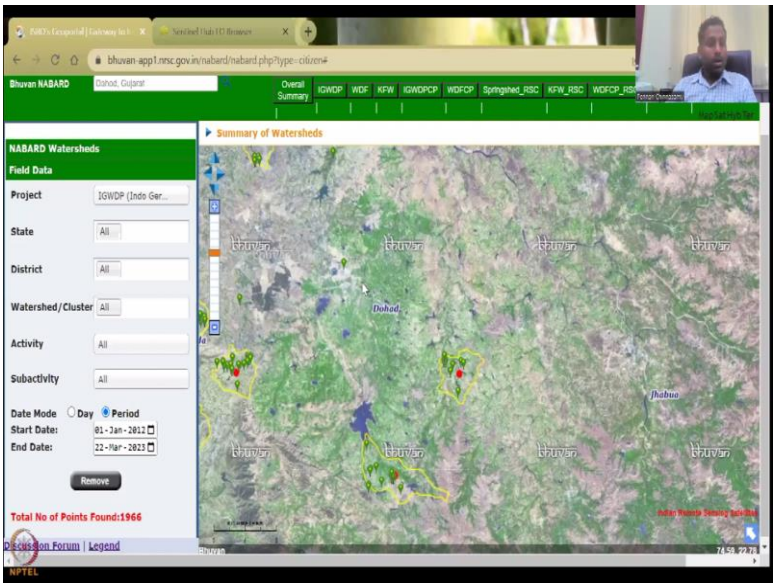
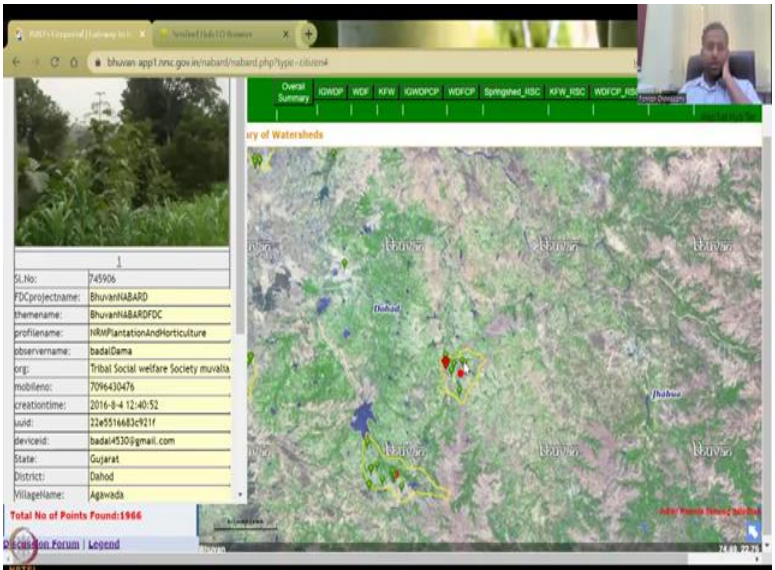
Remote Sensing and GIS for Rural Development
Professor Pennan Chinnasamy
Department of
Indian Institute of Technology, Bombay
Lecture Number 57
RS and GIS application for Rural Development: Monitoring & Evaluation using NDVI & NDWI

Hello everyone. Welcome to the NPTEL course on Remote Sensing and GIS for Rural Development. This is Week 12 Lecture 2. In this week we have been looking at the applications of remote sensing in GIS through case studies and live applications through dashboard and other data sources. In the last lecture we looked upon the NABARD Bhuvan collaboration dashboard where we looked at the locations of structures.

So, I will just showcase some more details that I have extracted just by going around with the software and website.

(Refer Slide Time: 01:01)

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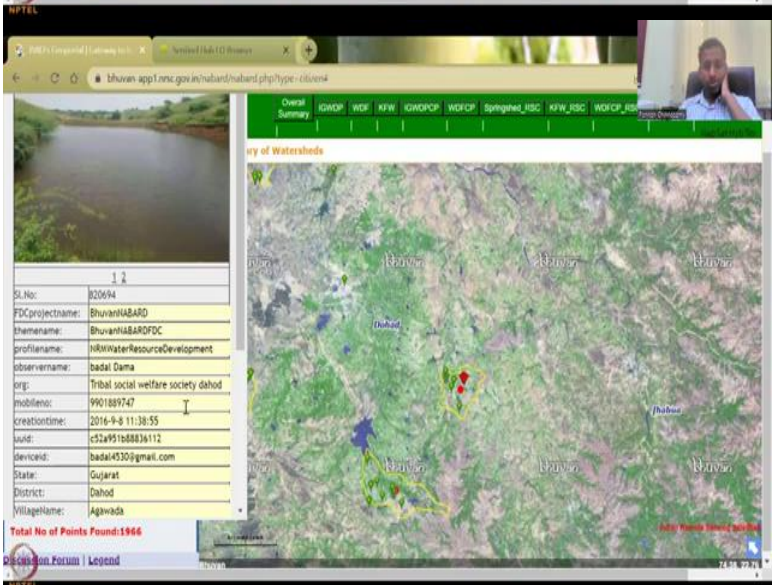
Overall Summary
IGWDP
WDF
KFW
IGWDPCP
WDFCP
Springshed_IISC
KFW_IISC
WDFCP_IISC
1
SL.No: 745906
FDCprojectname: BhuvanNABARD
themename: BhuvanNABARDFDC
profilename: NRMPlantationAndHorticulture
observername: badalDama
org: Tribal Social welfare Society muvalia
mobileno: 7096430476
creationtime: 2016-8-4 12:40:52
uuid: 22e5516683c921f
deviceid: badal4530@gmail.com
State: Gujarat
District: Dahod
VillageName: Agawada
Total No of Points Found:1966
Discussion Forum | Legend
NPTEL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Overall Summary
IGWDP
WDF
KFW
IGWDPCP
WDFCP
Springshed_IISC
KFW_IISC
WDFCP_IISC
1 2
SL.No: 820694
FDCprojectname: BhuvanNABARD
themename: BhuvanNABARDFDC
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observername: badal Dama
org: Tribal social welfare society dahod
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District: Dahod
VillageName: Agawada
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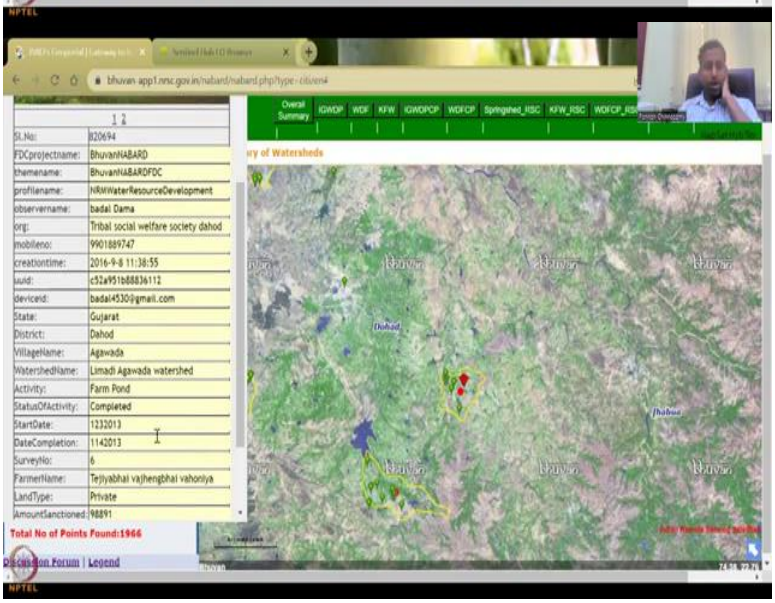
Discussion Forum | Legend
NPTEL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IGWDP
WDF
KFW
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1 2
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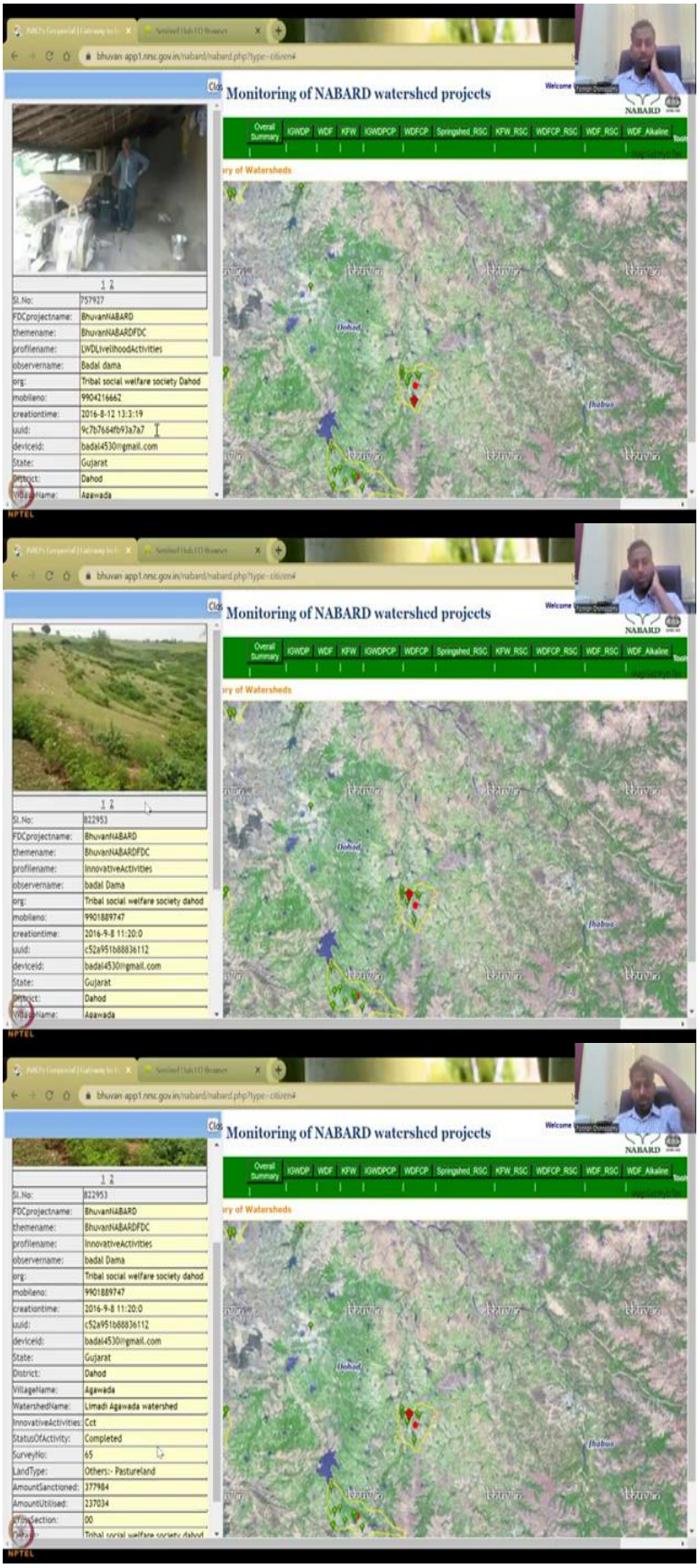
mobileno: 9901889747
creationtime: 2016-9-8 11:38:55
uuid: c52a951b88836112
deviceid: badal4530@gmail.com
State: Gujarat
District: Dahod
VillageName: Agawada
WatershedName: Limadi Agawada watershed
Activity: Farm Pond
StatusOfActivity: Completed
StartDate: 1232013
DateCompletion: 1142013
SurveyNo: 6
FarmerName: Tejiyabhai vajhengbhai vahoniya
LandType: Private
AmountSanctioned: 98891
Total No of Points Found:1966
Discussion Forum | Legend
NPTEL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Monitoring of NABARD watershed projects
NABARD
Overall Summary
IGWDP
WDF
KFW
IGWDPCP
WDFCP
Springshed_RSC
KFW_RSC
WDFCP_RSC
WDF_RSC
WDF_Akaline
ry of Watersheds
1 2
Sl.No: 757927
FDCprojectname: BhuvanNABARD
themename: BhuvanNABARDFDC
profilename: LWDLivelihoodActivities
observername: Badal dama
org: Tribal social welfare society Dahod
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State: Gujarat
District: Dahod
VillageName: Agawada
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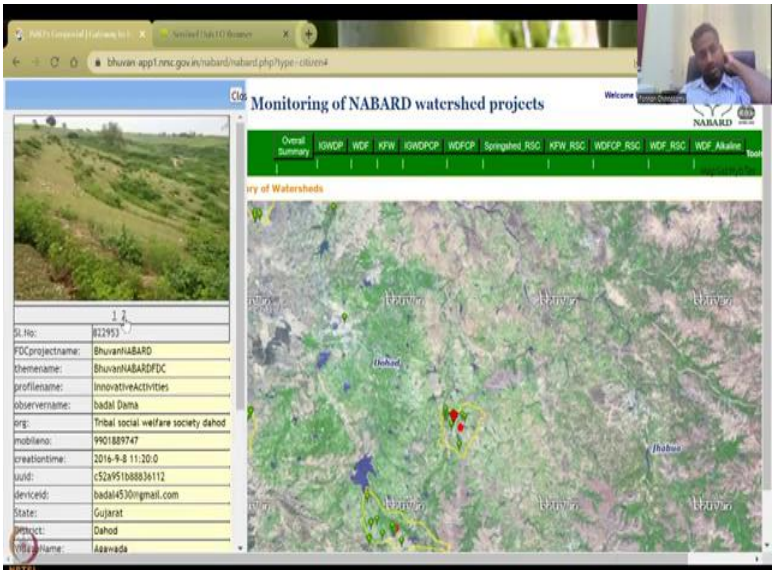
FDCprojectname: BhuvanNABARD
themename: BhuvanNABARDFDC
profilename: InnovativeActivities
observername: badal Dama
org: Tribal social welfare society dahod
mobileno: 9901889747
creationtime: 2016-9-8 11:20:0
uuid: c52a951b88836112
deviceid: badal4530@gmail.com
State: Gujarat
District: Dahod
VillageName: Agawada
WatershedName: Limadi Agawada watershed
InnovativeActivities: Cct
StatusOfActivity: Completed
SurveyNo: 65
LandType: Others:- Pastureland
AmountSanctioned: 377984
AmountUtilised: 237034
SubSection: 00
NPTEL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Monitoring of NABARD watershed projects
NABARD
Overall Summary
IGWDP
WDF
KFW
IGWDPCP
WDFCP
Springshed_RSC
KFW_RSC
WDFCP_RSC
WDF_RSC
WDF_Alkaline
SI.No: 822953
FDCprojectname: BhuvanNABARD
themename: BhuvanNABARDFDC
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observername: badal Dama
org: Tribal social welfare society dahod
mobileno: 9901889747
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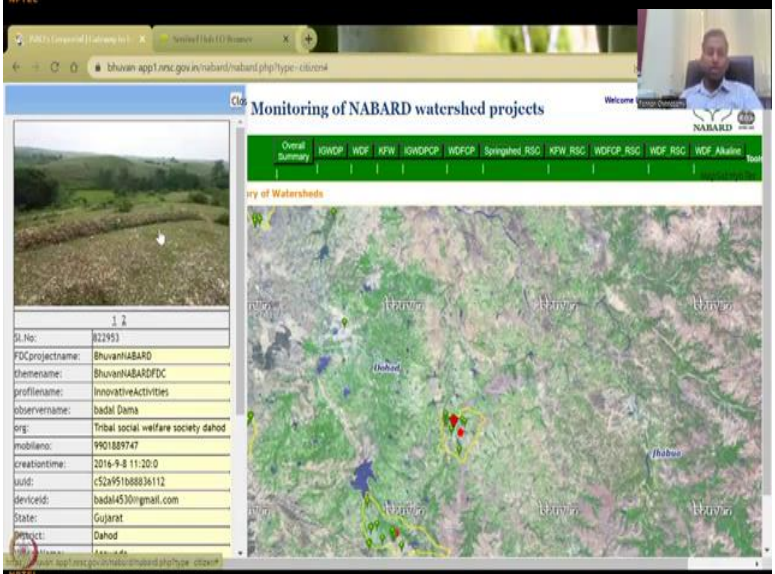
District: Dahod
Village Name: Agarwada
NPTEL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Monitoring of NABARD watershed projects
NABARD
Overall Summary
IGWDP
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WDFCP
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WDF_Alkaline
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District: Dahod
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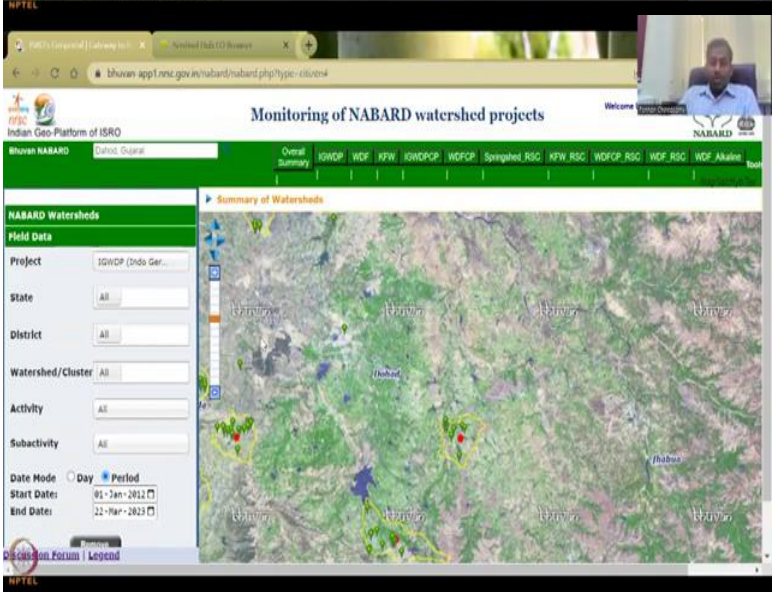
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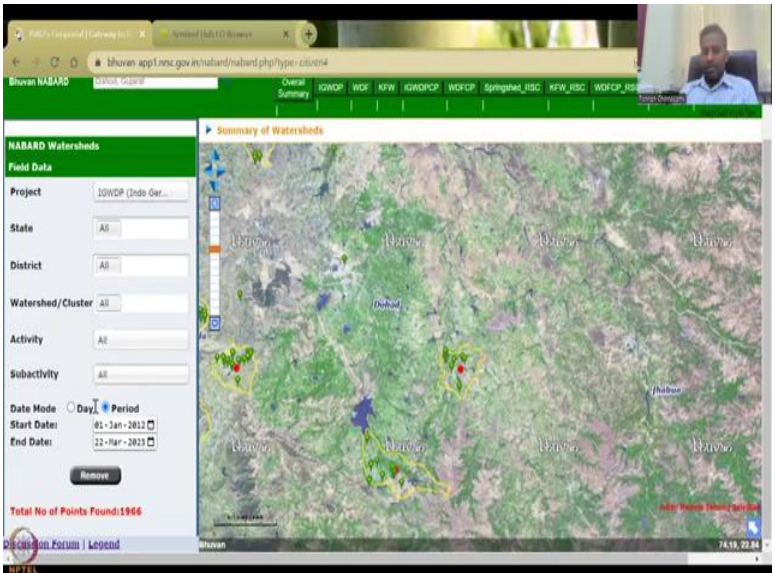
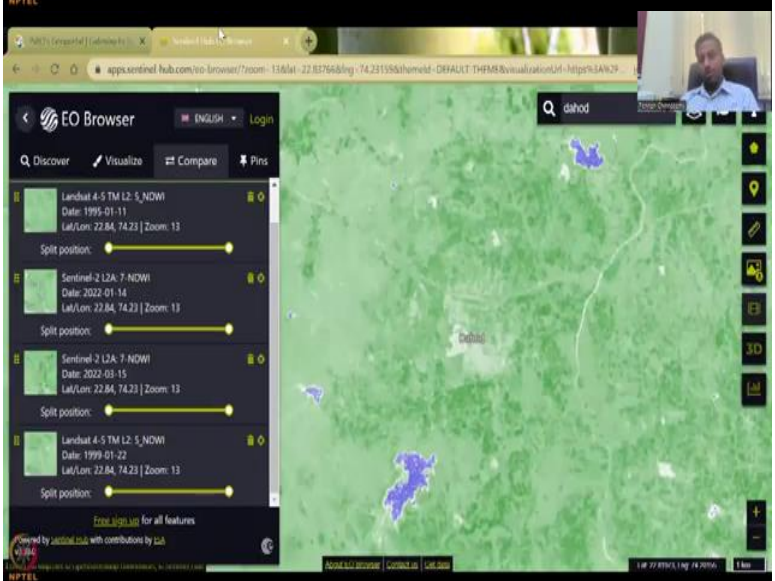
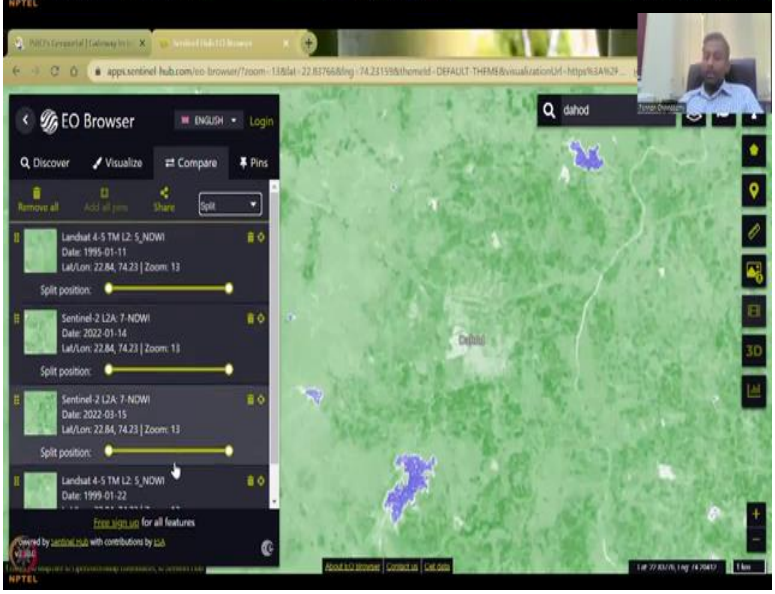
Monitoring of NABARD watershed projects
Indian Geo-Platform of ISRO
Bhuvan NABARD
Dahod, Gujarat
NABARD
Overall Summary
IGWDP
WDF
KFW
IGWDPCP
WDFCP
Springshed_RSC
KFW_RSC
WDFCP_RSC
WDF_RSC
WDF_Alkaline
Summary of Watersheds
NABARD Watersheds
Field Data
Project
IGWDP (Indo Ger...
State
All
District
All
Watershed/Cluster
All
Activity
All
Subactivity
All
Date Mode
Day
Period
Start Date:
01-Jan-2012
End Date:
22-Mar-2023
Discussion Forum | Legend
NPTEL


