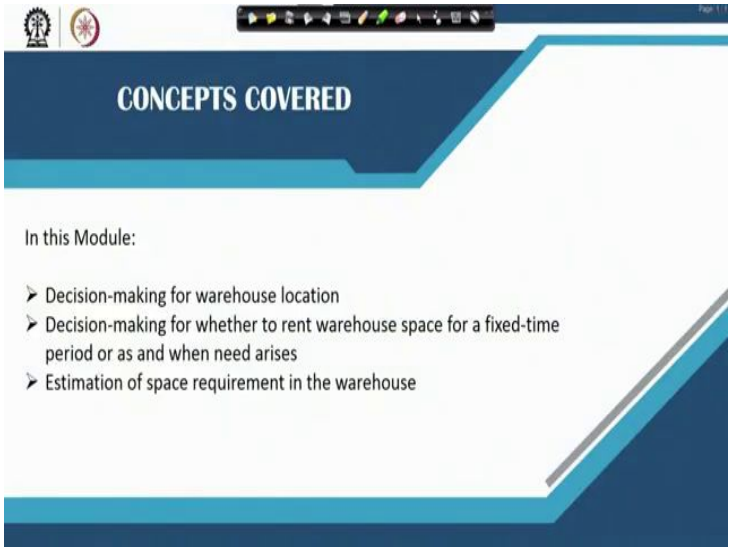

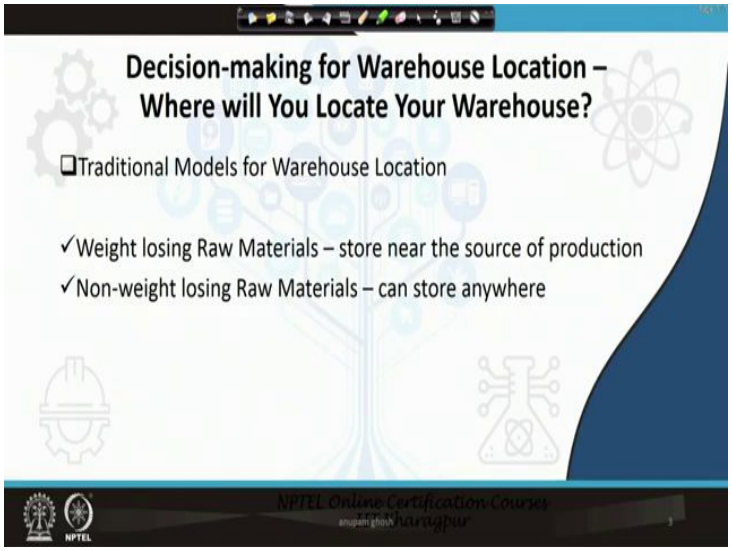

Now, let us see the traditional ways of warehouse location, decision, selection, etc. Now what were the traditions models of warehouse location? You know the traditional models where if it is a weight losing raw material where will you store it? If it is a weight losing raw material, just understand the logic the weight the raw materials will lose weight all will lose volume see here weight not only means weight it is a term weight means weight as well as volume both are applicable. Now, if the raw material loses weight or loses volume in the process of production then it is better to produce the final product near the raw material source. I am repeating, if the raw material loses weight or volume in the process of production then it is better to produce the raw material near the sources of raw material.

What do you mean by that? Let us take the example of cotton. Now cotton is the volumeness product it is a volume product. Now but when it is converted into rolls of fabric then what is happing? The volume is lost. Now, imagine truck force and vegans force of cotton though cotton is not transported in vegans in that sense but imagine truck force off cotton being transported from the field where cotton are grown to factories which are 500, 600, 1000 kilometres away. Imagine the N number of trucks that you will require and imagine a situation when, let the huge volume of cotton be grown in the fields and a knitting or stitching unit which is stitching and knitting the roles of fabric that is just near the cotton producing unit then such a huge volume of cotton will be converted into a few roles of fabric.

So, weight losing or volume losing raw material if it is processed near the raw material source it is always better. So, that is the first theory that whenever in the weight losing or volume losing raw materials you convert the raw material or stored the raw material near the source of production, clear?

