Remote Sensing and GIS for Rural Development
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Week - 02
Lecture No - 03
Remote Sensing for Water and Food Security

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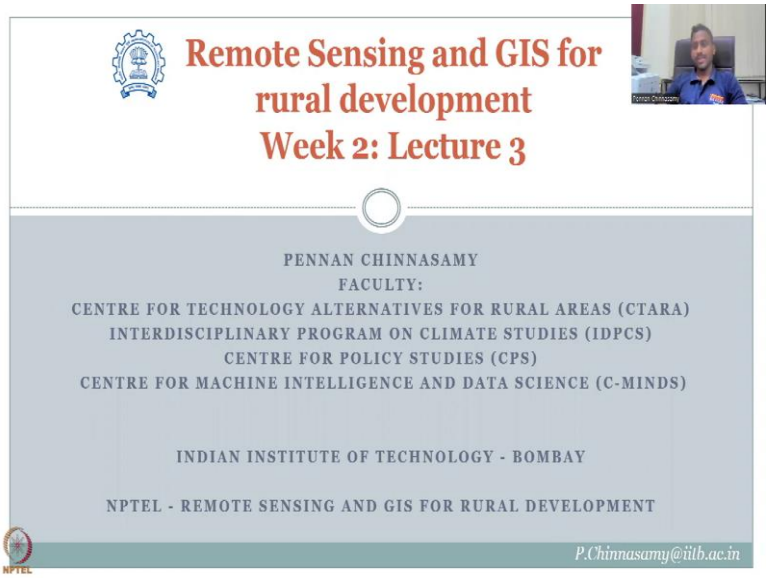

Hello everyone, welcome to the NPTEL course on Remote Sensing and GIS for Rural Development. This is Week 2, lecture 3. In the past weeks and lectures, we have been constantly focusing on rural development and different segments of rural development. Then, we also looked at what are the current issues in managing the rural development scenario. So, let us move on to today's lecture, which is lecture 3.

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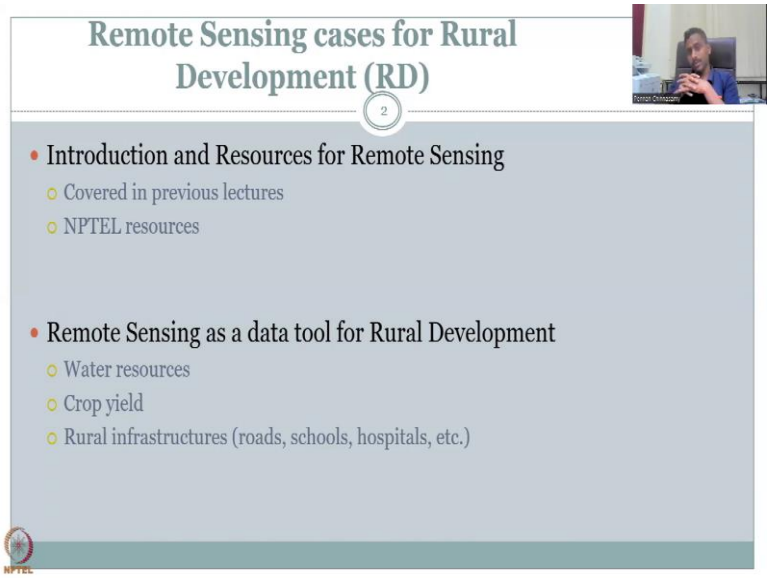

In the remote sensing sphere, we discussed what is remote sensing. Basically, collecting data without touching an object, there could be multiple reasons why you want to avoid touching an object while collecting data. Maybe you did not want to disturb the sample or is too expensive to monitor in close contact and scale and temporal issues. All these are definitely addressed using remote sensing data.

So, this is the core of why we are using remote sensing for rural development, across the world, cities, suburban's and even peri urban areas, which is in between rural and urban areas, we do see a lot of data collection for development scenarios, let us say for building roads, managing water, infrastructure, food, connectivity etc. This is however, very less in comparison, at rural agencies and rural areas and that is a core reason, this course has come into existence of using remote sensing and GIS.

