Remote Sensing and GIS for Rural Development
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Lecture No. 05
Methods for Crop Statistics using Remote Sensing data

Hello, everyone. Welcome to the NPTEL course on Remote Sensing and GIS for rural development. This is week 9, lecture 5. In this week, we have been looking at remote sensing tools and datasets that can aid in assessing irrigation, water demand and land resources.

Managing irrigation is one of the toughest things in India, because we cannot be just regulated to monsoon crops rain fed crops. In order to improve the livelihoods, increase the productivity sustainably, we will have to irrigate in the off seasons also. For example, vegetables, if you are going to wait only for monsoons during vegetables, then only seasonal crops can be done. So, that is why vegetables and fruits and flowers all these are big impact on the economy.

We need to sustainably cultivate them, apply water which is irrigation during the non-monsoon period. Non monsoon period is of two types; Rabi and Zaid. It is important to have water resources available and if not readily available, groundwater resources are taken. Unfortunately, groundwater resources consumes a lot of water for agriculture. Almost 89 percent of the groundwater that we extract is used for agriculture, and 2 percent for domestic and 9 percent for industries.

We hope that this system changes with more better access to water and new technologies to reduce the water demand and or use novel techniques and hybrid or native crop varieties that consume less water. Millets is one crop that everyone should embrace. The government of India has promoted millets as a revolution to the United Nations, which gracefully accepted and declared the current year as the millet year. That is why you will see lot of millet activity happening in the 2023.

Millets consume less water, more nutritious, by default organic, it does not need fertilizers or pesticides. And it was a stable food that we had for generations. So, these are really important because groundwater is less used. And when we come to groundwater, as I said, there is less data available in the government and private sectors. So, we use remote sensing as the nature of this course.

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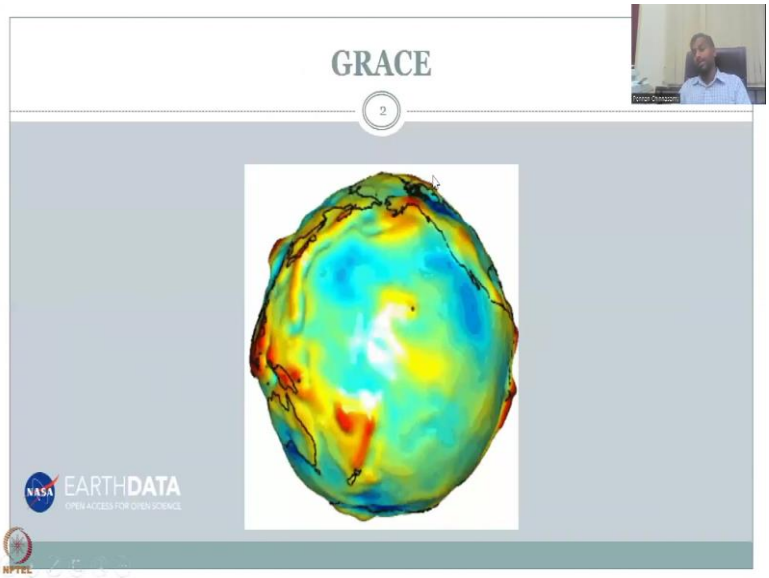

We had visited grace and this is the image of grace satellite output that you could see that the Earth is revolving to show where the mass is high. So, mass is always high on the extreme hilly regions, you have the hill regions along the mountain regions along the Himalayas, the Alps and CC Himalayan regions et cetera. So, you see a bulge, it is red because it is decreasing in water tested water storage. And that is mostly the snow melted. And the poles are also shrinking, because of the ice shaking happening.

Also, the Greenland which comes around here, this part also has been noted to lose a lot of water in the aspect. So, I am going to stop here to show the green how we are Greenland part and then the Arctic Antarctic regions also have been noted to have less water. Greece also has ocean data. So, that is why you see the data continuously throughout the globe. Unlike other data, which only captures the images, here you have a value and the value is converted to a pixel value.

So, the Earth's surface is not smooth surface. It has abnormalities heterogeneities in mass and because the mass change there is a difference in the pull on the satellite and the satellite accelerates and de-accelerates. So, this has been converted to a gravity anomaly, which is then converted to terrestrial water storage thickness, if you remove some components you get groundwater and soil moisture separately.

