Logistics & Supply Chain Management

Professor Vikas Thakur

Department of Humanities & Social Sciences

Indian Institute of Technology, Kharagpur

Lecture 44 : Facility Location Planning

hello dear friends welcome back to NPTEL online course on logistics and supply chain management so today we'll start discussion on facility location planning so this is very important concept as far as your operation production and operation management is concerned or supply chain management is concerned right so the basic purpose here is we'll decide where we should locate our if you are talking about production facilities, if you are talking about your warehouses, if you are talking about locating your vendors, if you are talking about locating fulfillment centers. So, obviously when we are taking those decisions many different factors will play a role, but yes one major factor will be how we can minimize the total transportation distance. Minimizing the transportation distance we can minimize the transportation cost and then the other factor may be on the side of customer where the level of services required may be very quick services required so then you want to be somewhere near to your end market. to your end customer right so that that distance can also be minimized and quickly you can respond to the customer demand but then yes then question comes then we cannot set up so many production facilities so many fulfillment centers so many warehouses for each individual market right so then we need to take this decision strategically so that's why this chapter is there of facility location planning we'll discuss about what will happen if we are not planning as per you know while considering all those important factors we'll talk about the three tier model of assessing the location competitiveness right and then we'll see what are the factors which are affecting the location decision and we will see some of the quantitative, qualitative models how we can use those mathematical model you know to finalize the location. So, facility location planning is basically combination of your operational research field and computational geometry. So, operation as I told you minimizing the transportation cost by minimizing the transportation distance.

In the transportation session also we will discuss about how we can minimize the total distance. So, operational research where we will look for some initial basic feasible solution, ah transporting you know raw material from various factories to manufacturing location or may be from various manufacturing locations to different markets right so how we can strategically design and then we can go for optimal solution where we can minimize the total distance we can minimize the total ah cost right So, important factor another important factor may be if you are dealing with some kind of hazardous material.

So, then also you will you know avoid being near to the society right. So, that also may spread the infection in the society.

So, in that way if you are dealing with those kind of products right. because every industry is coming up with some buy products so whenever manufacturing things are happening so waste is also coming out of that so facility location decisions are strategic having said that ,that means it will have long term impact which is quite obvious if you are setting up some your manufacturing facility here in Kharagpur or in Calcutta obviously you are looking forward for maybe next 20-30 years or maybe more than that you see how frequently we are changing let's talk about our IIT KGP campus so how frequently we will change this campus from this location to some other location this will never happen right so even if we talk about some production facilities as long as those production facilities are meeting all the requirements and are efficient in that way and getting all the resources required we need not to think about changing those locations right so and then it will have impact long term impact on the organization profitability productivity right and once you have invested you cannot reverse those decision because it is capital intensive right I can remind the case of this Tata Nano plant in best Bengal Singur right and they invested you know huge investment was done to set up that initial infrastructure and then they have to be there from may be because of some political issues some farmer agitation was going on all those things were there but yes then the problem was the location was not fixed properly taking care of all those factors which may be very important while you are starting any new location right So, as your environment is also dynamic, sometimes technology is changing, sometimes the nature of competition is also changing, consumer waste is also changing. So, we need to take these decisions in the dynamic environment. So, whether you have talked about when you are going for new location, if in case required so can you expand the capacity of the same because expanding the existing plant capacity is much cheaper and feasible than setting up new plant right so then those decisions are you need to take in light of these points decentralization so centralization or decentralization if you are picking up your inventory policy that you will maintain in the centralized bare house system So, then your transportation network you need to design in that way, but if you are decentralizing so many small order fulfillment centers are there. So, then again you need to pick those location from where the maximum orders are coming can be exhaust the full capacity of that small order fulfillment center or not.