So, the introduction to the remote sensing was given in the previous lectures and some NPTEL resources were highlighted. You would have noticed that if you had seen the NPTEL courses in the last two lectures, the introduction to remote sensing is itself a course, I would like you to take such courses to update the knowledge or go through the Rural Development course, which is the current NPTEL course, and then, specifically take remote sensing courses that you need, this will help you either way in selecting the remote sensing data for your own development scenario.

For example, it could be infrastructure, could be water aspects, it could be crop, agriculture, health. So, we will discuss this in some examples in today's lecture. So, what will cover today

is, how is remote sensing used as a tool for Rural Development focusing on water resources, crop yield, and rural infrastructures.

We will give you some examples in this course, in this today's lecture and while we build the course throughout the 12 weeks, we would also give you some live hands on experience of using such tools for rural development. So, there is rural development, there is remote sensing and GIS we are clubbing all three together where it sometimes most of the times is segregated separately, you have GIS separately remote sensing separately, you are rural development separately.

So, this course is forming a bridge between these sectors. And within the rural development, there are multiple schemes that you can look at, multiple themes that you can look at, we are going to focus on only a handful, specifically water crop rural infrastructure. Other aspects will definitely pull a longer time maybe warrants for another course. But for now, in this introductory based course, we will only cover these parts, as also given in the syllabus.

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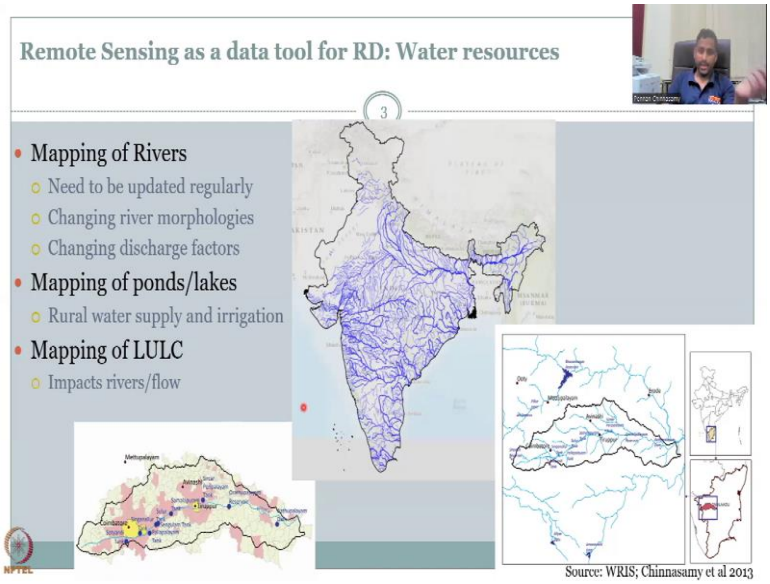

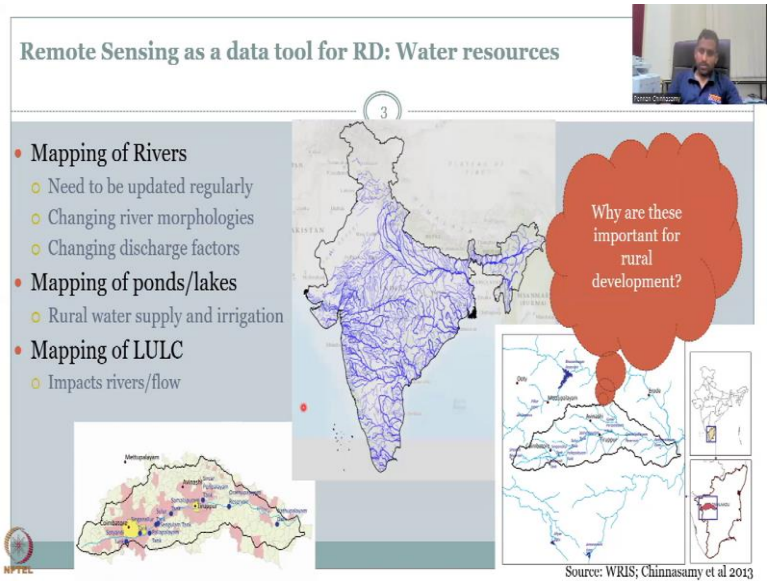

So, let us look at the first exam example where we want to use remote sensing. Right now, what you see is an example of water resources, maps, data, visualization, etc. So, in this slide, I will be explaining in detail, where and how you would use remote sensing as a tool for rural development, focusing on water resources.

