Remote Sensing and GIS for Rural Development
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Week 12
Lecture 5
RS and GIS for Rural Development - Summary, Wrap and Ways Forward

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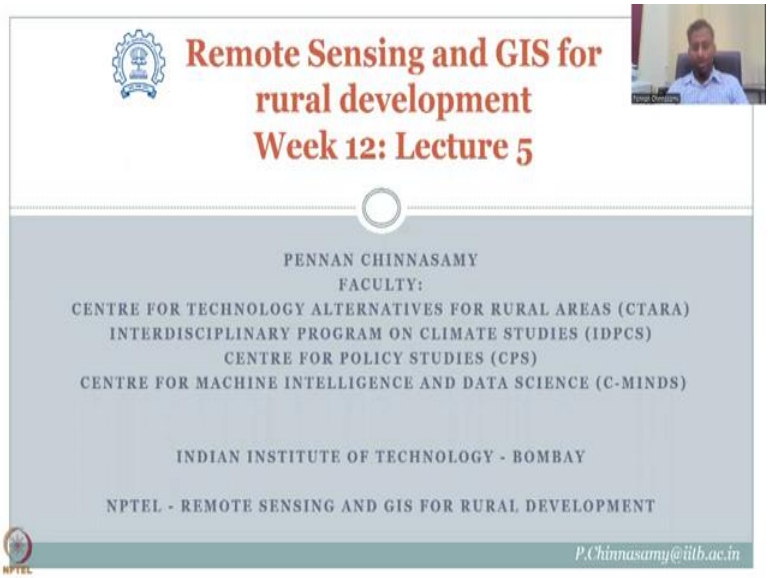

Hello everyone welcome to the NPTEL course on Remote Sensing and GIS for Rural Development this is week 12 lecture 5. We have come to the last lecture for this NPTEL course and we have witnessed many themes that are related to rural development and how they could be improved or monitored or efficiency assessed using remote sensing data.

The goal of this course is not using remote sensing as a tool just for mapping and taking data out but as an application tool for development. When I say development it is finding scenarios for development. Let us say we have a village and we need to assess how much resources are available for further development this could be small scale cottage industries artisans where they have handicrafts and food items that they could create and then water is needed for that soil which is indirectly giving the crops so we need good soil fertility, good water and crops for making these products.

And then we also notice that the accessories that are needed for them also are not well mapped which means like roads, amenities, roads, power, water supply, etc. Then finally we also thought about how rural development scenarios can be created in the wake of climate change, too much water, too less water what to do, groundwater cannot be pumped for long.

And we also looked at multiple satellites and studies that have used indicators for development.

So, in today's lecture I would like to summarize all the 12 weeks and then see and show how they are interconnected so that we have an idea about rural development as a whole and how these remote sensing tools and GIS can aid for further development. Please note that saying development does not occur through data and proven methods is also a cause to fight for Rural Development.

For example, you have a village where the land is fertile but there is no water that is a limitation so therefore NM sadguru foundation has worked very well on this particular theme there is lot of water in the river but the farmers are in a higher elevation and because of that the rainfall, all the rainfall goes to them and then goes into the river, valleys, so lift irrigation was done with a minimal cost like different pumping stages and stuff and the cost was put on the farmers who are growing the crops because initially they were growing nothing, there was this foraging or doing migrating to urban cities but now they are independent farmers in a community system.

So, this was possible because we could map the soil fertility, we could map the water availability. So, what was difficult is if it have a 2D map, a plane surface map then you have village and water supply but it is not connecting why because the 3D says it is at a higher elevation this is at a lower elevation so there has to be some network to pump against gravity and that is energy intensive.

So, this is what we had aimed this course can do, not all have the luxury are having good NGOs like NM sadguru are not blessed with very good NGOs that work for the people, a lot of ridges are still without connectivity and NGO helps or academic studies so the idea was to build the capacity using these lectures, introduce GIS and remote sensing concepts, introduce the data sources and possible problem statements for you so that you could visualize the problem and then work on solutions using maps and tools. Now, this becomes associated with rural development.

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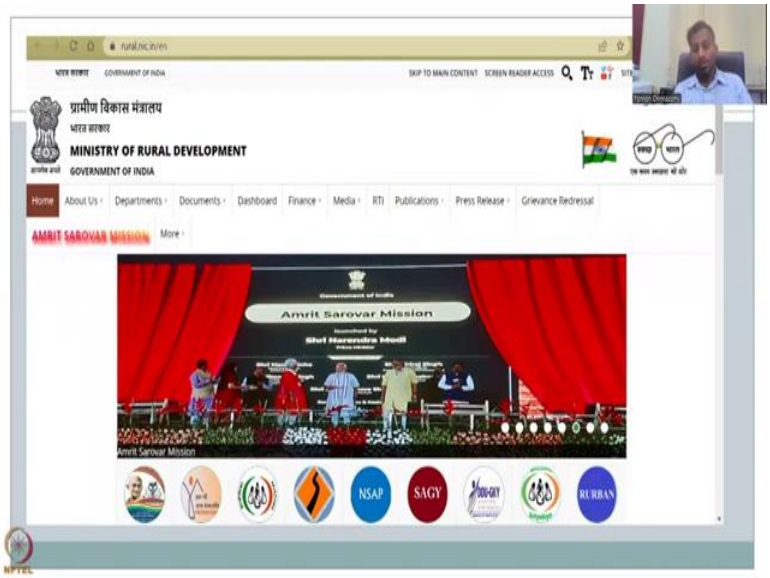