The second theory is the non weight losing raw materials it can be stored anywhere, non-weight losing means also non-volume losing raw materials it can be stored anywhere. Now this anywhere, where anywhere? Logically it should be near the market, because as and when customer demand arises it can immediately send to the customer premises. So, the traditional theory was raw material a volume less material store it near the production site and non-weight losing store it near the market.

But overtime, what is happening with tremendous development in the transportation systems IT infrastructure global sourcing global distribution everything these traditional theory is slowly losing (())(11:30) it is slowly losing importance.

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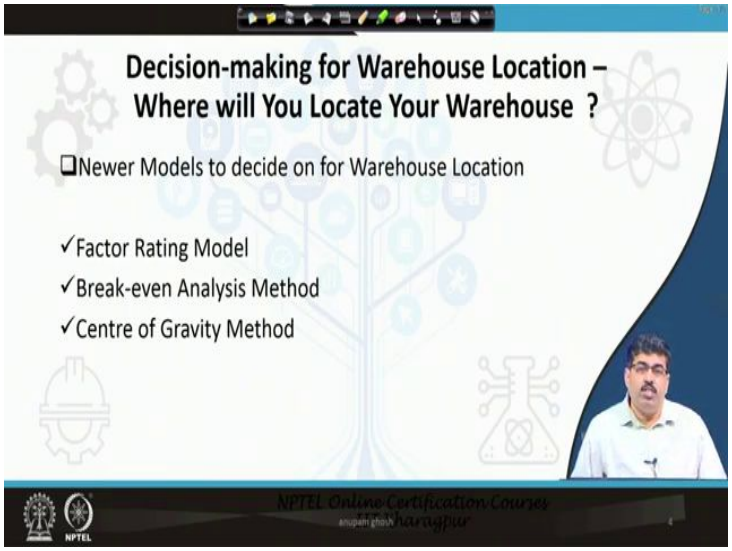

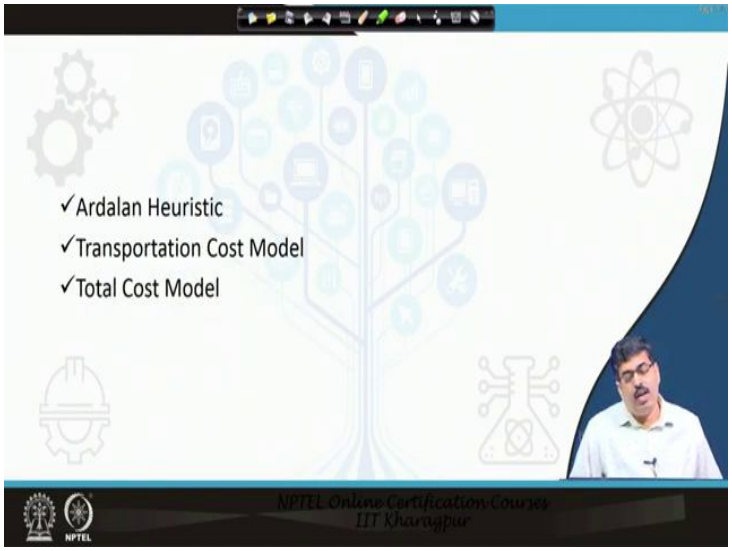

So, what do we do now a days? Now a days we use some sort of mathematical decision making, to take care of warehouse location decision. What are the common methods of warehouse location decision that we will discuss now. As you see factor rating, break even, centre of gravity, Ardalan Heuristic, transportation cost model and total cost model these are the six models that we will discuss in ware house location selection decision.

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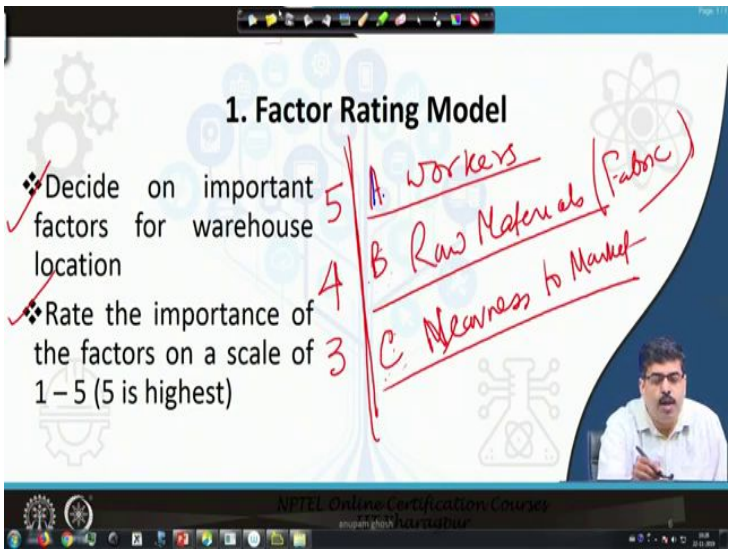

