

ECOL 572: ENVIRONMENTAL INFORMATICS AND MODLING

eLearning Module

Course Teacher

Prof. S Jayakumar

Dept. of Ecology & Environmental Sciences

Pondicherry University

Puducherry, India

Content

1. General Information
2. Course description
3. Course goal
4. Course outcome
5. Course structure
6. Course assessment
7. References

1. General Information

Course Code	:	ECOL - 572
Course Title	:	Environmental Informatics and Modeling
Number of Credits	:	4.0 ECTS
Course duration	:	18 Weeks
Level	:	Postgraduate
Course Teacher	:	Prof. S. Jayakumar
Prerequisite	:	Basic understanding on Mathematics (school higher level), English language skill, computer operation (Windows/Mac).

2. Course description

This course provides the fundamentals of environmental informatics, different types of database management system, spatial data structure, how to extract information from different data sources such as air borne data, space borne data, climate data, GPS, topographical maps and how to convert them into digital form. It also teaches the students how to integrate and analyse the trend and pattern. It also introduces the students the concept of weightage, how to assign class weightage and layer weightage. The fundamentals of spatial modelling and how to perform modelling to identify the suitability and vulnerability. It also introduces the components of an information system and of remote sensing. This course also demonstrates data collection using GPS, Map reading, DBMS, 2D analysis and 3D analysis

3. Course goals

The main aim of the course is to provide students what is environmental informatics and modeling and how can it be accomplished. The objectives of the course are to provide the important aspects of DBMS, to explain how do extract information from various datasets, to provide a fundamental understanding on how to integrate data, perform analysis and interpret the outputs, to provide the students to know about the basic components of information system, to make them understand how to perform suitability and vulnerability modeling and to demonstrate 2D and 3D data analysis.

4. Course outcome

By the end of the course, successful students will:

1. Know the significance of environmental informatics and its relevance to the natural resources management.
2. be familiar with various database management systems
3. be able to retrieve data from DBMS through query
4. know the different types of information extraction
5. be able to conceptualize the types of thematic maps required and the appropriate source of data to prepare the different types thematic maps in both analog and digital formats
6. be able to think spatially to manage the natural resources
7. be familiar with the concept and framework of information system.
8. know the concept of 2d and 3d data analysis.

5. Course structure

5.a. Course Content

Week - 1	Introduction to environmental informatics
	Environmental data, sampling, primary and secondary data
Week - 2	Data sources, data quality and standards
Week - 3	Introduction to database management system
Week - 4	Significance of DBMS and spatial data structures
Week - 5	Resource information extraction – air borne, space borne and data
	Resource information extraction from topomap and climate data
Week - 6	Digital database creation
	Introduction to data analysis and visualization
Week – 7	Data integration, trend analysis, pattern analysis
Week – 8	Understanding data layers and weightage
Week – 9	Spatial environment and spatial analysis
	Introduction to spatial modeling
Week – 10	Environmental suitability and vulnerability modeling
Week – 11	Structure and components of information system
Week – 12	Working with GPS and data handling
Week – 13	Map reading and information extraction
Week – 14	2d data analysis
Week – 15	3d data analysis

5. Course structure

Understanding the fundamentals of environmental informatics and
modeling in natural resources management

5.b. Mode of delivery



shutterstock.com · 1156405816

In-Class Lectures



PULSE

PONDICHERRY UNIVERSITY LEARNING SYSTEM

On-line lectures



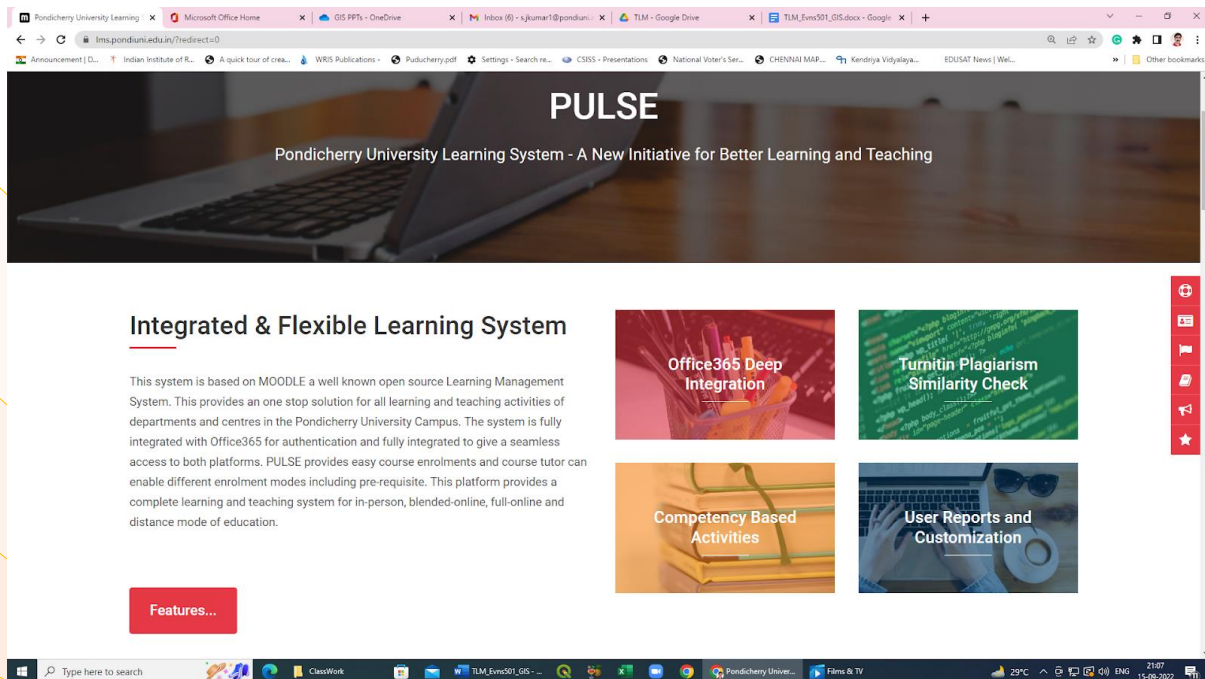
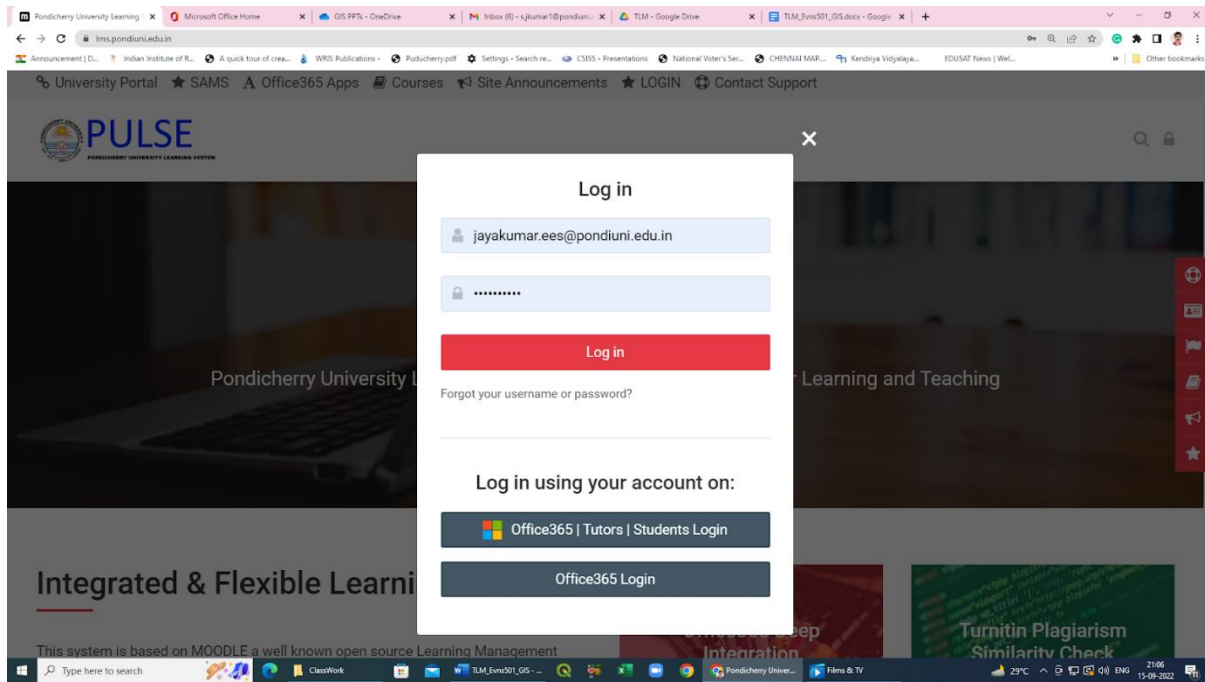
Microsoft OneDrive