So, let us start today's full lecture in terms of summarizing and stuff first I would like to go back to the ministry of rural development webpage where we discuss the different ministries available. What we found out is most of the people talk about the MG mgnrega scheme where the farmers are given 100 days work and wages so that they could stay in their villages throughout the year because 100 days is normally the non monsoon time no water, no crops growing so if the farmers are compensated for their time in that part then the rest 200 days they get good water and some soil and fertility they manage.

The good concept now coming is initially it was just 100 rupees and they were just do random stuff for the village but now they can work on improving the water structures, improving the soil fertility through IWMP practices and other things and that is where you see a confluence and convergence of schemes and then once a fertility is good so the 100 days they do not have work so they work for this they and government is paying them.

And then after that what happens the soil fertility is good now the farmer who has put 100 days can actually use the benefits of the soil fertility, the water availability and have better cropping. So, this will make sure that our backbone of our India which is the agriculture still gets a breathing space in the high-tech world and also grows along with the other people.

Still we are an agrarian nation which means most of the population is dependent on agriculture as a livelihood and then we do have to acknowledge that fact. So, what we did initially is we went through this web page and then discuss about the departments, the documents, the dashboard, again dashboard we covered in this week only to showcase that there are multiple dashboards and it is easy to use sometimes the data is already processed for

you so all you have to do is run it and then collect the results and then put it for your research outputs or your thesis, etc.

So, then you have your media coverage publications, release, etc. You can also see that the major themes schemes that are there under the ministry are the mgnrega is number one, then schemes for women, self-help groups, roads and then housing and then NSAP, SAGY, DDU-GKY, livelihood, building livelihoods so they are and RURBAN is mostly to scale between the urban and rural in between there is a percent of land that is called RURBAN and we also make sure that peri urban conversions, conversions of rural to urban or urban to rural has to be checked.

So, these schemes are already there and the Prime Minister's schemes are, more are coming on mapping so Gati Shakti has a big component for mapping anything like that that can lead to better development in India, it could be Industrial Development but still Industrial Development requires a lot of contribution from the rural world, and the rural world should be mapped so that is where we are also putting some recommendations for Gati Shakti on using mapping exercises for rural entities.

So, this webpage is very important as those who want to still be associated with India's rural development I recommend you to please keep a update on this website, visit it often so that you can have some data on the applications and think how this can work.

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And then course week by week topics we will start from here because I want to show how when you read and refresh your course for your exams please note that the questions will

come only from the slides and the understanding from the slides I did not take a book and go through it because many tutorials are there for that and there is no exact book for Rural Development especially for India and pan India.

So, I have talked about the issues and concerns and how we could manage it using our system. So, in week 1 what we have done is we had introduced what is rural development so it is very important to first get an understanding of what rural development is before working for Rural Development.

So, this aspect is missing sometimes when we jump into a research project or a theme or for a course we think these are fancy terms but it is very very important to get sensitized to the word rural development and then so we went in, dived into this first we talked about different sources and security measures like water security, food security in India and then how that puts a tremendous pressure on rural.

So, issues were first discussed and then some infrastructure issues like agricultural and rural infrastructures. Agricultural infrastructures include dams, irrigation channels, lift irrigation schemes which are not fully funded, check dams those kind of things, these are not just water but there is soil, there is fertility etc.

The rural infrastructures could include the schools, the libraries for rural people and then better connectivity of roads, water supply system, sanitation access to healthcare, all these stuff are very very important. I recommend you to go to villages often to see these structures so that you could assess the growth of India and also find some locations where some more aspects could be developed.

For example, we do have a very good schemes or sometimes the schemes find it difficult to get to the ground why, because there are multiple resources constraints. So, I always say that medicine is difficult to get into the villages but if you go to the villages you still find bottled drinks, so how can a bottle drink go through the roads and network but medicine cannot go, so this is something which always shakes me up in terms of thinking about rural development.

And if there could be a mechanism where we could use and benefit from the other resources that are available that could be a win-win. So, for example with along with these delivery systems some medicine can also be delivered to these shops just check, just go as a tour you

can go and then check what is rural development after this course to get better feeling of what is needed and how maps can help.

