Urban Services Planning
Professor Debapratim Pandit
Department of Architecture and Regional Planning
Indian Institute of Technology, Kharagpur
Lecture 23
Primary and Secondary Waste Collection Part III

Welcome back, in lecture 23 we will complete the third part of Primary and Secondary Waste Collection.

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So, the different concepts that we will cover is door-to-door collection system design, door-to-door collection system design criteria, cost and time calculation, labor productivity versus vehicle productivity and then we will do a case study on waste collection proposal for Alipurduar planning area which was a class planning exercise that we conducted and some other case studies.

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So, as per SWM rules 2016, the duties and responsibilities of local authorities and village panchayat of census towns and urban agglomerations require arrangement for door-to-door collection of segregated solid waste from all households including slums and informal settlements, commercial, institutional and other non-residential premises from multi-storage buildings, large commercial complexes, malls, housing complexes, etc this may be collected from the entry grade or any other designated location.

So, that is the rule what it says. So, that means, door-to-door collection is mandatory after solid waste management rules 2016 has come into place. So, to do this collection we usually suggested the rules suggest to involve informal waste collectors into the system to involve the self-help groups of that particular area and or form informal waste characters into self-help groups and then utilize them into the system.

Community of that particular area can be involved and finally private sector participation is also encouraged. So, to do a more better efficient door-to-door collection system. So, overall collection, operation and logistics needs to be planned that means this D2D operation, door-to-door collection operation requires lot of manpower, lot of planning also, so collection, operation and logistics because it involves a physical area, there are buildings, there are collection points, so all this needs to be considered.

And design of a collection system of as we have discussed manpower, equipment, time and cost, these are important. So, we have to choose appropriate systems and that has to be as per the local context.

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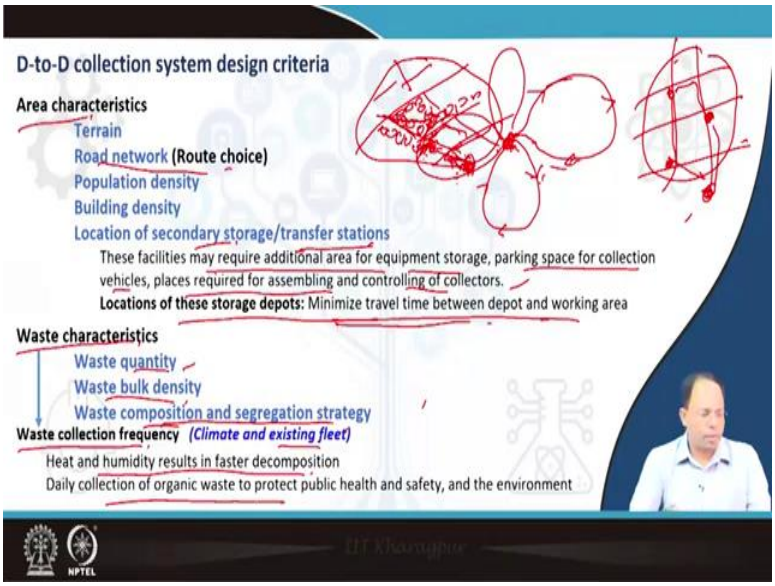

So, first of all the area characteristics plays the largest role, so terrain is important that is what slope, if the slope is pretty steep that means we cannot use hand cuts. So, in that case it is better to go with mechanical vehicles otherwise it is very difficult to push a heavy hand cut with garbage.

The road network, the road network for example in an urban area, suppose I have a neighbourhood and suppose this is the neighbourhood and the road network in the neighbourhood could be something like this or there is another road going like that and then there are some roads like that, every road has got buildings in along with it. So, the entire area is plotted and we have roads like this.

So, for, let us assume that we have designed, these are the buildings along the roads. Now, let us assume this is the point from where vehicles start that means this is the location of the secondary storage or the transfer station you can also call it. So, this is the location of that particular secondary storage but in case of larger areas we can also have a transfer station as well.

So, this, that means the LCVs collect from the larger area bring it to this particular point which we are calling transfer station where the load gets into larger vehicles and then it is

transported to the final landfill side or it could be small neighbourhood where the garbage comes to a secondary storage from there it is again transported by larger vehicles to the landfill side.

So, either you call it a secondary storage transfer station does not matter, so it is the point from where the LCVs or the hand cuts actually travel to the different generators and then they bring back the garbage. Now, the road network, first of all what should be by route choice? Suppose, this is door to door collection in that case I have to go to every door so the vehicle should cover each route so every point should be covered, the vehicle should travel in each of these routes. So, what should be the best possible route taken?