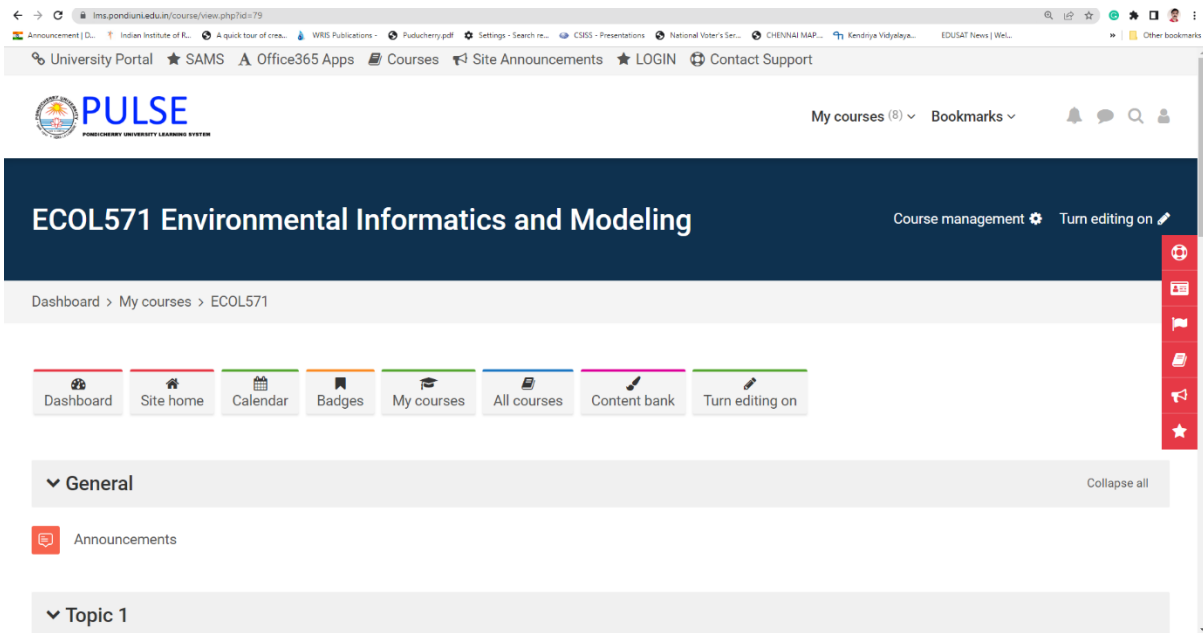


Microsoft Teams

**Students will get enrolled in Pondicherry
University Learning Management System and
the classes will be handled in hybrid mode**

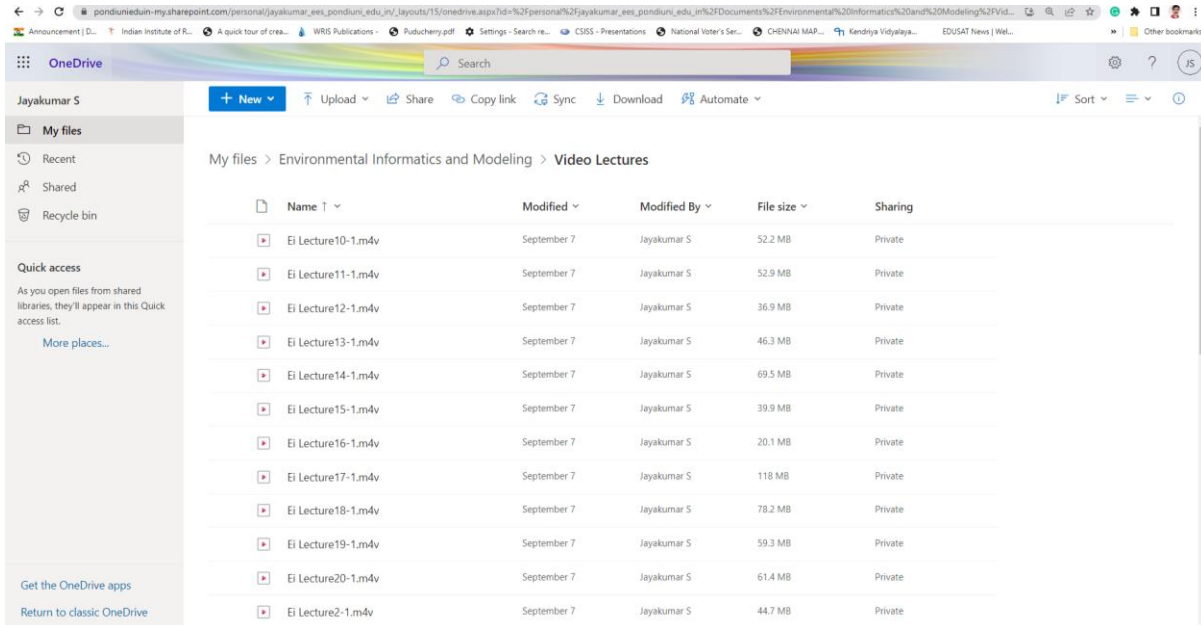
Pondicherry University Learning Management System (<https://lms.pondiuni.edu.in/>)





