Remote Sensing and GIS for Rural Development
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Week 12
Lecture 4
RS and GIS application for Rural Development- Indicators and Dashboards

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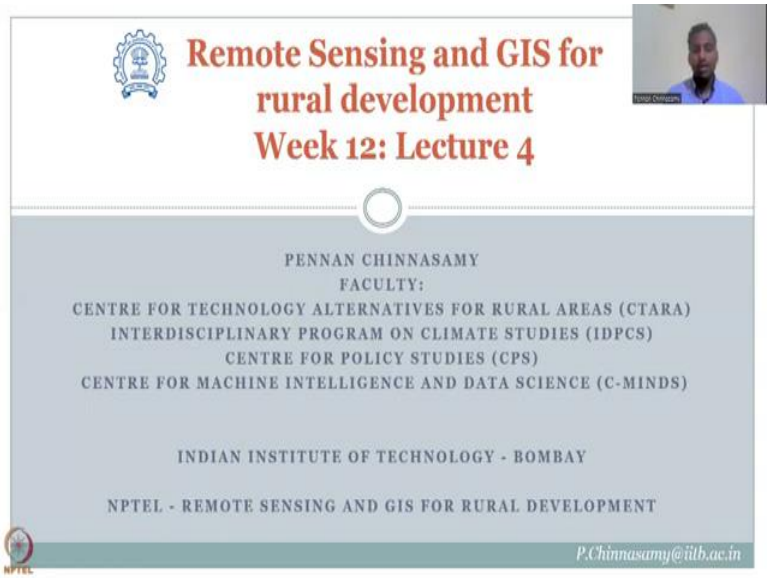

Hello everyone, welcome to the NPTEL course on Remote Sensing and GIS for Rural Development this is week 12 lecture 4. This is kind of the last application that we will showcase before we go into the summary and discuss about how the weeks are interlinked and what the future steps for this course could be. As I have always mentioned this is not just a learning of Remote Sensing and GIS but very specifically for Rural Development. And as the NPTEL reviewers requested multiple facets of rural development were discussed.

We also made sure that students who learn the concept of rural development engage with data sets that are easily available therefore open source data was shared and open source GIS platform was thought, all the exercises were done using open source software. On the same note we will be looking at the last applications for this NPTEL course which is creating indicators and dashboards.

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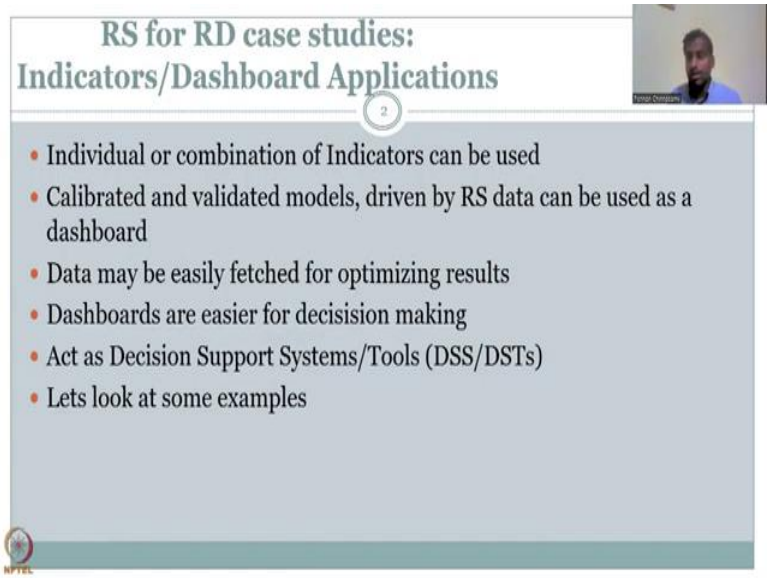

So, as all of you know that remote sensing for rural development has many case studies in terms of how we want to use remote sensing and at what spatial and temporal scale and we did discuss that multiple indicators are available, one such indicator that we went in depth was NDVI and also we looked into NDWI.

However, we have to understand that not all data sets are and indicators are readily readable by policy makers. So, unlike the other remote sensing and GIS users this is very different because we want to improve or serve the rural committees and for that we need to make sure that those decision makers and policy makers should understand these indicators.

So, the indicators can be very specific or applied, there can be one individual indicator like NDVI or a combination of indicators, we looked at this when we looked at the database for indicators. In addition these indicators can be used to drive models and can be used as a dashboard.

So, what is a dashboard? We are using dashboards without calling it dashboards in many instances, all the mobile apps you use have a inbuilt dashboard, dashboard will have multiple buttons you are allowed to select and then put in an area of request or an interest and then you see how the output is given.

We have looked at the water quality indicator and we mentioned that the model was developed using linear regressions and then calibrated and validated that is it we just gave it as an equation. So, how can an equation be helpful for a policy maker they are not going to

run these things, they need it as a visualization as a result that pops out and that is what a dashboard does.

So, in the dashboard on the behind scenes the algorithm will be there, the linear regression will be there. All the person has to do is just click on what area of interest and then boom the dashboard comes with the results. So, this is similar to the Google Earth engine Sentinel Hub that we were using wherein instead of downloading the data and doing the data for indicators all of them are already there on a dashboard you just click some buttons and then the results are populated.

While this has been a very extensive task in the past, now it is almost very easy to run these dashboards on open source systems, in the previous times you need to have a database, a server to hold the data for your dashboard and now you can just rent it up, you can just buy a portal and then you can put it for some time during your project very very cheap low cost or you can also use open source systems like Google Earth engine, OSM mapper trackers where you could just put your data there for a long time and then there is a dashboard that can be used for it.

So, let us look at the other benefits data may be easily fetched by optimizing the results so instead of looking at the generic data set you can optimize the results by using different data sets and your own data set in some instances and then put it into the mapping. Dashboards are easier for decision makings and that is why they could call as a decision support system DSS or a decision support tools DSTs and these are very important because as I said the policy makers may not be learning all these techniques and what remote sensing is but definitely they will know what on the ground it means.

So, by clicking different buttons and figures you will be able to get that support through the dashboard. Let us take a look at some examples, especially the ones from my team now because I do know as I said the constraints and why it evolved and we will discuss.

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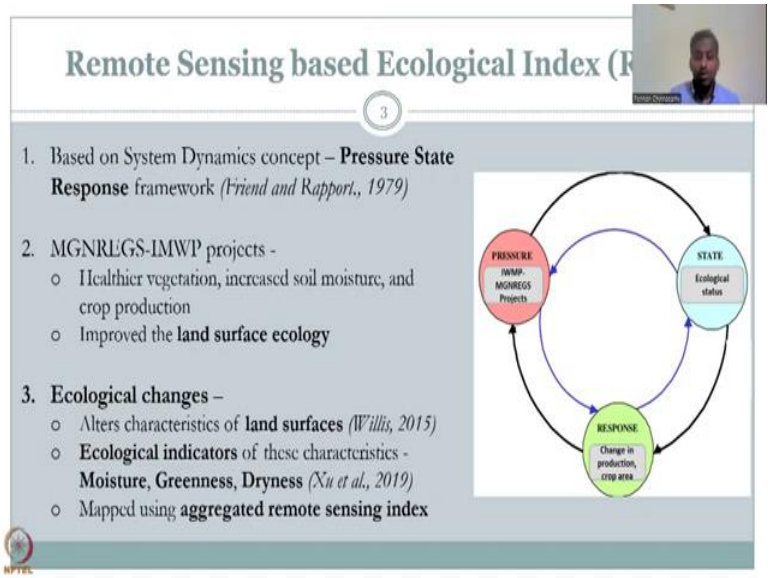

One important indicator that we developed is the remote sensing based ecological index, it was based on the framework for system dynamics concept of pressure state response framework we will show you what it means. So, when you have a pressure and this was done to evaluate or support the IWMP Mgnrega projects. So, in the Mgnrega there is a scheme where the farmers are kept without migration for 100 days by some nominal wage, so minimum wage is given so that the farmers do not migrate to urban centers.