So, obviously in this case the route should be such that the vehicle starts at one point goes along the route and then comes back. So, all along the way it will collect garbage, so it starts, it goes like this and again returns all the way it is collecting garbage. But the vehicle has got a capacity it will get filled after certain amount of time, so maybe a larger vehicle is better or we can design this route like this is one route similarly another vehicle can go and collect garbage in this particular route, so it will travel along this particular way and then again it will collect, come back to this common point.

So, this route has to be designed. Now, the other thing maybe this may be these vehicles may be only collecting waste from bulk generators or maybe collecting waste from community beans or maybe collecting C and D waste. So, in that case what happens in this particular area I know there is, this is the route network I have C and D waste over here or this collection points are over here, the vehicle starts over here, it has to first collect all this waste, travel along a particular route again return back to this particular point.

So, in this case I have to also plan how many vehicles are required, what sort of time it will take for the vehicle to make this particular trip and so on. In case of the door-to-door collection the other things involved is that loading, unloading time that is how long a person takes to throw.

Suppose a vehicle travels along a particular route it reaches this particular area, then it waits there it blows the person or he may go door to door and this, there is some time required for loading the garbage or the waste from each generator into the vehicle, so that time will be gone, the vehicle gets filled on along the way and then again it has to once it is filled it returns back and one and then it has to again go out.

So, it can make another trip it is better that it does not repeats on the same route, otherwise it will not collect some of, because it will repeat on certain routes and it has to travel empty without doing any work, so it is a loss, so all this thing needs to be considered, so this is the road network or the route choice which route should you take, which are the shortest paths all these things place a role.

Then population density of that particular area. Now, why population is important? If there are a lot of buildings together that means I stand, I go in front of a group of buildings, I blow my whistle and everybody will come out of the vehicle and deliver the garbage or I go to each house and deliver the garbage.

So, there my vehicle will be filled very fast because there are many houses nearby so that means I have to make multiple trips to different points, so I have to plan my vehicle size, I have to plan my journeys or my trips accordingly. So, in case it is very sparse then I have to travel a lot to get, my vehicle will get filled after a lot of travel, so that also needs to be considered in my vehicle design and what kind of vehicle I will choose and so on.

Then location of secondary storage transfer station, so if it is located we always try that these facilities may, location of this storage depots should be such that minimize travel time between depot and walking area, so it should not be too far away, if it is centrally located its best that means from the center I will go in different directions and come back.

So I will make this loop as I, as you can see over here I have created four loops, this is at the center is the depot and I will go in different directions and come back to this particular point, but usually that is not there, that does not happen. Why? Because land is not available everywhere.

So, government has land available only in certain points that is where we have to set up this kind of storage points, secondary storage or transfer stations and wherever we set those up from there we have to travel and that means we have to make sure that the route should be designed in such a way so that we minimize travel time between depot and the walking area.

Other than that there has to be adequate space for these stations or this storage where these facilities may require additional area for equipment storage, parking space for collection vehicles, space required for assembling and controlling of collectors, they also may wish to

take a path or wish to change or place for supervisors, maybe there is some small office all this thing also needs to be there.

So, this is what, how area characteristics influences the D2D system. Then waste characteristics, waste quantity that if the waste quantity is much higher in that case the vehicle would get filled very fast, so again that will influence my vehicle size. Waste bulk density, same thing.

That means if the bulk density of this area is very low in that case the vehicle will again get filled or I have to choose a vehicle at some amount of compaction is possible. Waste composition and segregation strategy as we have discussed earlier the size of the container, how many beans you will carry, what sort of divisions you will have in the vehicle all this is influenced by waste composition and segregation strategy adopted by that particular area.

Then waste collection frequency, if collection frequency is every day or if collection frequency could be like for organic waste it is every day, for inorganic waste every three days, it all depends on what is the waste quantity and waste composition. So, waste collection frequency in our climate in with considering existing fleet we have to take a call on what should be the collection frequency for this particular area.

Heat and humidity results in very fast decomposition in Indian conditions, so daily collection organic waste is absolutely required but other kinds of waste we can also do it at after few days or we have to design a system accordingly.