Bhuvan NABARD
NABARD Watersheds
Field Data
Project
State
District
Watershed/Cluster
Activity
Subactivity
Date Mode
Start Date:
End Date:
Remove
Total No of Points Found:1966
Summary of Watersheds
Discussion Forum | Legend


EO Browser
Discover
Visualize
Compare
Pins
dahod
Free sign up for all features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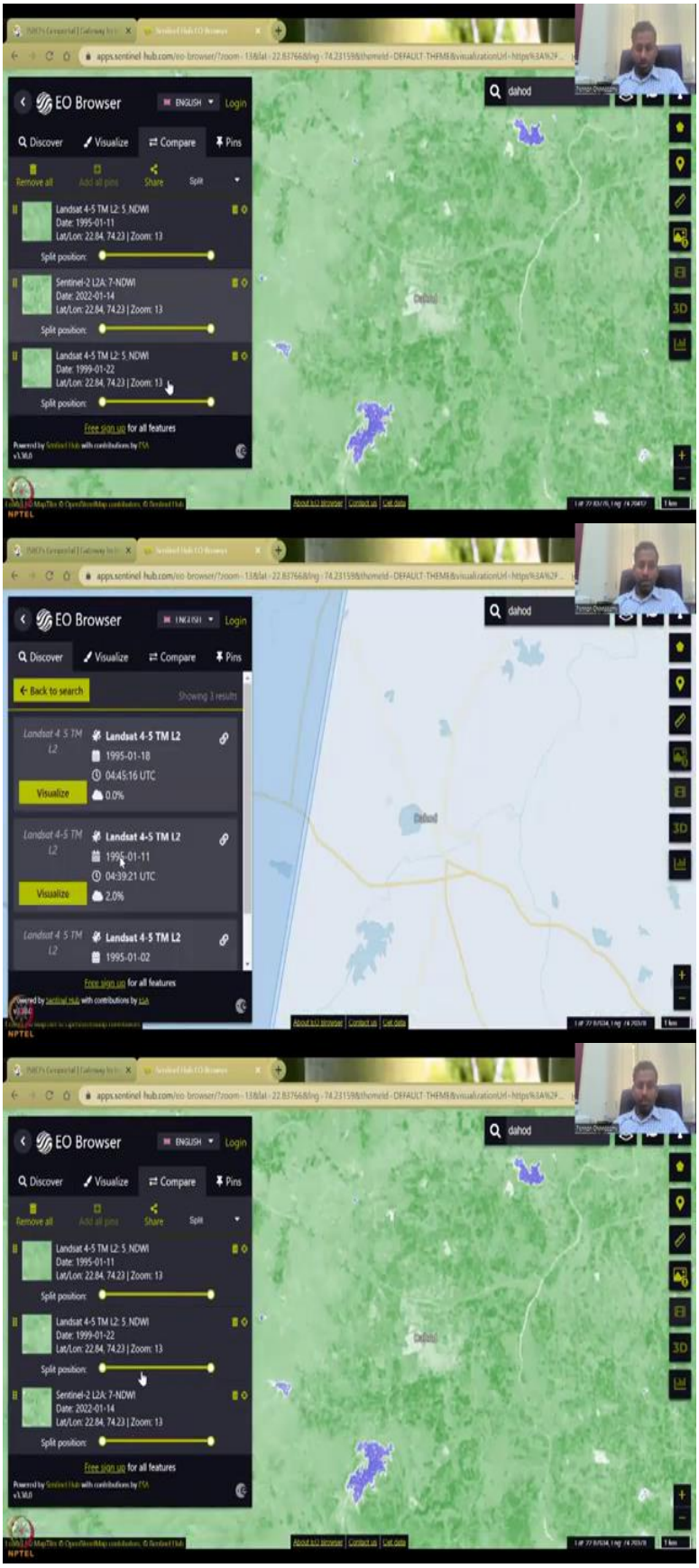
EO Browser
ENGLISH
Login
Discover
Visualize
Compare
Pins
Remove all
Add all pins
Share
Split
Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
Date: 2022-01-14
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5_NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
dahod
Dahod
3D
NPTEL

EO Browser
Login
Discover
Visualize
Compare
Pins
Back to search
Showing 3 results
Landsat 4-5 TM L2
1995-01-18
04:45:16 UTC
Visualize
0.0%
Landsat 4-5 TM L2
1995-01-11
04:39:21 UTC
Visualize
2.0%
Landsat 4-5 TM L2
1995-01-02
Free sign up for all features
dahod
Dahod
3D
NPTEL