This is much needed. However, I would like you to first think while this lecture, while this slide is discussed, I would like to think with the questions I am going to ask, it is kind of an interactive lecture. However, since you are not in person, I will try my best to make it interactive, I will pause in between to make you think and why and how this could be useful.

So, the first example is mapping of rivers. You could see that the India map has most of the rivers mapped. I will put my pointer, so that you can also see yes, so you could see the Ganges, the major rivers, Kaveri, etc, running across India and the Brahmaputra. But what is more interesting is to understand at a rural scale, which is district village, those kinds of boundaries, how are these maps, correct? This is not asking questions about a legitimacy or are we trying to correct a existing math? No, that is not the aim of this course.

If you understand how this data was created, and developed, it would have been induced or it could have used a field measurement and mapping and then bringing it on a topographic map. So, this image I am showing, however, that takes long time, a lot of cost and manpower. So, people had to be trained, they had to go to the village, or areas, map the rivers on paper and check it come back, map it back into cartographic map.

And then it has been converted GIS layers now. But we need to understand when was it done? It does not get updated every year. So, that is the first bullet, I am trying to say. Why is

it important to update it? Someone might ask in a rural setting for example. As I said India is developing at a high pace. Development includes infrastructures, let us say roads, tunnels, bridges, etc. When you build such structures, definitely the hydrology gets altered. The water movement when I say hydrology, it is the water movement, it gets altered, and with that alteration, some of the rivers are having low flow or no flow.

So, for example, let us take Kaveri river in the south, in some pockets where I used to go and have a bath in my childhood rural days. I could not see it during my college days, the water was not flowing. It was a perineal river which means it flows every day, every part of the year. However, when I went to college within a span of 10-15 years, the water was lost only during seasonal times it came which is the monsoons.

So, what has happened? So, in the 15 years, definitely the cities have changed, the villages have changed, there is been more groundwater pumping, which definitely influences the river. And there has been considerable uptake of water for agriculture, I will show you the crop maps. So, with this, we are limiting the water that flows in the river channels and then which gets divided into downstream areas and downstream farmers which needs to be updated.

So, this map is not to find reasons, but first to update. So, for example, let us take this river, if people are extracting more water on the upstream, then downstream farmers, downstream villages will not get water. So, that is how we need to document it yes, the river flows as per the map, the river is flowing from north to south.

However, over the years, this region is being expanded more in terms of water demand. And so, when water is being pumped and pulled downstream people downstream farmers rural communities do not get water or in other words, the river does not flow. So, is it right to have this, river still shown as a flowing river is the question or should this map be colour coded in terms of blue for Tyrrhenian, annually flowing rivers in blue, and then seasonal in different colours, so that we can understand how and where to supply water for rural people.

Again, supply of water for rural people is very, very important for development, you need water to cook, clean, wash, drink to participate in development activities. So, these are the basic amenities a human being would need, in order to develop. So, we need to give that in terms of this water maps, so a mapping of rivers has to be updated.

Number one, one was it needs to be updated because of some stressors. As I showed you, as I told you, the city has developed, people started to take more water, so we need to map. The next is changing river morphologies. What does that mean? Specifically, for the Ganges, so the Ganges is a Paleo channel having river, the Ganges has Paleo channels which means multiple channels run underneath the riverbed, it is a very very old river, suddenly Ganges will wake up one day and she will flow in a particular channel.

So, what you see here at a larger scale may be but when you zoom down, you will see multiple lines going, not all lines will get water and that is only controlled by Ganges herself. No engineering, no human anthropogenic activity will has been used to channelize the water, there could be reason why she flows in one direction but there is no stopping and turning the water as you see down in the south.

It is too powerful in this region the Ganges water it cannot be stopped and turned around as like even the Koshy bearish on the top it only successful up to a particular extent. So, what happens is suddenly the Ganges will wake up one day after a big flood and then take another route. If she takes another route, all the land, all the houses along those river channels will be submerged. And the following development scenarios like livestock rearing, farm, produce, agriculture, milk produced everything is stopped.