So, slowly what has happened is that time of the farmer has been used for IWMP programs. What is IWMP? Integrated water management programs and plans. So, these plans and programs are now being used for increasing water storage, soil moisture, etc. But what is the benefit? So, that is the pressure and the state you see the arrow mark going the black arrow mark, the state is the ecological status, we wanted to see how that impacts the ecological status.

This was a work done by one of my students Shivanand through his master's project and you could see that how the system dynamics approach was used and different key indicators and players are going to come out. So, the response is yes the pressure is the Manrega projects and then it is, it has some impact we do not know what but it has some impact on ecological status.

Normally it is a positive impact because we are letting people work for the nature rather than against the nature so the response could be change in production, crop area, soil moisture, etc, etc. And then that can also come back as a pressure on the system, a pressure is positive and negative also and we wanted to see how that keeps the cycle going on and on and on.

So, this framework was used for a Mgnrega IMWP projects to showcase better healthier vegetation, increased soil moisture and crop production through the better use of Mgnrega. So, if this is correct then all the states can adopt Mgnrega for better management practices rather than just paying them and not following up on their time, so this can actually create ownership for the program and also make them work for the nature.

So, this creates an improved land surface ecology, ecology is the living organisms at the land surface and mostly it constitutes the soil living organisms and also the plants. Ecological changes can be looked at as alters characteristics of land surfaces because if the ecological is good or activity is good it can impact positively the land surface as per Willis. And then these are theories so we can use pretty old ones.

And then we have the ecological indicators of these characteristics include moisture, greenness and dryness by Xu. So, these indicators are moisture, greenness and dryness but how you establish these indicators is also key for which we will be using remote sensing data. Mapped using aggregated remote sensing index as I said we will be using these index in the following part.

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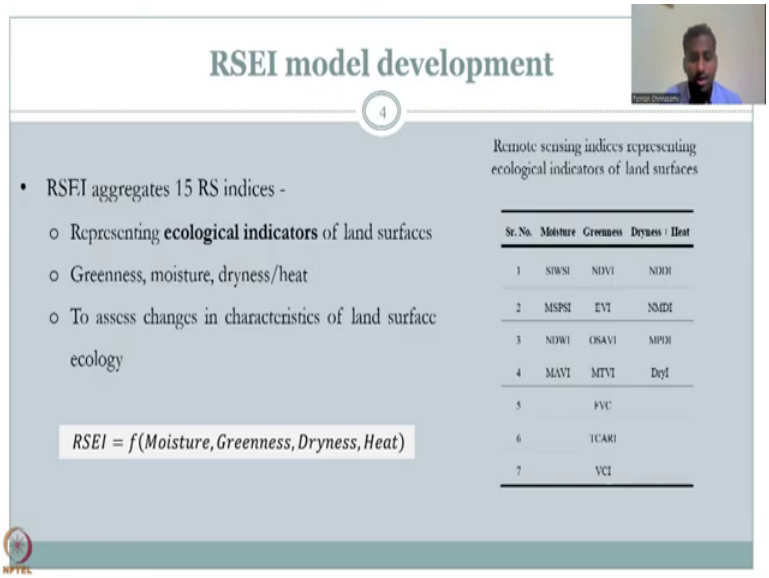

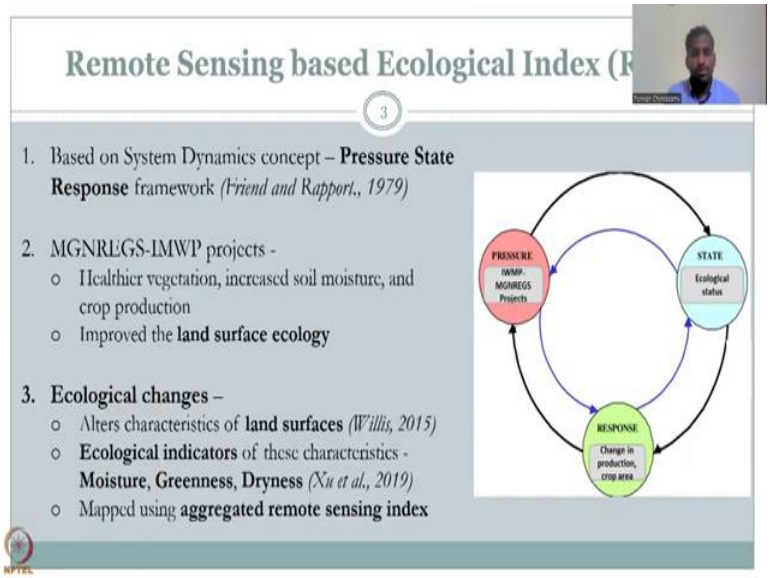

So, let us discuss how the RSEI model was developed. So, RSEI stands for remote sensing based ecological index. So, remote sensing is the key and the ecological index is done for a rural setting so that is where the rural part comes back into picture, yeah. So, what happens is RSEI aggregates 15 remote sensing indices so the first the literature view was done to analyse how many very sensitive parts are there for this model and it was found out that there are at most 15 remote sensing indices and that the RSEI is a function of moisture, greenness and dryness and heat so this was as found by the previous paper.

So, while this is a function how do you account for moisture? So, moisture we knew that in the previous exercise we did NDWI so same way we could do NDWI for the moisture, for greenness we can have the NDVI and dryness and heat could be coming from climate indicators. So, on that note there could be 15 remote sensing indices representing ecological indicators of land surface, so all of this can be put as a function to create the RSEI and then again the greenness, moisture, dryness, heat to assess changes in characteristics of the land.

So, this is very important and there are multiple multiple indicators so based on these functions of themes, moisture, greenness, dryness, we have multiple indicators and these are the 15 indicators that were selected from literature view as ISWI, MPSI, NDWI, MAVI, so this NDWI we have already done then we have NDVI, EVI, the vegetation index OSAVI, MTVI, FVC, TCARI, VCI. And then we have the dryness plus heat together as one theme because both of them could be functions of temperature, such as NDVI and DryI.

But the issue here is what we did extra modelling effort is all indicators may not have equal weightages, so if you see this equation here, if you see this equation here you have a function and the function says it is a moisture, a function of moisture, greenness and dryness and heat

however we do know that moisture and greenness and dryness heat may not have the same impact on RSEI so there should be some variable in front, a parameter, a normalizing function coefficient we will say in front of moisture to show that it is weight more or less depending on the area and the issue.

So, on this note we were looking at multiple multiple schemes and looking at multiple indicators then using the PACA approach which is the principal component analysis so to be honest you can start with more indicators you do not need 50 you can have 30, 25 etc you can just put a number and then for your particular area of interest you can run what is the most valuable or sensitive indicator and that indicator will be having a higher weightage.

So, for example my moisture, all my moisture indicators are having high weightage accept SI WSI, so then you can put SI WSI as weighted 0.1 where the others are one one one so you see how the value of SI WSI will go down if you put it in the same function, so that is what putting weightages will do for your data set.