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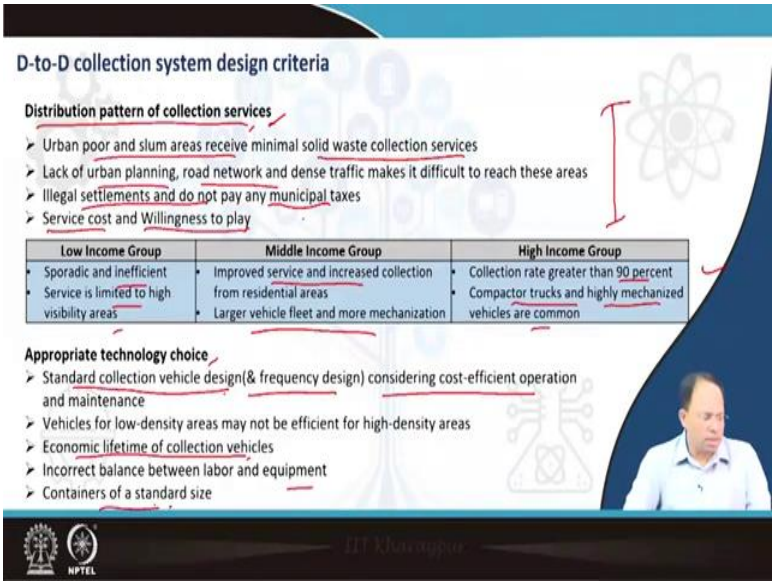

So, the other part of this designing a distribution system is to design the distribution pattern of collection services. So, distribution pattern refers to the way we design the services for different zones of the city. Now, usually we have seen that poor and slum areas receive minimum solid waste collection services.

Why? Because many of these are illegal settlements, they do not pay municipal taxes, so municipality does not recognize them, so that could be one reason. The other is they are, these people are not willing to pay money for this collection services, there could be other issues as well like the urban planning or the road network in this particular area does not allows vehicles to reach this particular spots.

So, all this contribute to lower quality of services for poor and slum areas. So this is something which has to be, we have to be really concerned. Why? Because in MSW rules in Solid Waste Management rules 2016, it is specified that we cannot ignore any of the areas in an urban area and particularly slums and all has to be covered by a door-to-door collection system.

So, usually this is what we see low income groups areas, sporadic and inefficient collections, services limited to high visibility areas, among this of course middle income group improves service a larger vehicle fleet, more mechanization, whereas high income group you see compacted trucks, highly mechanized vehicles, more or less 90 more than 90 percent collection rate.

So usually that is what we observe, but of course, we have to go for more equitable distribution of services, so that should be one of the considerations when we design our door-to-door collection system. Then the third point is appropriate technology choice. The collection vehicle design, the container designs and all this thing has to be of standard sizes and all and the frequency should be also aligned with design.

So overall we have to look into cost efficient operation and maintenance of this kind of vehicles as well as the system of collection. Vehicles for low density areas may not be efficient for high density areas. So, if we are using compactor vehicles and we are using larger vehicles in low density areas we cannot take them to high density areas or vice versa, we are using some vehicles in low density areas that is not suitable for high density areas and same of course.

And then the economic lifetime of the collection vehicles, what is the, for how long we can utilize these vehicles because these vehicles there is a lot of abuse on this kind of vehicles, so we have to replace them at certain intervals. Incorrect balance between labor and equipment.

So sometimes what happens we have to decide what certain vehicles require certain number of labors or certain systems require certain number of labors certain equipment and labor combinations like if I use a hydraulic tipper then of course I do not require labor to unload the waste, so we have to find the right balance between how many labor is required and what sort of equipment we should choose. Containers of standard sizes so these are other issues that we should consider.

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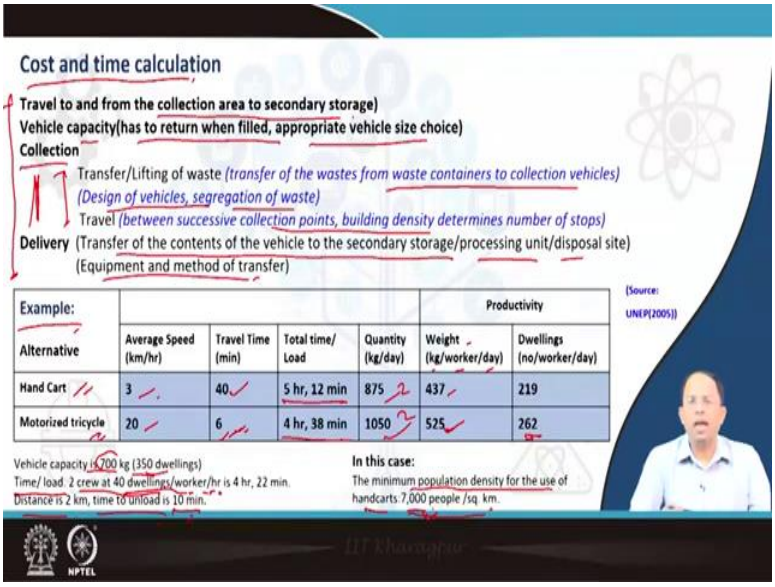

So, whenever we are designing the system we have already discussed on what are the things that influence the designing system, how do we design the routes and all, we will do detailed discussion on route planning and all this in subsequent lectures but what we have to do is we have to do the first thing that we have to do understand what is the cost and time required for the proposed collection system that we are thinking of.