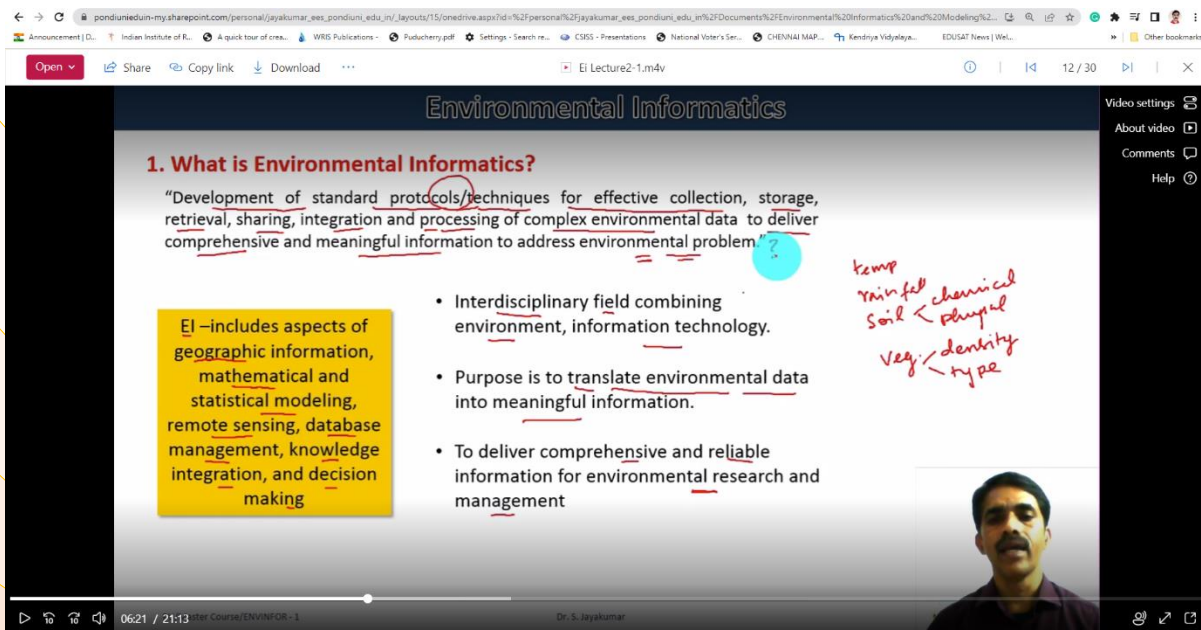
The screenshot shows a web browser window displaying the PULSE LMS interface. The browser's address bar shows the URL `lms.pondicherryuniversity.edu.in/course/view.php?id=79`. The navigation bar includes links for University Portal, SAMS, Office365 Apps, Courses, Site Announcements, LOGIN, and Contact Support. The PULSE logo is visible on the left, and user options for My courses (8) and Bookmarks are on the right. The main header for the course "ECOL571 Environmental Informatics and Modeling" is displayed in a dark blue bar, with "Course management" and "Turn editing on" options. Below the header, a breadcrumb trail reads "Dashboard > My courses > ECOL571". A horizontal menu contains buttons for Dashboard, Site home, Calendar, Badges, My courses, All courses, Content bank, and Turn editing on. The content area is organized into sections: "General" (with a "Collapse all" link) and "Topic 1". Under "General", there is an "Announcements" section with a red envelope icon.

Video Lectures stored in Microsoft One drive



Name	Modified	Modified By	File size	Sharing
Ei Lecture10-1.m4v	September 7	Jayakumar S	52.2 MB	Private
Ei Lecture11-1.m4v	September 7	Jayakumar S	52.9 MB	Private
Ei Lecture12-1.m4v	September 7	Jayakumar S	36.9 MB	Private
Ei Lecture13-1.m4v	September 7	Jayakumar S	46.3 MB	Private
Ei Lecture14-1.m4v	September 7	Jayakumar S	69.5 MB	Private
Ei Lecture15-1.m4v	September 7	Jayakumar S	39.9 MB	Private
Ei Lecture16-1.m4v	September 7	Jayakumar S	20.1 MB	Private
Ei Lecture17-1.m4v	September 7	Jayakumar S	118 MB	Private
Ei Lecture18-1.m4v	September 7	Jayakumar S	78.2 MB	Private
Ei Lecture19-1.m4v	September 7	Jayakumar S	59.3 MB	Private
Ei Lecture20-1.m4v	September 7	Jayakumar S	61.4 MB	Private
Ei Lecture2-1.m4v	September 7	Jayakumar S	44.7 MB	Private