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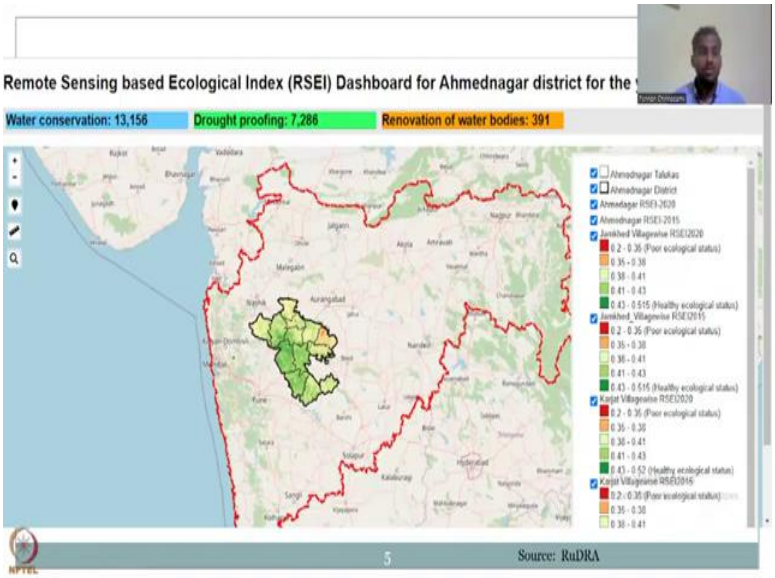

And then what will happen is we will be looking at the database of how many water conservation activities were going on, drought proofing activities and the denervation of water bodies, these are all the Mgnrega work, ultra IWMP, so there are lot of work going on but we do not know how it is impactful.

So, there is a dashboard that we created under the Rudra lab where we could see that these are multiple indicators that can be helpful for looking at the impact on the work done through Mgnrega and NI WMP.

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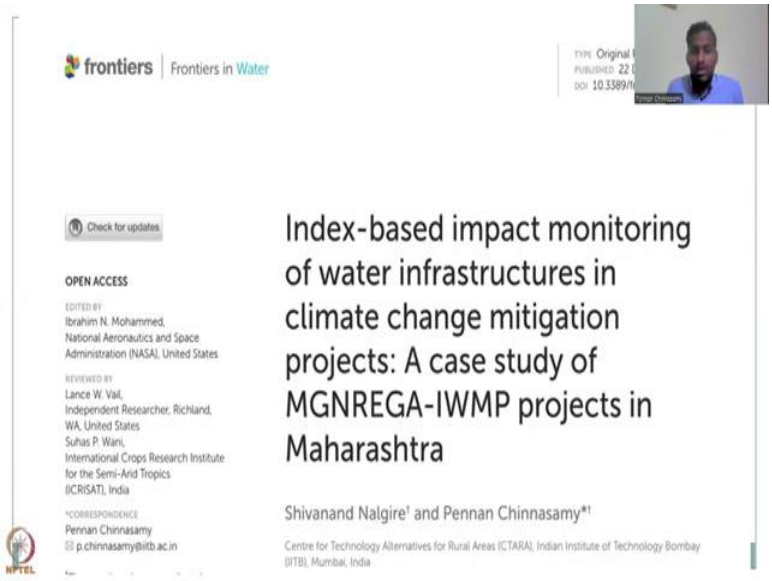

So, this has been published as a page paper as index based impact monitoring of water infrastructures in climate change mitigation projects, a case study of Mgnrega IWMI projects in Maharashtra. So, we have selected Maharashtra because while the student was working in Maharashtra we were able to get a lot of data that is very important for this project.

So, just not getting data from remote sensing is key we also needed to get and evaluate these schemes, so these schemes are present but we have to make sure that they actually were done properly or if it is just a number of let us say 7286 we need to be careful if that actually has some potential on the ground. So, as I said this paper was published in Frontiers in water. And let us look at the methodology.

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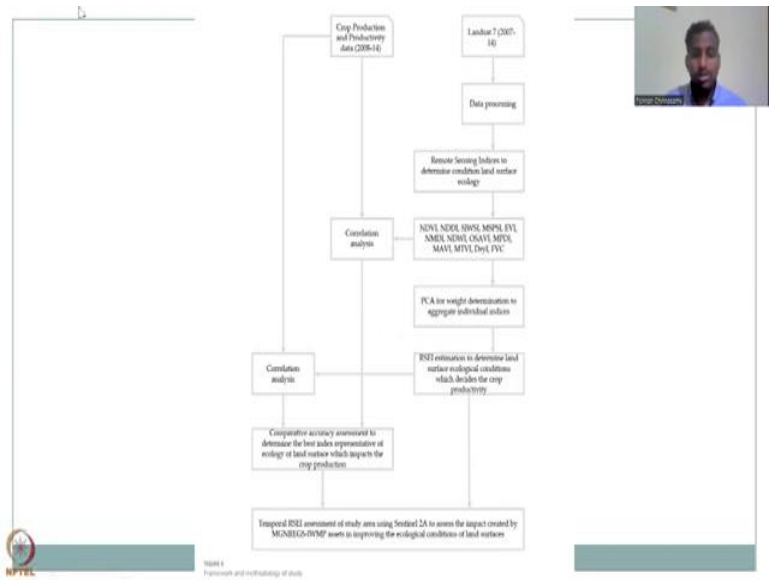

So, the methodology says that first we wanted to look at the satellite data let us look at the left side first which is the crop production and productivity data as I said we wanted to see if the Mgnrega projects had an impact on the crop productivity. Why? Because the crop productivity is kind of a measure of the ecological status only when this soil and the micronutrients, the organisms are healthy there will be a healthy crop production, so it is kind of working backwards up and you will see if we have multiple themes for this in terms of finding which route is better to attain crop production.

So, we assume that Mgnrega work will definitely impact the crop production and on that hypothesis this methodology has been done. So, we have to collect the crop production and productivity data from 2008 to 14. So, for example in my Dahod paper that I showcased we did not have that data for there because the farmers as I said are very very small scale farming they did not document all these things.

But here in Maharashtra it is a very progressive area where a lot of agriculture is going on so they always have good data and more importantly it could be the sugar cane which is very very important for the state of Maharashtra and the yield that they get. So, looking at this so first they did the crop productivity data and then they do some correlation analysis to find some relationship with the satellite data but before that we need to look at how do you get the satellite data, so Landsat 7 was used because that has the data range from 2007 to 2014 time frame and then some data pre-processing and post processing was done, remote sensing indices were then extracted out to support the ecological status assessments.

And all the 15 indicators are there, so all the 15 are driven by the Landsat data because there is multiple bands and the bands are enough to take this data out. So, that is what the data we would be taking at. And then we had the PCA, as I said the PCA part comes up where we had the weightage for each determinants and indicators separately assessed.

For example, if you can, if you can model the crop productivity by using 7 indicators not 15 indicators why would you use 15? So, that is one of the other reasons we wanted to use PCA so that to see that if it, if five indicators are very powerful and then three are very less powerful than we can negotiate the weightages and or neglect the weightages and then put zero, so which means it cancels out, so C 0 is also weightage.

So, that PCA exercise was done then the RSI estimation was done to determine land surface ecological conductions which decides the crop productivity, which improves the crop productivity or impacts the current productivity and then goes to correlation analysis so you

get the left side which is just the crop data productivity from 2008 to 2014 whereas the Landsat data one year before we always take for pre conditions so we have 2007 to 2014.

Remember that the crop productivity depends on the previous year's land. So, for example 2008 crop productive is taken that should depend on 2007 status of water land surface ecological status, etc. So, that is what was taken and then quickly all these were analysed for correlations and then compared to accuracy assessment to determine the best indexer presentative of the ecological of land surface which impacts the crop production.

So, as I said mgnrega, through mgnrega there is lot of activity done and the activity can impact crop production so we took the crop production data then we established the indicators for mgnrega work, take the indicators and put weightages on the indicators and only those with high weightages were used.