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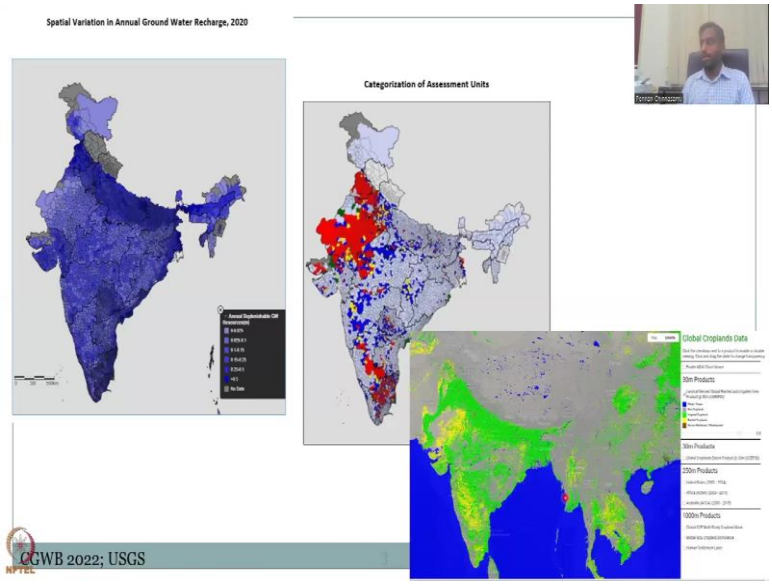