Introduction to Environmental Informatics



Environmental Informatics

1. What is Environmental Informatics?

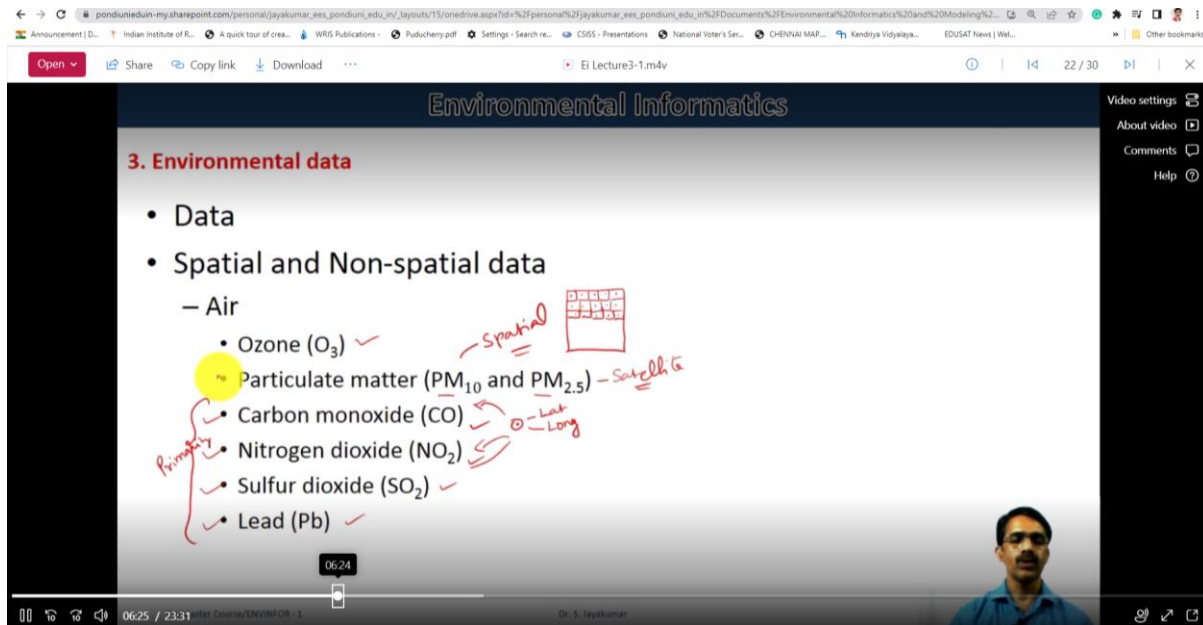
"Development of standard protocols/techniques for effective collection, storage, retrieval, sharing, integration and processing of complex environmental data to deliver comprehensive and meaningful information to address environmental problem."

EI includes aspects of geographic information, mathematical and statistical modeling, remote sensing, database management, knowledge integration, and decision making

- Interdisciplinary field combining environment, information technology.
- Purpose is to translate environmental data into meaningful information.
- To deliver comprehensive and reliable information for environmental research and management

Handwritten notes:
temp
rain fall
Soil ← chemical
veg. density
type

Environmental Data

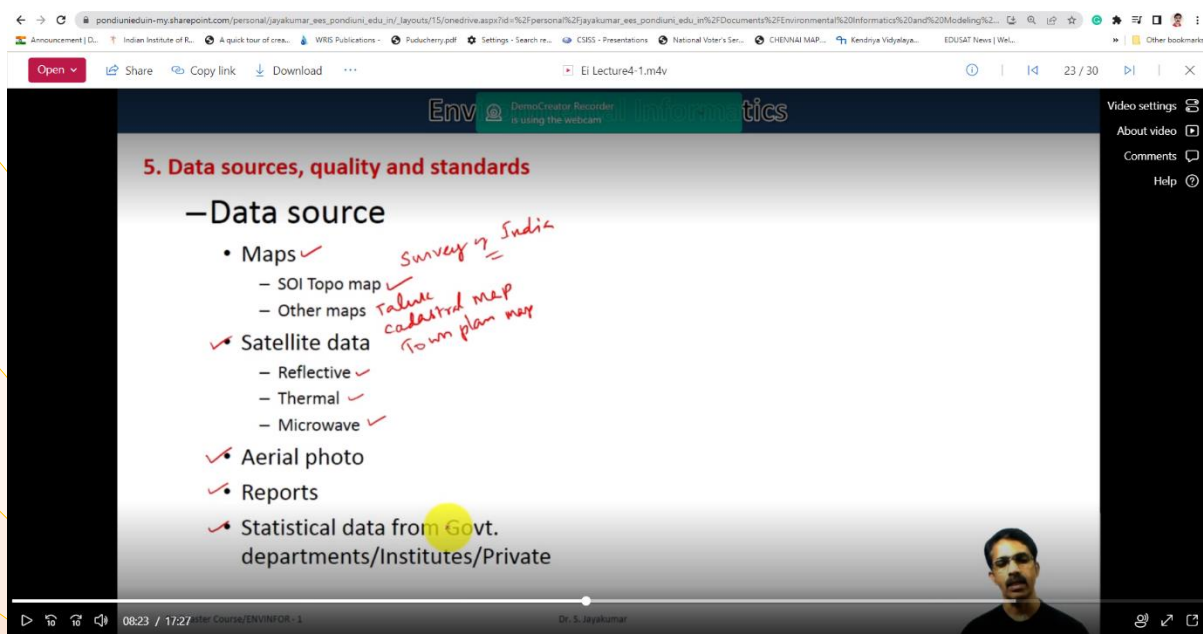


3. Environmental data

- Data
- Spatial and Non-spatial data
 - Air
 - Ozone (O₃) ✓
 - Particulate matter (PM₁₀ and PM_{2.5}) - *Satellite*
 - Carbon monoxide (CO) ✓
 - Nitrogen dioxide (NO₂) ✓
 - Sulfur dioxide (SO₂) ✓
 - Lead (Pb) ✓

Handwritten notes:
 - *Spatial* (with grid icon)
 - *Satellite* (with satellite icon)
 - *Primary* (bracketed around air pollutants)