So, if you can map these locations also that will be great. So, there is a mapping community that IIT Bombay is going to start under our lab it is called IU map and Indian Union of mappers where these maps can actually help discuss about rural development in a higher level. So, as I said there are a lot of issues we in the first week we went through most of these issues, we discussed them through scientific methods, literature review and some articles also from the government think tanks like CAG and stuff.

Then what we did in week 2 is we introduced the geospatial technology. So, first we had issues and in issues I had hints saying that remote sensing can help, GIS comes later so remote sensing, data monitoring all these things can help and or finding regions for activities. For example, if you have the water recharge structures needed there is a budget for water recharge structures but we do not know where to put it so that is where these remote sensing GIS tools can help to find potential recharge zones in the area.

So, week 2 was devoted for that for understanding what is the data issues and what is remote sensing. So, since we are having a course which is titled RS and GIS we discuss what is remote sensing and the very simple definition that we can give minimal definition is that it is something that you a process that you collect data from an object without touching the object.

So, if in those days you have a thermometer that you put in the mouth or your armpit and then you are measuring temperature that was not considered as remote sensing but nowadays during the Covid era you had the guns where they would take the temperature from you, thermometer guns and without touching your body because through Covid there was a lot of transmission so that is a remote sensing device, it is measuring a temperature of a body without touching the body, so that we used across and remote sensing is everywhere we use it but we do not call it.

Our photographs are kind of remote sensing we do not touch the object we take an image and then a lot of other things so satellite data is mostly remote sensing data it does not touch the object it just senses the reflection or of the natural environment which is your sunlight reflector or a natural body emitting in the radiation.

There are also other methods where we saw that the satellite can itself send pulses of energy and then wait for it to be reflected or refracted back and that is also called active sensors,

passive sensors are where we do not have to give that much energy. So, these are very important and very cool concepts.

Now, I would proudly say that most of you can discuss at higher level what satellite is and how satellites work through this course. So, there is one component where we talk about rural issues and then we find and identify remote sensing as a tool that can augment, that can aid for rural development and then we discuss about remote sensing etc and then the idea is remote sensing is still a tool but how do you process the data then you use GIS platforms.

So, we discuss about what is remote sensing very detailed and how it is being used for rural water and crop management acreage which leads to more development of rural agricultural practices and then what how do you assess the rural infrastructures using remote sensing. For example, there could be a scheme which says there is a full houses built but then the size of the house the dimensions the locations etc might be not accurately captured, so remote sensing can actually capture these at a very very high level of accuracy.

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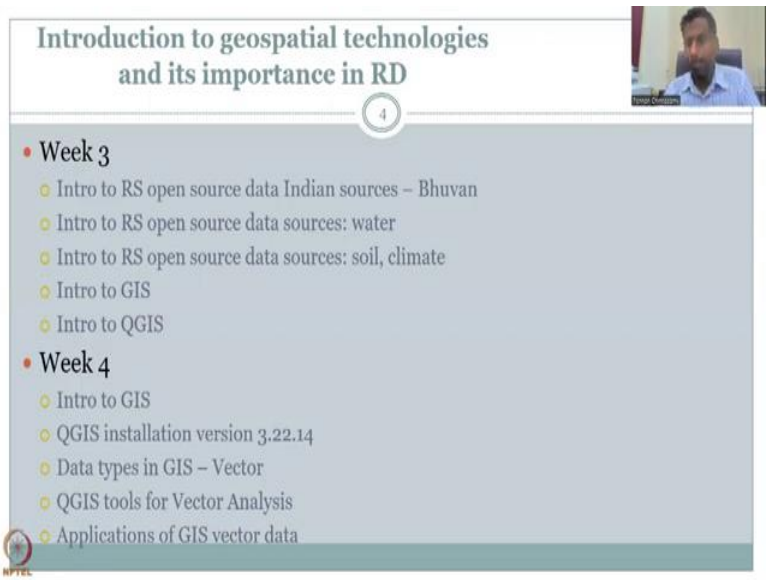

Then we went into week 3 where we had introduction to remote sensing and open source data systems so once we said okay remote sensing is could be a potential tool we also need to give them the sources for the data otherwise there is a big misunderstanding that it is a fancy tool it cannot be used for Rural Development so that is why we had promised that in this course we only use open source systems and data that is free so that we can use it directly for Rural Development, everyone is in the baseline we could build infrastructures, rural development scenarios using just the open source.

Because if it is urban cities there are bigger data sets that are available and there is a lot of money that is being paid for these data and software because there is a big need but people should also put the same need for rural entities however the data is at a different level. So, that is why we use open source data and we want to create capacity that can use open source data and open source mapping software which is QGIS.