EO Browser
ENGLISH
Login
Discover
Visualize
Compare
Pins
Remove all
Add all pins
Share
Split
Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5_NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
Date: 2022-01-14
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
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Dahod
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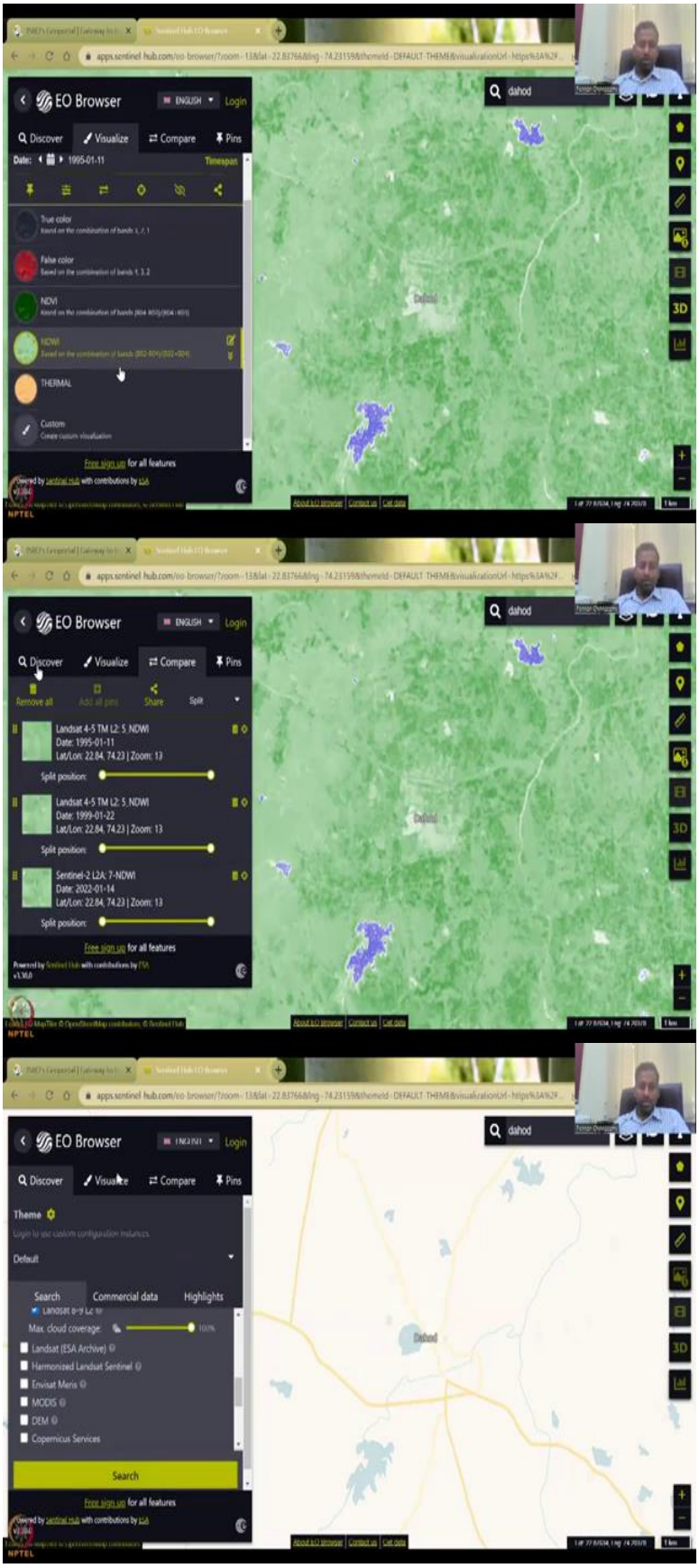
NPTEL


EO Browser
ENGLISH
Login
Discover
Visualize
Compare
Pins
Date: 1995-01-11
Timespan
True color
False color
NDVI
NDWI
THERMAL
Custom
Free sign up for all features
dahod
3D
EO Browser
ENGLISH
Login
Discover
Visualize
Compare
Pins
Remove all
Add all pins
Share
Split
Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5_NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
Date: 2022-01-14
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
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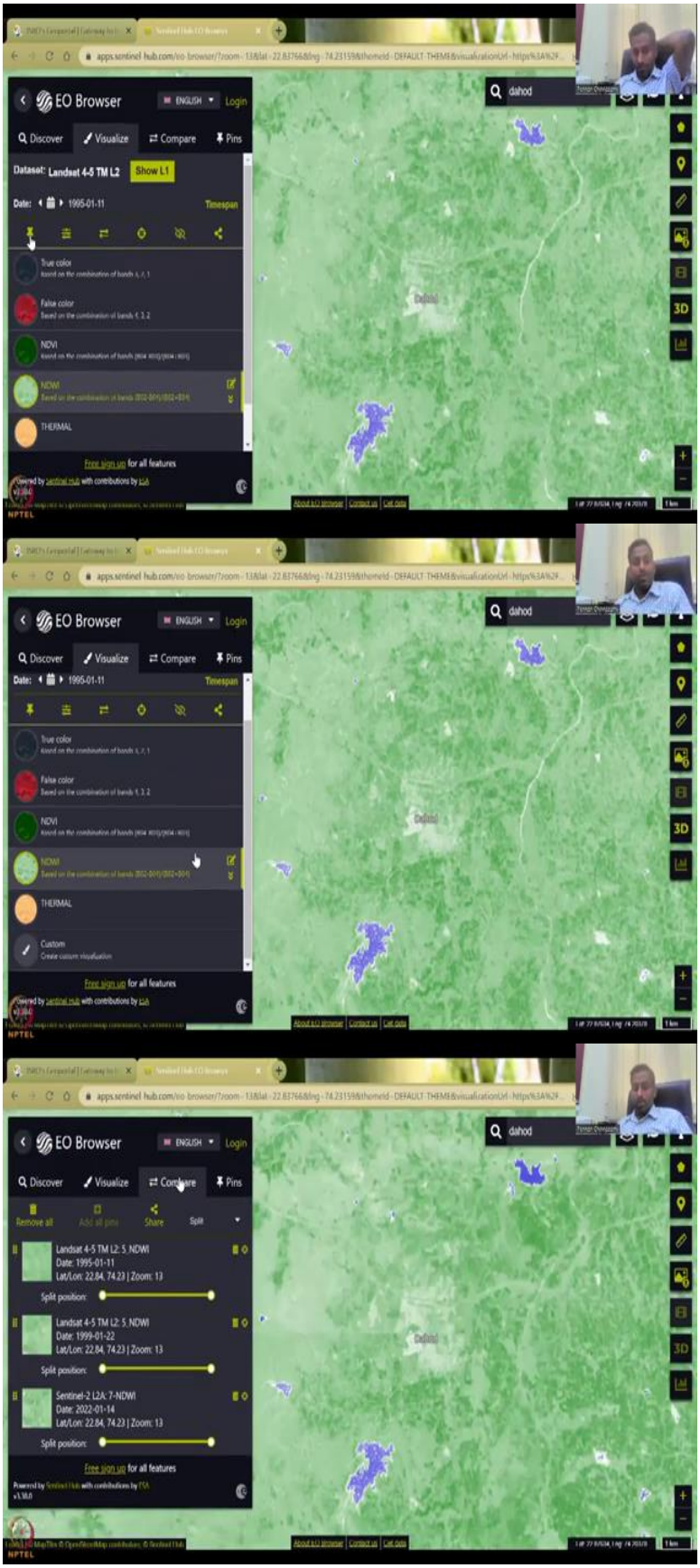
3D
EO Browser
Login
Discover
Compare
Pins
Theme
Default
Search
Commercial data
Highlights
Max. cloud coverage:
Landsat (ESA Archive)
Harmonized Landsat Sentinel
Envisat Meris
MODIS
DEM
Copernicus Services
Search
Free sign up for all features
dahod
3D


EO Browser
ENGLISH
Login
Discover
Visualize
Compare
Pins
Dataset: Landset 4-5 TM L2
Show L1
Date: 1995-01-11
Timespan
True color
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NDVI
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Free sign up for all features
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Date: 1995-01-11
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Free sign up for all features
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Login
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Compare
Pins
Remove all
Add all pins
Share
Split
Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5_NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
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Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
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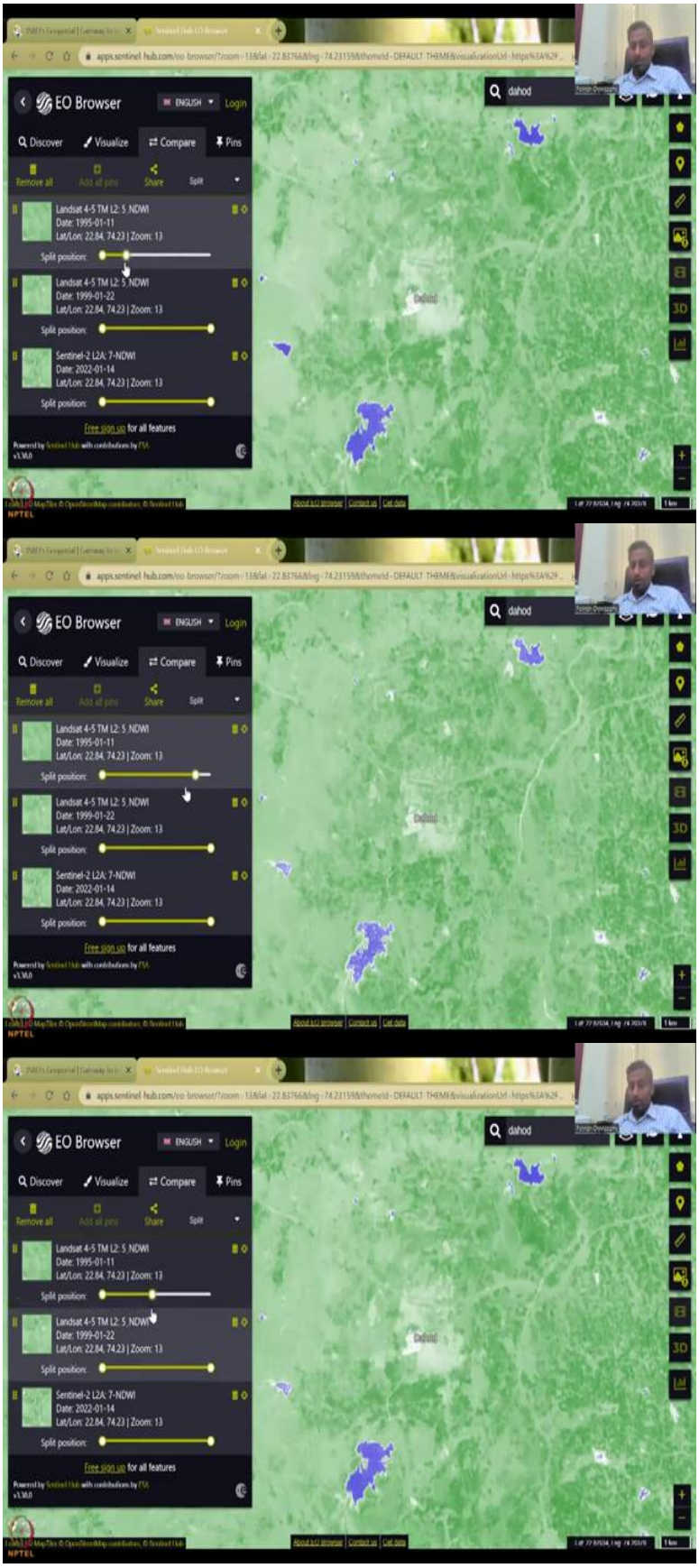
dahod
3D