So, if we are proposing, we are considering multiple types of collection system then we have to evaluate the overall cost of that system and the time that is involved and we can also convert time to cost as well. So, as we have discussed earlier so there are the cost and time calculation is done in terms of first we have to evaluate the time like travel to and from the collection area to secondary storage, vehicle capacity.

As the vehicle capacity, what should be the vehicle capacity, because it has to return when filled, appropriate vehicle size choices has to be done. Then in the collection thing, in the collection part the transfer and lifting of waste that is transfer of waste from waste containers to collection vehicles. The design of vehicles, segregation of waste all this thing plays a role.

The travel, that means if I design the vehicles in such a way so that I make the transfer convenient then I will spend less time in the transfer, transferring of waste otherwise we have to again work on, we have to it will involve more time. Travel between successive collection point, building density determines number of stops among those points.

So, this will increase the time of the overall collection. Delivery transfer of contents of the vehicle to the secondary storage, processing unit or disposal site as per requirement. Equipment and method of transfer, so these are the things which will play influence by overall collection system. So, time is how we are going to calculate and then cost is as per the equipment and the manpower that is required we have to calculate the cost.

So, you can see over here we have considered two alternatives, one is a hand cut another is a motorized tricycle which one we should use in an area, so this is just an example, so it is not any rule or something just an example to show you the difference.

The speed of a hand cart is around 3 kilometers per hour because you have to push it whereas a motorized tricycle it is around 20 kilometers per hour. So, I can decide on the route of this particular vehicle for the same route that we have chosen we can use both a hand cart and a tricycle and can determine what is the overall travel time.

So, we can see the overall travel time in hand cart is more because of lesser speed, in motorized tricycle the travel time is less, that means the vehicle could be utilized multiple times. The total time including the load time of course that is and so that comes to around 5 hours 12 minutes for the hand cart, the loading this part of this, whereas for motorized tricycles because this part is less the travel part is less the loading part probably would be same so it is still a little bit lesser.

So, quantity of waste that could be handled by the hand cart is 875 kilograms per day, whereas by this motorized tricycle it is 1050 kilograms per day. Now, coming to productivity that is a weight of waste per kilograms per worker per day it comes to around 437, in case a

motorized tricycle we can productivity is 525, so that is the amount of waste per worker per day can handle.

So, of course a tricycle will require certain number of workers, a hand cart will require certain number of workers. So, when we divide that using the total waste we will get this figure. So, as you can understand over here we are assuming two workers in both cases, so that is why we are divided by 2.

In case of dwellings how many dwellings you can cover because this can travel faster you can cover larger areas, so over here we can cover more number of dwellings. So, this is how we can determine the productivity of different systems and from productivity we can actually compute the cost.

So, time to load to crew at 42 so the loading rate is 40 dwellings per worker per hour so that is how much time it takes for loading waste into this particular vehicle means the crew has to go to that building, carry the garbage and load it into this particular vehicle so that they can cover per worker per hour can cover around 40 dwellings.

So, we can determine the manpower requirement based on the density of that particular area, so we can determine vehicle capacity based on how many dwellings I can cover, what is the total amount of waste that is generated.

Then distance of travel from transferred point or the storage point to that particular collection area or along that particular route. Then time to unload once you bring the waste back to the storage what is the time to unload all this needs to be added up to determine what is the overall time that is taken for this particular operation. So, you have to plan the operation for this door-to-door collection system in this particular way.

So, in this particular case it was found that the minimum population density for use with hand carts is around 7000 people per square kilometer when this density increases then we have to better go for, when the density is lower we can go for LCVs and so on but when this is higher then it is better to go with hand carts.