Now, let us first go into factor rating method, now this is just a word to mention that these are location models. Location model are equally applicable for warehouse location for production site location. So, facility location basically you can say, we can use these methods.

Now, factor rating model this is the most simple model that is possible and sometimes this is basic model that is followed by many small industries, many small and medium scale industries who do not have that magnitude of business who do not have that divers amount of the geographical regions to cover they follow this type of a model this is the basic model does not required to much of mathematical applications just common understanding and this model really haves the smaller medium enterprises.

Now factor rating model is, let us say you have the option of setting up warehouses or production unit at three places. Now, you have to decide your finances do not permit setting up warehouses at all the three locations or the market demand does not variant you to set up warehouses all the three locations. So, what do you do? You have to select one location. Now, what we mean by factor rating is before going into setting up locations you first decide on what are the important factor that is relevant for your organisation, what are the important factor relevant to your organisation

Now, assume you are in the production business of, let say garments or let say your shoes. Now, see for garments what are the most important factor? Most important factors if you see is your most important factor is your workers, second most important factor is your raw

materials, what are raw materials for garments? That is your fabric and the third most important factor maybe, the nearness to market.

So, most important factor is your workers, because garments, the main cost is the fabric cost and the labour cost. So, most important factor workers second important factors is availability of raw materials and the third important factor is your near nest to market. So, decide on the important factors for warehouse location.

Let us make this A let us make this B and let us make this C. Now, go to point number. So, first is we have finished off with this decide on the important factors in warehouse location workers, raw materials and near nest to market.

Next is rate the important of the factors. For your business these three factor is important, but then if you are asked to rate the factors which is more important than the other what score will you give which factor is most important, second most important, third most important. So, rate it on a 1 to 5, now for garments industry that the fabric is somewhat universal you will get the same quality fabric in every part of the country. But then worker cost, (())(16:54) fiancée of the workers work that varies.

So, workers is most important, so let us rate the worker, factor worker as 5, raw material that is the fabric is 4 and near nest to market definitely you will have to sell that is 3. So, 5, 4 and 3 is your impotents of the factors, understood? So, the worker is the most important 5 raw materials is the second most important and near nest to market is the third most important. So, that is the factor rating model step 1

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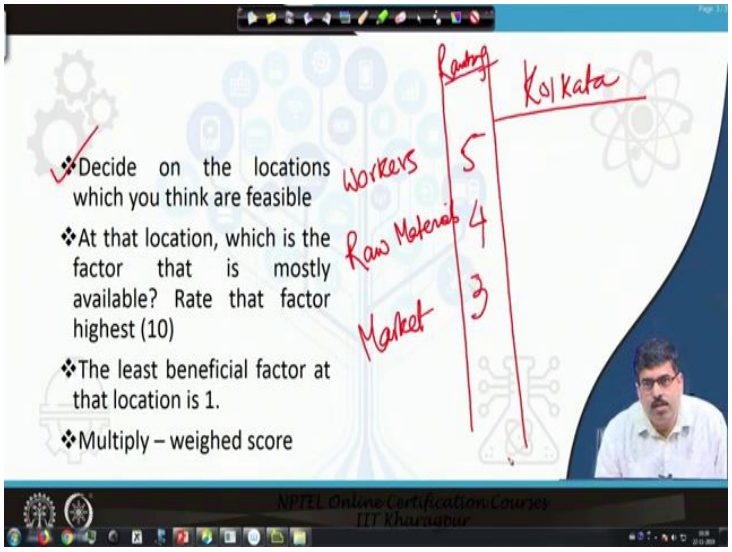

Next we move on to decide on the location which you think are feasible, so we will take location A location B and location C. Decide on the location you think are feasible at that location which is the factor that is mostly available, rate that factor as highest. Let us do this small exercise.