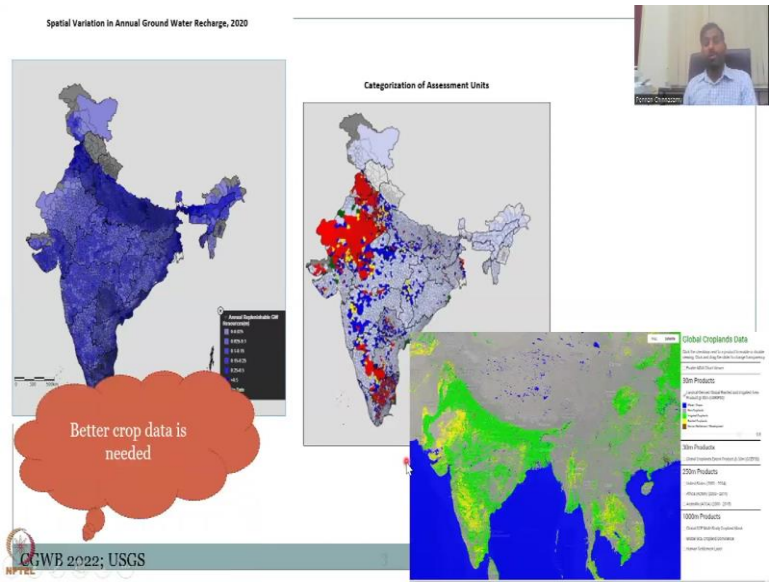

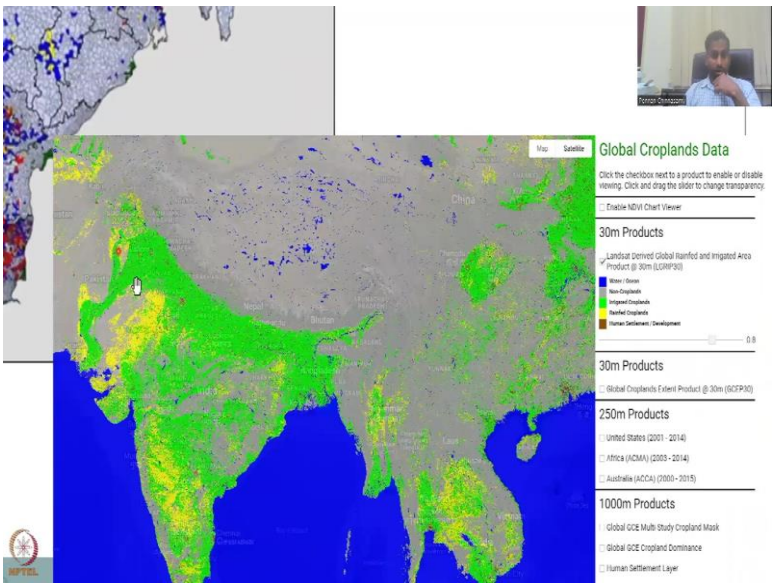

So, this I will continue the discussion on one more important aspect is that coming back to the slide that we had started to show that the groundwater recharge is happening and there is a lot of depletion happening on a different scale. So, there is recharge, however, there is more water taking than recharge. So, there is over exploited and critically exploited regions in India. And that mimics that follows where both rainfall and irrigated crops happen, especially irrigated crops as discussed in the, the legit. You can see that the irrigated crop lands are green. So, along with the green areas, you will see a lot of groundwater depletion in the CGWB dataset. So, here and here is almost the same.

You do not have depression along the Ganges most of the reasons because of the recharge happening, but if you recall the grace data anomaly, the Ganges basin is also decreasing very, very heavily, and it is mostly because of India side not the China and Bangladesh or the Tibet side, because it was a very, very small, maybe Nepal also is there.

So, Nepal also gets a lot of irrigation. So, there is a combined effect of irrigation and also climate change pulling the groundwater resources out. And that is why we have a depletion as per grace data in the Ganges basin's terrestrial water storage uses. The terrestrial water storage is mostly the snowmelt and that can happen in China, Tibet, India also because a lot of the snow cap regions are in Nepal, China and Tibet, if there is a small loss that reflects considerably on the grace data.

So, now we have looked at this is we look this as a groundwater aspect from CGWB and Grace data. But there is something else which is important, the water resource as a recharge, and then estimation of groundwater impact is important, but why is the groundwater going down? Why is the irrigation demand high? It is high, because of the crops, we are using certain type of crops and therefore, there is a necessity to identify the crop statistics. So, let us see how a crop statistics is needed. So, better crop data is needed. So, initially, what the government does is it sends a lot of team on the field to collect data, both at the state and the national level.

The data is kept together as an agricultural statistics and that is also shared with the water boards like Water Resource Department, WRT, PUD, Public Utilities Water board and also the Central Groundwater board and other boards that monitor and manage the water resources. However, if the data is lagging in time, and if the data is having some errors and issues, then we will not have good estimates of the water demand and water use. So, that is what we are going to look at in the next slide. Why do we need crop statistics?

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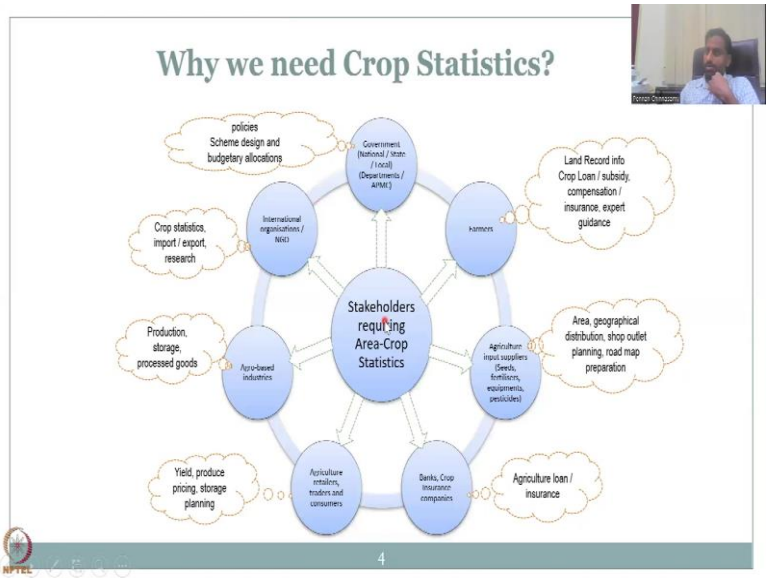

So, let us have an analysis. Stakeholder this is after a big review, a lot of literature review has been done to arrive at these conclusions. So, let us look at what this crop data is needed for, so, stakeholders require area crops statistics include government, national, state and local departments, because they have to give water released water from dams based on the crop data. And if the crop data is wrong, then the release might be wrong and the farmers might be upset that either too much or water is nice or too less water is released. And so, there is a crop damage.