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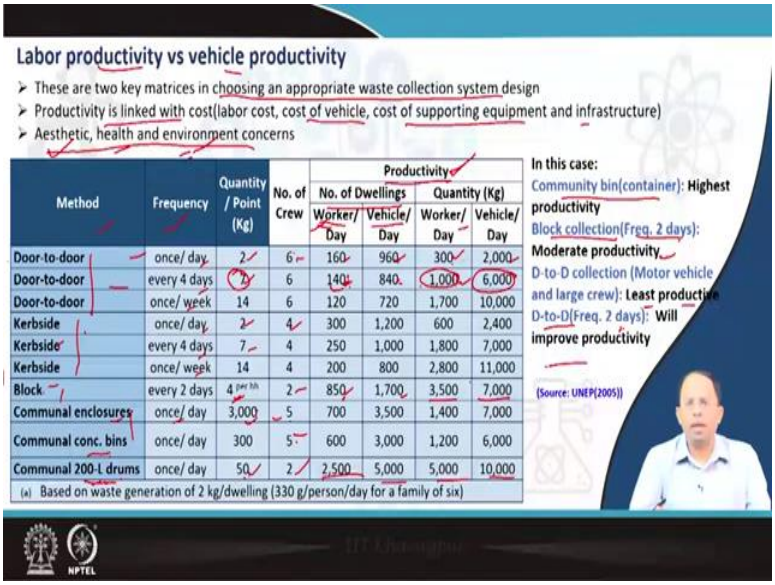

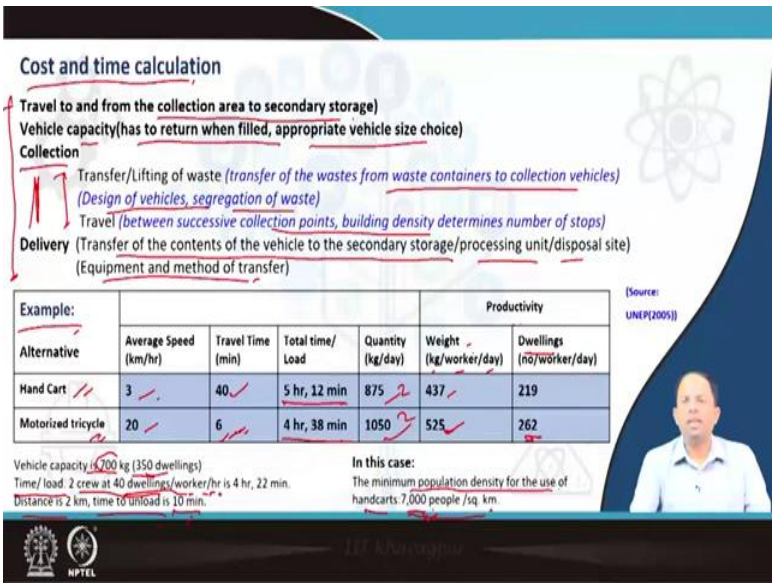

Now, coming to labor productivity versus vehicle productivity you already saw that in the earlier slide we have shown that the dwellings this is we are talking about productivity in terms of the workers but over here we are talking about both labor productivity and vehicle productivity.

So, that means how much a vehicle is utilized and how much a particular labor is utilized, so our target should be maximize the utilization of both labor and vehicle because that influences the cost, the more productive a vehicle or more productive a labor is my overall cost would be less.

So, this labor productivity and vehicle productivity are two key matrices in choosing an appropriate waste collection system design. Productivity is of course linked with cost, labor cost, cost of vehicle, cost of supporting equipment and infrastructure all these are cost and all aesthetic health and environmental concerns these are also there.

But this comes these are secondary, so first we have to, the kind of collection system that we are proposing first we have to evaluate based on productivity and vehicle productivity and labor productivity and the cost of that system.

And then we have to also consider that in each of the system it results in certain kinds of acetic conditions, certain health and environmental safety has to be there so accordingly you have to decide. So, when these two are more concerned then I can say that well because of health and environmental concerns or because of aesthetic concerns I will not allow community bin collection only door-to-door collection is allowed.

So, in that case we cannot evaluate door to door sorry, commodity bin collection but if both systems are allowed or if both can happen simultaneously so I can evaluate which system is better more efficient for this particular area and then we can take a call. So, which system is appropriate also depends on the local context road network as we have discussed earlier many factors.

So, over here I show you an example where door-to-door collection system, kerbside collection system, block collection system, as block and door to door is more or less same whereas kerb is where you have to set the garbage outside and the vehicle will come and lift the garbage into the vehicle and then put back the garbage container.

And again the generator takes back the garbage inside, the container inside so that is the block kind that is the kerbside collection system which is as we have discussed earlier these are better for low density highly affluent areas and we find this system in developed countries.

And then there are communal enclosures, then there are different varieties of the system, the variety is in terms of the frequency, door-to-door collection could be once per day or it could be every four days or it could be once per week. Similarly, communal enclosures could be once per day and communal enclosures the variety could be it could be just a open enclosure,

masonry enclosure, it could be a concrete bin or it could be a 200 litre drum or this fixed containers.