Decide on the locations which you think are feasible assume we have taken Kolkata as the location, what are the factors that we have taken? Workers next is raw materials and the third is market. What rating we have given? For workers we said that is most important for the garments industries so we have given 5, raw materials we have given 4 and markets we have given 3 right? 5, 4 and 3, what we have mentioned is decide on the locations which you think are feasible.

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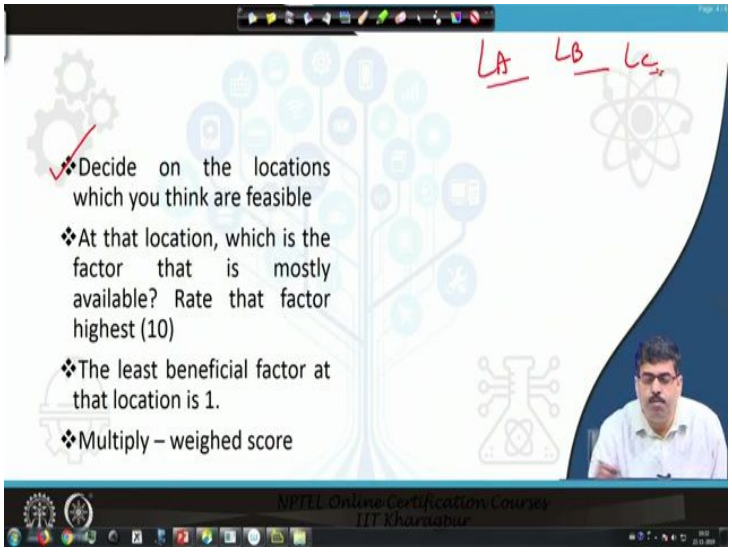

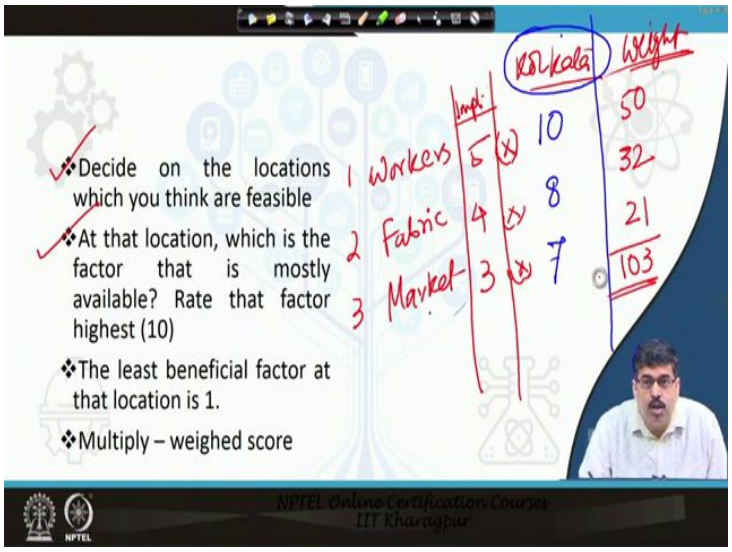

Let us assume that for, I am storing garments for that we that identified three locations in India, what are the three locations in India? We have to be near to the market and the finish products if near to market the three locations maybe Kolkata which caters to the entire eastern part of the country other location is definitely Mumbai which caters to the western part another location can be Delhi, northern part. So, we have identified three locations, location A, location B and location C. So, decide on the location which you think are feasible in the previous slide what did we learn? We learn the factors that are most important for my warehouse location selection.

Now, we have decided on three locations, location A B and C. Now, let us take only one location and do this problem this is the most simple form of warehouse location problem that will come across as we proceed the problem will become a bit more complex.

Now let us take one location that is Kolkata, what are the factors that we had mentioned? We had mentioned 1 as workers, the second one was fabric and the third one was nearness to the market and we have given a score also important score and that score was 5 that score was 4 and that score was 3, remember we have done this in previous slide. Now, next point at this location, which is the factor that is mostly available. So, at location Kolkata which is the factor that is mostly available, rate that highest 10. At location is workers available or is fabric more available or is market more available? We can give same score to many points also.