Also, other subsidies are targeted around this crop statistics for example, fertilizers, which is highly, highly subsidized in India and pesticides. So, the farmers pay around 20 percent in some regions, the rest is paid by the government of India. There is loans given as per crop statistics. They will give you a loan on your crops right so if your crop is growing, you want to finish the crop harvest, you need some money, you can apply for loan, they will give you a loan.

Land alone is not important, your land can be barren, barren land is not counted as a land for loan. So, going back government resources are used considerably. Policy is a scheme design and budgetary allocations are done wherein you have multiple policies that can help to save water, save budgets on fertilizers, if you have good crop estimation.

Then of course, you have scheme designs, especially the scheme designs for the farmers, the loan scheme, the water canal schemes, WUA associations, water user associations, et cetera. All these schemes are better applied to the farmers and the public if there is a good crop statistics data, so policies, scheme designs, and budgetary allocations are very, very

important, especially for farmers. So, we put farmers as a key stakeholder and within the farmers land according for crop loan subsidy are being acquired by the farmer if the statistics is correct.

For example, the farmer goes to the Water Board and says, for my field, I need water. And he says you I am growing Paddy; I am growing sugarcane. Well, the government officer might look into the record and say no, you are growing mustard, I cannot give you 10,000 liters, I will give you 5000 liters because your mustard does not consume almost half of sugarcane or not even half. So, why should the government give you so much water. So, this argument comes when there is a difference in the statistics between the farmer and the government officer.

Same for subsidies as power subsidies for pumping groundwater and subsidies for your crops loans, crop loans are there, mudra schemes et cetera. And also, your subsidies for fertilizers, storage, other accessories. So, that is very, very important land record for problem subsidies. The other which is very, very important in the recent years is compensation. Due to climate change impacts, there is lot of negative impact on the farmer side. The crops are lost, let us say you have a big flood coming, a big rainfall event, all the crops are down. So, that is a, the water is just stagnated in the soil for a couple of days, the roots rot and the plants die.

So, in that time, there is a team of central government employees and state government employees who go down and assess the damage and then they give compensation. So, this is very, very time consuming, and there is a lot of delay and also non representativeness because everyone hectare of land cannot be assessed. So, wherever the official score is the official record, if they say the sample for one village to three places, that is the average they will apply for the entire village. So, this is very, very costly, the officials come time consuming, they take time and then the compensation is given to the farmers. So, that is one aspect where you actually need high resolution statistics of crop data.

Then you have your insurance agencies. So, you have to insure so, the Pradhan Mantri insurance scheme is also there for crop protection and that is based on the crop type for a particular land and geolocation. For example, if you are growing paddy in Kashmir, they will not give you insurance because it is cold, you should not be growing there. You should be doing saffron flowers, some types of fruits kiwis et cetera, but not rice and sugarcane. For example, has altitudes.

For example, Nepal high, high altitudes you have rice, but very, very less yield will come so, for that yield you cannot get a big loan same in the Marathwada region and Vidarbha region in Maharashtra, which is a very drought prone region, you cannot expect to have a very low insurance for sugar cane because sugar cane needs to grow for 12 months at least. In that scenario, when there is a big dry region the Vidarbha region, how will the insurance agency give you loan?

So, this is also very, very specific of the location and the crop that is grown. And so there is very high demand for scrub statistics for loan and compensation. Expert guidance is important, like we do get as faculties and rural development faculties sometimes we get calls to recommend a particular crop type and depending on the soil type, water type, groundwater quality, climate, et cetera. So, for that we will need more statistics on what was grown in the land, how long was it grown et cetera.

For example, if you grow sugarcane for a long time, then your soil is depleted of nutrients. It is not only fertilizers, subsidized fertilizers you use and nutrients come up, there is multiple other things that you need to do. One thing is cross cultivation of legumes, which eras nitrogen into the soil. These aspects are yet to be fully understood. And for that we need scrub statistics. Then this is the farmer side. The very, very important stakeholders along with the government. So, the government and farmers are kind of together, the government operates for the farmers, the farmers seek the government for help, and they have tie up with the crop statistics.

The next one was the agricultural input suppliers, like seeds, fertilizers, equipment's, pesticides. So, these are the companies that actually provide these at a subsidized rate. The subsidy can be given by the government, but they are not manufacturing the fertilizers, they are not cultivating hybrid seeds. So, that is a different entrepreneur track startup ecosystem or a company ecosystem that give seeds for example, all agricultural universities, work on hybrid seeds and new climate resilient seeds.