So, if you would be heard, you would see these kinds of people moving from one bank to the other man because the river suddenly changes direction. So, is not it important to map these to update these data? Yes, so that is where changing river morphologies have to be mapped. Also, as I was saying in the previous example, if you have rivers being disturbed by construction like a big road coming along the banks, stilts being put, bridges built, it will alter the river morphology, how the river flows it will alter because you are engineering the water to go in a particular direction, it will add low flows, but high flows it will change these have to be mapped.

So, constant updation needs constant in the older days, as per older days you need to go constantly to the field map the data bring it onto the map, put it on GIS and then the portal this takes time. So, for that remote sensing gives you a better faster and more importantly cost-effective method.

Changing this discharge factors, I have touched upon it in the previous example which means the quantity, the volume of water that comes in a river will be changing and that has to be mapped in different colours or thickness of lines, if you can see here, Ganges lines are almost

the same as your Kaveri, Narmada etc thickness. Does that make sense? Because you know Ganges can be very huge, whereas Kaveri is maybe one tenth of the size in some segments.

So, it is very important to catch this thickness and build the thickness how much water passes through the cross section and that gives you the discharge. And this discharge is also not the same as 10 years ago, mapped 20 years ago mapped, why? Because the demand is changing, the alteration of the land, the climate change, sudden floods, sudden outburst of clouds, we call them here.

So, we have seen in Uttarakhand a lot of glacial outburst, sudden melting, all would bring excess volumes of water and the discharges changing. So, these have to be mapped at a very, very high scale. So, at an India scale, for administrative purposes, maybe it is good. But for development and managing water, you need to zoom down to smaller smaller locations. And remote sensing areas, because you can do it every 10 days. Whereas this took maybe 5 years, 10 years to make a map.

Remember, the census data takes one complete 10-year interval for us to map the population. Another thing for water is this is reverse. We have discussed we also need to look at surface storage structures and natural and manmade structures could be dams, ponds, lakes, all manmade different structures are natural ponds, natural lakes, etc.

This is important to map because rural water supply and irrigation is being fed from these sources. Let us take an example. In those days, a lot of religious places had tanks. And those tanks in the villages I am saying the people would go in the morning take water and come and during flood or rain event, water will come from all the streets and go into the tanks. And the tank was kind of recharging and also storing the water.

So, people used to use it very carefully. One of the reasons because it is religious, is because people would say that, it is religious purpose also so they would not pollute the water. You would not see much irrigation from a religious tank, but it is mostly for domestic water and cows, cattle, livestock etc. So, this was very, very important for rural water supply.

However, when the villages started to expand, you would see that these small tanks are all not having enough water, because the roads were disconnected. The drainage to the tanks and ponds were stopped, encroach. And so, there was not water much coming in. In fact, a lot of regions in the south are called they have lot of tanks and lakes for example, Bangalore or Bengaluru was known to be a city of lakes.

However, if you go now and see the number of lakes have diminished considerably. They have been converted to urban settings, drained and then converted to plots. It still has a lakes name. So, if you go there, you will see that the name of that land, the area is still the lake name. But when he goes search for the lake, it would not be there, it will be drained and all the drainage which is coming into the lake is disconnected.

So, these are the outskirts of Bengaluru. So, those are the rural areas I am saying. So, all these have been disconnected and changed. So, it is important to map it to understand and help the Rural Development economy. And that is what I am talking about. mapping of ponds and lakes are also important. So, if you could see here, this is an example of the Noyyal river basin that we did in Coimbatore in Tamil Nadu, and you can see that we have mapped all these tanks.

When you map the tanks, you also look at the water level and water quality, which is very, very important, if you have water there, it should be portable for drinking and usable for irrigation. If you call it as a rural tank for irrigation or for domestic use, what is the point of having a water structure, water inside and quality is not good, the quality can be compromised by multiple reasons, we would not get into that, but it has to be mapped.

So, you could understand that this map was one of the first to put all the tanks in the basin also update the size of these tanks, the size on the gazette on the administrative portal might be big, but now because of encroachments and the land change it could have been made small, this happens everywhere sometimes legally, sometimes it has to be charged. So, this is where Noyyal is as I said South India Tamil Nadu and the Noyyal basin.