Data Sources, quality and data standards



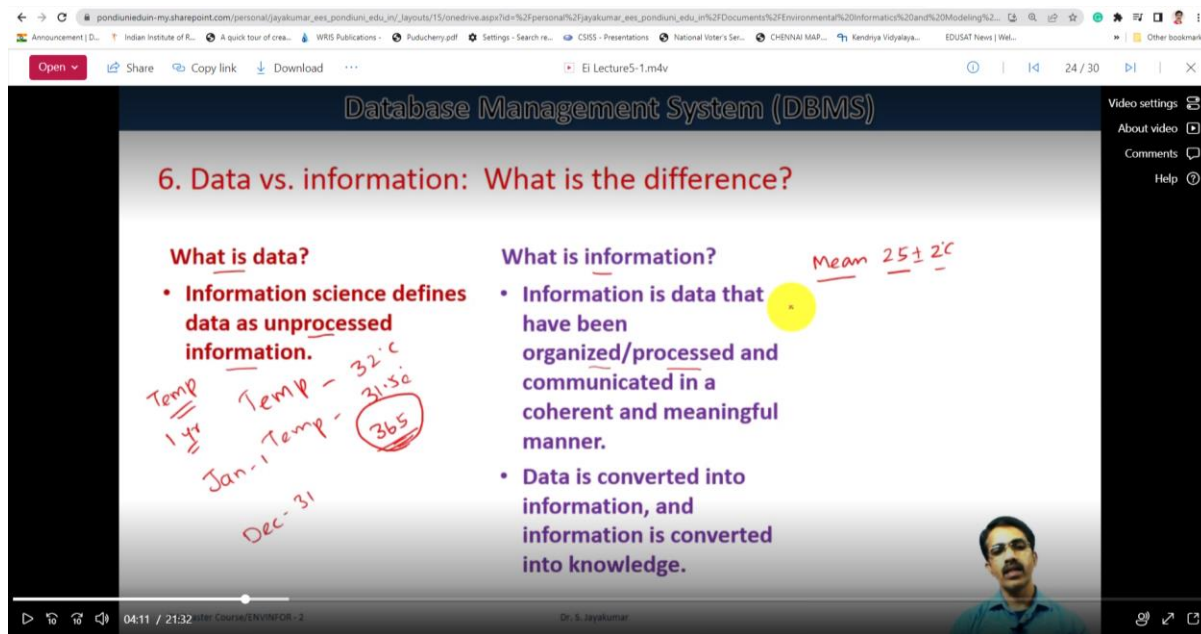
5. Data sources, quality and standards

–Data source

- Maps ✓
 - SOI Topo map ✓
 - Other maps ✓
- Satellite data ✓
 - Reflective ✓
 - Thermal ✓
 - Microwave ✓
- Aerial photo ✓
- Reports ✓
- Statistical data from Govt. departments/Institutes/Private ✓

Handwritten notes:
 - *Survey of India* (next to SOI Topo map)
 - *Taluk cadastral map Town plan map* (next to Other maps)

Data vs Information



6. Data vs. information: What is the difference?

What is data?

- Information science defines data as unprocessed information.

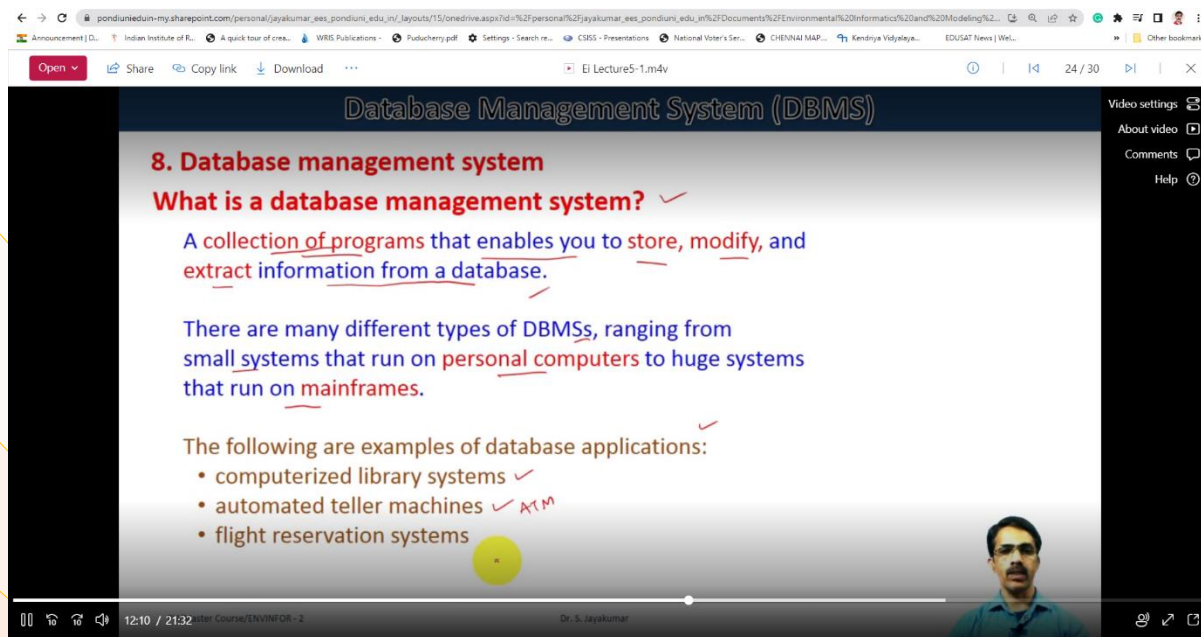
Handwritten notes: Temp 1 yr, Temp - 32°C, Jan-1 Temp - 31.5°C, Dec-31, 36.5

What is information?

- Information is data that have been organized/processed and communicated in a coherent and meaningful manner.
- Data is converted into information, and information is converted into knowledge.

Handwritten note: Mean 25 ± 2°C

Database management system



8. Database management system

What is a database management system?

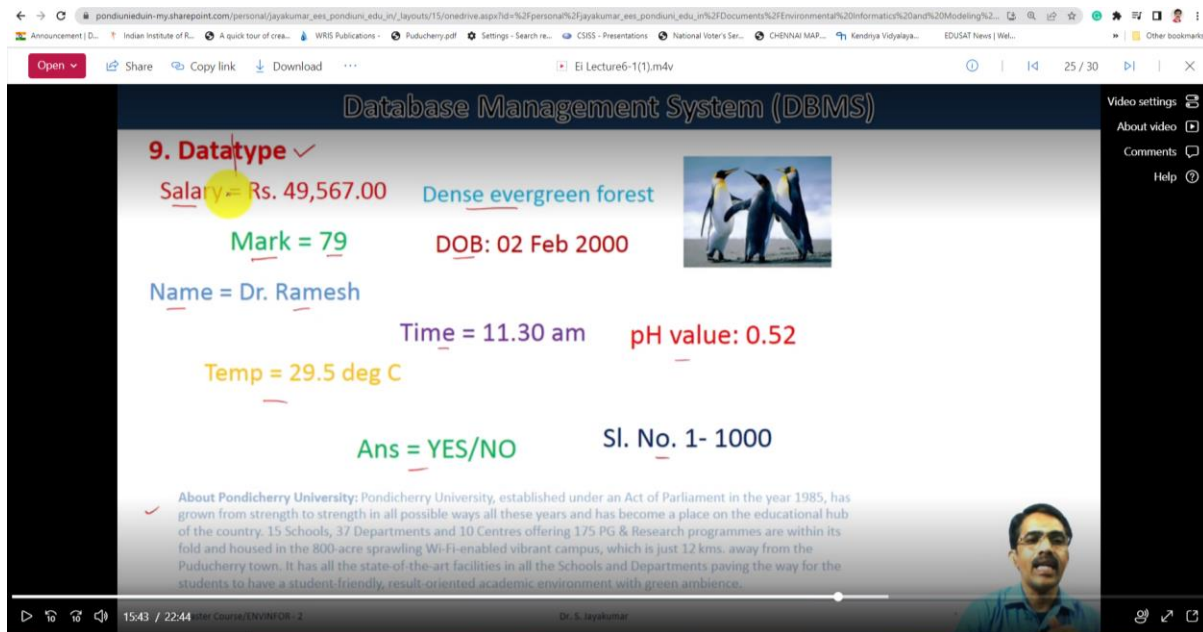
A collection of programs that enables you to store, modify, and extract information from a database.