EO Browser
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Login
Discover
Visualize
Compare
Pins
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Add all pins
Share
Split
Landsat 4-5 TM L2: 5 NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5 NDWI
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Split position:
Sentinel-2 L2A: 7-NDWI
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Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
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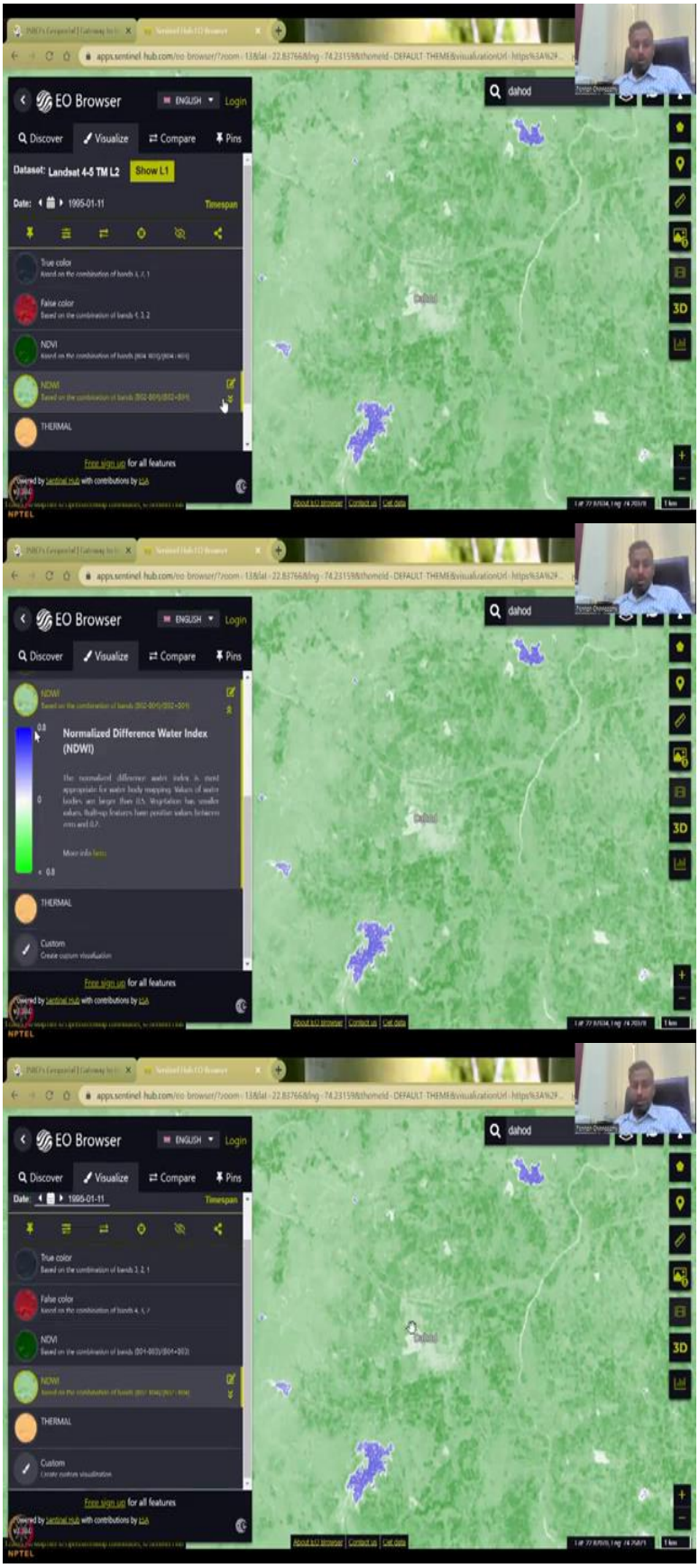
EO Browser
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Visualize
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Pins
Dataset: Landsat 4-5 TM L2
Show L1
Date: 1995-01-11
Timespan
True color
False color
NDVI
NDWI
THERMAL
Free sign up for all features
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EO Browser
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Discover
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Compare
Pins
NDWI
Normalized Difference Water Index (NDWI)
THERMAL
Custom
Create custom visualization
Free sign up for all features
dahod
3D
EO Browser
ENGLISH
Login
Discover
Visualize
Compare
Pins
Date: 1995-01-11
Timespan
True color
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NDVI
NDWI
THERMAL
Custom
Free sign up for all features
dahod
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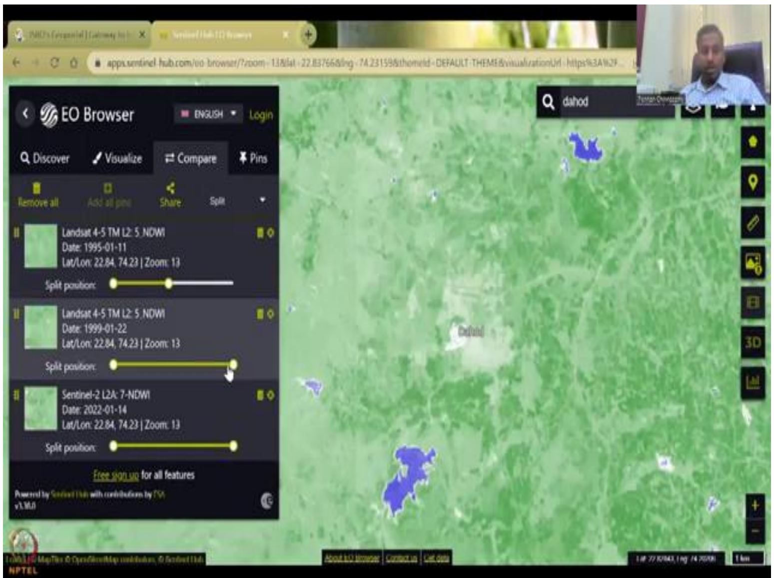
EO Browser
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Remove all
Add all pins
Share
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Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5_NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
Date: 2022-01-14
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
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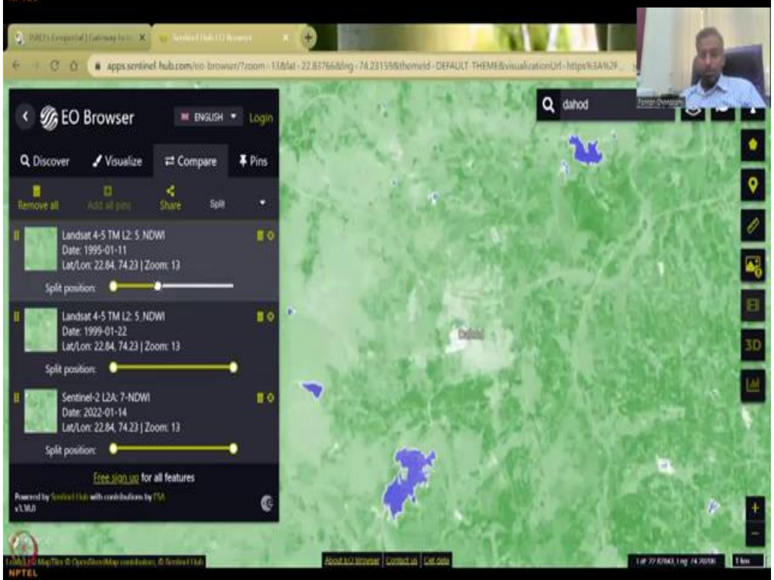
EO Browser
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Pins
Remove all
Add all pins
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Split
Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5_NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
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Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
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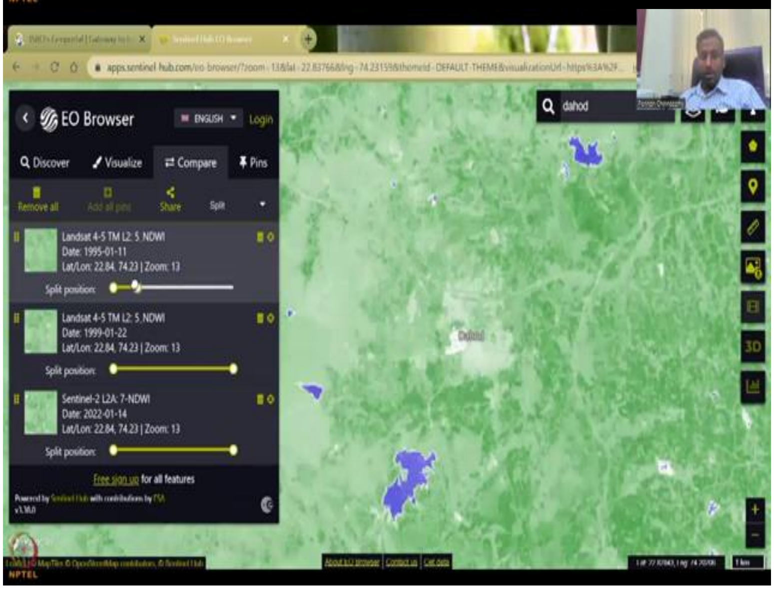
EO Browser
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Discover
Visualize
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Pins
Remove all
Add all pins
Share
Split
Landsat 4-5 TM L2: 5_NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
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Split position:
Sentinel-2 L2A: 7-NDWI
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Free sign up for all features
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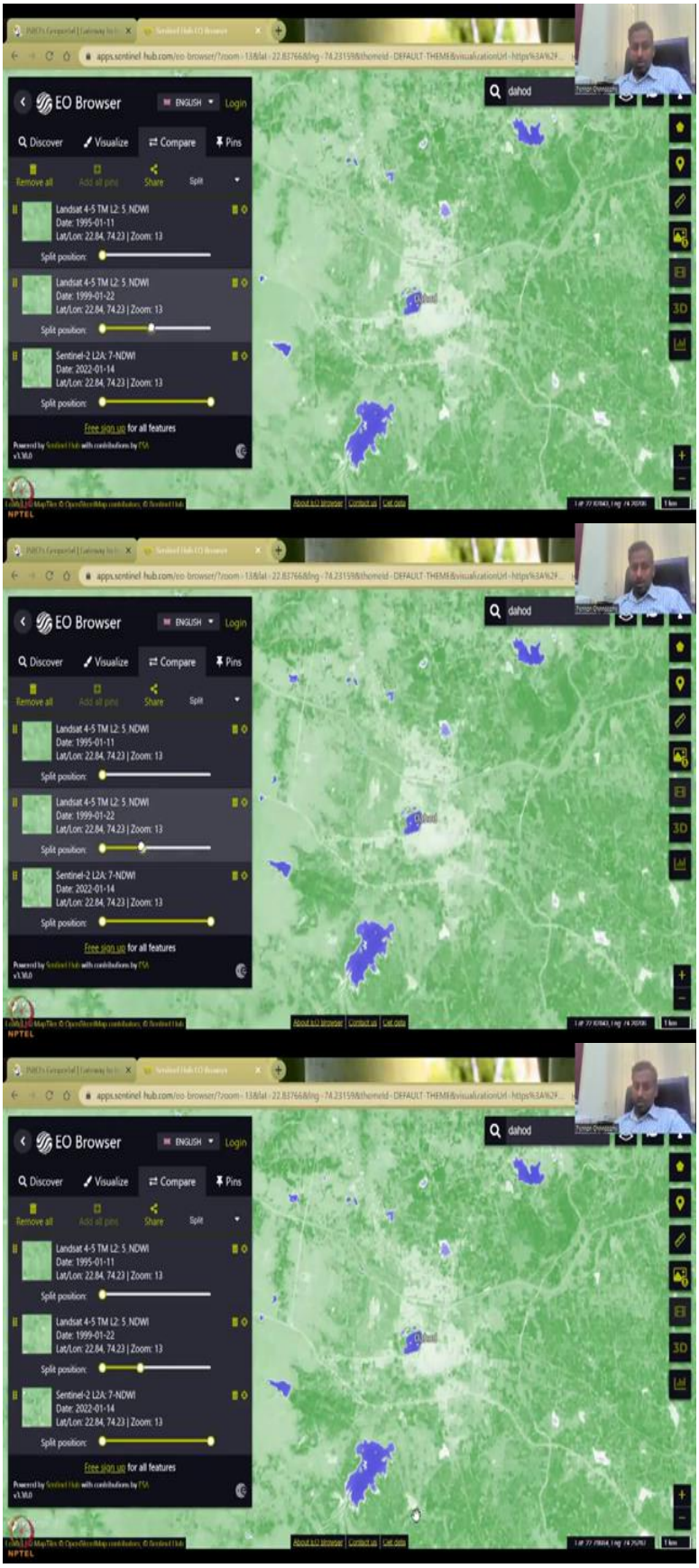
NPTEL


EO Browser
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Visualize
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Pins
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Add all pins
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Split
Landsat 4-5 TM L2: 5 NDWI
Date: 1995-01-11
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Landsat 4-5 TM L2: 5 NDWI
Date: 1999-01-22
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Sentinel-2 L2A: 7-NDWI
Date: 2022-01-14
Lat/Lon: 22.84, 74.23 | Zoom: 13
Split position:
Free sign up for all features
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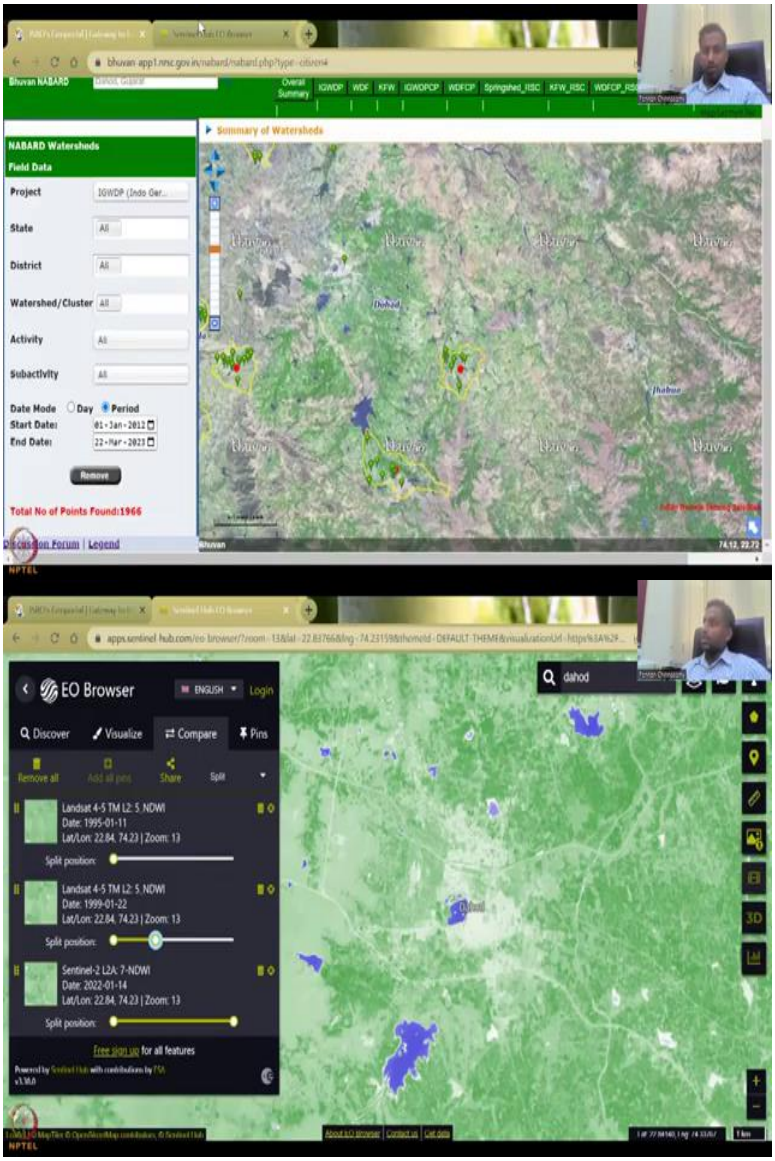

So, you could see here that we have Dahod region and I have selected the IGWP project the Indo German project watershed development programme and of all states Dahod we have selected you can see here Dahod I have selected and a period of 1 Jan 2012 which is the earliest and till date yesterday which is the latest. So, we have around 1,966 points of data and you can click on just to see what it is there is a horticulture.

And then there is some water rejuvenation tribal social welfare society board, farm pond has been created and then multiple photos of the farm pond has been made, some processing livelihood option have been given to the tribal and then some stroke stability have been done. So, pasture land conversion of barren to pasture land etcetera. So, all these are parts to these are bumps to slow down the run off.