We also need to see the mapping of LULC which is Land Use Land Cover, I have said about converting a lake into an urban setting. So, that is the land conversion, how does the land conversion impact rivers and flows. So, these points are important for rural development. However, since data is not available at regular intervals, we will have to use remote sensing to augment the data. That is the argument that we like to keep here. Let us see why are these important for rural development.

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The next slide and how this can help in the management. As I mentioned, if you map a water body, you can look at the water quantity, how much volume as I said the thickness of the river or the thickness, the boundary of the lake pond etc. You could see here all these are encroachments, or this is a lake. But now there is no water.

So, you can understand the water quantity, is it really coming in? How much is coming in? Is it being encroached? People dumping waste in it, all these can be mapped. See landfills along the borders or boundary of the channels. It is also important to understand the water quality. Again, please look at these images. There is water flowing, but would you call it water? It is liquid? Yes, it is water, but it has high pollutants. It does not satisfy the common man's understanding of water, which is to bath or drink or use it for agriculture. See what is different. We are talking about inlet water correct.

So, all these water issues are happening and the government cannot be monitoring at every single inch correctly. It is super, super expensive, time consuming. So, for that remote sensing data, satellite data can be very helpful. Identifying sources of water and distance. This is also important because if you know where your water source is, like well which is operating or land a piece of land where agriculture water is needed.

You can know from a GIS based map the distance required to commute to take the water and that estimation can help you to put a budget for it let us say pumping cost or taking a tanker and bringing or water for domestic use or for urban setting, the cost is very important for transportation. So, you need to identify the distance, to prepare a supply and demand

estimates, so as I said if you know a field is there at a particular distance, how much water does it need for a particular crop and that can be estimated by the mapping of water bodies.

Because when you map the water body, you also map the volume, the quantity and the quality and knowing that you could easily map the demand and supply ratios to protect water resources from pollution natural and anthropogenic, the natural pollution occurs because of the underlying rocks like for example, arsenic or inundation, because of sea water, all these are natural pollutants.

Anthropogenic is as you could see people dumping waste, fertilizers washing in landfills, these are industrial effluents you could see like throbbing chemicals, etc. All these are they can be mapped because a satellite can capture the different colours. And if there is a big colour change, after some time, you could say that oh it is because of pollution. encroachments yes, if there is a channel 10 years ago and 20 years ago, it was this big and then 10 years ago it will becomes this big and then now it is this big, then you know that it has been encroached people build houses along the water channels.

Blockages I mentioned in the previous slide, there could be some blockages of channels to go at the water can go through and come to the water bodies this can be mapped and the final thing is for sure the climate extremes floods and droughts. So, this drying of a lake could also be because of a climate impact, which is drought, big rainfall deficit.

So, you do not see what are the lake? How do you know because of satellites, because every month you cannot expect to get observation data. And mapping of hotspots, hotspots are important to collect data and immediately put action on the ground. See every region may not be impacted equally, there could be some hotspots like the Ganges, the Yamuna. So, at once people can go and start some interventions to save the water. That is what mapping hotspots mean.

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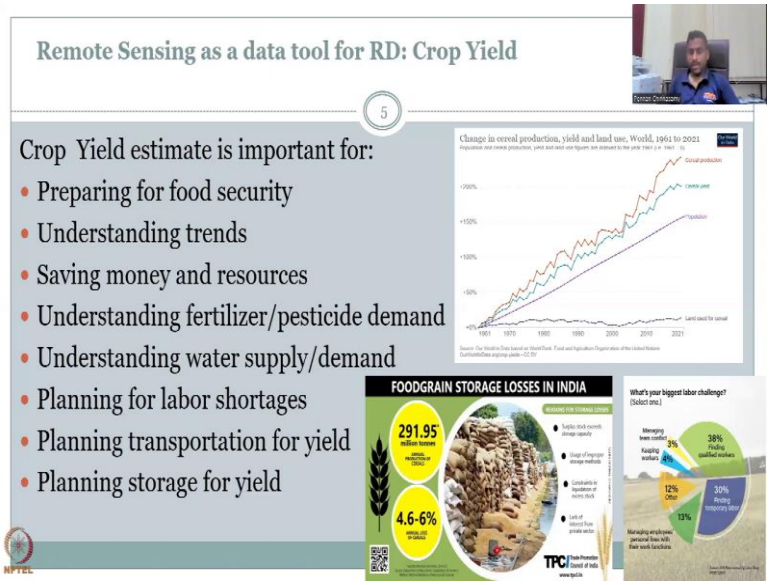

The next part is we look at crop yield. So, crop yield estimate is important for preparing food security. So, I am going to talk about now how do you use remote sensing data for estimating crop yield? And why is it important? First, let us say why do you need to estimate crop yield crop acreage crop growth etc. Because as I said in the previous slides, the population is always increasing.

