Infrastructure Planning and Management
Indian Institute of Technology, Madras
Urban and Rural Infrastructure Part 1B

Lecture 8

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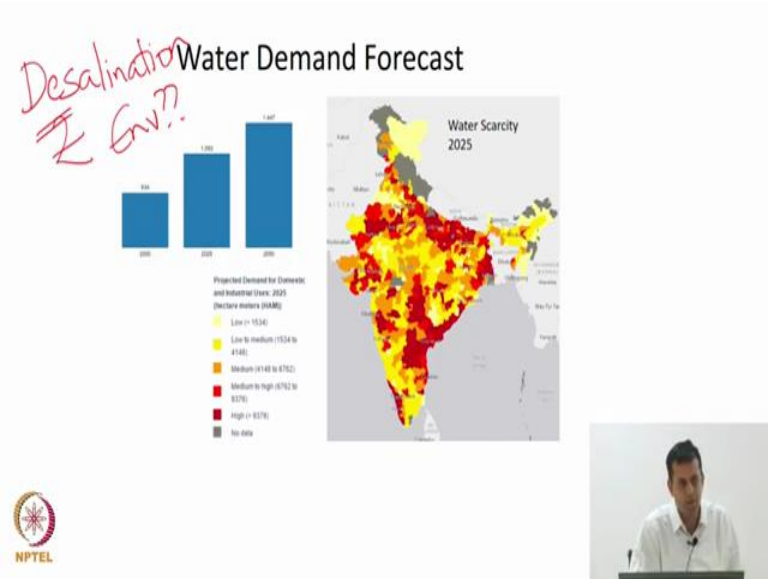

Let us look at a few key things in the urban and rural sectors. So, you know, all of these numbers are pretty scary? So when I look at water, we talk about water for a second. Look the population is increasing. There is more migration into urban areas and that creates all kinds of problems with regards to water. So the very first problem is water supply. So I have, for instance, if you take Chennai, I am very familiar with Chennai, so we will use that as an example. But you could look at other places as well.

Chennai gets its water primarily from, most of India gets its water from the monsoonal rainfall. And our monsoonal rainfall, always there is sort of high intensity short duration. So if you look at Chennai, our entire rainfall typically happens in the October, November, December maybe January kind of months. Normally it is about two, two and half months of intense rainfall. So we do not have rain throughout the year, there are few rivers that run but many of them are rain fed. And therefore it comes, the amount of water you have comes down to how efficient are you in storing the water when it rains. We have a few reservoirs. We have this Chembarambakkam reservoir, we have something called Poondi reservoir. We have something in Red Hills. These

are some reservoirs, now these reservoirs have a fixed capacity. So they can serve a certain number of people. As more and more people start coming in, obviously the amount of water per capita will decrease. Add to that, the fact that if your monsoons are very intense, and you see, if you have slow amount of water coming through a long period of time, then your reservoirs are going to continuously be filled, so the rate of outflow might be the same as the rate of inflow. You can get to steady states and all of that. But obviously that is far from the case here. The case here is that you have a steady outflow. In fact the outflow is increasing because we are drawing more and more water. But at the same time the rainfall patterns are now turning out to be highly erratic. So I guess, in your first year or second year, you guys must have, some of you might have been around when Chennai had unprecedented floods. The next year we had virtually no rainfall. And so we have to think very carefully about how do we manage, where, how do we store our water and how do we then use that water, how do we distribute that water to a population that is continuously growing, given that we do not even know how much rainfall we are going to get next year.

So it is a relatively difficult problem. One of the problems with the floods was even though there was a large quantum of water, a lot of it eventually flew into, flowed into the Bay of Bengal. And therefore while we can claim that there was so much rainfall, all of that water is not necessarily used for drinking purposes or whatever. And therefore one of the things that a state like Tamil Nadu is doing, so what are we doing to mitigate that risk? Right, that the fact that I do not know how much rainfall will, I do not know when rainfall will happen, I do not know what intensity, I do not know how much rain I will get. I do not know if my reservoirs are going to be full. Meanwhile population is increasing. So what are we doing about it?