So, at the end of the day what would happen is you have a temporal RSEI assessment or the study area with using Sentinel 2. Why would Sentinel 2? Now, we know that which bands are needed for the indicators and now we know also that it has some correlation with the crop productivity. So, after 2014 it is smart to use the new data set with the same wavelengths or bands, so the number of the band would differ because Sentinel 2A has high spatial resolution and temporal resolution, a Landsat was at 30 meters 16 days whereas Sentinel is at 10 meters 6 days so we have better spatial temporal resolutions.

And also it has multiple bands which are sometimes higher than Landsat depends on what you measure so in that case it is better to use the same algorithm for a particular study site and then use the updated satellite source, but to assess the impact Sentinel 2A was used migrated, the assets that are created during the MGNREGA, IWMP, etc so the assets were already showcased in this part.

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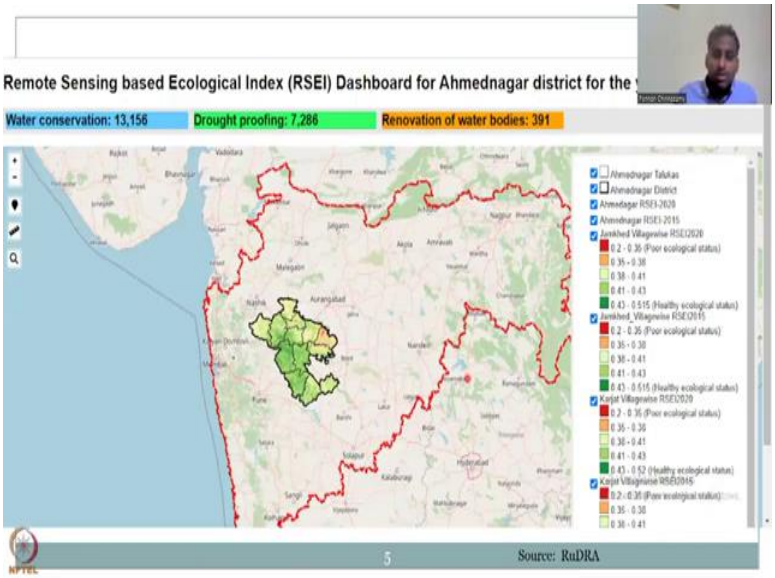

So, on the top we have the water conservation assets, drought proofing assets and then Rejuvenation of water bodies this kind of your tanks and then nalas, canals, etc.

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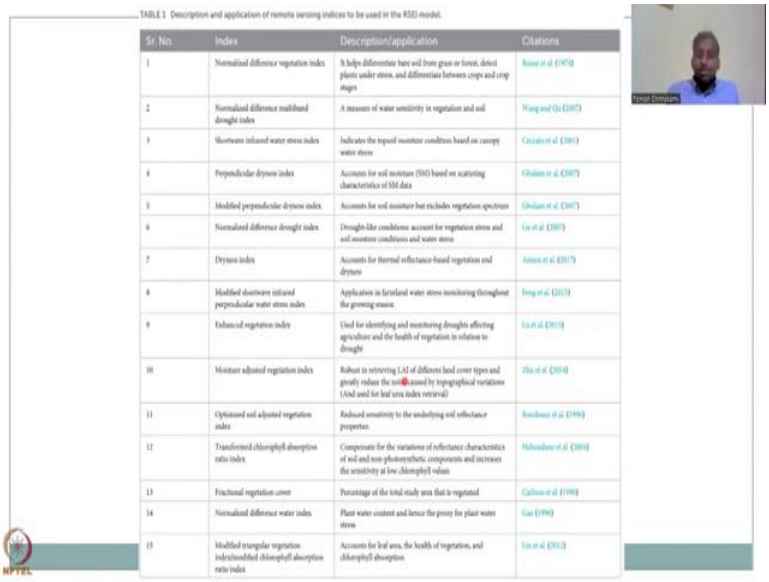

This gives you all the indicators like a database we always have and then some papers that have used it or devised these indicators are on the right side so what this index is used you can definitely look into it.

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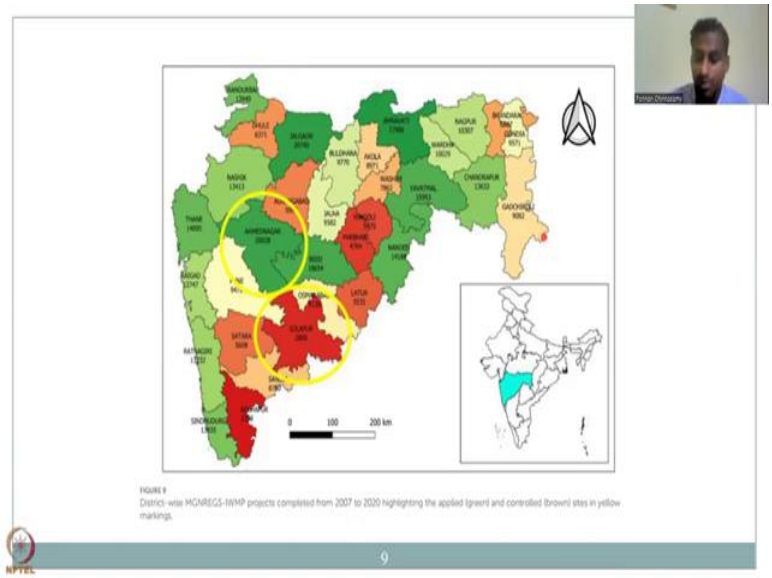

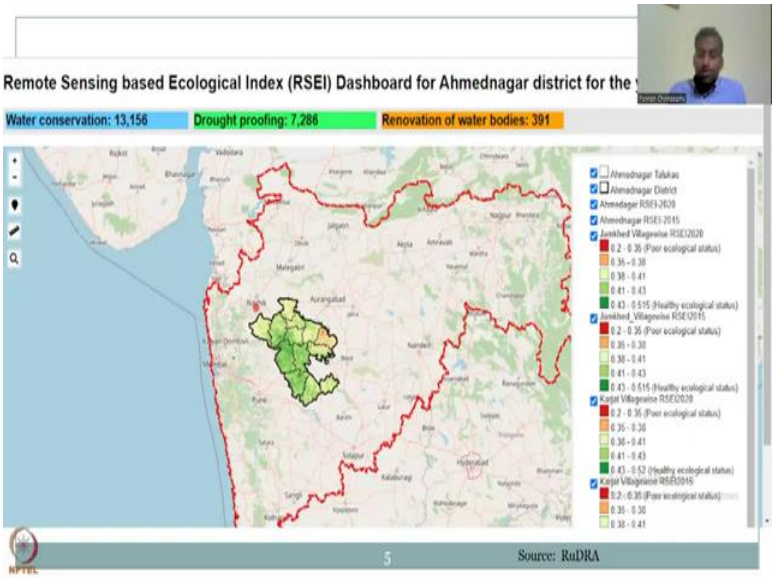

And the RSEI was done for the entire state of Maharashtra. So, before that the number you see under the district is the number of IWMP schemes or projects that were completed from 2007 to 2020 and then now the it is compared to RSEI so if the RSEI is higher you could see that highlighting upright green and controlled on brown sides and yellow markings if you see the RSEI is pretty high then it is green in color because ecological status is improving whereas brown color indicates a very low RSEI.

So, what you could see here is Ahmednagar and Solapur are very very similar in geological and environmental conditions which is very important to have you cannot take two study areas very different it has to have some commonality or most commonality, so the rainfall, temperature, the slope, the gradient all are same between Ahmednagar and Solapur.

However, there has been more IWMP projects in Ahmednagar so look at it, it is almost 10 times, Solapur has 2800 schemes projects running whereas Ahmednagar has 20028 projects running completed etc, etc. So, even while running the project or establishing the project there is a considerable improvement in the ecological status for example you are building a check dam, a series of check dams or a cascade dam so you will build one by one however while you build one the impact is still coming through the picture, that is what I mean.