plant shut down that cannot easily happen right so today you are starting something tomorrow you will shut it down that cannot happen so what will happen if you are going without proper planning what you will do you will sell of that facility to another company now you invested there you have your brand image your many employees are attached

with your brand many local people or maybe the industry are also looking forward towards your new investment right and then you suddenly you have to withdraw from there right so that means you will sell off your existing facility now selling off that inefficient facility which you realized later on obviously will not give you the returns which you were expecting by you know starting that new facility So this is forceful decision that you have to sell the facility to some your competitor, some other industry and then maybe the other industry the same infrastructure may not be feasible. So then they have to do some again repair of the infrastructure, same machinery will not work, so they have to transport same manpower will not work. right so then that is the damage to the overall brand image that company right so the second decision may be you close down your operation and liquidate the asset similarly so now you are shutting down any big company brand you know outlet that means brand image you just imagine your people will think about you right and then you are liquidating your assets so somewhere you are selling the furniture somewhere you are selling your machinery to your competitors right so that the further financial losses can be avoided So, liquidation can provide you immediate cash inflow, but then then again the book value whatever is right now for those all those assets other than may be the property rates will still be same or may be increase can increase, but if you talk about the other investment you have developed all the assets. So, that you will sell on lower cost right. So, that is again the big question.

So, managing shutdown is again a problem. so you need to go for lay off of the employees that is not easy to just fire employees you need to comply with all the regulatory requirements so that transition period is also very difficult to manage continue operation in the existing location now you realize that this existing location is not you know efficient but still you don't have any other option so that means other players may be making 5% profit by selling the same products and you are still making 1% or 2% or even sometimes you are struggling to get that 1% even right so you are you know that this is the limitation of this location you are not getting the raw material you are not getting man power you are not getting the proper technology the infrastructure parameters we will see what are those parameters factors which will affect your facility location decision if all those factors are not working for that particular location so then either you will continue or you will sell your facility or relocate your facility to some new location right so again now you are doing the transition from one location to other location you are liquidating some assets you are selling those assets or maybe some of the assets or machines you are taking away with you right to the new location that is something extra unnecessary cost in during that process transition process many defects or damages will happen and again you are picking new location and that is you are not again sure about how that decision will go right so these are some of the you know things if you are not considering all those factors and taking that strategic decision in a in that

way then you are calculating all those factors so while when we are going for this new facility location or facility location these all situations are there you are setting up new service center you are setting up new production facility you are looking for your new vendors where those vendors should be you are looking for new warehouses where you want to locate the warehouses so that may be in that 100 kilometer region you can ensure the same day delivery right so anything you are designing any educational institution you are designing again you are looking for where that facility location should be right where your institute should be where may be the land cost may be little cheaper right so those many decisions you are taking when you are going for this so this is whenever you are going for foreign investment or even in the domestic investment as well first is country competitiveness you are looking for like when we are evaluating whether we should go for investment in some country so major factors you are looking for may be the political factor is very very important whether the political scenario is such that they are supporting that particular industry or not with maybe some concession in the customs and duties or maybe whatever taxes they are charging or maybe there is welcoming tax kind of structure which right now Indian government is working so that the investment can be invited so that is one point technological aspect whether you are getting that technology in that particular country or you have to import from somewhere else right so those operational whether that international that country is open for international trade or not right what are their policies once you have decided particular country you will see the sector competitiveness the particular sector if you are going into real estate industry or if you are going to hotel industry or if you are going to manufacturing industry or automobile industry so then you will see who are other players who are working there if no player is there you are starting your automobile manufacturing unit let us imagine where you will get the raw material and for manufacturing car you need more than 500 vendors or may be more that so developing all together new vendors in new country will be big question right and then company competitiveness whether you are getting that skill labor quality of infrastructure in that country or quality of technology if not then let us collaborate like Hero did with Honda, Maruti did with Suzuki so that we can you know import some foreign technology and can implement here so what are those factors we need to consider when we are going for facility location first is availability of minimum primary infrastructure in that you talk about the road connectivity in that you talk about the electricity in that you talk about the IT infrastructure air connectivity water facility whether those primary infrastructure parameters are okay or not that you need to because if you are fixing one location may be more than thousand or may be ten thousand people are associated with you and then all those people so then you need these resources right so then what is the location disaster scenario there, natural disasters, if you are setting up your location maybe where the chances of cloud bursting, floods, earthquakes are more so that's why Japanese organization they are coming up with that kind of infrastructure because they are earthquake prone so anytime that can happen so how quickly you can