Student is answering: (audio too low)

Okay, so there's something called rain water harvesting, that we did. So that was one measure saying what rain water harvesting does is, it forces all plots to direct some of the rainwater into the ground, so that at least your ground water levels get recharged. That is fine but that does not necessarily translate into drinking water. Now what a lot of people do, most residents do, we have bore wells, right?

We will drill borewells and we get water out of the borewell which means if the metro water does not supply water to me, I am in short because I have got a borewell that I have dug. But actually bore wells are illegal. You are not supposed to be digging borewells because ground water is not your resource or my resource. It is a community resource. So what rainwater harvesting brings up the ground water level but it still does not deal with the problem of the source.

Alright, so what are we doing about it? So I think the point that Laxmikant is bringing out is, so let us admit now that surface water and ground water as far as consumption is concerned are linked. So because we are not able to provide reliable water supply, we have to look at ground water sources. Now in the past if you go to the history of Chennai or any other area, the kings in olden days actually had a very cleverly built interconnected system of tanks. Here we call them the "aeri" system. In different parts of India you probably call them, you know differently. Even places like for instance, in Rajasthan where you get very little rainfall, they had very interesting ways in which they would manage the infrastructure. So what they would do for instance is, you would have a series of ponds that are probably at decreasing elevations and so essentially have a lot of rain somewhere, that's overflowed, it goes to the next pond, that's overflow goes to the next pond. And so you have a series of lakes that are filled and finally water drains out.

You give yourselves the maximum probability of catching all of that water depending on the rainfall and then based on that you actually supply. And population did not necessarily over strip the ability to supply. So you had a self-functioning system. What has happened in the recent years is that we have had a lot of development happened and lot of that development has happened in these natural waterways. As a result of which what has happened is, the water flow path has been blocked because you have actually built a multi-story building or a whatever. And that therefore has led to some fluctuations in water supply. One of the things we have done because now we have the technology, we have the electricity, start extracting water from the ground, which is okay as long as the water I extract from the ground goes back in when it rains. So that is where rainwater harvesting and all of that comes in. But one of the factors that mediates all of these is the extent of pervious or impervious surface that you have. So if I develop a certain area, and I put a nice sort of concrete, asphalt roads, sidewalks etc so the surface is impervious. When it rains, the water is going to run off elsewhere.

It is not going to seep back into the ground where I am living in, where I am drawing groundwater from, right. So the whole notion of low impact development essentially says, look, you have got to develop but can you develop in such a way that you do not alter certain basic ecologic functions. So altering this these ecologies lead to both problems. They lead to water shortage because you are blocking waterways, you are, you know depleting or reducing the ability for groundwater to seep into the ground. But they also paradoxically, while they also facilitate drought, they also facilitate flooding. Because these waterways are blocked, that water is trying to flow through gravity and it sort of comes against a blockage. So it keeps rising and that area gets flooded.

So both droughts and floods are sometimes a consequence of relatively poor, not poor planning but rampant development. And why do we have this development? We have this development because you have people from rural villages just sort of coming in, and you need to build houses for them, you need to build schools, you need to build offices. There is so much development that needs to happen. We are a developing country. The auto industry wants a place to manufacture something, the IT industry wants a place so that they can set up their IT offices.

We have a development need and that needs to be met. And it is a rapidly growing development need. And by trying to meet that, sometimes you lose sight of some of these ecological functions, right. So one of the things that we are trying to do on the supply side, right, in Tamil Nadu is desalination. We're blessed with the coastline and we are saying okay, let's just take water from the sea and desalinate it. Not a bad idea, except there are couple of issues to think about.