So, the higher color the green color indicates a higher RSEI whereas the brown indicates a lower RSEI and you could see that that beautifully correlates to the number of schemes that are present and that is almost similar stories for across. However, we have to make sure that the geology ecological conditions are the same otherwise you are comparing apples and oranges, you need to compare apples and apples so that is what we have done here otherwise for example I could have compared Ahmednagar to Bhandara or Gondia or even Gadchiroli which are in different colors, not green in RSEI.

Why did we do this? Because we want, we cannot have this control there because rainfall is the same in here whereas the rainfall is much drier may be on this side and that cannot be a ethical comparison it has to be same, the area, the product. So, when you do remote sensing please make sure that you cannot show that oh one area is getting more rainfall and then the crops are going well whereas the other areas are getting less rainfall and crops growing well, and that could be because the soil condition is good, the groundwater potential is good, all those things.

So, please make sure that both these two areas that you compare are of the same nature and as here it is the same nature the only thing different is the IWMP numbers it could be because of the budgets that were located, the population of farmers or other externalities because Mgnrega money is directly linked to the number of farms.

So, we have established a fact that this RSEI can be used as a tool for establishing the benefits of Mgnrega and these dashboard that Shiva created could always get updated easily on the open source mapping dashboard software, so this is an open source dashboard, he does not have to pay for it all he just do is we map kind of thing where you on my map you put all these values in and you keep updating and then the data set gets updated on the map, there is no payment however there is only a particular storage you can use it is like a Gmail where you can use a particular storage after which you have to pay.

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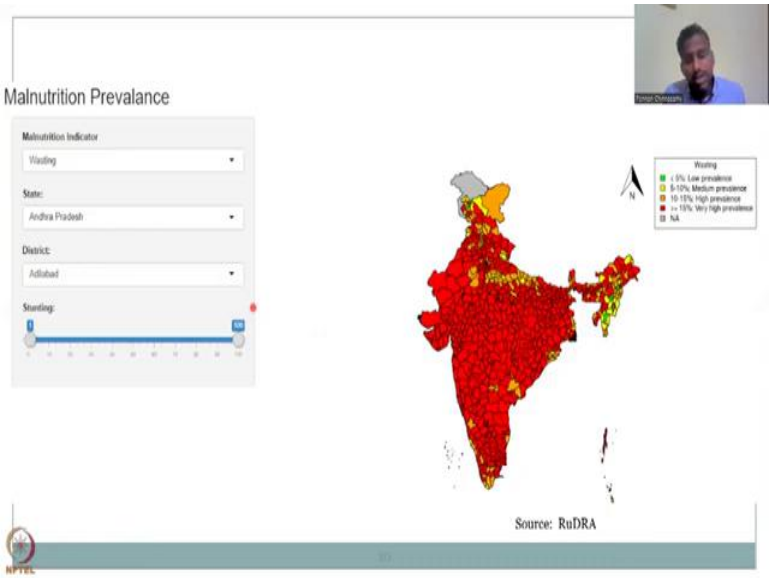

Let us go to another dashboard that another student had created through the GIS and work. So, this was looking at malnutrition indicators in rural India especially the different blocks and what you could see that if you put it as numbers and tables it does not look that great but if you put it as a image with blocks colored differently based on the way the percentage let us say here wasting is very high as red and then and 10 to 15 percent is high prevalence 5 to 10 percent is medium and then less than 5 percent is good which is green.

I will not get into the malnutrition indicators of wasting, stunting and then anaemic but we will just look at why this could happen so here you could see malnutrition indicators wasting and stunting and stunting could be your, for your particular age there is a growth chart you are not growing well and then there is also you are underweight so there is another indicator which is underweight.

And these all have some causalities we do not know what causalities but when you make a map and you see these clusters coming out then that is an indicator of some problem there for example there is some problem in this side and then there is some problem here on the coastal regions and in the southern tip of India of Kerala and so these indicators can be used definitely however as I said dashboards can be used, this was done in R programming again it is very simple to use, you cannot make very high commercials yet with open source, why because you do need a big storage space.

With the available storage space in your Google drive you can connect it to R programming R dashboards and then you can do it. So, see how beautifully a data set has been plotted your GIS map is there but then it is static whereas your dash board is dynamic you can see that

there is a slider if you move the slider then you have a difference of combination of malnutrition and stunting in the state Andhra Pradesh state district Adilabad and that can actually create better understanding of the data.

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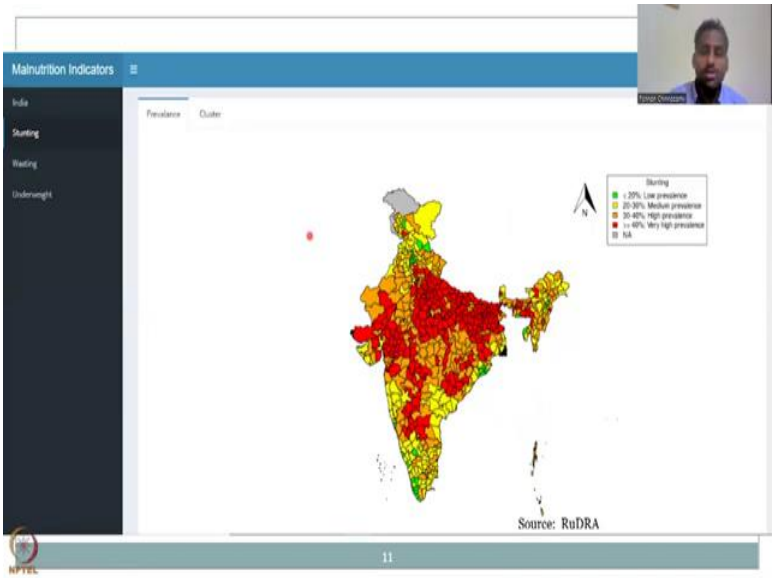

Also another map has been done for, so these are the three indicators is stunting, wasting and underweight and you could see that you have another map for stunting so the stunting map need not be the same for the wasting, you can see stunting is more prevalent along the Ganges basin very very strange with such a fertile land why there is stunting maybe there is a particular scheme that the government should work on to improve the stunting issues in that part of India.

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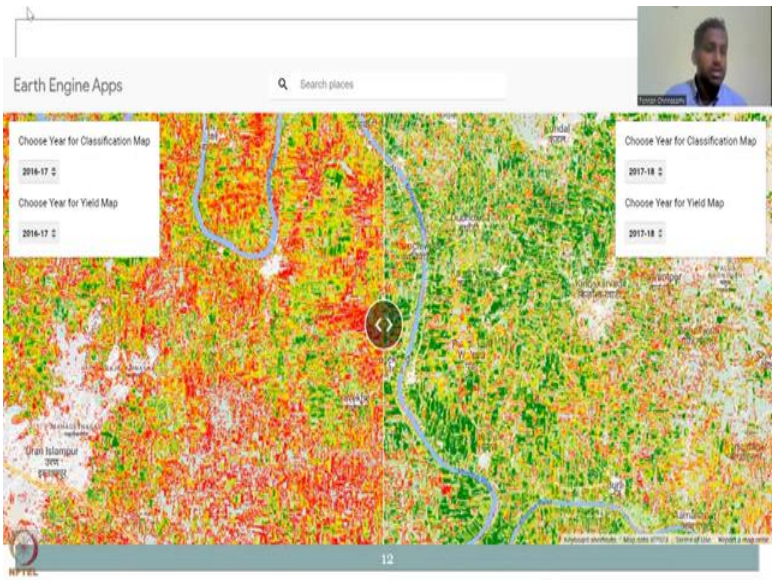