you know the damage is done and then how quickly you are responding back so this is very one very beautiful case study of Nissan you just see how after earthquake within I think 44-45 days they resume the operation so means that kind of strategy may be very helpful in that way property tax or corporate income tax sale tax what is the structure whether your government is providing you single sales tax structure or multiple tax structure tax points are there where they are collecting the taxes so then you are not may be comfortable with that kind of structure right so that also you know a very big hindrance when you are picking up any strategic location you have that labor availability or quality what type of human skills are required to operate that particular production plant that also you need to take then construction cost and quality you might have seen when we are going for you know picking up any location so let's talk about the educational institution only so we usually set up the facility somewhere little away from the city because in the main city the cost of construction the cost of land the initial investment right that will be very high And then you need big infrastructure, so that will carry huge cost. So, in order to avoid that how you can move little bit away from the main city and then you can, but then you need to somewhere you are compromising with the infrastructure available in the main city. So, can you you know drag all those resources to that point. IT industry already i talked about why it is required economic development incentives so whether sometimes one country may be or states within countries some states are also promoting particular industry so if i take the example of pharmaceutical industry if we talk about pharmaceutical industry we are having almost 20% share in the world market and we are exporting if we talk about specifically vaccines we are producing more than 60% the whole world whatever is producing we are contributing 60% that means somewhere we are promoting that infrastructure And then we have seen in Himachal also there is one region specifically in Baddi area where you know these incentives are provided to all the pharmaceutical industries and whatever we are producing in country almost 30 to 35 percent production is coming from that area only.

but that state wants to promote this particular sector so that the employment opportunities can be generated this was the main purpose to generate more employment opportunities within that state quality of life obviously when people are shifting with you managers all the technicians all whatever manpower you are using so they need good education facilities they need healthcare facilities that basic infrastructure where they can enjoy sports activity cultural facilities all those things should be there so that their families can be engaged in that infrastructure when you are picking the international facility location almost same factors will be there but I will just quickly go what are other factors which you can consider when talking about the economic factors so other than what we discussed maybe the transportation is big big factor when you are setting up your cheap location in some other country right because overseas then transportation if

the demand is coming from some other country you are manufacturing somewhere other country you need to take care of that and then the economic stability of that country as well taxation policies already i discussed and maybe while setting up your production plant in that country maybe you are getting exposure to new market like now apple is you know planning their manufacturing within India because now from Indian market they are getting you know use response so just to take care of that demand they are setting up plant here and then environmental factors environmental regulations some countries are more conscious about sustainability and all those measures so how you can take care of that political and legal structure so whether the political stability is there this already we discussed other than that IPR how they are providing the you know those laws how they are enforcing that IPR can be protected in a better way and ease of doing business again this is political decision social factors may be the cultural factors very important the local culture is aligning with your organization culture what you are doing and then some demographic trends like we are saying that we are the youngest India is the youngest population so when we are looking for youngest workforce so maybe then India can be the best location for investment right so then technological factors R&D and innovation maybe what is the infrastructure for that, whether the government is providing or maybe the academic institutions, higher institutions are collaborating with those industries for better technology, innovation, product related, services related or manufacturing related. some additional factors may be supply chain and proximity to suppliers how may be suppliers are your some in china so you want to be near to your supplier so that that distance can be managed proximity to customers then apple is now moving to their manufacturing in india so that they can minimize the distance right operational flexibility is there if you can scale up scale down operations minimum cost you can do that whether you can avoid the language and communication barriers healthcare and education facilities are available or not so these are some of the factors when we are going for picking up the location we can check those factors So, now what are the different options we have when we are picking the facilities, right? First is separate facilities for different products and services. Now, like we have different products, right? So, for each product individual facility will be there. If you go to ICICI bank services, one facility will be there, right? If you go to ICICI mutual funds investment, another facility will be there in the same city. if you go for loans another facility will be there in the same city if you go for some other product maybe investment or some other product then the other facility will be there right so this is means when you are going for specialized facility so that means special services can be provided in that way more quality you are giving more focus on providing the quality services right so merging all the services under one roof maybe then little bit complex infrastructure will be there and may be consumer also can sometime you know confuse with the products right so then you can like proctor and gamble they are having one facility for solely for manufacturing household cleaning products other manufacturing facility may be for manufacturing the personal care items