First is desalination is very expensive. The reason it is very expensive is also because it is highly energy-intensive. So it is not sort of a simple water filtration technique, it is highly energy-intensive, all of that. It is also a bit, you know, environmentally unfriendly. Because one of the things you got to think about is desalination essentially you take water and you really push it through the small pores so that all the impurities stay behind, is what we call brine. What do you do with the brine? You take the brine and you dump it back in the ocean and that has consequences for marine life in the ocean.

Alright, so there are some issues with desalination but desalination is a good risk mitigation measure because whether it is going to rain next year or not, right, chances are that the ocean will

still be there with enough water for me to desalinate. So if you look at Tamil Nadu for instance, we have said look, our rainfall patterns are very erratic, we do not know where to store water. They have already built 200 million liters a day worth of desalination. There are some plans to build about 500-550 million liters a day more capacity.

But even that won't supply the entire city, that supply half the city. So water supply is a big issue because people are going in. But then the problem is after I supply water, there is this whole matter of water distribution. Water is a bit like power, there is generation, transmission, distribution, right. You do not generate water. I mean you can if you look at desalination as generation but otherwise you catch water. There is a reservoir component. But then you have to distribute it.

Here is where there are tons of problems. So if you look at the water infrastructure, and here, I am going to come to your point, there are two terms that are very often used called UFW or NRW. NRW means non-revenue water. UFW means unaccounted for water. They are both being more or less the same thing. And the logic is simple, somewhere near my reservoir I have sent in x liters, million liters whatever of water through the pipe. How much of water do I actually get at the other end? And what you get at the other end is sometimes a small fraction of what you sent in.

So where is that water going? Okay, so there are two things, there are few things that could happen. Sometimes if you have open channel flow, there could be some amount of evaporation. There are evaporative losses but these are generally in the 4-5 percent kind of range. These are not in the 20-30 percent kind of range. So what else is happening? One other option is that there are leaks in the pipe. You got very old infrastructure that is rotting, there is leaks in the pipe and water is, you know essentially just going nowhere, like going into the ground.

And the third possibility is that people are actually stealing water, just like we talked about people stealing power, you have people stealing water, putting the linking into the mains etcetera. Either ways you have water that is unaccounted for or non-revenue water, okay. And that upsets the overall water balance. At least you should have, I mean you should supply water to everybody but you should at least know where that water is going. So there is a distribution problem or a transmission problem. In distribution, we have a problem with regards to pricing.

[Professor-Student conversation starts]

Professor: If you want now talk about what you wanted to say there?

Student: (audio not captured)

Professor: Okay. So essentially what is, what do you, what do all of you pay for water? Anyone know? In your houses wherever you are, roughly what are you paying for water? How many of you pay a fixed fee for water versus a fee based on how much water you use? How many of you pay a fixed fee for water irrespective of what you use? How many of you think you pay a very, how many of you do not know? That's fine if you do not know. Go and find out. Call your parents today. How many of you pay a variable fee? So yeah, in Germany you guys pay for use. So in most cases in India we are still paying a fixed fee for water.

[Professor-Student conversation ends]

So irrespective of how much water you use, I will charge you a certain amount per month and that amount could be as low as 50 rupees. 50 rupees a month per household, you use as much water as you would like. Now this leads to two problems, just like with power. What is my tendency with regards to water? Waste water. Is there any cost to me of leaving my tap open all day and coming back in the evening and shutting it down? Nothing, I am not paying anything extra for water. So that is one set of problems with having this kind of charging regime.

The second is how much money is the metro water or the water board making, the water authority. So in Chennai, we have the Chennai metro water sewage and sanitation board. But how much money are they making? Very little. Because you are consuming a ton of water, you are paying them 50 rupees a month. And so their finances are relatively low which means they do not have the money again to start fixing these leaks. And so you have the whole vicious cycle coming in. So the metro water system, for instance is continuously you expect some amount of money to come in from the state government's budgets etcetera to fulfill your daily operation.