Similarly, for kerbside also we can go for different frequencies once a day, every four days, once a week and so on. So, we can see that we can vary the frequency, we can vary the method and based on that everything will change. Like for example, if it is door-to-door collection for once per day then the waste generated is only two kilograms per household or per point.

But if it is every four days obviously four days what the waste will be stored, so that becomes 7 kilograms per household or per point. If it is block collection it is 4 per, every two days that is 2 kilograms multiplied by 2 it is 4 per household, if it is kerbside collection then again it is 2, 7 its remains more or less same but if it is communal enclosures we assume that there are certain number of peoples will deliver waste to this particular enclosures.

So you see that in larger communal enclosures it is around 3000, in smaller 200 litre drums only 50 people or 50 families can collect. So, that means there will be lot of spots from where we have to collect waste whereas in over here this large communal enclosures are at certain intervals.

So, the number of crew that is required to manage a door-to-door collection of this is 6, for a kerbside collection you require a crew of 4, for block collection you require a crew of 2, for communal enclosures you require a crew of 5 or for bin collection you do not require crew of 5 because you just have to use this, lift this particular drums and empty it so a 2 size crew is adequate, whereas for community enclosures you have to clean you have to do lot of other things that is why you require more number of manpower.

So, based on the analysis what was done for evaluating the system in a particular area it was found that in terms of productivity for when we consider the number of dwellings covered we see that worker per day or vehicle per day that is these vehicles which are utilized or these workers per worker we can see that each worker can cover around 160 number houses.

Similarly, he can carry around if it is 160 houses around 300 kilograms of waste per worker he is covering 300 kilograms of waste, whereas per vehicle we are covering around 960 houses or because it is making multiple trips and then again overall in quantity it is around 2000 kilograms of waste is handled by 1 vehicle.

Now, if I go for another kind of collection you can see in door to door collection if it is every 4 days you see the productivity per worker is actually becoming less. Why? Because the worker is not utilized because the vehicle is getting filled and it has to do lot of journey.

So, it, the worker is not utilized and whereas the vehicle, sorry the number of this, the number of dwellings he is covering is less but the total quanti, sorry I made a mistake so the number of these dwellings he is covering is less but the total quantity of waste is more because each dwelling is creating more quantity of waste, because each dwelling is creating around 7 kilograms of waste.

So, overall the productivity is increasing in terms of this quantity of waste but the number of buildings that are covered is less, so that means the travel time will increase. So, it all, the cost of travel will increase so that overall cost is a function of both productivity as well as other parameters like their cost of travel, fuel use and so on so that part will increase.

Similarly, we see that for block collection we see productivity like 850 workers per day, sorry 850 dwellings can be covered by each worker whereas for vehicle 1700 dwellings could be covered in terms of waste handling 3500 kilograms per worker whereas 7000 kilograms per vehicle that could be covered.

So, you can see that for different kinds of collection system it results in different kinds of productivity, productivity is one parameter but there is also cost which is productivity results in cost because you will require less number of workers, less number of vehicles when you are more productive but at the same time the transport cost would be increased.

So, productivity is a, is one part the transport and other cost also is comes into play and overall we will get a final cost. So, in this particular case you can see that community bin containers has highest productivity, community bin containers like over here this has got the highest productivity so this is the best possible system in this particular context.

Block collection frequency two days has got moderate productivity, block collection is something like our door-to-door collection where every two days it is showing moderate productivity. Door-to-door collection using motor vehicles and a large crew is a list productive but door-to-door collection if it is done for a frequency of two days will probably improve productivity.

So, again this is very very specific to this particular case, this particular context in your locality, in your city it would be different but you have to follow this kind of calculations or you have to do this kind of evaluations to come to a final solution which is better.

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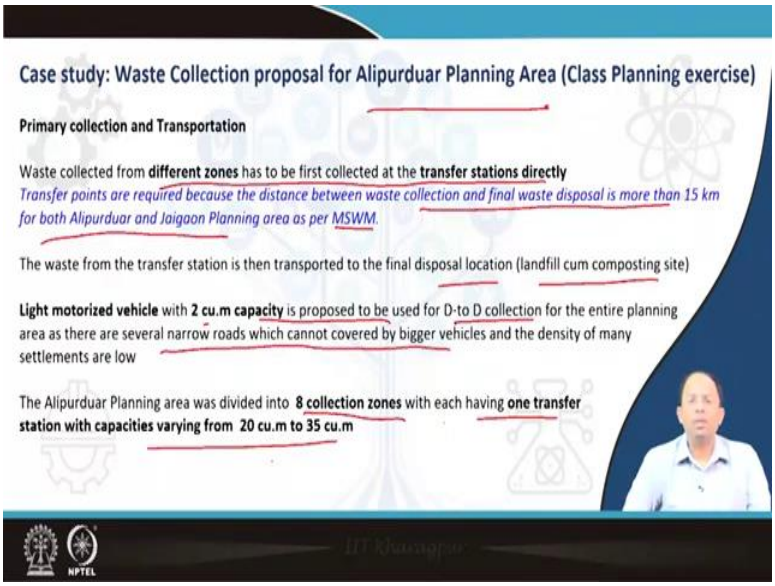