In Kolkata workers, the charges of workers is pretty medium, is fabric available? Yes. Is market available? Yes. So, in Kolkata, which of the factor is mostly available rate that as 10. Kolkata is huge number of worker. So, Kolkata we can give worker as 10, fabric for Kolkata yes fabric is available, 8 and market we can give a 7 or a 6. So, in Kolkata or, at Kolkata workers highly available 10, fabric? Yes it is available 8. And market yes can we sell it yes it is 7. So, what did we do in the previous slide we learn that for my business which of these factor is more important that is workers, fabric and market, importance of these factors.

Next column is for this location is mostly available that is 10, 8 and 7. And the last column will be a weight. Weight is simply multiplication. So, 5 into 10, 50, 4 into 8, 32 and 3 into 7, 21. So, what is Kolkata score? 103. Kolkata score is 103 similarly you can do this for other locations like say Kolkata, Mumbai and Delhi we have spoken about we can look at, do this exercise for all three locations and then we will find out the location with the highest score and that will be most attractive location.

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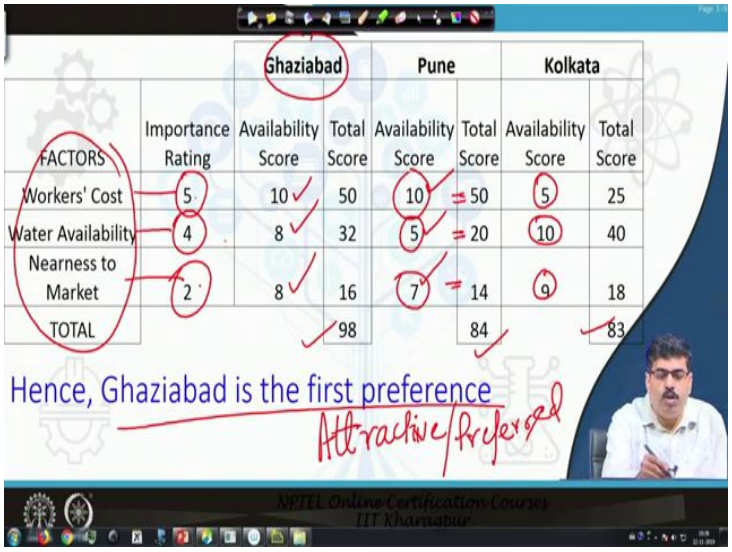

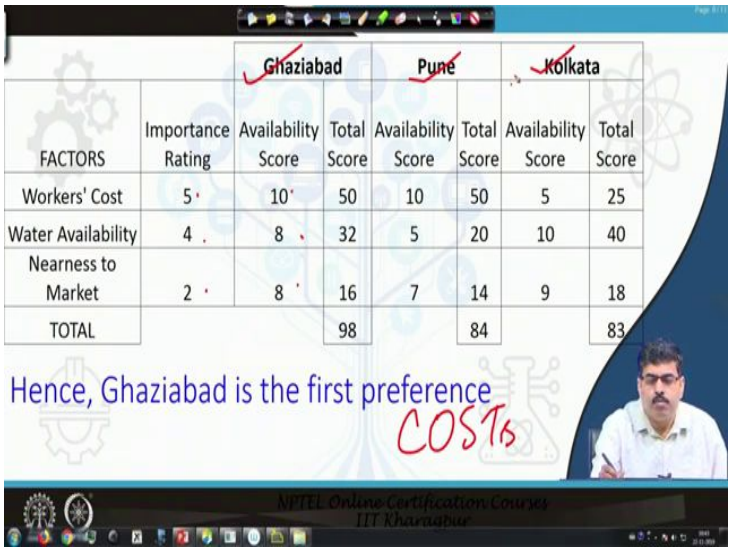

This is just a snapshot of what we were speaking, we first took factors, worker cost, water availability and near nest to market. These was three factors, we rated those three factors in terms of importance. For Ghaziabad, we took workers whether they are available? Yes 10. Water available? Yes 8. And near nest to the market 8. So total score was 5 into 10, 50, 4 8 za 32, 2 into 8 is 16. For Pune worker is it available? Yes. Water is it available? Yes 5. And near nest to market? Yes 7. Bombay would have been better.