So that water stays and then rejuvenates the aquifer and soil moisture. So, these are good for application and image is very qualitative, it is an angle image and there is lot of issues that can come up with an image because maybe it is not taken in the correct position sunlight etcetera. So, there were satellite data arrow down to that will give a better application. So, what we are going to do is we are going to show a study where does this work all these data and produce maps.

In the meantime I have also selected Dahod region and for two timeframes I have selected the data. So, for example, we have 1995 01 11 so Jan 11th 1995 I have data and then Jan 14 2022 I have data. I can remove this one March is out of the picture and then 1991 is also there. So, 1991 can go above. So, I have selected this we will need them I have shown you how to do it, you select Dahod go to discover data in the back to search you can search for data.

And then come to compare and then compare to data. So, once you visualize you can go back to which dataset you want and then you can add it to the visualization if needed. So, I have done it in the discover you will find which dataset and then in the search dataset and then you will see which options you have and would you want to add pins, difference advance options of time span etcetera.

So, here in the compare you could see that 1995 is on the top and on the bottom is 1999 you could see that the water levels are increasing for the same month could be because of rainfall also, but look at the NDVI NDWI which is water inlets are getting bigger. Water in NDWI we can see here green means less water, blue means more water and so we can see that there is lot of built up area coming up here and that is why you see a green colour.

And then the blue colour signifies more water. So, on the top it is 995 I am bringing it down now 1999 you are saying and if I reduce 1999 you can see 2022. So, in the 2022 frame beautifully you see more water bodies coming up in Dahod. It is a good sign of water being stored on the surface and being used for agriculture and substance. So, this is a good estimate, but let us see what we have done through studies and come back and revisit this aspect. So, I will go back to my slide for today.

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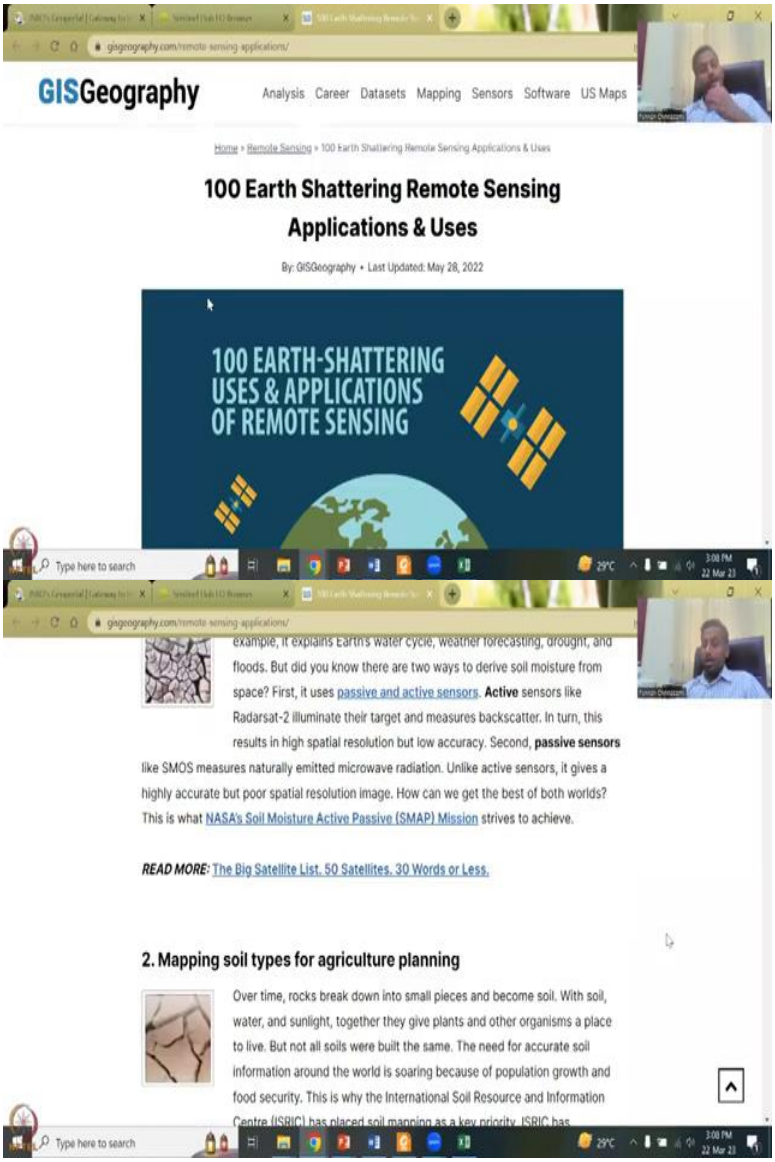

developed a methodology to predict spatial soil properties in 1 km grid cells at a global level – ISRIC's 1 km Soils Grid Map. Also, scientists used covariates such as climatic indices (based on MODIS imagery) and conventional soil surveys to create these global spatial prediction models.

3. Quantifying crop conditions with Normalized Difference Vegetation Index (NDVI)

The global food supply is being monitored with satellite imagery and the Normalized Difference Vegetation Index (NDVI). Near-infrared radiation is being used to detect healthy vegetation in agriculture. Healthy vegetation reflects green light and absorbs red and blue light. The green light that our eyes see is chlorophyll created by plants during photosynthesis. Chlorophyll will **reflect more light in the green and near-infrared spectrum** compared to other wavelengths. This is why near-infrared radiation in combination with NDVI is one of the primary remote sensing applications in agriculture and the environment.

4. Saving money and time on the farm with precision farming

Precision farming is like a **hidden goldmine** in agricultural production. Savings estimate 10% in fertilizer. On top of that, crop yields are also improved. Precision farming uses different wavelengths of light to see how healthy crops are. Variable amounts of fertilizer are worked out keeping money in farmers' pockets. Also, remote sensing in agriculture helps identify pests for better control and management on the farm.

Archaeology

5. Predicting the occurrence of dinosaur tracks for paleontologists

Remote sensing gives insight into understanding exactly where dinosaurs once roamed the Earth. Cantwell Foundation lists four primary geospatial factors in the occurrence of fossil sites. These four factors are vegetation coverage, slope, aspect, and proximity to landslides and all can be obtained using remote sensing. Forget about doing guesswork and put your best foot forward.

factors in the occurrence of fossil sites. These four factors are vegetation coverage, slope, aspect, and proximity to landslides and all can be obtained using remote sensing. Forget about doing guesswork and put your best foot forward.

6. Unearthing ancient archaeological sites like the Mayans and ancient Egypt

Unearthing ancient archaeological sites must be one of the neatest remote sensing applications on the list. Remote sensing applications in archaeology include infrared and stereo imagery. Infrared radiation has longer wavelengths and can penetrate around a meter of depth on the surface. Stereo imagery shows subtle variations in elevation on the ground. It was a bit of a surprise when archaeologists found square patterns on the ground over vegetation growth. These square patterns are of course **ancient buildings and pyramids**. Scientists have already discovered ancient Mayan and Egyptian civilizations using photogrammetry and infrared imagery.

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Arctic/Antarctica

7. Calculating the depth of snowpack

Forget about putting on your winter jacket and scarf for measuring snowpack depth. Snowpack is the accumulation of snow over extended periods of time. Specifically, they feed into rivers as the snow melts. This is why snowpack makes an important source of information for flood control and drinking water. As you can imagine, there is a high level of difficulty measuring the depth of snowpack. NASA has had the most success using LiDAR and a spectrometer as part of their airborne mission to measure snowpack depth. Both these variables explain the absorption of sunlight and the rate of snowmelt.

8. Exploring, protecting, and navigating in the arctic

parking lot

Looking for remote sensing applications with a great return on investment? Investors find using satellite imagery at big box store parking lots gives the most bang for their buck. Companies like RS Metrics count the number of vehicles in parking lots. In turn, this gives a snapshot of earnings, conversion rates, and market share. All things considered, it's a simple high-tech strategy that can give market analysts the information needed.

11. Getting a top-down view when purchasing real estate

When you're in the market to purchase a home you want a complete view of the property and surrounding area. Potential buyers are interested in knowing schools, shopping districts, and parks before their home purchase. This is why the use of satellite imagery in real estate has been a real growth segment. It also allows everyone in the home buying process a top-down view. Appraisers, insurance companies, and lenders can get a quick glimpse of the home through the convenience of the internet.

to electric power, and distribution of income. Higher radiance correlates with Gross Domestic Product and has also been compared with human well-being. Who would've thought you could learn so much by mapping economic activity at night?

14. Planning spine-jarring black diamond ski runs with aspect data

In countries like Canada and Russia, the territory is wide and below freezing for a good portion of the year. The mountainous terrain is ideal for ski resorts. But with so much ground to choose from, site selection is more difficult. This is why recreation planners are turning to laser technology for planning ski resort locations. Aspect data refers to the horizontal direction a mountain slope faces. The *greater* the angle, the *more* black diamond ski runs.

Climate Change

Climate Change

15. Identifying forest stands and tallying their area to estimate forest supplies

Global forest supplies are being monitored because they not only provide valuable materials (think construction, paper, packaging...) but they also absorb roughly one-third of carbon dioxide emissions. AVHRR, MODIS and SPOT quantitatively measure the loss and gain of our global forests.

16. Comparing climatic factors from past to present

Understanding the state of our climate has **immeasurable importance**. NASA is mapping different climate factors on a monthly basis to see how much these variables change in Global Time-Series Climate Maps. Through this lens, we can map out climate variables like carbon monoxide, chlorophyll, and aerosol size as a function of time. Remote sensing satellites include MODIS, CERES, AMSR-E, TRMM, and MOPITT. Never in our history have we understood Earth's climate as we do today.

17. Measuring the rise of sea levels

Every year Venice is sinking a little more. Measuring the rise of sea levels is a perfect example of a large-scale application done cost-effectively. There is no need to go on the beach and bring out your measuring stick at sea level all along the coast. In order to understand sea level rise, you need good baseline spatial data. Measuring sea level rise is a function of time with centimeter accuracy measurements using remote sensing data.

18. Comparing the past and present with human impact change

The Landsat missions are the longest-running Earth observation missions ever. Its digital records date back to the 1970s. If we want to understand landscape change, the Landsat missions give us a snapshot back in time. We can learn from the past for future generations. Oil spills, deforestation, wars, chemical spills, dead zones, and smog are unnatural, man-made disasters. We can prevent them all and watch them from space. For example, this Esri story map shows how human activities are reshaping Earth's surface using Landsat imagery.

Crime

19. Spotting swimming pools for late-night dives

Not all satellite imagery is used for good intentions. If you own a swimming pool, it may be a target for a strange craze called *'dipping'*. Teenagers have been using aerial and satellite imagery on Google Earth to locate swimming pools. At night, they would take an impromptu dip in any of the largest pools they could find. This activity is of course trespassing (which is a crime). In other words, don't try this at home, kids.

20. Narrowing down a search for a missing body

Remote sensing can save time, money, and manpower in locating missing people. Crime detectives want to narrow down their search before they go on a quest. Remote sensing tools can explore the search area with a *fine-tooth comb* and pick up anomalies on the ground. This could include anything from a rabbit hole to the crime scene, itself. This is truly a time-saver if you have a rough idea of the search location.

21. Putting illegal boat dumping under the microscope

When a boat was dumped illegally with all identification removed in Santa Rosa County, crime **investigators took their search to Google Maps**. Using historic aerial and satellite imagery, they went on a hunt for its rightful owner. What crime investigators found was the same boat and the address of the illegal dumper. Case closed.

Disasters

22. Monitoring active volcanoes using thermal remote sensing

Volcanoes form when hot molten rock from the upper mantle finds its way to the surface. Eruptions are dangerous to humans and the surrounding environment. There are over 600 active volcanoes on Earth. Volcanoes are often inaccessible *(unless you are Mario or Luigi)* making remote sensing applications like thermal and mid-infrared clear solutions for understanding volcano activity. AVHRR and MODIS are prime candidates for volcano monitoring.

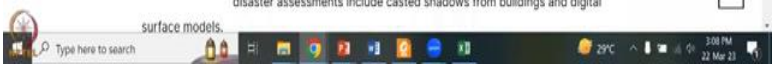
23. Inventorying potential landslides with interferometry

23. Inventorying potential landslides with interferometry

Landslides are often under-represented in hazard research. But every year in the United States, landslides cause loss of life and billions of dollars in damage. The first step in inventorying potential landslides is using stereo and optical images with slopes. Slope instability triggers can be several things – earthquakes, erosion, poor drainage, and more. InSAR can provide early warning signs for landslides because of how well it measures ground surface displacements.

24. Quantifying the damage after an earthquake

The result of an earthquake can be catastrophic and at times difficult to assess. But an earthquake assessment is essential for rescue workers. They need to be done quickly and with accuracy. Object-based image classification using change detection (pre- and post-earthquake) is a quick way to get damage assessments. Other remote sensing applications in disaster assessments include casted shadows from buildings and digital surface models.



Ecology

27. Counting polar bears to ensure sustainable population levels

The sad story about the polar bear is that it is listed as one of the first animals that will become extinct because of global warming. Ecologists are turning to satellites as their primary source of information because they need a firm count on polar bears for their survival. So... How do you know the difference between a polar bear and a big white rock? In two images, polar bears moved, while rocks stayed in the same spot.

28. Uncovering habitat suitability and fragmentation for panda bears in protected areas

Giant pandas eat bamboo for 99% of their diet making them the ultimate *bamboo-holic* of the animal kingdom (think alcoholic but bamboo). Habitat is important for pandas. This makes roads and infrastructure **ecological**

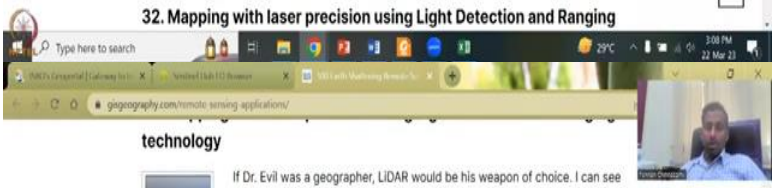
Research has shown that variables like vegetation (NDVI) and relief (slope) are drivers for wildebeest movement patterns. However, rainfall may also have an impact on migration patterns as well.