So, we gave an introduction to open source data systems not only from India which is Bhuvan but we also gave NASA ESA which is the U.S agencies for space research and also the European agency ESA. So, then we also looked at themes, thematic so some students are more interested in surface water hydrology, groundwater hydrology, soil moisture so we gave them all data sets that can be developed using these remote sensing tactics.

Then we went to introduction of remote sensing for data for soil and climate because soil, moisture and climate play very vital role in the rural development. Carbon sequestration is also there and we need to understand that rural communities play a very vital role in sequestering carbon without their knowledge because in the process and maintain the land properly there is a lot of carbon that could be sequester.

So, now we have discussed about these data sets and how to use the data sets we need a software and that is where GIS comes, GIS stands for geographic information systems, we said that this is where the data converts to information so it is not a GDS well Geographic Data System which is not it is an information so from data from the remote sensing we convert it to an information tool using GIS because GIS plays a very vital role and again we gave us very short introduction to QGIS which is quantum GIS and open source software for using GIS.

The other objective I cleared here is that these tools are as important however we cannot in this course give full lectures on these because each one is a lecture by itself an NPTEL course by itself. However, I have given links to good NPTEL courses that I feel that talks about the basics of remote sensing, the applications of remote sensing and GIS I have also given a lot of tutorials and links to learn GIS, QGIS, etc.

The idea is if you have the basic understanding then you can fit in quickly into this course. We did give some more hands-on exercise I gave another week of GIS, QGIS training we introduced again the GIS concept, install QGIS software and then different types of data in GIS which are vector and raster. And we discussed about the tools that are available for vector analysis.

This was followed by applications of these tools in real-time data, so there are a set of tools that are available for vector analysis we discussed them and then we said okay now these tools have very specific roles and can be very very handy in certain types of rural development applications. So, we discuss the tools and we discuss the applications also.

One example I would like to offer now is now we know how to extract the location of schools and now if I put a buffer using the vector analysis tool buffer then I could say that within 300 meters how many houses are there, I can extract the number of houses and then say that this school is very very optimal for the houses within 300 meters or 400 meters because the students, the kids can walk and come to school and then go back fast if they take like how my father and my family had to struggle to go to school like it takes like two, three hours a day just one way then the student gets very tired.

And it is the energy is lost mostly for commuting and then once you go commute and then you sit in the lecture or the class then you are not in a very good person to grasp all the education that is one of the reasons you see that these school buses and college buses nowadays have a lot of people sleeping, just keep on sleeping so that when they go there they are fresh or and or they do not have energy to work on after class. So, this is very important please understand that the vector tool buffer played a very widely role.

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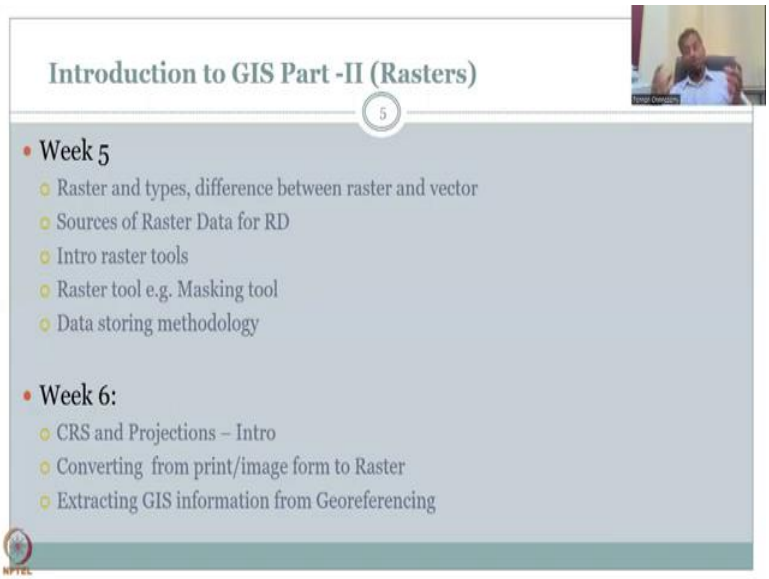

In week 5 we shifted to the other part of the data system which is raster data, we differentiated how vector and raster are different and for rural development raster data is a boon because it gives a continuous data across the surface not only one, two data points but across the surface you have data, continuous data.

And we gave introduction to the raster tools, one of the raster tools is masking and then how the data should be stored. This is very important why because we have a global data that comes in as rasters, where pan world, pan India will come. How do you extract just your village, so for that we have discussed masking tools and also I need to introduce here again that we have given links to authentic boundary data for India which is very very important, I still see a lot of boundaries that are misrepresented across publications, it is as per the law of Indian government you cannot have wrong boundaries on your publications, reports, etc. under the penal code it is not allowed and strict actions will be taken.