So, again 5 into 10 is equal to 50, 4 into 5 is equal to 20, 2 into 7 is equal to 14. So this your Pune score, Kolkata again 5 into 5, 25, 4 into 10, 40 and 2 into 9, 18. So, which one most attractive Ghaziabad is the most attractive, so we will use the word here most attractive or most preferred location. So, this is your factor rating model.

So for this model Ghaziabad is first preference. Now, the question is this model is very very simple where are these models used we have already mentioned that these will be used for those companies who have a very very small business. And sometimes if you see this, this model can be applied in the downstream supply chain also. For example, we have a finish product ready. We did this model for warehouse location. Now you come to a situation when you are planning to have 3 or 4 retail outlet in your city then how to decide on which retail outlet is most preferred location wise.

So assume now you are in Mumbai and you are planning 3 retail outlets 1 in Andheri, 1 in some other let say Malad and one maybe in Thane or one maybe in Dadar some place. So, then again you can use this type of a factor but only thing is that factor will keep on changing.

Later on we will learn another model called Ardalan heuristic, Ardalan heuristic will show you how you can use this type of model in deciding on retail outlets. So understand something, these models are mathematical ways or tools which help you to take a decision. The mathematic remain same your application may change you can apply it for upstream supply chain that is raw material warehouse, you can apply this model for finish product warehouse location you can apply this model for store location. So, the mathematical modelling remain same but your application may vary from situation to situation industry to industry and the merit of this method is, it is simple to understand easy to make your employees understand also and for a small business where to much of complexity is not there this model is works pretty fine.

In fact this was the model, this is the model which traditionally is used even today by many many companies in India. Now, this is one of the models and the other model is, if you notice very carefully this model there is no actual data involved this model is based on perception. Some perception data this is what? These are numbers based on perception this importance rating this water availability this importance rating this preference code all these are perceptions of the managers perception of the feed stuff no actual data is involved.

But when you have all the costs at all these three locations then it is better to go into a more objective evaluative, if you can use the word model. Where you will consider all the costs and then we can model the location decision, that we will pick up when we use a model called a Break-Even analysis.

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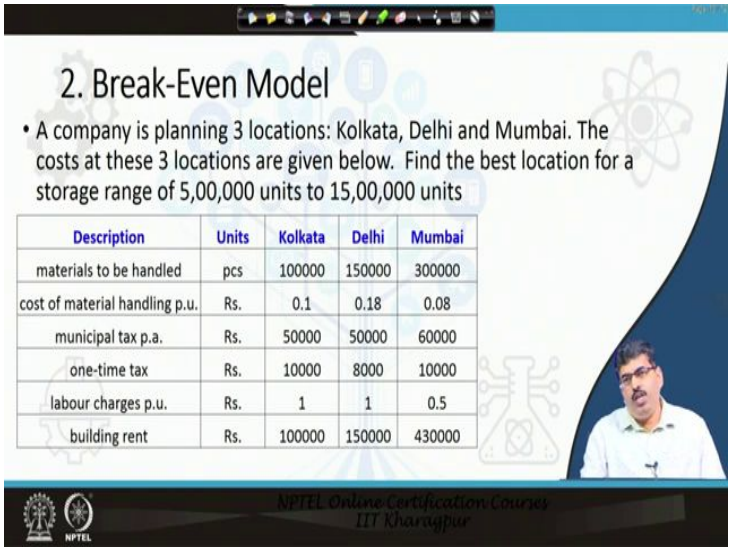

This is what is Break-Even analysis, which we will pick up in the next weeks or the next session. So what we have learn up till now? Up till now we have learn that for simplistic situations factor rating model is beneficial and when you do not have numeric data to prove your points when it is more of a perception then this model is beneficial and also when you are starting a new business you do not have any idea about backing off numerical data you have to fully depend on others perceptions and your own ingenuity then also this model helps. This model look simple you might feel what is there in this, but this model is very very much important and very very much relevant for new businesses, for small businesses, for some localised business decision making. With this we end this particular phase in the next one we will come up with Break-Even analysis or the Break-Even model. Thank you.