31. Using habitat suitability models to predict the abundance of mosquitoes

Habitat suitability models are making some interesting predictions on the abundance of mosquitoes. Remotely-sensed factors such as greenness, brightness, temperature, and especially moisture positively correlate with the over-occurrence of mosquitoes. Knowing the location of high concentrations of mosquitoes can guide risk assessment for disease-carrying pathogens and mosquito fogging efforts.

Elevation

32. Mapping with laser precision using Light Detection and Ranging



technology

If Dr. Evil was a geographer, LiDAR would be his weapon of choice. I can see it now, pinky in the mouth saying ***"bring out the laser"***. LiDAR measures the distance from the airborne platform to Earth's surface using laser beams. This is how LiDAR got its name – "Light Detection and Ranging". What makes LiDAR so special is its densely sampled points at laser accuracy. LiDAR generates point clouds for digital surface models, digital elevation models, and light intensity.

33. Estimating surface elevation with the Shuttle Radar Topography Mission

Imagine you are a surveyor and your crew chief asks you to survey the whole world. You need to map 30-meter grid cells and are given only 11 days. *What would you say?* I'd expect some profanity... This is essentially what NASA's Shuttle Radar Topography Mission (SRTM) did in 11 days. The secret to its success is Interferometric Synthetic Aperture Radar.

gisgeography.com/remote sensing applications/

34. Deriving elevation and contours using photogrammetry

Photogrammetry dates back to the mid-nineteenth century. It is used to find the geometric properties of objects by measuring distances between objects. Some of its derived products in GIS include contour mapping, surface models, volumetric surveys, and 3D mapping. It's also used in other fields such as crime scene mapping, archaeological excavations, and architecture.

Engineering/Construction

35. Planning an optimal telecom network capacity

It's estimated that 87% of the world's population now uses mobile devices. The astounding rate of growth in this industry requires extensive planning for optimal network capacity. Telecommunications companies use remote sensing because it's a cost-effective way to optimize capacity requirements

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Environment

37. Monitoring the environment with the ESA's Copernicus Program

As for remote sensing applications in the environment goes, the European Space Agency (ESA) Copernicus Programme may be the most ambitious yet. The goal is to achieve a completely autonomous monitoring system. Its purpose is simple – understand the health of the Earth. Copernicus' six Sentinel satellites collect comprehensive pictures of the following themes: land, ocean, emergency response, atmosphere, security, and climate change.

38. Keeping a watchful eye on biodiversity

Biological diversity (biodiversity) is the wide variety of animals and plants in a geographic location. With the spatial and spectral resolutions of sensors improving year by year, remote sensing applications in biodiversity are beginning to play a larger role. It remains in the early development stage but strides are being made using hyperspectral and 3D vegetation structures

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signs of wealth using satellite data. Not a bad idea that more than 15,000 swimming pools went unclaimed to tax authorities in 2010. The money-strapped country is looking at increasing its tax revenues using remote sensing applications using satellite imagery.

45. Detecting land cover/use types for decision making

"Land cover" is the physical property of the surface. *"Land use"* explains how land is being utilized. When a mayor of a city targets a 50% urban tree canopy, **spatial resolution matters**. A Landsat pixel spans multiple parcel boundaries and is not a realistic representation of a tree canopy. The Spatial Analysis Laboratory (SAL) of Vermont compared the National Land Cover with object-based classification and found it was significantly underestimated (11% vs 39%). A mayor would be very embarrassed to know their objective is almost exceeded.

groundwater. Groundwater activity can be understood by its rock types, soil, land use, and rainfall. Remote sensing groundwater prospect zone maps are used to locate well sites.

51. Preventing the degradation and loss of wetland ecosystems

Once seen as a nuisance in agriculture, wetlands are being drained and lost. Suddenly, they have become a rare precious resource. Wetlands serve many purposes. They help purify water, control flooding and improve shoreline stability. This is why remote sensing applications to inventory wetlands have grown so much over the years.

Insurance

52. Charging higher insurance premiums in flood-prone areas using radar

Ever notice your home insurance premium sky-rocket from the previous year? You *might* have to thank a geographer for that. Some of the unique GIS and remote sensing applications that insurance companies use include radar and hydrological modeling. Geographers can map out areas more prone to flooding, how often these areas would flood, and how badly the damage could be. In turn, this helps them better assess risk.

53. Doing the detective work for fraudulent crop insurance claims

As the climate becomes less predictable and more destructive (such as droughts and floods), farmers have to adapt to this new reality. In this case, crop insurance can help farmers supplement their income when their fields don't get seeded. But what happens when farmers commit crop insurance fraud? This is why insurance companies and the USGS have teamed up to investigate any wrongdoing. For example, the USGS measures vegetation growth using Landsat's red, infrared channels in combination with NDVI. Using this information, crop insurance companies can verify seeded crops and catch fraud.

gisgeography.com/remote sensing applications/

54. Spying on enemies with reconnaissance satellites

Militaries are harnessing the power of satellite imagery to retrieve intelligence on enemies. As for remote sensing applications, reconnaissance satellites go all the way back to the 1950's US Corona Program. Its purpose was to spy on the Soviet Union and China after the war. But satellites have come a long way from taking photographs and parachuting down to the surface. Now they're so secretive that if they told you... well... *who knows* what they would do to you

55. Snapping aerial photos for military surveillance using messenger pigeons in World War II

Never trust a pigeon as your photographer. No matter what the occasion is, weddings, birthdays, and times of war. Pigeons almost never follow their flight path and almost never return cameras to their owners. These were the hard lessons learned when the German military used the Bavarian Pigeon Corps to do their dirty work and spy on enemies.

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56. Searching for aircrafts and saving lives after fatal crashes

Of all remote sensing applications, there may be no other that touches the heart as much as saving another life through search and rescue. Hundreds of satellites orbit the Earth each day. Each one has its own life-saving ability – but only if it's in the right time and place. This also applies to defense and military uses and applications as well.

57. Navigating ships safely with the most optimal route

Imagine. The Titanic had GPS positioning and stirred clear from the iceberg. Hundreds of lives were saved and husbands around the world could've avoided watching the Leo and Kate romance movie about it. But the harsh reality is that icebergs still threaten ships 100 years after the Titanic sunk. Ship navigation has improved. GPS is not the only ship navigation tool. Other remote sensing applications in ship navigation include routing analysis, wind and wave information, and ship proximity.

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58. Picking up on signals from submarines in shallow water

Submarines have the reputation of being excellent spies because they are capable of operating underwater. Much research on using earth observation data to track submarines has been kept on the down-low. But new insights indicate some capacity to detect submarines at shallow depths. Satellites might see subtle undersea disturbances caused by submarines using SAR. Another indicator may be vibrations in ocean temperatures using infrared detectors. This means *submarines may have no place to hide at all.*

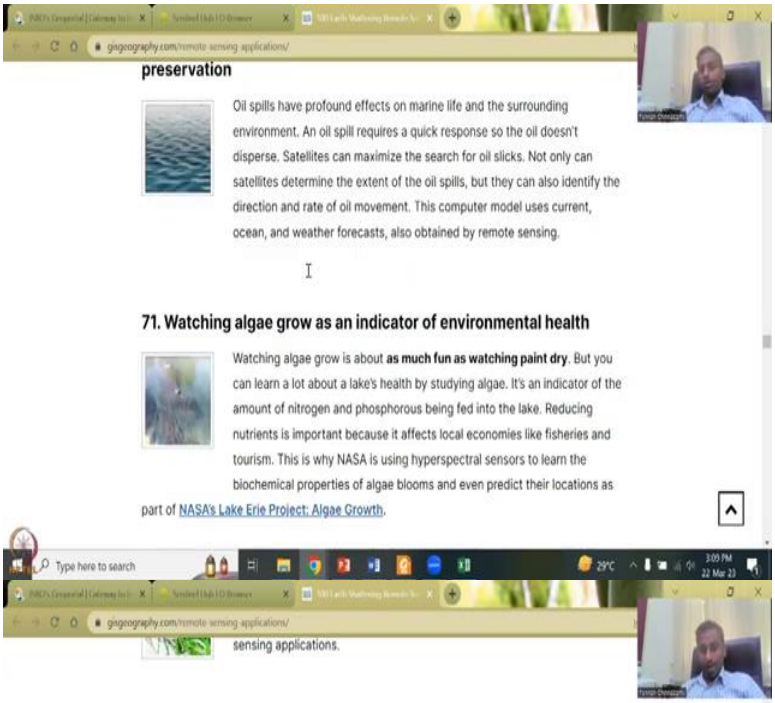
the wheel.

66. Providing a base map for visual reference and assisting orient the map reader

Orthoimagery provides an extreme amount of detail of the focus and surrounding areas. Maps always communicate a message. As maps are location-based, aerial imagery assists readers to orient themselves. It provides context and reference information and can instantly provide the lay of the land. And nowadays, there are so many sources to choose from such as Bing, Google, Open Street Maps, and NASA's Globeview.

67. Measuring gravity with the GRACE satellites

This may be one of the neatest remote sensing applications on the list – measuring gravity. NASA's Gravity Recovery and Climate Experiment (GRACE) consists of two satellites in the same orbit approximately 220



preservation

Oil spills have profound effects on marine life and the surrounding environment. An oil spill requires a quick response so the oil doesn't disperse. Satellites can maximize the search for oil slicks. Not only can satellites determine the extent of the oil spills, but they can also identify the direction and rate of oil movement. This computer model uses current, ocean, and weather forecasts, also obtained by remote sensing.

71. Watching algae grow as an indicator of environmental health

Watching algae grow is about **as much fun as watching paint dry**. But you can learn a lot about a lake's health by studying algae. It's an indicator of the amount of nitrogen and phosphorous being fed into the lake. Reducing nutrients is important because it affects local economies like fisheries and tourism. This is why NASA is using hyperspectral sensors to learn the biochemical properties of algae blooms and even predict their locations as part of NASA's Lake Erie Project: Algae Growth.

sensing applications.

75. Tracking sediment transport into rivers and lakes

Sediment loading is one of the most profound anthropogenic factors in aquatic systems. It affects industries like tourism, fisheries, and ecological functioning. It would be useful to understand exactly where suspended solids enter and leave. The reflectance of water in satellite imagery increases with more suspended solids. But in order to monitor nutrient loading, we need continual coverage and temporal analysis.

Society

76. Monitoring the global sex trade situation in remote areas

The global sex trade is a growing international crime where one's rights are violated through commercial exploitation. Often involuntary, the flow of human trafficking has been tracked using the latest satellite imagery from

78. Preventing the spread of diseases in epidemiology

The birth of epidemiology came shortly after Jon Snow mapped the spread of cholera from a contaminated pipe in 1854. Ironically, this was also the birth of Geographic Information Systems. There is a clear connection between epidemiology and geography. Some diseases are best-suited for climate, land use, and air. Remote sensing applications in health use these remote sensing data and prediction models to understand epidemiological processes.

79. Understanding the human rights situation in North Korea

Remote sensing can give an in-depth look at hermit kingdoms like North Korea. Remote sensing enables what some travelers may never get to see in their lifetime. Ostrich farms, breweries, towers – all uniquely North Korean. But satellites also enable us to see the darker side of North Korea. Those wanting to escape North Korea are sent to prison camps. These camps are clearly seen from the skies.

seen as impervious surfaces from satellites.

Transportation

88. Inventorying and assessing rural road conditions with UAVs

How safe are your roads? Transportation planners have been taking some Earth advice on unpaved roads. With the integration of remote sensing and GIS, unmanned aerial vehicles are providing answers on pothole detection, washboard analysis, and crown conditions for unpaved roads. With centimeter accuracy, rural road conditions can be assessed and inventoried saving time and money.

89. Driving with no hands (autonomous vehicles)

If Google's self-driving car got pulled over by the cops, how would it react? The first secret behind the car is the LiDAR which detects pedestrians,

What is Remote Sensing? The Definitive Guide

What is Photogrammetry?

OBIA – Object-Based Image Analysis (GEOBIA)

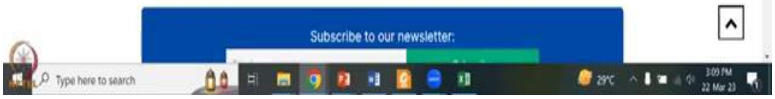
The 50 Most Influential Satellites in History

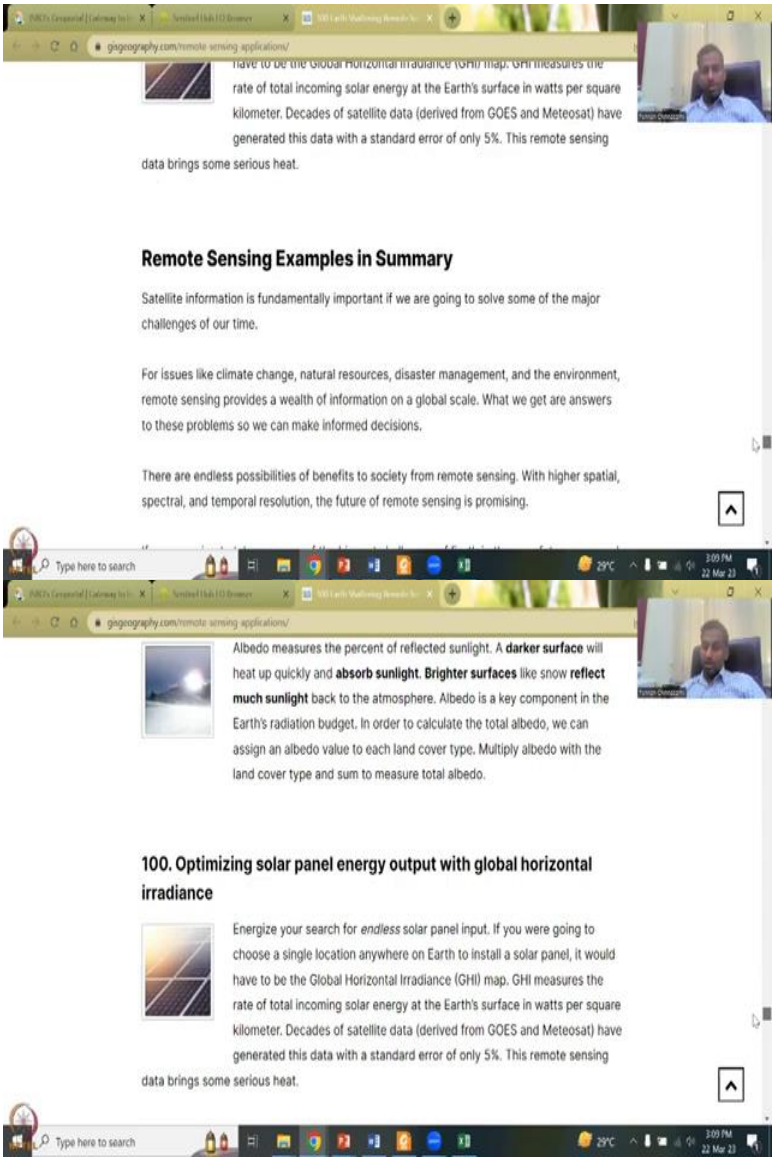
What is NDVI (Normalized Difference Vegetation Index)?