So, now coming to some case studies, as you can see that we did every year in our department we take our students to do a development plan exercise and they do all aspects of development, covered all aspects of development plan exercise including infrastructure planning and solid waste management planning.

So, we have gone to Alipurduar planning area where our students have proposed a collection system for this particular area. So, first they have divided the entire area into different zones I will show that and waste collected from different zones has to be first collected to and brought to transfer stations.

So, we could have called it storage point, secondary storage points but we are calling them transfer stations because the waste is collected by LCVs and then we are using larger vehicles to transport the waste to this final disposal sites and this because we are using LCVs we are not, we are directly bringing the waste to transfer stations and we are not agglomerating the waste at the neighborhood level.

So we are doing, covering multiple words and this LCVs can cover each different parts of the word and directly bring the waste to this transfer stations so that's the beauty of using motorized vehicles that means they can travel longer distances.

But if it was done via tricycles or hand carts then we have to design a primary collection system and a secondary storage system and from there we have to use vehicles to bring it to the landfill site or to transfer stations over here. So, we found that directly using LCVs and transfer stations and then directly transporting the waste is cheaper than using hand carts, secondary storage then taking it to the transfer station or taking it directly to the landfill site.

So, transfer points are required because the distance between waste collection and final waste disposal is more than 15 kilometers for both Alipurduar and Jaigaon planning area and as per MSW rules we can say that we require a transfer station in this case. The waste from transfer station is then transported to final disposal which is a landfill cum composting site.

Light motorized vehicles with 2 cubic meter capacity is proposed to be used for door-to-door collection for the entire planning area as there are several narrow roads which cannot be covered by larger vehicles and density of many settlements are also low so there is no need for door-to-door, using this hand carts or push carts so instead it is better to use LCVs because it is low density area at the same time the roads are not that wide also.

So that is why it is better to use LCVs which are smaller vehicles but also can travel a significant amount of distance. So, the planning area is divided into 8 collection zones with each having one transfer station with capacities varying from 20 cubic meter to 35 cubic meter.

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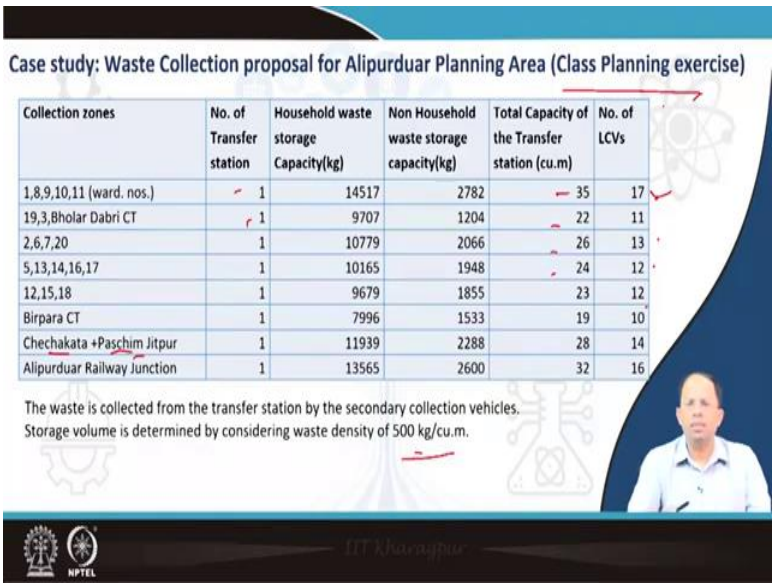

This is how it looks so collection zones include what number, the first collection zone is include ward number 1, 8, 9, 10, 11, this is as per that particular area. So, we are considering multiple wards in each of these collection zones and sometimes where we have also used certain areas which are beyond the wards because there are some zones when we are doing a larger area it we are also considering areas beyond the ward boundaries so that is why this other areas are also considered.