So, please be careful and do not tell that we did not inform while teaching, the boundaries of India should be intact it is our integral property and I recommend everyone to use the sources that are recommended by the government which is the Survey of India Maps, we have given the links as I said these get updated very very accurately by the government of India and cite them. So, you can cite that this is these are the boundaries I use, this is the citations I have.

You could say that India has actually bombarded on all angles on the prop, on the boundaries right we are always under attention for boundaries because the people misplace their boundaries and India is fighting back it is our integral property so we should also as citizens through this course make sure that we use correct boundaries.

For example, in the waterways there is a particular boundary, in the Himalayas there is a boundary, on the northeast there is a boundary, all these places have boundary issues. So, please make sure that we follow what is the government's rule room and make sure that we support the government's activities.

Then we have the week 6 where we talked about the CRS and projections the coordinate reference systems and projections intro we give which are very important but nowadays because the data is so dynamically you can change using GIS softwares these are very very quickly it will change, in those times we have to go to the catalogue, change it, copy paste it, etc. So, now I will just click up a button it changes.

And then you also had a hands-on tutorial of converting a print image to raster, Georeferencing an image and then once your geo reference you can extract data and information from it through extraction tools or new shape files, that was very very important because a lot of data is not available and so we had to use a scanned map down scale it into your.

So, for example a map could be this big of a table you scan it in a commercial scanner, make it as a small PDF, zoom it in and then out, zoom it in and then you put it into your GIS map because the whole world is in that, in your GIS. So, this map cannot be bigger than that, so you can put it to fit and then play with it in terms of zooming in and out and then extracting the data out.

So, that was very key it is a good trick that I have taught a lot of students because the maps have a lot of value and data however it was not digitalized there was a lot of money that was need to be spent in those days to digitalizing it but now you can do it with very very quick time and an open source software so all you need is your time, within an hour you can actually cheer up an instant image take the data out and then put it on a map which is no one will have this data, so only the paper data is there and now you have converted to digital data.

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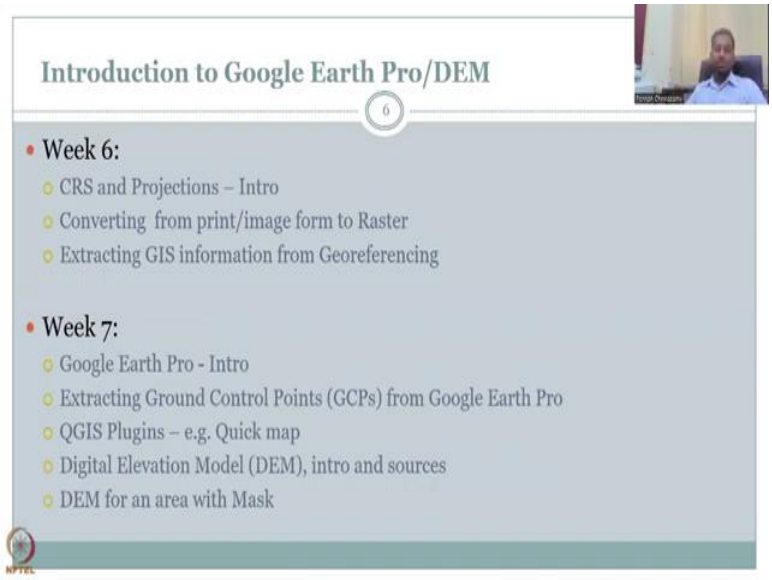

Then there is week 7, in week 7 we have the Google Earth Pro we introduced the another open source software platform dashboard where a lot of data can be stored and extracted based on your regions and also it was very handy to extract ground control points for georeferencing then we looked at the QGIS plugin called Quick map which gives you a base layer behind your maps so that you can extract more data or information.

Suppose you are making a new shapefile you wanted to make sure that there is a base map under your map to negotiate the locations and accuracies. Then we jumped into the digital elevation models which are very very important, it captures the elevation gradient across the area and we gave them an introduction to these models and then the sources and how do you extract it out using the raster data tools which is the mask.

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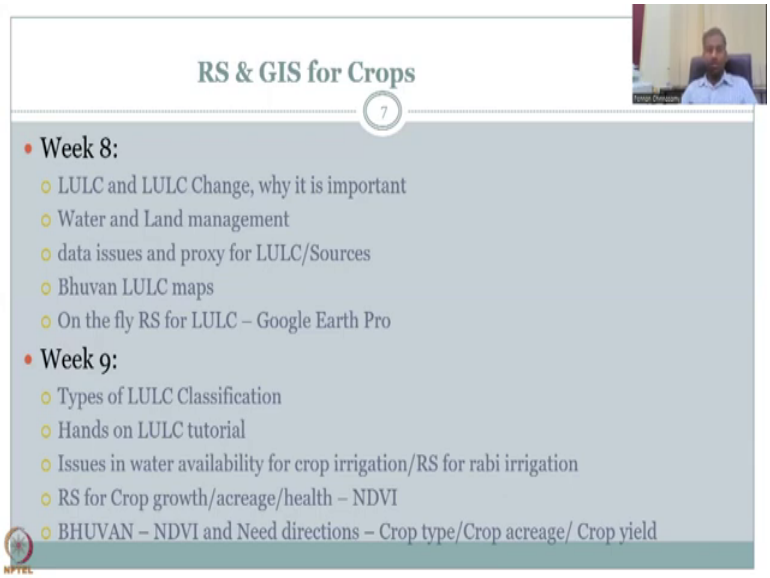