A Complete Guide to LiDAR: Light Detection and Ranging

Learn Synthetic Aperture Radar (SAR) by Example

How GPS Receivers Work – Trilateration vs Triangulation





Before we go into that I would like to introduce you the many options to look at applications of GIS do exist. GIS geography has a website in which there is lot of data, accessories, carriers, analysis and then there are updated regularly some steps etcetera. I can just show you real quick if we click this we will open the webpage for the applications. So, I am just going to go through the screen where it is opening up.

It is screen on I am going to share and now you can see it. So, you can see that the 100 applications have been done almost a year ago and just see how many role applications can be there, there is agriculture, soil types, NDVI is big those who like to do NDVI you can know that it is one of the big applications and then Antarctica takings is not part of us and then climate change, forest agro forest for rural development and then disaster monitoring, damage after an earthquake, ecology, habitat monitoring etcetera.

So, there is lot and lot of data around this line and we could see that how you could take aerial photograph also in the military time and then snap it through the current areas also we can do, mining can impact rural developments. So, you can also map where the mining is happening on societal issues, human rights etcetera. So, there is lot of applications again solar options is very, very important for rural development that is also happening.

So, we have all these and then as I said we get back to the presentation where we have this link posted and feel free to go ahead and look at these options.

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Please remember that all these options do exhibit a cross cutting theme because rural development is a complex entity, there is agriculture and rural development, ecosystem and livelihoods, domestic use and sanitation has to be at risk and climate change which is happening more on the rural development scenario has to be addressed. So, all these are there and we have to be very focused on collecting data and mapping them.

So, that we attenuate or reduce the impact on the ecosystems. So, we have remote sensing identified for each and every parameter in this lecture. So, for example, for agriculture we use NDVI and NDWI, landsat images, groundwater from grains etcetera, ecosystem livelihood which is mostly dependent on agriculture we had, we also maintain some aspects of animal, husbandry and poultry farms, aquafarm etcetera.

Domestic use we looked at groundwater, rainfall availability, farm ponds, water for Jal Jeevan Mission and of course climate change. We have shown how to use climate indicators and climate change scenarios from remote sensing estimates.

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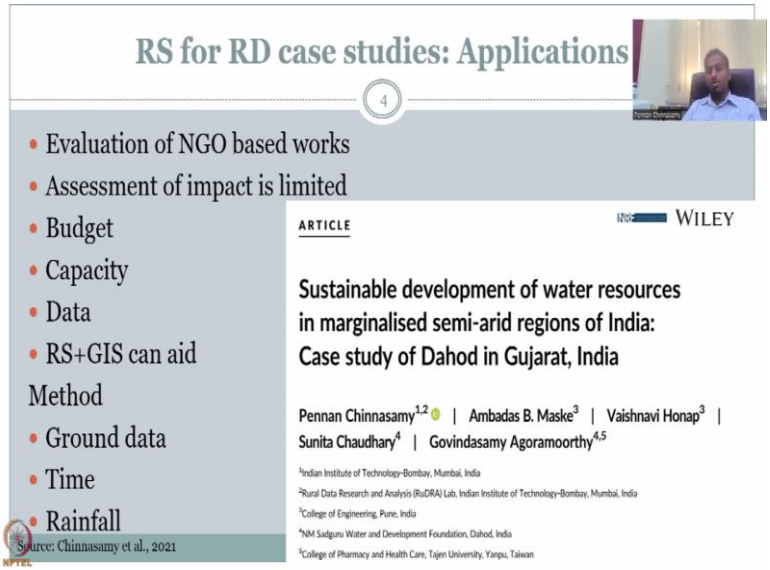

So, we have lot of remote sensing for rural development case studies, the applications involve evaluation of NGO based work. So, this is what we have done in the first section which is today we will be looking at how to evaluate NGO based work because NGOs are very focused on working on the ground. I work with multiple NGOs, I currently still work with NGOs.

And they are on the ground who are working very, very hard for the rural development most of them I am saying and what they do is they work very closely with the farmers and stakeholders and bring them up in their potentially good options. The salaries are very low so not lot of people you find in NGOs and even we are finding hard to sent our students into those kind of streams because most of them want higher paychecks.

But the point here is it is very, very related because with less money they cannot afford to build the capacities for collecting data, monitoring their impacts. Suppose, we have an NGO that is working on rejuvenating farm ponds or agricultural lakes. The idea is they will rejuvenate it, people have the potential benefits and they continue rejuvenating it, but normally what happens is they ask the farmers and people oh are you having water.

And if they say yes great water is coming and they happily move on to the next, but if someone ask them what is the quantity, how much water has been improved, what is the metric, the yield that has been improved that is very hard to quantify for them because they do not have budgets for putting people on monitoring. We have budgets only to do the work, we do not have budget to do the monitoring in evaluation.

So, the assessment of impact is limited and this is kind of sad because NGOs need to accredited for their work and for the knowledge that they develop if not then the system will collapse. If no one knows that NGOs are working hard or not then how will the funds come to NGOs. So, only the top NGOs that are very good, very well known who is still established. So, it is important for them to do assessments.

And impact evaluations for which we have worked with foundation in NGO called Dahod NM Sadguru Foundation which I have already told and as I said they have very less budgets for manpower and models and software to evaluate their impacts, capacity is very low. We will need to build capacity for that and data acquisition, observation data is also not enough. So, in this case remote sensing in GIS can come very handy.

In fact, they can alleviate all these stress on the system and bring clear indication of their impact and work. So, what method did we use? We used just some ground data that they had. I will go through the study in detail and show you how quickly you could do and get published in a very, very good journals because I hope masters and PhD students are also taking their courses and it is very important for PhD students to write papers.

What I am going to show now is a student intern he was not even a student under me he was a student intern just internship 2 months, 3 months. He worked very hard and this paper through the team came out to be a very good genre paper. So, time is also needed where we need to put a time on the assessment period. So, you need ground data and time that is all you need.

So, when did the structures or the investment or infrastructure come in that is the time and ground data of the locations and that is remaining satellite data can address. One more data we need is the rainfall again even if the rainfall is not available from the ground we can always estimate it through satellite products because we have satellite data coverage of rainfall for a long, long period.

So, this article had come in the NRF the National Resources Forum which is the official journal for the United Nations a very, very prestigious journal. I am very happy to say that a work by two interns have ended up in this who are the third and fourth authors on this who wrote along with me and one collaborator from Taiwan and then the NGO person also. So, number 4 is NGO so you could see that NGO person is also involved.

So, these NGO person normally they do not have time to write papers or evaluation because they are always on the field. They have to work hard with the farmers and since I have been on both the sides I know exactly like how much time we have to spent on the field and once you confirm we do not want to open the computer just getting ready for the next day. So, we as academics and institutions should support the NGOs who are on the ground, working very hard with the people to bring up their livelihood along with their garments.

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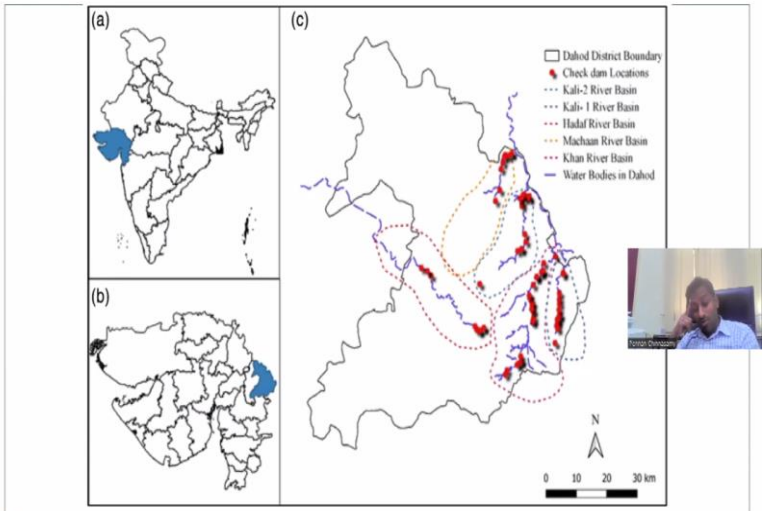

FIGURE 1 Dahod study site (c) location in Gujarat state (b) of India (a). The Dahod map also shows the location of basins and location of check dams
Source: Chinnasamy et al., 2021

So, let us take this case study we have work on the Dahod district and you can see Dahod is part of Gujarat, Gujarat is in blue in colour then we have Dahod region which is this part again blue in colour and then we have different basins small, small basins have been demarcated roughly from the data they had and we can also take a DEM and then do the watershed analysis.

But also what you found is there is lot of check dance. So, the idea here is the Dahod NM Sadguru Foundation the foundation is called NM Sadguru Foundation, they invested lot of time you can see an NM Sadguru Water and Development Foundation Dahod they invested

lot of time in getting budgets for building check dams and they build their check dams for their farmers.

They do not stop there so their mode is one more higher level where they formed village communities to use and manage the check dams through lift irrigation system and other things. So, now we have a system that is blocking the water and then water stays on top the surface water and then some water infiltrates, into the groundwater aquifer but most of the water is still there and getting pumped out using lift irrigation schemes to their farm lands.

And most of these regions are tribal region and most of these regions were not the agricultural for the past 100 years and that was because it was initially a forest. So, if the forest evolved with whatever rainfall it had in soil moisture, but now lot of forest has been cleared and the cleared land could not sustain any growth because of limited rainfall, the rainfall is very less around this region.

We will have a data to show what is the average rainfall in the summer around 400 to 600 m with some odd peak discharge and peak rainfall. So, we have all these sub basins classified after we had the location of the check dams only the check dams wherever they are you mark the boundaries and we found that this specific boundary the Hadof river basis and more check dams and we have selected that for further analysis as follows.

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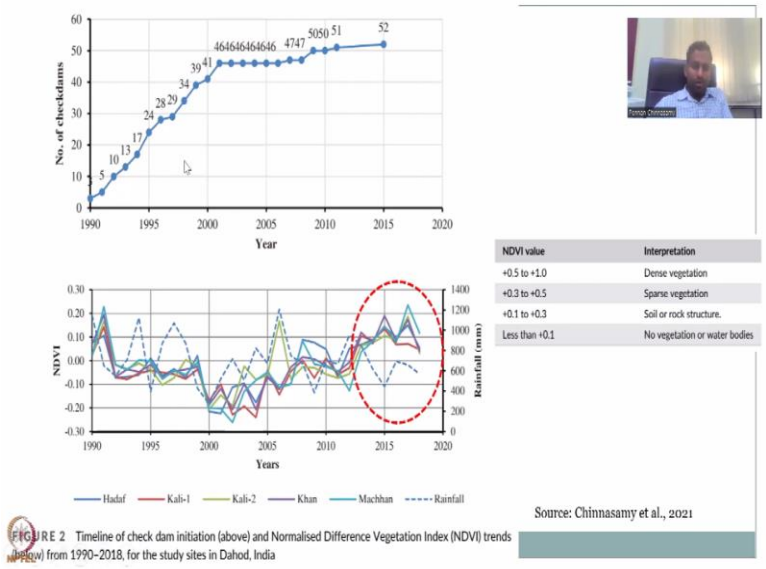

FIGURE 2 Timeline of check dam initiation (above) and Normalised Difference Vegetation Index (NDVI) trends (below) from 1990–2018, for the study sites in Dahod, India

So, what we did is we first plotted the time as I said we needed time of ground data. So, when did the check dam come? So, approximately 1990 they started and they started keeping on

increasing the check dams. So, this is a cumulative graph of the number of check dams, you can see number of check dams increase steadily from 1990 to 2000 and then there were some slow development not much development here maybe they were building larger check dams.

And it took some time and then story picked up again until 2015. So, we use our data to 2015 we wrote the paper around 2019 and it got published around 2021. So, the idea here is we had collected the locations and the time of the check dams. So, now you have 1990 to 2015 the check dams. So, if you look at the rainfall and see how the indicators of soil moisture and plant growth happens you will definitely see an increase because of the check dams because the check dams have a principle of storing the water and then letting it percolate.

And then the plant is taking it up. So, if you know that the check dams are coming into existence especially this part 2015 lot of big check dams came in you could definitely see that for the same rainfall the dash line is the rainfall. So, for the same rainfall you will see a higher peaks of the NDVI because they are giving more water in the storage than run off. So, they are converting the rainfall into run off and then keeping them in the system.