So when you talk about desalination etcetera, none of this comes from their own pocket, it is funded by somebody. One of them was done on public private partnership etcetera, which means it makes it difficult to improve on the water infrastructure. But there is a big, so with power, I

can change the power tariffs relatively easily. With water it is a bit more difficult, why do you think that is? Why can't I just double or triple the water tariff, Harsh?

So big issue is political, because there is still a belief that water is a basic human. Everyone must be supplied with water. Water is sort of, you know, it is God's gift whatever. So not only should everyone be supplied for water, there is in some cases a belief that water should be given free for everybody. And therefore when you start pricing water, it goes down very badly from a political perspective. People start sort of arguing, saying how can you price water? Is it right to price water? And of course, in politics these are things that opposition parties will like to jump on and so hiking tariffs is a very very politically fragile kind of game.

From an economics perspective, the answer is actually quite simple. Anything that is scarce or anything that is finite, it must have a price, right. If it is infinite, then it does not have a price because we can go and get however much of it we want. But if it is finite, it must have a price. And water, drink, potable water, we all know, is finite. There is a certain fixed amount of water there is and therefore there must be a price. And lower the quantity of water available, the higher the price must be, sort of what the economist will talk about. But that is of course difficult.

So the water sector has all of these challenges. We may not be doing a great job of managing our reservoirs and catching enough water for storage. We may not be doing a really good job of distributing that water, because all these pipelines are leaking. We may not be doing a great job of pricing the water and reducing the kind, the waste at the end user level. We may not be doing a great job of controlling or regulating or monitoring ground water levels. Because ground water levels have all kinds of impacts, your soil stability changes if the water level goes down, which means the foundations on which your houses are resting, might no longer be as safe as you might have thought they would be. So all kinds of ecological balances are there. And the problem is the metro water bodies do not have the money to do anything about it, right and do not have the authority or do not have the political willingness to do much about it because water is such a sensitive subject. Although ironically, okay, who does not get water? Which section of society normally does not get water?

Student is answering: Poor.

Professor: The poor people normally do not get water. The reason is all of us have water connections. When your apartment or house got built, you got a water connection. Now water may not come every day, right but you do get water. But you know, poor people sleeping in slums have no water connection, right. So where they get their water from?

So there might be some public taps. But if you do not have public taps, so the public taps run dry, what do you do?

Student: Water lorry.

Professor: You get a water lorry. You see water lorries everywhere. There is one filling station right outside IIT, so you will see actually a bunch going on the road. How much does water in the water lorry cost per liter? Or whatever, per kiloliter whatever. So normally you are talking about at least a 10X difference between what you are paying to metro water and what you are paying to the water lorry. So the irony of the matter is I am a relatively well-to-do middle-class person with the water connection and I pay a pittance.

This supposedly poor person with no money pays ten times what I do and yet, you cannot ask me to pay more for water. So this is sort of I think one of the some of the things that we have to get our heads around, is that people talk about the reason that you cannot increase water prices is because the poor cannot pay. So they come and say people like you can pay but the poor cannot pay. But if you open your eyes, it turns out that not only can the poor pay, the poor are paying. While you and I are sitting happily paying our 50 rupee equivalence, people actually are paying for water tanker loads because there is no other water available. So we really have to think carefully about the economics of water supply. So water supply I think is one sort of very important thing to think about.

[Professor-Student conversation starts]

Student: Why not a hybrid pricing for a fixed amount that…

Professor: Correct. So there has been all kinds of, so there is lot of literature on pricing. So for instance, people talk about what we call telescopic pricing, which we, where we say the first few kiloliters. So the United Nations has, you know, a number on the amount of water a human being needs. Anyone know that number?

Student: 135 liters

Professor: 135 liters per capita per day. It is being debated, looks like it is a bit of inflated number. I think people can live on 100 whatever.