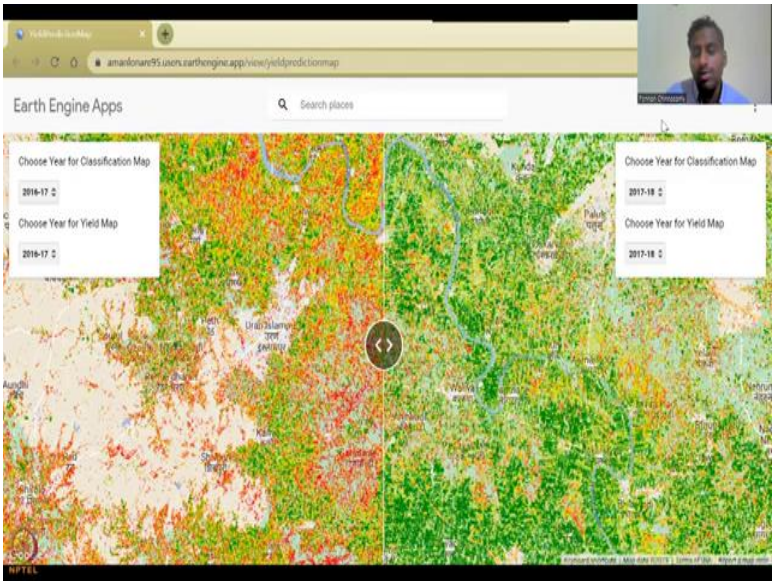
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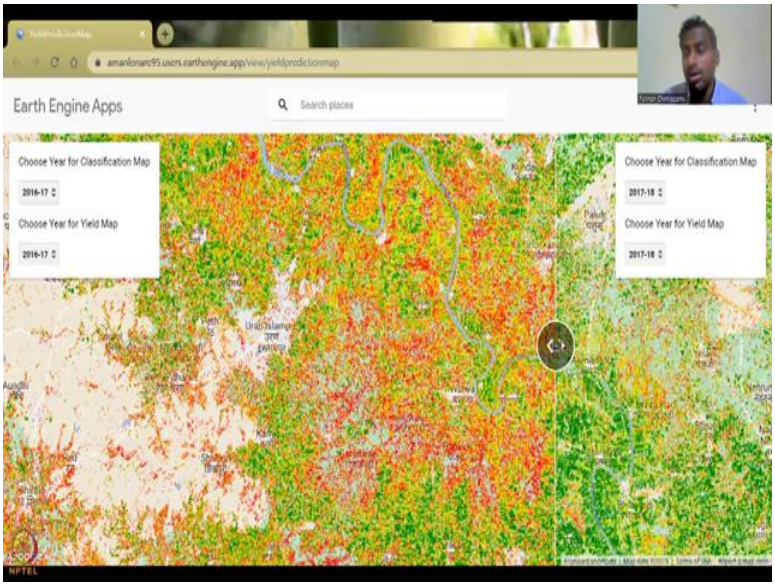
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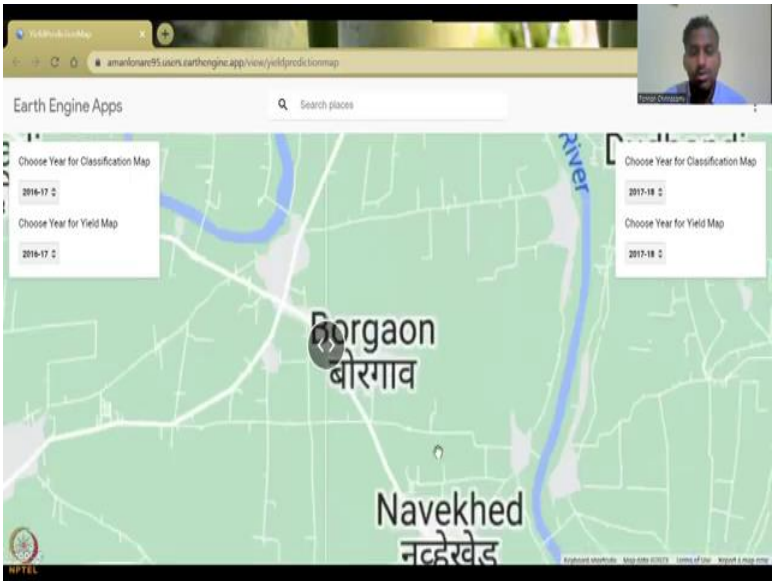
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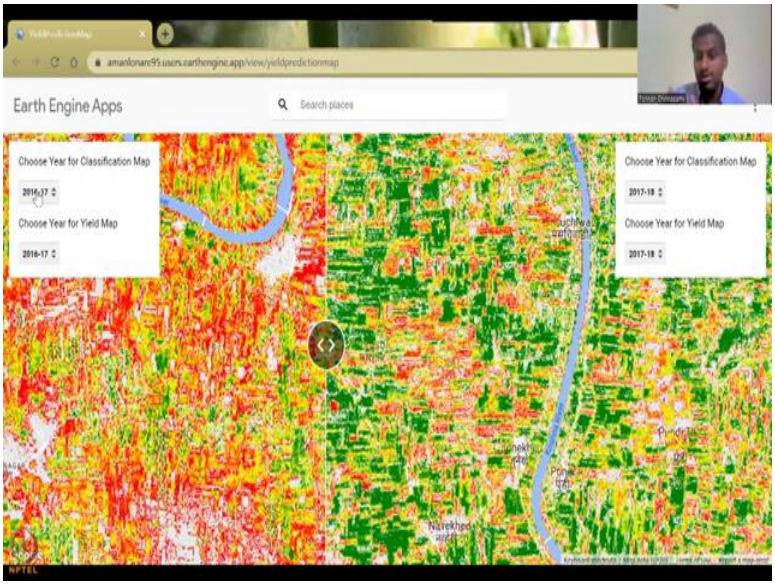
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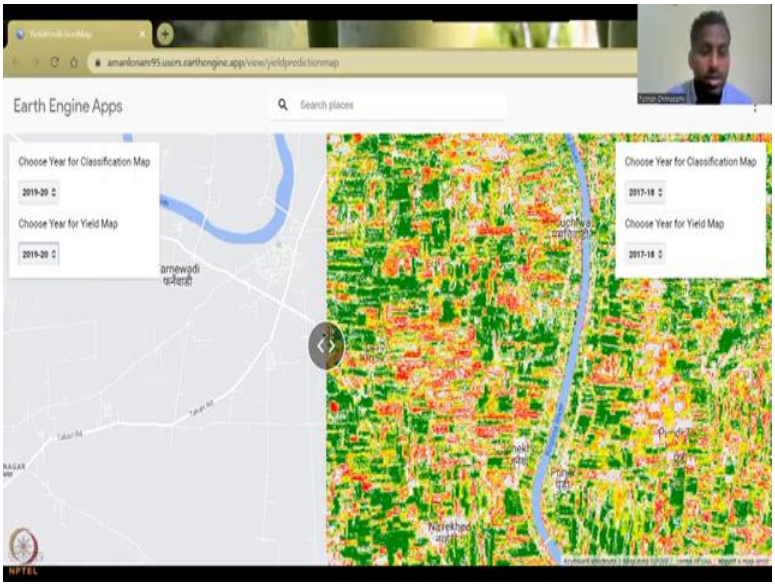
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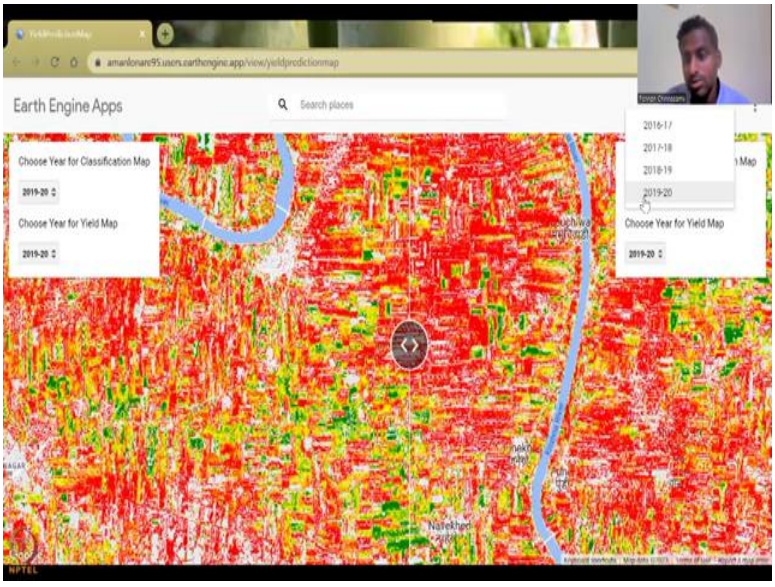
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Choose Year for Yield Map
2019-20