And so each area has got a transfer station and household waste and non-household waste both is collected from this particular areas using LCVs from both bulk generators and household generators and total capacity of each transfer station is given over here and number of LCVs required to cover each of these zones is also provided over here. So, that is the total number of vehicles which are required.

The waste is collected from the transfer station by secondary collection vehicles, storage volume is determined by considering waste density of 500 kg per cubic meter. So, this is a very basic way we have done the exercise but at least it should give you an idea about there could be different variations in the way we plan our waste collection system.

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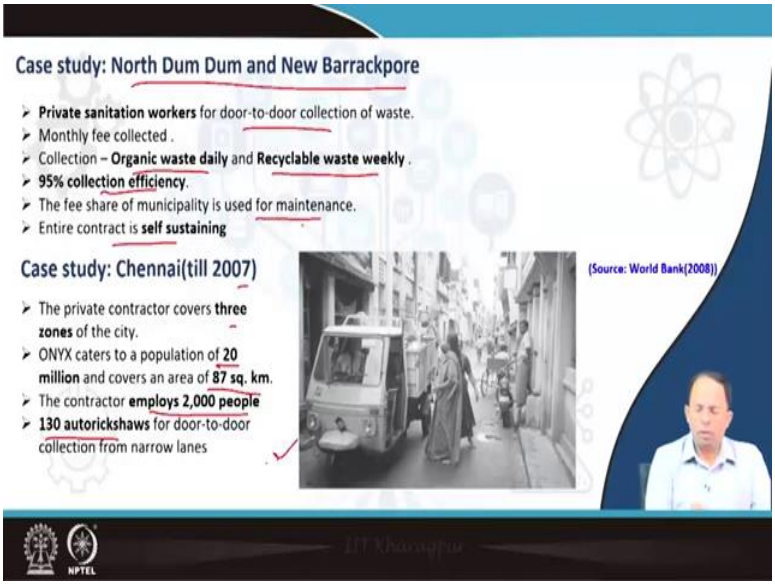

Now, coming to some other case studies the first case study is North Dum Dum and New Barrackpore. Private sanitation workers were utilized for door-to-door collection of waste and against a monthly fee that they also collected a monthly fee user charges. Organic waste was collected daily and recyclable waste weekly so you can see that we can vary the frequency of different kinds of waste.

95 collection efficiency, fee share of municipality is used for maintenance, the municipality gets the share of the fee. And entire contract is self-sustaining because it is a private contract we are generated collecting user charges and they are sharing some of the money with the municipality as well.

The other case studies from Chennai in the year 2007 it is a little bit older case study. Private contractor covered three zones of the city it was on called ONYX and they catered to a population of 20 million and covered an area of 87 square kilometres. They employed around 2000 people and 130 autorickshaws for door-to-door collection from narrow lanes. So, this is how the system look like.

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So, these are some of the references you can study.

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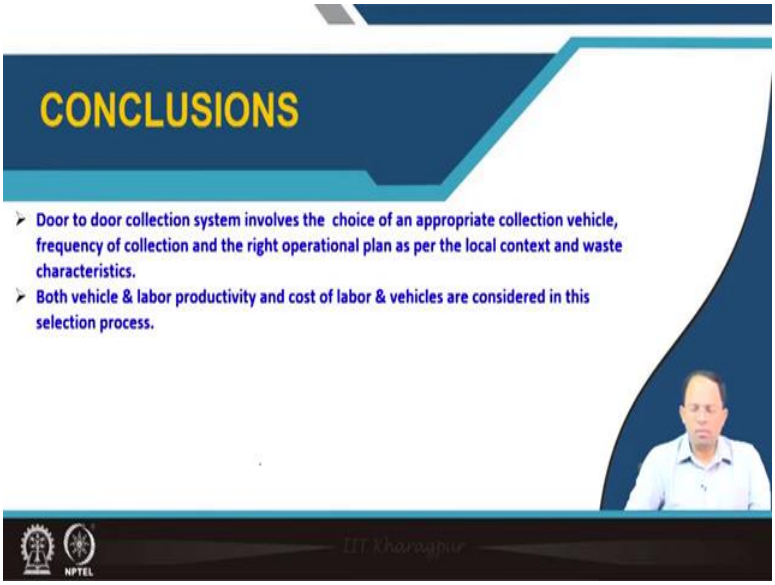

So, to conclude door-to-door collection system involves the choice of an appropriate collection vehicle, frequency of collection and operation plan as per the local context and waste characteristics. Both vehicle and labor productivity and cost of labor and vehicles are considered in this selection process. Thank you.