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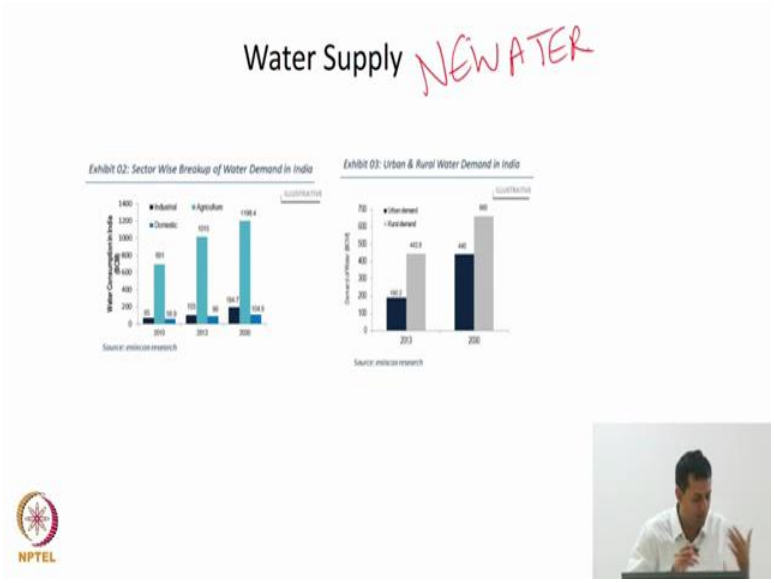

I actually heard once that Hamburg delivers about 80 liters per capita per day and they seem to be very happy. I am not quite sure if that data is true or not. But anyway I think whatever it is, right, so let us take 135 liters per capita per day. So one view is to say, take a family of four or family of five because you have parents, two children, maybe one grandparent who is staying with you, whatever. So family of five multiply 135, divided by 5, approximated to about 700. So let the first 700 liters that I supply per day, be either free or at this 50 rupees or at some nominal rate. Beyond that let us charge, let us start charging. And let us start charging telescopically, which means I will give you a rate from 700 to 1,000 and then that rate will be much higher from 1,000 to 2,000. What is the logic? The idea is that people who are using more and more water probably are people who are living in fancy homes, need to water their gardens, need to water their cars et cetera and therefore they pay more. And others essentially are living in these sort of small families etc. So we tried that out. The problem is sometimes you have a few water connections for a large number of people.

So there is actually one water tap which 15 people are using. It looks like they are consuming a lot of water, they get put in the highest band. So that is one type of pricing. That is what we call

telescopic pricing. Another type of pricing is just demographic, you identify rich neighborhoods and say you guys pay x, you identify poor neighborhoods and say you guys pay y. Now the problem is that neighborhoods are not so nicely drawn. So you might have slums at the fringes of the rich neighborhood. So there is some thinking on pricing, which I think is, which means sort of, need to think about. There are these hybrid things possible.

But I think the point that Tilmaan made is a good one, which is why do we need to constantly generate new water? So why cannot we just recycle water? And today most studies show that if you consume a 100 liters of water, then 80 liters essentially goes into some kind of drainage system. So if we look at where you consume water, so there is some amount of water that stays in your body. So you drink etcetera but a lot of it is, if you are washing vessels, that goes into the drain. If you are bathing, that goes into the drain. Even when you go and urinate, that is water going back into the drain.

So roughly about 80 percent of water goes back into the system, possibly more. I am just giving you a ballpark figure. And that water can be treated, most of you have taken some course or the other on environmental engineering and you know that all kinds of treatment system, primary treatment, secondary treatment, tertiary treatment, sewage treatment plants, all of that. And generally what we seem to be able to do is recover again about 80 percent of that water and actually treat it to very high quality.

So if you say, if I supply 100 liters, 80 comes back into the system and I could recover 80 percent of that. That means for every 100 liters that I supply, I should be able to put 64 liters back into the system, which means tomorrow morning I only need to supply 36 new liters. I do not need to supply another 100. So every day I essentially need to supply 36 more liters because 100 liters going into the system, about 64 comes back, which means I brought down my water supply requirements by a third and it is relatively, and there is all kinds of ways of doing it.