There are many different types of DBMSs, ranging from small systems that run on personal computers to huge systems that run on mainframes.

The following are examples of database applications:

- computerized library systems ✓
- automated teller machines ✓ ATM
- flight reservation systems

Data types



9. Datatype ✓

Salary = Rs. 49,567.00 Dense evergreen forest

Mark = 79 DOB: 02 Feb 2000

Name = Dr. Ramesh

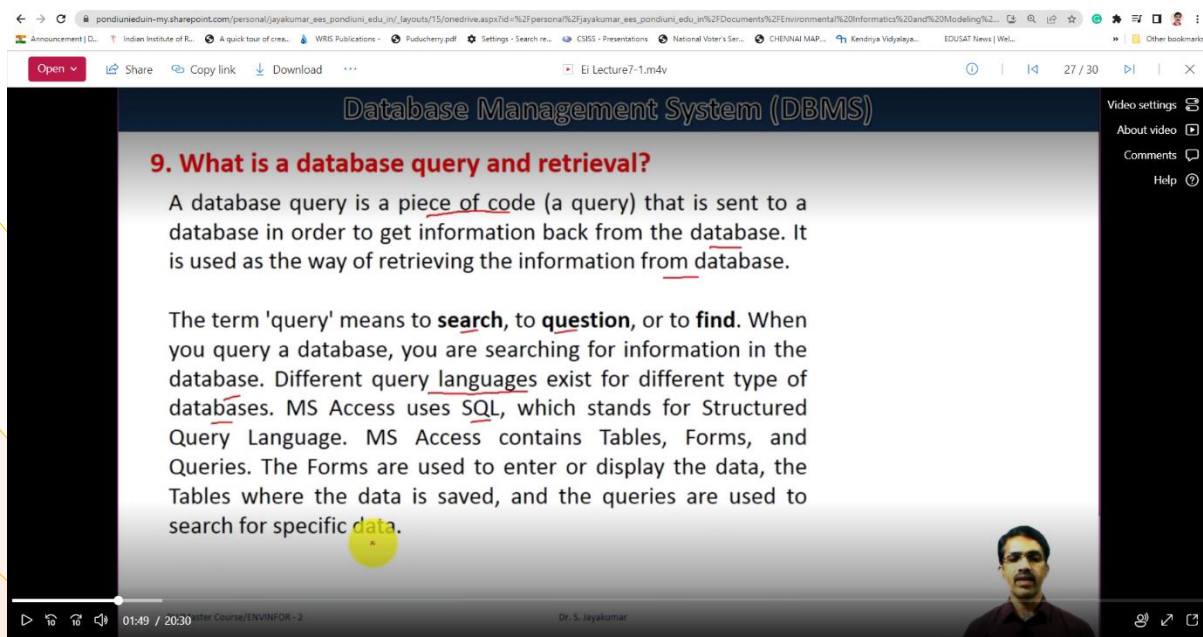
Time = 11.30 am pH value: 0.52

Temp = 29.5 deg C

Ans = YES/NO Sl. No. 1- 1000

About Pondicherry University: Pondicherry University, established under an Act of Parliament in the year 1985, has grown from strength to strength in all possible ways all these years and has become a place on the educational hub of the country. 15 Schools, 37 Departments and 10 Centres offering 175 PG & Research programmes are within its fold and housed in the 800-acre sprawling Wi-Fi-enabled vibrant campus, which is just 12 kms. away from the Puducherry town. It has all the state-of-the-art facilities in all the Schools and Departments paving the way for the students to have a student-friendly, result-oriented academic environment with green ambience.

Database query and retrieval



9. What is a database query and retrieval?

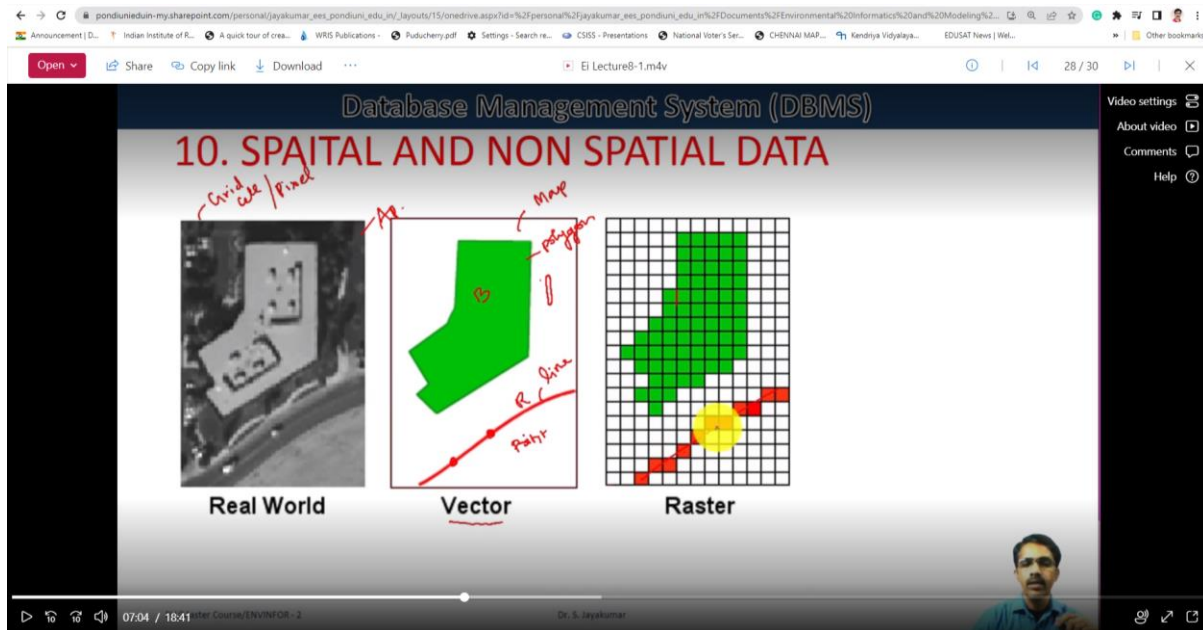
A database query is a piece of code (a query) that is sent to a database in order to get information back from the database. It is used as the way of retrieving the information from database.