And it is sometimes until we taper off until then we need to cater to the food security and that job is predominantly done by our rural villages. So, we need to support them for the development of food security initiatives. Understanding trends, so, which kind of crop is needed, how are they growing for example, you could see here the trends.

So, there is a population trend and the land used for cereal has not changed much this is the change percentage from minus 61 to 2021 the land used is not changed, which means the no extra much extra land is added for cereals, but the production is kept on push to increase how? By alternative methods, excessive water use, excessive fertilizers pesticides or different hybrid crops etc.

So, this is very very important for food security. And to understand this, you need to map these areas acreages and crop yield. Again, sending observation data collecting by government does take time. So, you can use remote sensing data. You also need to understand that you need to save some money and water if you know the crop yield is not going to come. So, that can also be mapped using remote sensing data, satellite data can give you a picture every 10-15 days.

So, if you know that the crop is not growing well, you supply water, still the crop is not growing well then you can stop and save the money because this is where farmers put excessive water and money and then they lose the crop thereby ending in farmer suicides etc because sometimes the loan is taken. So, this managing of money and resources is very important for rural development farmers lives and crop yield.

Understanding fertilizer and pesticide demand. As I said, if the image shows that the crop needs more fertilizer, it is not growing enough, or it is changing colour because of some pesticide attack or pest attack. So, you need to apply pesticide. So, these can be discussed, mapped through remote sensing.

Understanding the water supply and demand yes, if you know how much acre, how much land acreage, the crop is being used, you can estimate the water demand, the water supplies, how much water is supplied, what the demand is based on the crop, whereas supply is how much you give. And that is very, very different. Planning for labour shortages. So, labour shortages is a big issue. There is been a survey done by a lot of NGOs and what comes out big across the world, so across the world, what comes up big? Is finding temporary labour. Why?

Because the farmers would not need a person to work every day of the year. Even if it is sugar cane, grows 18 or 16-12 months, you do not need a person to manage it every time. So, you need to find temporary labour. So, while sowing, while cutting, while harvesting, while weeding, taking care of the plant, you need these kinds of people. So that is very, very hard.

And in fact, in the south, you could see people being brought from different states, different districts to work in lorries, they work for 2 or 3 days, and then they go back. So, it is very, very expensive. And sometimes it is not worth for the farmer to bring that money, people with so much cost. And then still the product is not getting profit, for example, tomatoes.

Now, Bhendis are thrown away, because in some parts of the states, because it is not getting the right price. The 38 percent is more finding qualified workers. So, that is a different story of how do you map these kind of qualified workers for agriculture, planning transportation for the yield? Now, you have let us say you have done all the budgets, water budgets, pesticides, fertilizers, and then you have harvested using the laborers and taking it in sacks in banks, where do you store it? How do you transport it? This is very, very important, otherwise, the farmer will get into loss.

And it is a big big issue, because around 4 to 6 percent of annual loss of just cereals is experienced in India, because of stock storage issues, transportation issues, you could see how the bags are not properly used, or proper bags are not used for storage and it has fallen down and it is all wet. Once it is wet in the sales mix there. It is not good enough for anything, you cannot sell it at the price the farmer once, so it is a big loss for the farmer for the government which stores this in their government, go downs and storage units.

And the government can also not plan unless they know this the yield. So, this is on both sides. The farmer will know the yields by these remote sensing maps and then take it to the storage. Now, the storage unit will be more prepared to house all these crops, crop harvested deal as long as they know what is the demand. So, with this, I will stop here we have looked at remote sensing for water and remote sensing for crop yield. We will look at the infrastructure in the next lecture. Thank you.