To complete I will show the land use land cover classification done by another student we have already discussed this how different AIML packages were used for classifying the land into sugarcane, grapes and other aspects but I did not stop him there I asked also him to make a dashboard so that the policy maker can quickly look at it.

So, when you give a land use land cover map it is just a paper map or a report or an image on your email but it does not, it does not help you to fully look into some options or comparison, comparisons and maybe this is not done for the Sentinel hub for this area so it is better always to have one for yourself and that is what this student had done to look into the area of one yield predicting.

So, I have opened this it is as I said it is in a Google Earth engine apps you can have an account there and then see how the data works. So, what you, what the student has done is on this side you have the year for classification which is 2016 and then the yield. So, we want to see the classification and how much yield comes because if you have grapes 10 acres and 10 acres of sugar cane they need not give the same yield every year because the acreage is different, how much yield comes is different, the yield depends on the on many factors climate change, water, labour, correct time, labour pesticides, fertilizers, disease attacks all these are there.

So, that is why we did both so for your classification map we wanted to see your yield map and then the previous the years the upcoming year from the 2016-17 was 2017-18 we have that. So, you can see that how this map readily captures it so on the left the 2016-17 map shows clearly that it is not growing well the yield is still less and or the cropping pattern has changed, it is not the same.

So, you can zoom in to Borgaon, I will just give it a minute to so this is running behind in real time because all the data was downloaded in this Google Earth engine or given links for example if you want this to be run on Sentinel 2A data then you just write a code on the dashboard and then link it to it so that it pulls the data from Sentinel and then maps it, so you cannot go too much out because this data was done for the Maharashtra region so we can just focus on the Maharashtra region Sangli to look at it.

So, you can also change so what is the dashboard this is what the dashboard does you can change the years as I said he went in 2019-20 so we have that here you can just choose the one part I am just going to show you so let us say 2019-20 and then 2019-20. We can search multiple paths in the same map or just one part so that you can look at the difference.

So, now I just put just for your sake all of them the same so that you could see that both the left and right are actually the same maps and there is no change much so it is pulling the data from a database it is not made because if you just make it then these two will now crash because if you put the same date.

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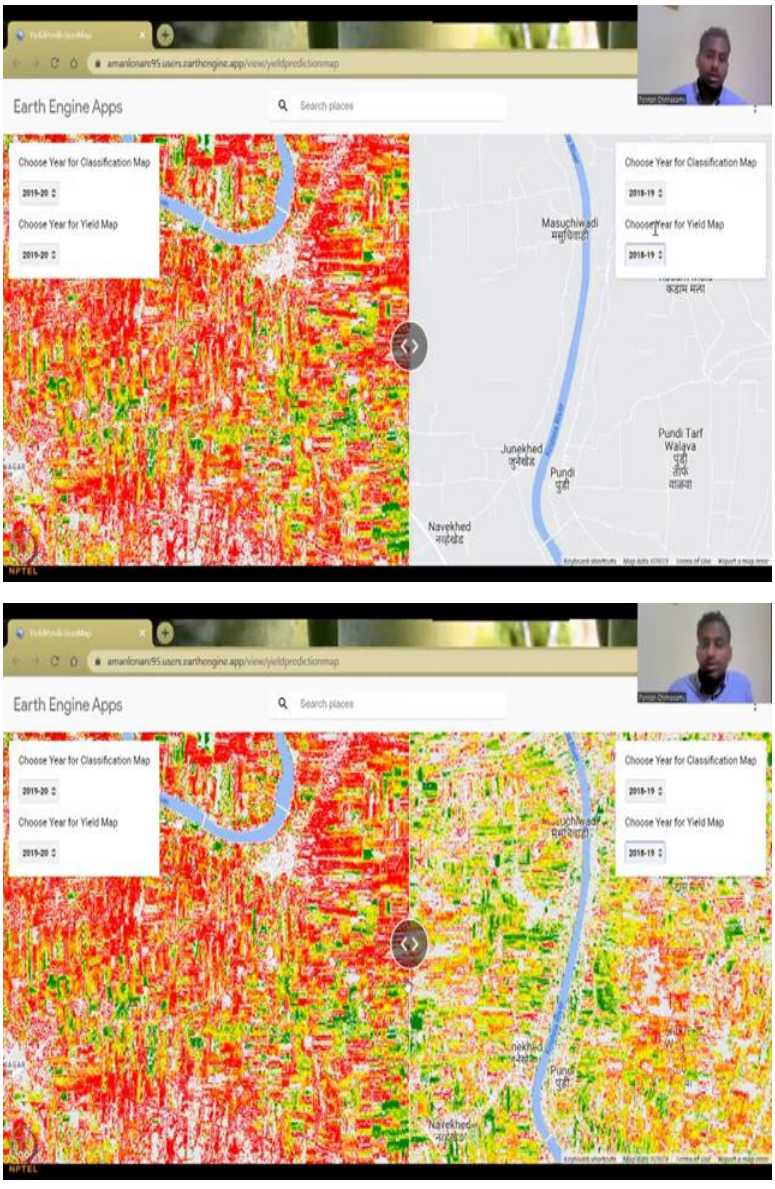
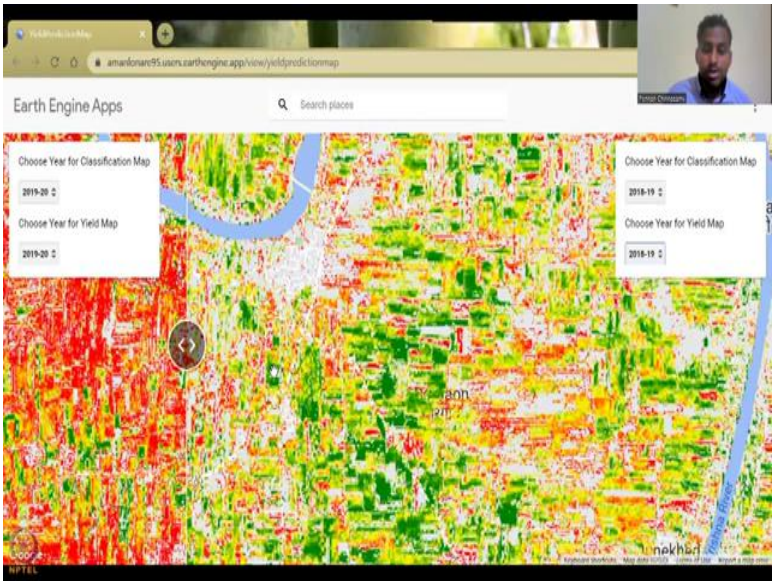
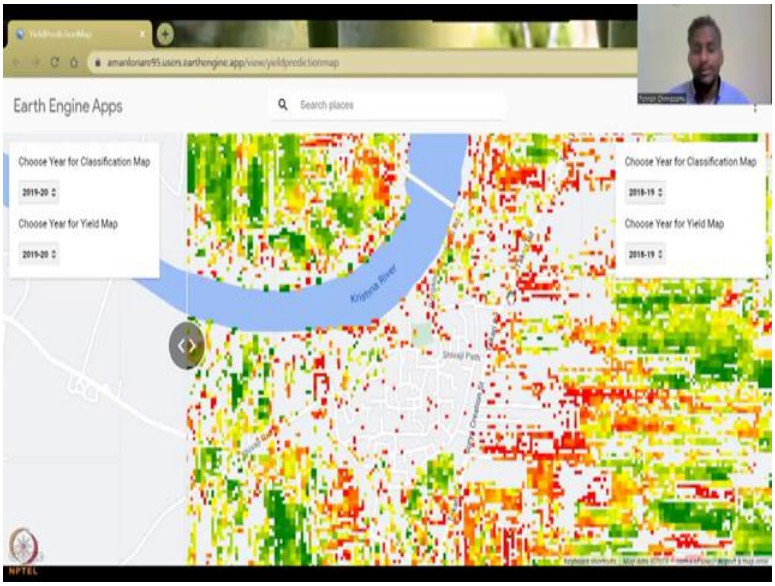
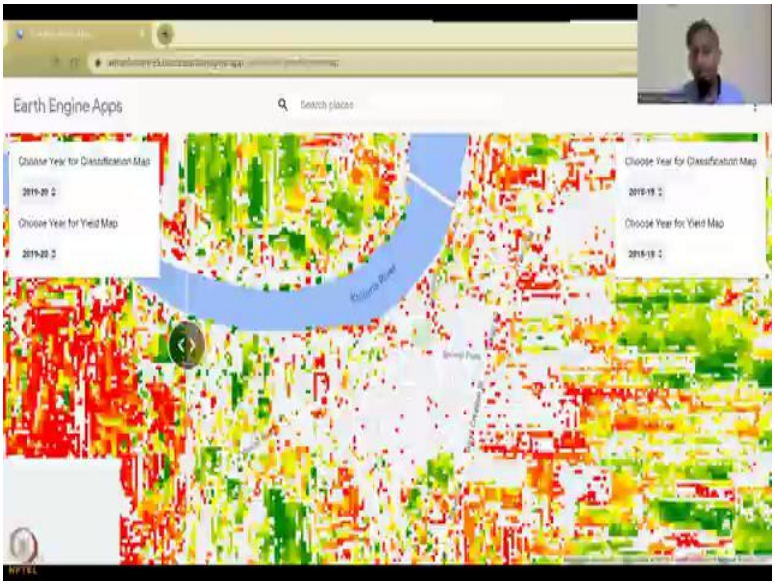