right so different facilities for different types of products separate facility for serving different geographic which is quite obvious one facility here in calcutta other facility may be in delhi other facility manufacturing like how if you talk about automobile industry they are also setting up different facilities talking a example of amazon so they are you know setting up fulfillment center near to you know big market so that immediately they can meet the need coming from those different markets right.

So, this will reduce the you know distance between the consumer and your facility and will reduce the transportation cost as well. separate facilities for different processes like let's say if I am having one manufacturing facility where we are doing the assembly another manufacturing where we are doing molding kind of products plastic products we are producing another facility I am having where we are doing the packaging so these three different units right so molding may be the same unit providing the plastic component to my assembly line as well but then they are providing selling components to some other competitors or other players as well right so that means that is separate entity so then we can have separate because separate process so separate facility will be there Tesla is doing that and where Giga factory is in Nevada where they are focusing on producing batteries and energy storage products while their Foremont factory in California is dedicated for assembly line, vehicle assembly line so dedicated operation, streamlined, more efficient and quality product you can produce if you are having dedicated expertise for that particular facility right so evaluating location alternatives so these all factors we will consider this is not fixed right when if you talk about the research also so many research articles are coming on selecting the plant location So then different methodologies we are using, research methodologies, hybrid methodologies we are using at the next level, we will discuss here the basic methodologies, but yes these factors are not fixed, sometime the availability of raw material is very very important, sometime your industry is dealing with heavy industry so rail infrastructure is very important sometimes your industries like IT industry where the quality of life usually people focus on that right so means different industries different parameters and then the weightage assigned to those parameters may be different right so we will see that so first we will go through the qualitative models where we are taking the subjective you know judgments from the expert over those parameters let us say I am having a b c 3 different locations and then I am having factor 1 factor 2 factor 3 factor 4 factor n, n factors are there against each factor we will evaluate a b c location. right and then maybe we can compare these factors so when we are saying qualitative model maybe we will give them option very good good neutral or poor very poor right like we can design that scale that is up to you how you can design the scale but yes from maybe 5 to 1 you can design the scale 7 to 1 9 to 1 10 to 1 whatever scale you want to design right 5 means very good facility from where you can drive the highest efficiency right so that is that belongs to highest score so this is simple comparison chart analysis model where you can identify

the critical subjective factors like quality of life may be one may be the availability of raw material may be another one may be the education facility another one healthcare facility another one the infrastructure electricity supply water supply road supply those factors are there and then you can compare those factors among themselves you can take the subjective criteria into consideration and we will say that this facility is best this is just quality this is point rating method again i was talking about how you can design these different factors are there these are the location alternatives may be 1 to 10 you are giving you know rating to all those locations when talking about factor 1 which is related to may be the availability of raw material supplier so facility A 9 points out of 10 B 7 C 8 right and then whosoever is getting the maximum score is the best facility available but this is qualitative judgment right then factor rating method again same method right here what we will do we will assign weightage to these factors right this is first factor out of from 1 to 5 we will assign the weightage let's say this is first factor very important we will give 3 weightage here we will give 2 here we will give 1 3 1 likewise we can assign the weightage whenever we are getting the score we will multiply that score 9 into 4 6 into 2 7 into 1 5 into 3 6 into 1 so whatever total score will be that will be the score of this facility similarly we will find out for b find out for c right here we are providing the rating to the different criteria we are using to evaluate the factors and in the end whosoever is getting the best highest score we can this is weighted score we can find out in the qualitative as well qualitative rating. Now, quantitative rating similarly point rating method like we did in 1 to 5 scale here also make you know out of 1 or 100 percent you can say we will assign weightage to different factors and those factors will be you will assign cost factor market factor operational factor other whatever list you can prepare right what factors you are looking for when you will evaluate the facility location and then you will assign weight let this total when you are assigning weight total weight should be 100 right or 1. So let us say similarly if I will take one example and will explain with the help like this example.