These seeds can be given to farmers and noted how it grows for which you need crop statistics. It will grow well in the agricultural universities, why, because that land is not totally depleted in nitrogen and phosphorus or soil nutrients and also it has good supply of water because it is a research academic institute, water supply is not stopped during the summer seasons. So, good water supply is given because the research has to continue to monitor the crops.

So, you can grow well in the lab, it is kind of open land, but will it grow well in the land and that is where this agricultural input suppliers are coming into picture, they must produce these seeds and then give it to farmers. So, for them, why is it important? They need to know the area, acreage, how much area do you need the seed, you cannot give like potato is big now and mangoes are very big because they actually consume a lot of water and India has been looked as a chief exporter of mango pulp and mango. Mango Juice is very popular in India. Mango lassi is popular in India for the area. So, where does it grow? How does it grow? So, these kinds of data are important for the agriculture input suppliers.

Geographical distribution, where do they place their offices is directly linked to the crop statistics. Why would you put a mango agricultural supplier in a region where there is no mango, so for that we need these kinds of assessments. Then shop outlet planning, roadmap and preparation.

So, for the future also, if they see that suddenly system is evolving, like for example, in Pune region, I have noticed that a lot of bananas are being grown from sugarcane areas. Why? Because bananas, the export market is big. They are exported to Arab countries and along Europe. So, there is a good demand for these bananas. And so suddenly then you see some shops coming up, some brokers offices that come up to procure the bananas and export to Europe.

So, these happen when the crop statistics is there. And the roadmap full time, future preparations et cetera are also done. So, this is also very important to have crop statistics, then the bank crop insurance companies not only there are central government schemes to give you insurance, but there are a lot of private Institute's private banks that give farmers loans and for them they need crop statistics. Again, if you are a banker, you do not want to give a loan to a land which is barren, which is nothing is growing how can a bank give money? So, that is where a crop statistics is needed and high high resolution, high temporal and spatial. 10 years ago record from the government will not be helpful.

So, if you go back to the record that we took from LULC in Bhuvan website, it is 2015-2016 How can a bank give now with the data for the 6 years before? So, current data is needed. And yes, we understand that it is time consuming, but it is good to have high resolution, recent data for helping the farmers and allied people. So, these are indirect resources for the farmers the bank crop insurance et cetera. So, they what do they use it for? They use it to

assess the agricultural loan and insurance, how much insurance can we put based on the location, based on the climate interference and the crop that is grown.

If it is, for example, like banana in a flood prone region, they will not give loan that easily or they increase the insurance price, because banana is very susceptible to floods and cyclones. So, only regions where it is very fragile. Even if you push down, it will that the plantation will fall down. So, even if a big cyclone or storm comes, it will just uproot the system. So, for that we need better crops statistics. Then we have agriculture retailers, traders and consumers. So, some of that we already discussed in the agriculture input suppliers, the retailers are the businessman.

For example, if you have a big demand in Mumbai is there for fruits and organic vegetables, broccoli, mushrooms, et cetera. So, where do they get them from? They get them from the villages nearby. So, only when the demand is there, the mushroom will be grown because in farm land and rural regions, you do not see people eating so much mushroom, and or fruits that they grow. So, it is all sent exported to cities. And that is the demand the agricultural retailers need to know traders and consumers.

So, as a consumer, I need to know where my crop has been produced from, why, because if I take an apple from thousands of miles away, I am sure that they will put lot of preservatives to preserve that apple to come here to my team. Rather than that, if I take an apple let us say from Kashmir, then what happens is, the Kashmir apple has less pesticides and fertilizers because the shelf life is small, you can also bring it in a plane within a day or a truck or train that India is well connected with.

And you can quickly get it but for example, if I am taking an apple from Australia region or European side, then there has to be more care taken for the apple which also decides on what food I eat. So, nowadays, there are methods to reduce the fertilizers, the processing of food and some other techniques I used.

So, agricultural retailer's status and consumer data is also important because they need to know what is the yield, if there is one ton requirement of mushroom per day in this for the city of Mumbai and Mumbai area, you cannot just give half a ton. 1000 kilos is 1000 kilos and to be honest, if you look at the (agri) student dining rooms and all they have so much of mushroom because they like these mushroom infused food. So, that is the demand.