In week 8 and 9 we devoted two weeks on land use land cover change this was very important because as I said to consider and support further rural development we need to understand the resources available which starts with land, fertility, soil and water availability. Then you say okay an industry a small scale industry can come or not, a processing, decentralized processing can come or not these kind of things can be done.

For example, there is no herb medicine gardens available so we do have the folk medicines in a very very traditional medicines in a very non-traditional way, so you just hear okay these herbs can be cured but do not, we do not have a industry that is being developed all around it, there are other industries coming but we need all parts of India to be mapped because depending on the region India has rich knowledge of traditional medicine, these can be developed if you have more understanding of LULC.

Then this LULC was also contributing to the water and land management we discussed a lot of these proxy data that LULC can give to support water and land management. We also looked at multiple sources for LULC starting from BHUVAN, Google Earth Pro on the fly LULC, etc. We also discussed that there are some data issues and capacity issues across so you see outdated maps mostly and the classification is not following a particular method it is very important to use one common ideology across India and there are literature, traditional literature that talks about these land.

For example, since I was growing up in Tamil Nadu and taking a literature, in those days the land was divided as per the water and fertility available. So, for example, Kurinji means it is a land type it is a land use classification, land cover classification Kurinji which may, which

means that those land parcels the label parcel, it represents the land that is on mountains, hills and around it very very close the foothills.

So, you will see that the growing of crops was different, flowers was different there, jackfruit for example is one which only grows in those kind of altitudes and the process of livelihood options this is I am talking about thousands of years ago so these schemes were already done LULC was already done and based on the LULC the livelihood was assessed.

If you were in the desert area is called Palai, there is not much work you could do but there are some works that were done. Naval was nearly coastal regions where fisheries was important, aqua was important, aqua culture and most of fishing and then processing the fish.

Naval would be more on lands, flat land where you did cultivations, rice, millets, millets was more important so this is also another thing that we need to understand with the LULC classifications there was a lot of ideologies from the past that what did we grow now, what was grown before and why this transition has happened and how it impacts the land.

For example, we have converted from millets to rice in the past and because of that the soil fertility has changed because of that the water availability has changed, millets could use only one third or one-fourth of the water that the rice use and this is where we could save and then feed more people, millets are more nutritious and these were the traditional rural food but now we have changed is it good or bad we do not know because it is taking a toll on the water and soil industries.

Then we also looked about issues in water available for crop irrigation especially the rabi and zaid irrigation season, how do you assess these irrigation seasons we looked at using the different indicators. So, LULC also gives you options to look at NDVIs and other indicators, BHUVAN indicators we have seen and then we stopped saying that even though these are there, there is more need for crop type, crop acreage and crop yield mapping.

So, if you know the crop type then we can say okay the same colour is there from the spectral image so we can make a parcel of sugarcane, for example, and then we know the area of sugarcane that is called crop acreage, once we know the acreage, a particular yield estimate is there, let us say one ton per acre and if this one ton is not reached then there is some issues there so how can we help them, this is rural development. So, just supporting and developing more for their reliable options is very very key for rural development.

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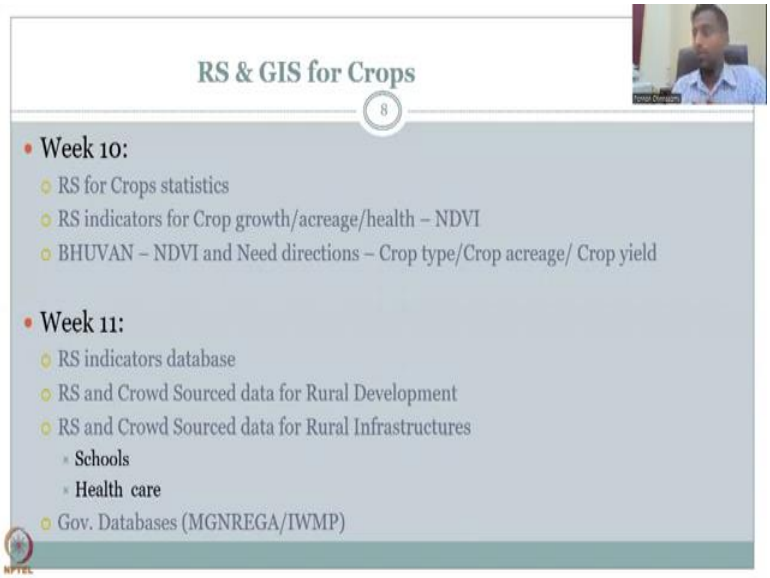