The term 'query' means to **search**, to **question**, or to **find**. When you query a database, you are searching for information in the database. Different query languages exist for different type of databases. MS Access uses SQL, which stands for Structured Query Language. MS Access contains Tables, Forms, and Queries. The Forms are used to enter or display the data, the Tables where the data is saved, and the queries are used to search for specific data.

Spatial and Non-spatial data

Database Management System (DBMS)

10. SPATIAL AND NON SPATIAL DATA



Real World Vector Raster

07:04 / 18:41 Dr. S. Jayakumar

Characteristics of vector data

Database Management System (DBMS)

Characteristics of vector data:

Points

- **Zero-dimensional** points are used for geographical features that can best be expressed by a single point reference — in other words, by simple location.

Examples include wells, peaks, features of interest, and trailheads.

- Points convey the **least amount of information**.
- Points represent Areas - **scale**.

For example, cities on a map of the world might be represented by points rather than polygons.

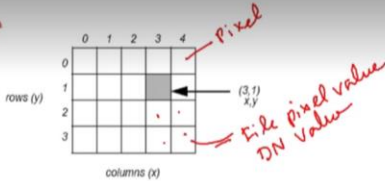
- **No measurements** are possible with point features.

14:03 Dr. S. Jayakumar

Spatial data structure

Database Management System (DBMS)

Spatial Data Structure



rows (y)

columns (x)

File coordinate system

Raster Data

- Data are divided into cells, pixels, or elements
- Cells are organized in arrays
- Each cell has a single value
- Row and Column Numbers are used to identify the location of the cell within the array.
- Perhaps the most common example of raster data is a digital image.

Which data model is suitable?

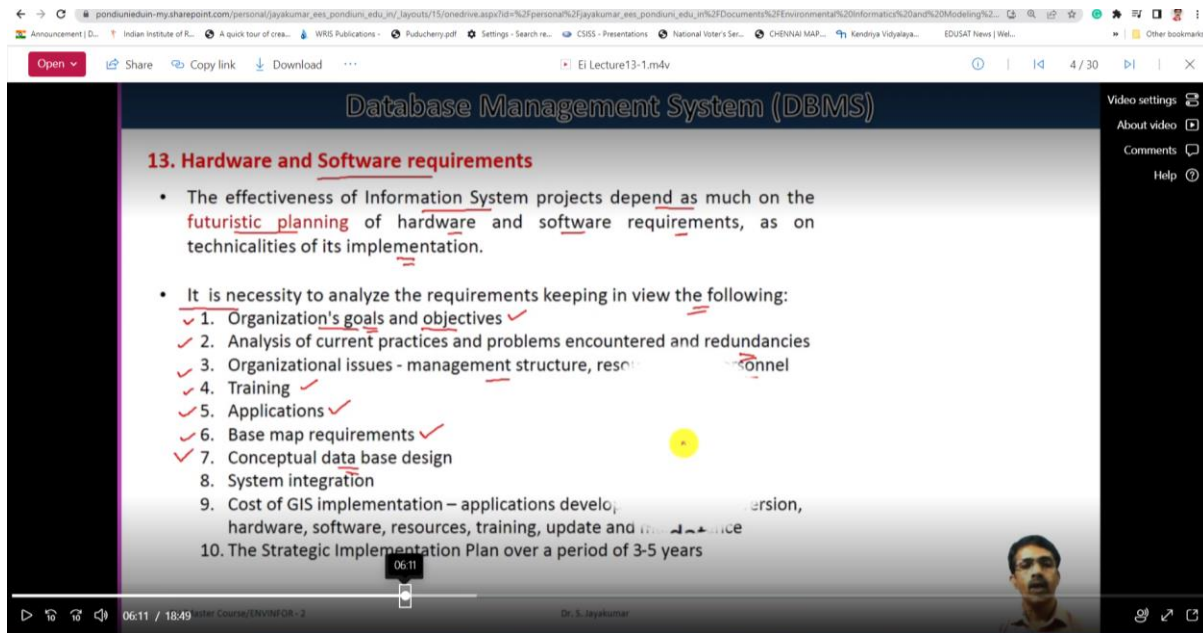
Database Management System (DBMS)

11. Which data model is suitable?

- The question of which data model to use in GIS depends on the nature and objective of the GIS project.
- Primarily the model type will depend on the nature of the data. Issues of concern are
 - the volume of the data generated,
 - ease of analysis and accuracy.
- Generally, vector data sets are economical, are relative size, and have a high level of positional precision, use in mathematical computations.
- On the other hand, grid data sets tend to take up more space and have a coarser resolution, but work with mathematical.

Handwritten notes: 'GIS Models Raster', 'Vector → Raster', 'not', 'difficult to'.