So, you could see here as the results. First let us see what is the NDVI value range we have minus to plus 1 and the plus 1 is dense vegetation around 0.5 to 0.1 we have set good vegetation and the sparse is 0.3 to 0.5 and then 0.1 to 0.3 is soil or rock structure, barren land and then we have less than 0.1 is no vegetation or water bodies. So, you could see that the NDVI certainly increased a lot.

All these are the different check dam basis that we saw here. So, these are the 1, 2, 3, 4, 5 basins which are given here also 3, 4, 5 plus rainfall. So, rainfall is looked at this axis right hand axis while the other all have NDVI in the left axis. So, you can see that the dash line rainfall ranges between 400 as I said 400 to 1,200 is the peak year, but most normally around 800 and 600 the rainfall levels comes up.

And what happens here is you can see the response of the rainfall on the NDVI is changing. So, if the rainfall is the same you would almost expect a similar NDVI because the water is being taken by plants and plants grow, but if you have storage then the water is being stored more in the storage tanks and those have access to plant grow soil and other components. So, you could see here for a rainfall of around 1,000 you have only the NDVI around 0 on negative ones.

So, most of the negative parts are here in the early stages. So, check dams are coming, but slowly they will improve the quality and then you could see that suddenly they will start to peak and then go away from each other sub basins especially lower on the positive side even the rainfall is coming down. So, that is the impact. So, the impact here is even if the rainfall is coming down after let us say 2012 to 2015.

And then to 2020 even the total annual rainfall is coming down in this areas. The NDVI is still increasing it shows that the structures are there who have buffered, who have stopped the runoff from the system and kept the water into the ground water so that it can be used for crops. This is a very key finding in the exercise why because we assumed that NDVI would be constant without any change with rainfall.

And the check dams love slight indication on the soil, but it was not the case. Plants were happily extracting more of the water and growing healthy. You can see the NDVI is very healthy around 0.2, 0.3 etcetera around sparse vegetation. So, here you do not have dense vegetation because of the rainfall region and also it has been always and that for a long time barren land.

So, converting a barren land to some kind of crop land is very, very difficult, but slowly it is happening thanks to the efforts of the NGOs NM Sadguru Foundation and the check dam idea that they have. It was not super scientific it was something that worked in the region and they just used it which is a basic science, you do not need rocket science to save most of the world problems, you just need good signs basic fundamental science.

So, here the farmers are extracting more water so how do you reduce it by adding more water structures that can capture the run off and put it into the ground.

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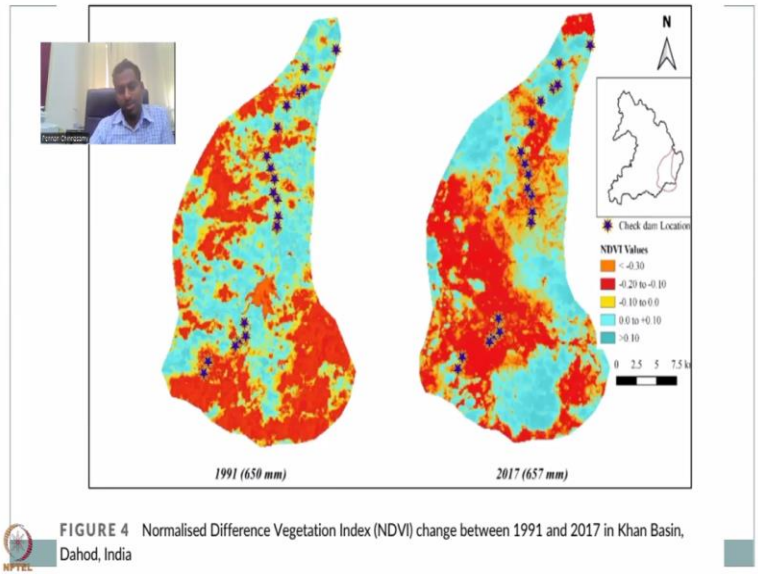

FIGURE 4 Normalised Difference Vegetation Index (NDVI) change between 1991 and 2017 in Khan Basin, Dahod, India

You can see here this is another testimony of what is happening. We will pick 2 years of same rainfall 1991 and 2017 same rainfall. So, someone should not ask us oh you took rainfall high year and showing high NDVI. So, we wanted to make sure that the 1991 and before and after are same. So, around 63 is the average rainfall and then for 2017, 2018 and 2016 it is almost the same.

So, there is no big flood before this event and this year and then we saw that 2016 is okay, but 2017 was better in terms of average rainfall 650 and 657 millimeters is almost the same. So, let us assume that both are same just 7 millimeter difference is not big and now you could see a special distribution of the location of the check dams. So, these are the location of the check dams in one of the sub basins which is Khan basin.

And you could see that how the colour has been changing from negative the negative values are red and yellow to blue. So, blue is happening a lot because and the water flows from top to bottom and then you have lot of water that has been stored. So, you can see a big, big blue colour here which is being used for recharging and growing the plants. So, NDVI value is really high.

There is lot of crop growth and crop diversification also which adds to this finding of increased NDVI. So, we see a graph of how we will change the average value of NDVI change across the Dahod district which is in the previous one and there are different time scales. So, we have different sub basins and then time scales for 1990 to 2020 we have the

NDVI, but in the special resolution image we picked 2 years with similar rainfall pattern and precedence conditions.

And we looked at if the NDVI has sharp change and you can definitely see a bigger change in the top basin where most of the runoff is going to be held back and then stored for improving the soil moistures which improves the NDVI value.

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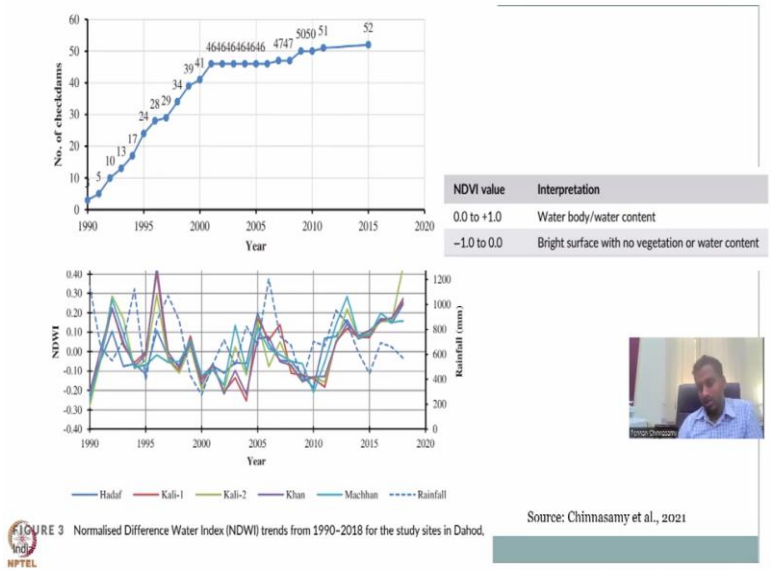

For NDWI again we have the negative values as not water present in the soil and are not healthy water levels. So, you can see here from the explanation of what is the NDWI. You could see that the NDWI value ranges from minus to plus and then vegetation has smaller values. So, vegetation and built up areas has small values whereas the higher values are blue and that is what we are also seeing here.

So, here the negative values which is mostly the built up and barren land whereas the soil water capacity has been increased drastically and that you could see definitely in the drought years even though the rainfall is coming down. These NDWI values does not come down fast. Here we have used 0 to 1 as the water body water content the positive values are reflecting water content whereas negative to 0 is bright surface with no vegetation or water content.

So, this is just barren soil land build up and you have less water content in the soil. So, inside the soil there is more water content and that is even true during the less rainfall year which is being supported throughout this image because of the use of satellite data to understand this

phenomena. So, you can see normalized difference water index trends from 1990 to 2018 for the study sites in Dahod India.

And it clearly says that due to the increase of check dam the NDWI values have increased A and also when the rainfall comes down the NDWI value does not come in down at once because there is water storage in the water structure. So, it will help to improve the NDWI and NDVI value which we see in this small exercise. This is very, very important because no where could you see that the NDWI is above peaking the rainfall data in high extreme.

So, for example, if it is a positive rainfall it goes positive, but here rainfall is going down and you should expect the NDWI and NDVI to go down, but you could see that both are highly stable which just stay stable or it goes actually up and the up is because of you have good water storage which is still recharging the surrounding area from the check dams. So, with this I think we have looked into one exercise where we have this change in the rainfall pattern.

But still it does not negatively impact the NDWI value and that is purely because of check dams because check dams do have that potential of doing this. So, this is a special recognition.

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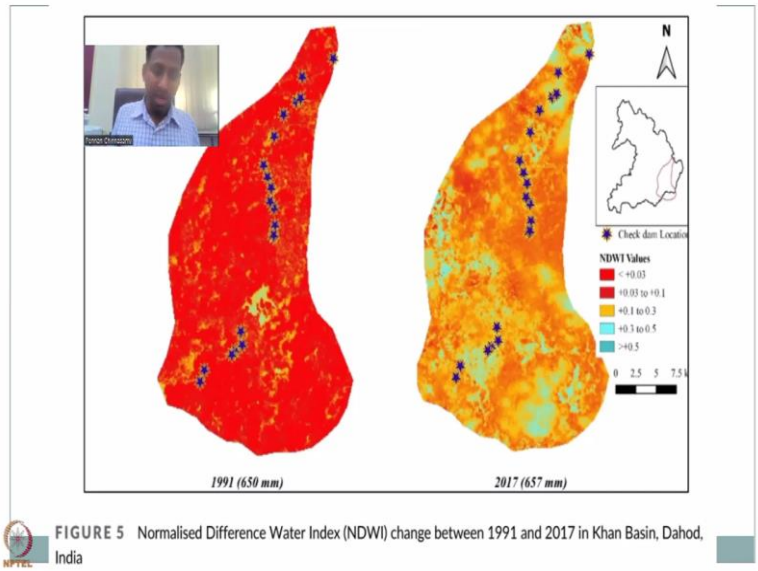

FIGURE 5 Normalised Difference Water Index (NDWI) change between 1991 and 2017 in Khan Basin, Dahod, India

And as I said the NDVI may not change drastically because mainly small, small vegetation shrubs are grown. If you go to this region the tribal region of Dahod you will see that mostly growing pickle, chilly, some fruits and vegetables like tomato, cucumbers etcetera, but not

high value crops and crops that can cover entire land. So, NDVI would not be a great estimation, but NDWI which talks about the water content is and you could clearly see that everywhere it was red during the 1991 650 mm rainfall period.

But during the 2017 657 millimeter rainfall period you could see that it has been improved from 0.03 to 0.1 to 0.5. So, all of these areas converting back to positives and the positive is definitely due to the increase in recharge from the check dams and special distribution of the water to all these locations and all these was done without even going to the field because I know the field.

I have been through the field the student had only very limited time of 2 months to 3 months to work on this. So, we gave them the location of the check dams, gave them the theory that the check dams the hypothesis of the check dams improve the NDWI or the null hypothesis it does not improve the NDWI value for which we had extracted the values and then plotted it and then see visually comparing and also very quantitative we are comparing because now we have the pixels values.

So, we can quickly say that 80% of these pixels values are above the red values. So, that clearly indicates that the soil water content and the surface water body storage across the basin has improved drastically because of the check dams, you could also see more and more of this happening in the downstream areas because water can percolate from high elevation to low elevation and that is what you are seeing that the water comes down.

And then gets reallocated into multiple sectors. So, those who cannot do this as a full exercise this exercise is done like you download the Dahod map first step and then you can put it into the location of the check dams, download the rainfall, download the landsat bands basic bands was for NDVI we have NDWI minus red and NDWI plus red whereas for this NDWI you could use a different band which is given here.

So, normalized difference vegetation index you can have for sentinel through I think we use sentinel landsat images because those are older images. So, BO3 minus BO5 by BO3 plus 5 for sentinel we can use B03, BO8. So, really good data set that can help these are the very, very important indicators that is why sentinel hub is also having it and you can clearly see that the difference between the images is very comparable.

So, I am just going to keep this image to the side here and this can come to until the Dahod Hub and then this can come here. So, you could see that on the right side you have a sentinel image from 2022 in Jan. So, almost Jan we are seeing same rainfall is happening similar rainfall, but you have better water bodies, number of water bodies and the number of water structures are really high which is really good to see.

Whereas here you can see that it is all white this is not enough water and this is also not enough water somewhere good water is there and then you have these big water bodies, but all of this is being increased drastically much more deeper water levels and that is what is reflecting in the NDWI values. So, with this I think we have showcased one study the time taking is very less 2 months is needed if you know how these GIS works.

And honestly I am saying if the students knew how to work with this dashboard and he would have done within a month also. So, you can just include your area of interest, download your data or upload your file for your boundaries and then after you log in you can just extract these datasets as needed and then you do have a data protocol to sign up and say I need this data and whom the data comes.

So, you could actually do wonders with this area of data and as I said you can add your share files of it. So, first basically we will make the share file in GIS or Google platform and then save it as a share file, bring it here and then download the data. So, it is always easy to download the data from these sources it is legit, it is from space agency so you would not have big bucks while storing the data.

Just be careful you do not have pop ups which could have been done by previous installation of other software not through GIS. So, you can download this image as a JPEG you want to show options or not and then with no Geo reference or you can Geo reference it. So, you can download and then Geo reference also as I said you can do analytical basic download image option is there maybe they are asking you to pay initially these were also free, you get free access to this but now we have to pay.

So, the point here is we can quickly do these maps you do not have to take and subtract two images to calculate the values. You can quickly do this and then estimate the differences based on the water that is being stored in the check dams. To be honest there is not lot of these studies that have been done like this and one of the reasons that is why this has been accepted in a very, very prestigious dam.

With this, I would stop today's lecture and I will see in the next lecture where we will talk more about some applications from the group and how we can us use RS and GIS for addressing them. Thank you.