And if you come to other demands like milk and dairy that is also needed because Mumbai does not have much cows. It has to come from outside. So, the processing has to happen. Cows have to be reared outside the city and for the cows there is a feed that is needed. So, normally if you go to Pune regions, you will see cows and just for the cows to eat there is a lot of maize and fodder that is grown. So, yield, produce, pricing, storage, planning all our allied to rural livelihoods.

And for that there is a very important need for heavy crop statistics currently. Agro based industries and production and storage and processing industries as I said, once you have the produce, they have a factory nearby so there is a lot of FPOs farmer producing organizations. What do they do is they are like, like 50 to 500 farmers come together and say okay, let us do a kitchen or a jam. And so, all of them combined and produce and then they process it and then they make the product and this production and storage is highly, highly dependent on the crop statistics, how much area is grown and how much is the demand. So, demand let us say Mumbai is requiring 500 bottles of jam a day.

So, what will happen is violence very small versions giving an example. So, they will need to know if they have 5000 plans to give supply for 500 jam, because the size reduces. So, this is kind of some calculations that is needed based on the statistics of the crop. So, the crops citizens are very, very important for a company so, now, you put yourself as a company, a factory that is making jams and juices, if you are not getting everyday the supply, then you will either have to procure the raw material, which is like grapes, banana mango from very far away, which increases the price and your company will not evolve, your company will run into losses, because everyday you cannot change your price of the jam and juice.

But if it is a local area and you know for sure how much crop area acreage is done crop statistics, then you know how much produce you can do. So, you will just say no, I can only give a 500 jam, if you like we will give it or we will convert that into juice or other products. And the last but not the least is the international organizations in NGOs. They are very, very important for the Indian system NGOs non-governmental organizations because they work very closely with the farmers and strive to increase their productivity.

So, for them, they need to know what is the crop statistics, how much is imported and exported and research. Research is where we come in academic institutions like IIT Bombay, we need to know the crop statistics. So, that I need to know how much groundwater is

extracted the water balance and is it sustainable or not. So, for example, we saw in the last lecture that the Ganges water, terrestrial water storage is declining.

So, now we should be telling them that you should not be pumping so much. You should reduce the crop acreage, the crop statistics should be reflecting a reduction in the total crop and yield so that the groundwater comes up to sustainable levels. So, this is where international agencies and academic institutions come in place, especially NGOs, because NGOs work for the people on the ground. I am talking about agricultural NGOs, like Dan Foundation. And then we have EMI where I was working, so, all these work for the farmers with the farmers, and they give kind of regulations and rules.

So, Watson is one which works for millets and Odisha Government has put Watson on the millet mission. So, what happens is, they tell which areas are suitable for growing millets. And they monitor the millet acreage using GIS and satellite data so, that they get good account of the acreage and how much is growing. So, this is a very important diagram I would like to share with you so that it is cyclic. It is two ways; it is the government also can give data the farmers also can give data. Right now, the important part is who is giving this data? So, that will be answered in the next slide.

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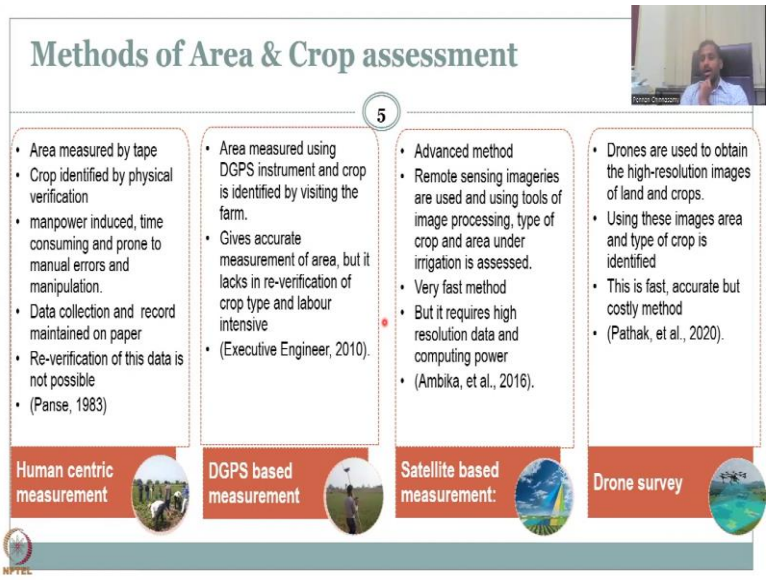