see now land cost is 20% weightage is given construction cost again 20% proximity to customers again 15% this is 15% proximity to highways so that is means all those factor here only 5-6 factors are there and this should be 100% over 1 right so maybe 0.1% is left out which other factors also you can consider and these factors will change and the weightage will also change Now, we have given for rating for location A, we have given rating for location B, you just multiply this with the weightage 0.15, 0.1, 0.1 and whatever score you will get for all the facility you can say location A is better than location B.

so here we have assigned the weightage also to this is first quantity method point rating method where you are assigning weightage to the criteria and then you are evaluating

different locations based on those criteria multiplying the weights and you are getting the total score this is another method which is based on simple median model Again, now this work on the principle of that we need to find out the coordinates of the location and whenever we are going for new location, the purpose here is the new location should have the minimum distance from the old locations. Now, these 5 locations are there. Now, the new location which we are going to find out should have minimum distance from all these 5 locations. So, these locations are having these x and y coordinates and the cost of moving one unit one unit distance is 10 rupees same cost it is kept right it can be varied if you are transporting in hilly area obviously cost will be higher so annual load for each kept this plant is given now you can calculate the total load and you find out the total load We calculated the median what is the median of the total load that is why it is known as simple median model. Now, we will draw x and y and we will draw all these 5 location based on these coordinates on x y plane.

So, just I will explain how we will do that see Kanpur location is 50 So, you can see Kanpur location is 50, 10 right. Similarly, we can find out the other location Sultanpur, Sajapur and Breli all those locations we have as per their x and y coordinates we have located. We will move while finding, first we will find out the x coordinate. While finding the x coordinate, we will move towards the x axis. Now, when we will move towards the x axis, which one is the first facility coming on the way? First facility is coming Bareilly.

So, we will find out what is the load on Bareilly facility. So, load on Bareilly facility is 452. is it covering our median value our median value is 1432 no it is not covering the median value so we will not consider this one we will go further next facility is coming Shah Jahanpur so that is on this location now again we will add this 452 into the value of load of Shahjahpur and then this is 453. So, total is 1130. Is it covering the median value? No, still it is not covering the median value.

Then again we will not consider this. Next we will go on the x axis. Next is Kanpur facility. So, again we will see whether we will add the load of Kanpur facility as well and if we will add the load of Kanpur facility, we can see it can cover the median value which is 1432. So, the x coordinate of the new location will be the x coordinate of your Kanpur facility which is 50, here it is 50.

Similarly, we will go for y axis we will keep on adding the facilities until we will cover this you know median value and wherever we will get the median value we will find out that coordinate and if here we will move first two facilities we will add up we will not

cover the median value next is your gonda if we will add this facility then we will get the we will cover the median value so that means the y coordinate of the gonda will be the coordinate y coordinate of your new facility. So, where you should set up new facility? You should set up new facility at 50 kilometer x coordinate and 50 kilometer y coordinate. So, this is the new facility location. Now, we need to find out the transportation distance and that will be the minimum from the old one. So, how we can we can find out the transportation distance? Rectilinear distance we will find out.