We looked at that in week 9 and then in the week 10 we looked at the crop statistics, how we can use remote sensing for crop statistics. And indicators for crop health and growth, again NDVI was key because the greenness of the plant indicates how good the crop is growing, how healthy the crop is going and based on the healthiness the yield changes, so you get that, if the health is of the plant is deteriorating the farmer has to rush to put fertilizers, pesticides or water which cost money and if the farmer is being told that do not just let it go we will pay the money that you are going to invest because your yield is not going to come that much, you do not spend thousand rupees to get 50 rupees, so that is what unfortunately happens in rural regions.

So, you would see a lot of times on the news that farmers throwing down the tomatoes for low price or letting the cattle and livestock just eat the tomatoes and flowers and vegetables. Why? Because they do not even have money to harvest it and bring it to the market when the market rate is so low and tomato is a very good example sometimes you buy tomatoes for 100 rupees, sometimes you buy for 5 rupees, look at the difference.

So, if the farmer thinks oh I am going to get 100 rupees so I am going to spend 70 rupees to harvest it, take it to the market and then right there I do some commissioning and sell it so at the end of the day I make 20 rupees profit. If this profit is there it is fine but if you are going to, if the market price is only 5 rupees because of the bumper crops then what is the point of taking this to the market and the market taking to the market is also going to be expensive, you have to pay for transportation.

So, this is what the crop growth acreage and health can help and as I said BHUVAN gives you data but still there is more data needed. And then in week 11 we said, we discussed about the RS indicators which are very important that can help, just the banks, just the satellite data may not be enough you would need more data along with the remote sensing indicators.

So, that, for that we said crowd sourcing will be a way forward and we found OSM app as a very good crowd sourcing tool which everyone should be using for working under the rural development. Not only you are downloading the data but you can also contribute so that others can be able to use it. So, in the in the exercise also we found that my own village school was not mapped, my father's school was not mapped.

So, we created the map and if you open OSM there is a map of my father's education, so which is good like now through the course we could work with students and then showcase a live example that the database is for rural schools but there is missing this school and I know that school exists because when I go to the village I see it, I see it on the map but it is not on the database.

So, we can as a crowd sourcing initiated we can also download the data and input the data, so that was looked upon and most importantly schools and healthcare because this plays vital role for rural development if students get an opportunity for higher education and education they get access to more and more development scenarios, same as healthcare we have more health care options and if their health is better, then we have better access for them and they can concentrate on rural development issues not their health issues.

So, if you are always sick you cannot concentrate on your studies, so same thing like this if the rural population is not healthy they have to be given the right opportunities for health care. And healthy as in they do not, if they are sick they should not be walking or going one day travel for different villages and stuff so they have to have access to a good quality healthcare systems.

So, then the last one we looked at is the government databases for Mgnrega and IWMP. So, Mgnrega is the 100 day scheme as I mentioned but more importantly it covers the data sets of where these structures are coming up so as I said initially it was only 100 rupees but now we have them giving data for where the locations, where are they put to you, so that the farmers and people, rural people where are they going and putting their systems in, so that is what the Mgnrega database has and how that IWMPs are done the integrated water management plans

and projects. So, the government databases we have discovered and how can we use that for indicators we covered in week 12.

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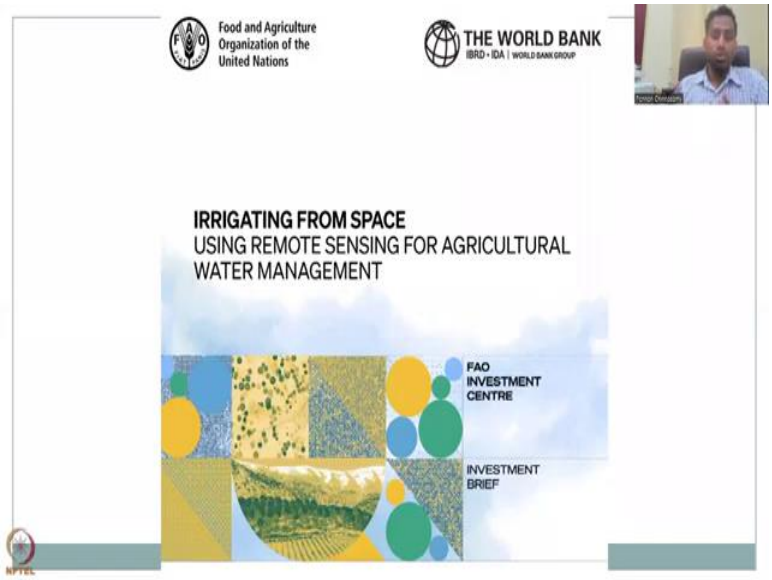

And this book was just recently reduced, released by one of my colleagues in the World Bank and he had put it on his social media so I just thought this couple of days ago, irrigation from space as correctly says using remote sensing for agriculture water management, water management is very very key for the remote sensing applications and also for rural development. So, I encourage you to go and read this book, it is free open source and it is, this is what most of the governments will follow because it has been written and published along with the FAO which is the food and agriculture organizations of the United Nations with active funding from the World Bank.