Earth Engine Apps
Search places
Choose Year for Classification Map
2019-20
Choose Year for Yield Map
2019-20
Choose Year for Classification Map
2018-19
Choose Year for Yield Map
2018-19
NPTEL


Earth Engine Apps
Search places
Choose Year for Classification Map
2019-20
Choose Year for Yield Map
2019-20
Choose Year for Classification Map
2018-19
Choose Year for Yield Map
2018-19
Krishna River
NPTEL


Earth Engine Apps
Search places
Choose Year for Yield Map
2019-20
Choose Year for Yield Map
2018-19
NPTEL

So, we can put the previous year just make sure that both are the same and then the yield and the classification is done, so more on this the paper has been shared and we can definitely look at these models more in detail and upgrade them so these papers were done in Cambridge a lot of professors were working on it so I said okay this is very good and you should collect data so he went to the field collected the data on the spectral signatures and then he ran the codes for the spectral signatures which classified the land but he did not stop there as I said I asked him to do a dashboard and now this can be showcased to multiple people to see if this is worthwhile the time or to make a decision.

So, for example, now you can say that oh along the river there has been good benchmarking so that it is not fully populated along the rivers, there is some space and different crops are growing, the white land and reflects the urbanization and then the crops are green and red depending on the crop type and yield. So, let us get back to our presentation where we have most time to complete.

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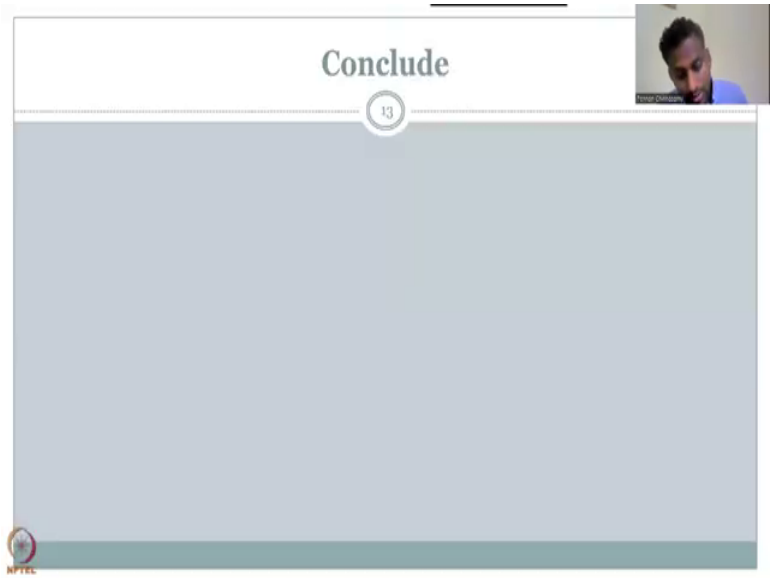

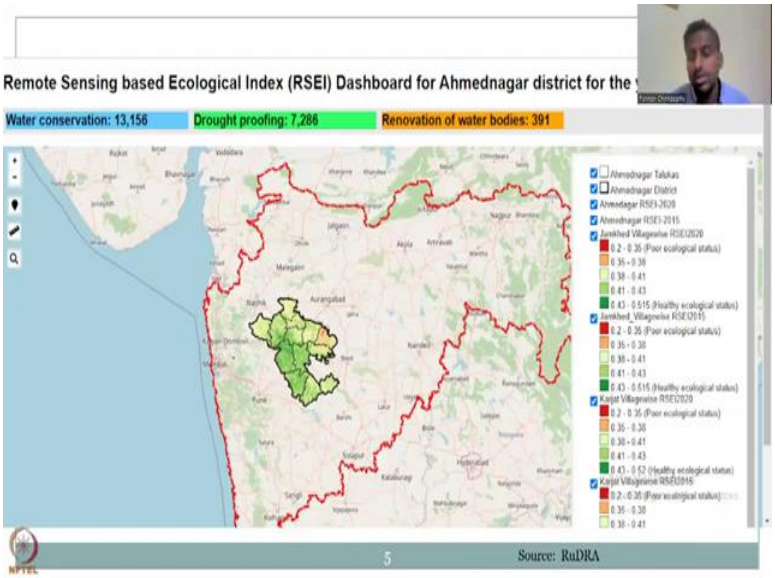

So, with this I would like to conclude today's lecture on the fourth lecture on using of indicators and dashboards now you could see that initially just the bands are not enough you should convert them to indicators and then also that we should we saw that indicators are not enough it has to be in a dashboard so that readily you can visualize what are the issues in these districts village wise and then look very specifically for precise management practices.

This is similar to precision agriculture or precision surgery if I need to operate here in those days they will cut the entire thing and then go in and operate but now precision is there you just apply medicine here you just apply surgery if needed otherwise you can just put medicine inside there in a capsule.

So, these kind of things are coming up in big time and that is where dashboards also fall in the same place. With this I will stop today's lecture I will see you in the next lecture which is the final lecture for this NPTEL course. Thank you.