Rectilinear distance between two points can be calculated like this. So, we will find out the rectilinear distance from the new plant to every plant so from 50, 50 if I will find out the distance you can find out. the transportation distance here we have found right so this is x and y coordinate the first is 10 50 so that total distance you can find out right and similarly you can find out the for the other facilities as well so now annual load we have cost per unit distance we have transportation distance we have we calculated the transportation distance as well right here it is not added So, I forgot to add this. So, you can just add the transportation distance and this will be for first plant 50 minus 10 magnitude plus 50 minus 80 right. Similarly, we will find out all the entries whatever value here will come we will multiply 10 into 452 into this value that will be your total transportation cost.

right so similarly you can find out the total transportation this will be the minimum transportation cost to transport that material another is center of gravity method location here what we are doing we are again x and y coordinates we will find out we are providing the weightage to all the serving locations and all the manufacturing or raw material suppliers weightage will be assigned to each right and then we will multiply that weightage with the load and we will find out the x coordinate and y coordinate how we will do that for the same problem we will take this for x coordinate this will be xi li divided by total load right now xi li means this 10 into load is 452 plus next is 30 into load is 678 plus next is 80 into load is 483 plus so on will add for rest of the 2 and divided by the total load whatever load is and this is how we can find out the x coordinate of the new facility. Similarly, y coordinate of the new facility will be calculated like this, multiply all the y coordinates of all the facilities with the load divided by the total load. So, this is how you can find out the, see the same it is done here, the x coordinate similarly you can find out the y coordinate, center of gravity. So, here the center of gravity principle has been taken care and as per the weightage assigned we will calculate the x coordinate and y coordinate see some example how we can implement sugar mills now sugar mill you want to find out the location near to sugar cane farms so how you can do that again you assign weightage to sugarcane farms from where the maximum production is coming and then you can just find out your new location right tea factories

again should be where you are growing the tree leaves in Assam maximum raw material is coming let us shift your tea manufacturing unit near to Assam similarly crude oil companies from where you are getting the maximum raw material crude oil This is another important Varingnon's framework we are using to locate the facility. See different nodes are there and all those points are tied with the common thread.

Now these points are representing either raw material supplier or markets. market 1, market 2, market n, raw material supplier 1, raw material supplier 2, raw material supplier n. Now what we are discussing till now we are giving weightage to raw material suppliers or manufacturing unit it can be manufacturing unit as well. Or we are giving weightage to different markets. If the demand comes from a particular market, high demand is coming, and you will assign high weightage.

You will assign low weightage to that market if low demand is coming. What will happen if I assign those weights to all these points so these all are tied with a commstandarde common thread so that a common node will move towards the direction where more weight is there that means where we are providing more weight where we need to set up the location priority location so wherever this common thread common node will come in the equilibrium in the frictionless surface that will be the new location so you can just on a table you can design this frictionless surface just put the weights and you can find out the new location but here we are this the median location finding method was working on rectilinear distance right rectilinear distance and we saw how we can calculate rectilinear distance like this what this model works on Euclidean distance Euclidean distance. And how we can find out Euclidean distance? This is how you can find out the Euclidean distance. distance x1 minus x2 square plus y1 minus y2 square whole and the root so from these points you can find out the distance and then you can find out the total minimum cost so this is already i explained raw material locations or manufacturing locations or raw material markets or end market you can find out and then you attach the weight at first there priority and then you can find out the common location right so we can conclude here that facility location planning is very critical aspect strategic decision and it is long term investment once you have chosen that location you cannot withdraw from there if you are withdrawing that is the huge loss to your brand to your product or whatever services you are offering right so when you are picking up new locations you need to evaluate all the micro as well as macro factors so political pastel analysis you can do political economic social ah legal technological all those factors you can evaluate right within that industry also you can find out the competitiveness right so facility location is just not you should pick the least cost location but you need to take care different factors you need to decide which one which factors are more important for you and you can see companies like Amazon and Toyota they have

successfully implemented these techniques to you know find the new locations so these are some of the references you can go for thank you very much