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So, we would, we are here on the last slide for this NPTEL course which as I said I enjoyed as much as you had taken it. To conclude the NPTEL course of Remote Sensing and GIS for Rural Development was discussed we started with the concept of rural development, we work backwards, so we said the topic is remote sensing and GIS for rural development but we start what is the rural development, we went into remote sensing and then GIS.

We defined and elaborated these schemes of rural development and how that works for everyone who work on the rural development scenario, what are the key players, what are the key stakeholders, who are them and where are they located and how data has been transferred. Then the key concept was analysed for rural development what do you mean by rural development and how can you access these key concepts.

So, this part was covered using studies and also government reports because we have to follow the government regulations in assessing the concepts. Then we had open source remote sensing and GIS tools discussion this was important because when you work on a system we should not be tripled is what I would use without data you cannot work. So, someone should not come to me and say I would like to work on it but there is no data, so that is the only reason that there is a lot of efficiencies lost in the rural schemes, so that is where we said open source remote sensing data and GIS can be used.

And these links were also so finding the data is also a big task. So, I think I can even go on a lecture just sitting with you and looking at how to search for data, how to collect data, it takes time, okay. But still we shared with the class what datas we had and I still remember like many times when I present even the top stakeholders like for example like academicians or government officials who say where did you get this data, I did not know this data existed.

So, this comment comes because they are not aware and also maybe I was not aware I was told by someone or I searched I was lucky I got it. So, this part is to be done and that is where I said we shared an indicator database, I shared a database with hundreds, 250 plus indicators using remote sensing and the links to where you can find the bands and the links where you can find and download the data. So, all these links were given for you to understand the concept of remote sensing and bring it together for using data.

Then the last thing we discussed was how do you synergize all this data. You have remote sensing data, you have government observation data, you have crowd sourcing data. How can you synergize them into a particular output and that was called synergize mapping which has been as I again I am saying has been trademarked but still feel free to use with a simple TM and it has been very very helpful for creating a new understanding and database across the system.

So, application of remote sensing GIS can lead to better understanding this is there to conclude and management for rural resources that can aid for rural development. So, you could see that application of RS and GIS first increases the understanding for management and the resources identifies new resources potential and this can lead for rural development.

Then we also shared across how the government is working, how the FAO is working on these things, there is a lot of books, links and I would be happy to keep on updating on our websites throughout the course and stuff, so that you could definitely get into more data. If this was a live course I would have given a project as a final exam but since there is an

NPTEL online course I would encourage you to think about these themes and most of your questions will be or all of your questions will be from the slides that we discussed, the recordings serve as notes, the slides serve as your reading materials along with the concepts and links that I have shared.

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With this I would like to conclude finally with a thank you note. I thank all the government of India sources where they give the observation data and the platforms, the dashboards without which we cannot even start thinking on these processes. So, the initiation came from the observation data and then the QGIS team for giving us this beautiful software for working on, they still keep on updating it and there is a strong community of people who work free for this software on their volunteer time.

Then we also thank the remote sensing data platforms especially ISRO, NASA, ESA because we use them a lot in this course again all of them are open source there it is supported by some governments but we are using it for our rural development which is very very good. This is how science and data should be, it should be across everyone, everyone should have access to it, data should flow like water I heard and that is a good term to say like how water flows data should also flow so that everyone gets access to it.

I also like to thank my collaborators and NGOs because they give us good understanding of the problem, good data through crowd sourcing which is now being put on the web. Then the NPTEL team from IITB and IITM for giving us the chance and supporting us throughout this work. I would like to time thank my TA especially Pranath because he has been very active in the forum discussion and answering your queries.

And my team Rudra which is standing for the rural data research analysis lab. This is the team that supports me in understanding the problems, bringing new problems and data sets that come up. So, you would have seen a lot of papers and outputs, dashboards that were discussed, all of them came from the Rudra team.

I also would like to thank the departments that I am associated with CTARA, IDPCS, CPS, CMINDS, four departments in IIT Bombay that I work across. And all the participants without you in this course would not have been possible, I would like to thank all of you for putting your time on this course and I will see you in future courses that work on development scenarios. Thank you.