You have these large centralized sewage treatment plants, where you bring all the sewage, you treat it at scale and you distribute it. If you go and talk to Professor Ligi Philip and others, they will talk about all kinds of decentralized plants that can be installed at an apartment level, at a community level. So you pick and choose what you can do. So I think this is a very important option. What is happening today in India is we are doing it a little bit with industry. So there is

some waste water that is being treated and supplied to industry that requires water. So the leather industry, the textile industry, sometimes the automotive industry, if they want to use water as a coolant etcetera.

Why do you need drinking water for that? You can use recycled water. So there about I think about 90 plus 90, I think about 180 odd million liters a day in Chennai that sort of going there. What, why cannot we use that for domestic purposes? Most of the problem is psychological. Question is people are saying look, what am I drinking? Am I drinking my own wastewater? How effective is that? Ok, and that is obviously a big cultural barrier to break. But Singapore for instance, does that all the time. So Singapore actually, and they have actually branded it. They have actually got something. If you go to Singapore, you can drink what is called new water. Ok, that is what they call it. They say, they do not call it recycled water, they call it new water. And so Singapore essentially, any water that you drink, and they actually sell new water bottles which is completely 100 percent recycled water. But even otherwise in Singapore you can open the tap and drink water because it is sort of well treated and all of that. 3 percent of that water is recycled water and nobody has a problem with, I mean, I went to Singapore a few times and I am still alive. So you can certainly drink that water.

We also do something very similar at IIT, I do not know how many of you know. We have a treatment plant at IIT, it is sort of on the way to the Research Park, past Mandak hostel. And that treatment plant treats a lot of our water. As most of you know, some of the new hostels etcetera, that is what is being used for flushing the toilets etcetera. We do not, the metro water supply does not go into flush the toilets. We recycle our own water. We have a dual piping system, so there is another set of pipes that come in and that is how you flush your toilets etcetera.

But there is some amount of that water going into the lake and some of which is actually then making its way into the system. Ok, now of course, in India none of us drink out of the tap, we still bottle, boil the water or purify it, reverse osmosis, ultra-violet whatever it is. But the feed water going into that, particularly if you are on campus, some of that is actually recycled water. Right, and judging by the fact that over the years attendance is not dropping, right, I assume that it is again not entirely unhealthy for you guys to be consuming that kind of water.

And therefore what happens is one, when we had that drought a couple of years ago when the city was screaming and crying for water, we were still watering our entire vast 550 acres worth of campus. And we actually had excess water that we were trying to give away because we were recycling water. So recycling is a very powerful strategy but politically it is not permeating far enough yet, at least in the Indian context.

[Professor-Student conversation starts]

Student: Why do people need to know where the water comes from? For example, in my hometown, people don't know where water comes from. At least 50 percent of that is treated because it starts somehow a network.

Professor: Yeah. So that is a good question but this is where….

Student: Just fed into the system, you can make

Professor: Absolutely. I mean personally I am of the same opinion but many people are not. There is a very sort of clear, as a water supply department you are supposed to deliver a certain kind of water, to my doorstep. It is sort of an attitude that, a lot of non-governmental organizations and others have.

Student: Once somebody asks you, tell them

Professor: Yeah. Once you tell them with social media the way it is, so these are things that are again politically sensitive. So by the way lot of you probably did not know that this was happening at IIT. You knew the recycling was happening but did you know that was going back into the, parts of it was going back into the system? Okay, beyond the flushing many people do not know that. And that is exactly sort of your point. People do not really know, people do not really care. But outside there is always this sort of investigation of what is going on.

So anyway, so I think that these are so, but I think this is the way of the future. I think at some point we will have to put our heads down and say we have to sort of look at waste water treatment. In fact, I am engaged now and also drafting, helping Chennai draft a strategy. And this is one of the things that we are thinking that we will need to sort of put in it as a recycling strategy for Chennai, because how long are you going to go with rainfall patterns being variable

and population increasing, trying to supply water. Last comment, then we will move away from water.