You can see that there is a lot of methods to assess crop area, a crop type and area, the oldest version and still is going on is the area measured by tape. So, they go to the field, let us say sugarcane. So, they measure the area with the tape, length and breadth multiply you get the area and then you get the acreage crop statistics. So, crop identify by physical verification they go there, sugarcane yes is sugarcane, manpower is induced, time consuming, prone to

manual errors because you will go there, sugarcane you can monitor by your visualization, but then in between there are other crops. And or when you use a tape, you cannot cover the full distance.

So, approximately you will say, okay, it is I look at the field and say, it is 10 by 10 meters, that is all the plot is. So, these are big, big mistakes, because even a meter or two extra will consume more water or more subsidies in fertilizers. So, data collection records are maintained on paper not digitally done. It is time consuming, the export has to go there. Re-verification of data is not possible. Once you come back, there is no verification of the data as described by Panse, 1983.

Then we have DGPS based measurements which is the digital geo positioning system measurements. They are measured using high tech devices. And they go to the farm, measure the device, use it to measure the area, acreage, et cetera gives accurate measurement, but it lacks in re-verification of the crop type and labor intensive. So, you can see that a person has to carry it every single step, and then say, this is the area of sugarcane, and then they draw the boundaries to bring the data together.

So, then we have satellite data measurements, which is the remote sensing-based measurements. So, the first two are not remote sensing, both of them are you physically going in touching the plants and monitoring it. So, those are kind of monitoring on the field. Whereas, satellite-based method is more advanced method, remote sensing imageries are used using GIS tools like image processing tools for identifying the crop type, and crop acreage, how long the how big the area is, and three, so this is a spatial term, you have the crop type and crop acreage. The spatial term is done now the temporal term is, is it going throughout the year, if it is growing throughout the year, then you know that it is irrigated, not rainfall.

So, rainfall is only three months, if you if the farmer grows a 3 month crop, which normally people do, they grow the monsoon crop very high in terms of like Paddy, and then they clear the field. And then, they put sugarcane or something else, which grows for one year or less. So, you can identify the irrigated, non-irrigated, the crop type and the crop acreage using satellite. It is very fast method. It does require some resolution data and computing power, but in the current scenarios that computing powers are fast. And or you also have dashboards that I have shown Google Earth Engine, the Sentinel EO hub, all these are giving you tremendous computing power, which is a stable internet.

So, you do not have to have high powered computer, you just have these are areas I need, click the button, it will run in the supercomputer of Google and then put it up for your analysis. Then the last but not the least, and the most expensive one is drones. It is a type of remote sensing, they are used to take up high resolution images of land and crops. It is really good. But the concern is, as I said, the price is really, really heavy. Using these images, crop type and crop acreage can be identified. It is fast accurate, as I said, it is very costly, and not all can afford.

So, you need a person to go to the field to fly the drone, satellite you can sit here and then map, we can sit here in the live class and then show you how the NTBI was done. So, the point here is drones are good, are very, very accurate, but it consumes a lot of time, money and capacity is needed.

So, with this, I will kind of wrap up today's lecture in the ninth week, so that we have a base setup to look at some tools from week 10. From week 10 what we will do is we will look at some indicators using satellite data. Because of all this data, you already have government data from human centric approach, some DGPS measurements are also available. Satellite data is what you can do using the links that I provided in the class. For example, the Google Images, or the NASA images from GLDs website GSDI as you see, and NASA links and also the central hub.

So, I have given you a lot of links, where you can download the data and see how the crop area can be mapped, monitor and then extracted. This results in considerable rural development because after a flood or big damage, you cannot wait for the human centric approach to happen where people go there and measure the damage and all. That can be done within a day as soon as satellite data comes, you have a notification you look at the data, run these analysis and then plot it.

So, this is how satellite data can help in saving time and opportunities for crop type assessment, first crop type and then crop acreage which contributes to crop statistics. So, with this, I will conclude today's lecture. I will see you next lecture. Thank you.