Student: Telescopic pricing is successful in in power sector, why not in water?

Professor: So it has been tried. See the thing is you, telescopic is fine but you have to sort of weed out these anomalies. Problem with telescopic, in certain places is there will be one connection which seems to be consuming a large amount of water and you really hit them with a large price. But it turns out that is not one connection. It is a bunch of poor people sharing one tap. So you need to be able to iron those out. You need to be able to say no, that is an anomaly, we will not charge this telescopic price there. But when the millionaire waters his, 3 Mercedes Benz and Audis and his lavish garden landscape and all of that, then we will actually increase the price that we charge.

So there has to be some sort of oversight, governance, all of that. So water is a very sort of interesting subject. I am going to move on now because we are sort of way behind.

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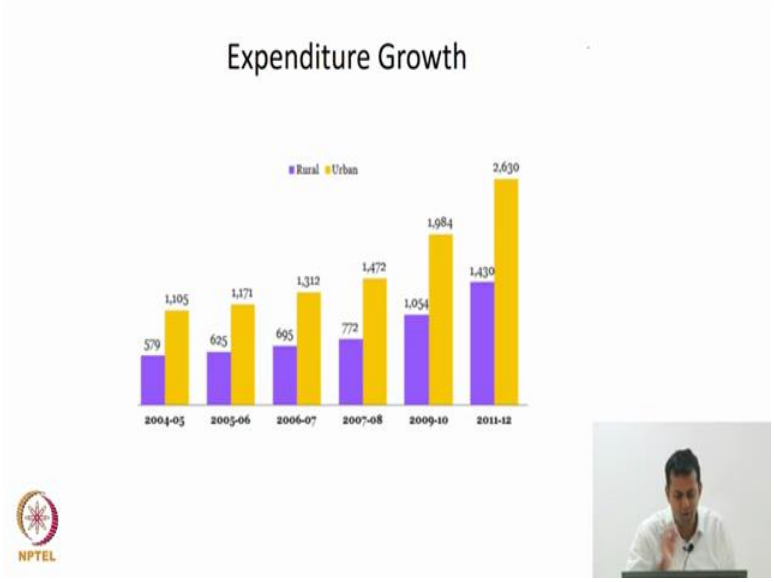

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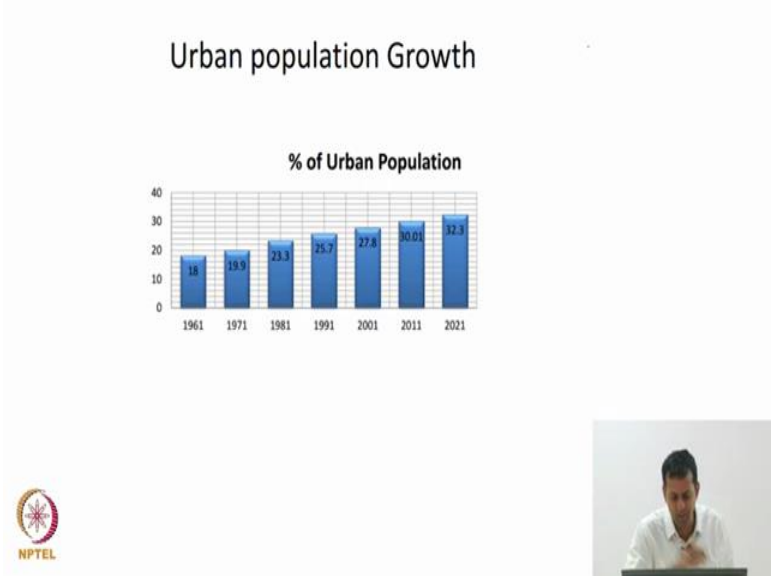

So these are just data etcetera, urban population growth as you can see. A lot of it is because of urban to rural migration all of that.