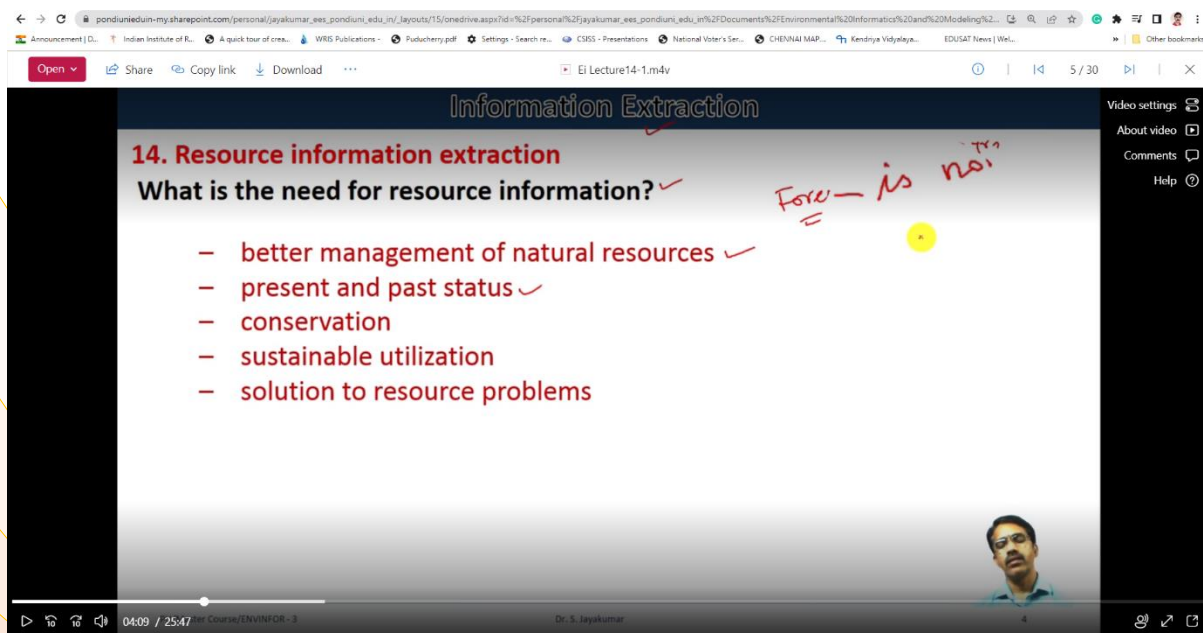
Hardware and software requirements



13. Hardware and Software requirements

- The effectiveness of Information System projects depend as much on the futuristic planning of hardware and software requirements, as on technicalities of its implementation.
- It is necessary to analyze the requirements keeping in view the following:
 1. Organization's goals and objectives ✓
 2. Analysis of current practices and problems encountered and redundancies ✓
 3. Organizational issues - management structure, resources, personnel ✓
 4. Training ✓
 5. Applications ✓
 6. Base map requirements ✓
 7. Conceptual data base design ✓
 8. System integration ✓
 9. Cost of GIS implementation – applications development, hardware, software, resources, training, update and maintenance ✓
 10. The Strategic Implementation Plan over a period of 3-5 years ✓

Resource information extraction



14. Resource information extraction

What is the need for resource information? ✓

- better management of natural resources ✓
- present and past status ✓
- conservation ✓
- sustainable utilization ✓
- solution to resource problems ✓

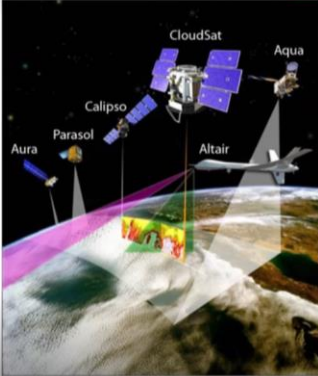
Foro - is not?

Space-borne data

Information Extraction

16. Space borne data

Space borne data – Remote Sensing images



- Satellites take picture of the earth surface from 700-800 km - picture from space
- Continuously take
- Sun-synchronous from 0.6m to 10.0m
- Pixel size varies
- Micro level
- Information extraction
 - Image interpretation
 - Classification
 - Visual
 - Digital
 - Unsupervised
 - Supervised
 - Expert
 - Object oriented
 - Head-up

Active Sensor - Microwave Passive

12:25 / 16:25 Dr. S. Jayakumar 36

Positioning system

Information Extraction

18. Positioning System

GPS

Global navigation satellite system (GNSS)

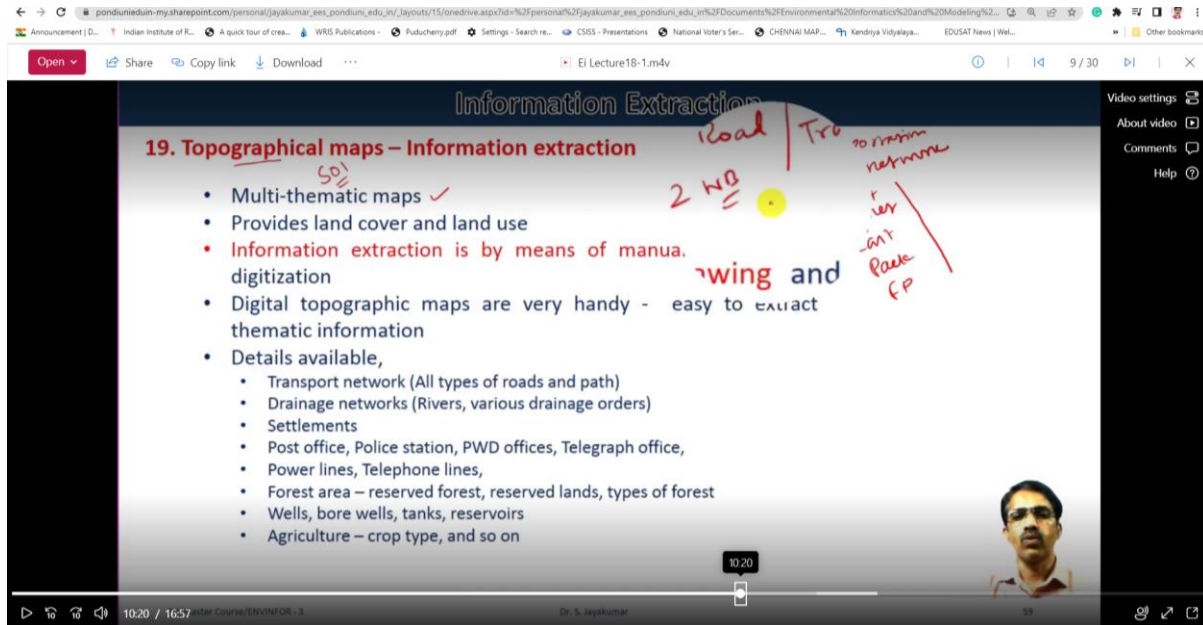
- NAVSTAR Global Positioning System (GPS) - USA 32 medium earth orbit satellites operations since 1978
- GLONASS - Russian since 1995
- Galileo - European Union - 30 MEO satellites some are operations since 2014, expected to be in full service till 2020
- Beidou-2 - China, 30 MEO satellites, expanding current regional service into global by 2020

Regional satellite navigation system

- Beidou-1 - China 16 satellites, covering Asia since DEC 2
- IRNSS - India 7 satellites covering India, 7 satellites launched, 5 will be operational.
- QZSS - Japan 3 satellites system for Japan, first satellite launched in 2010

04:19 / 16:57 Dr. S. Jayakumar 39

Information extraction from topographic map

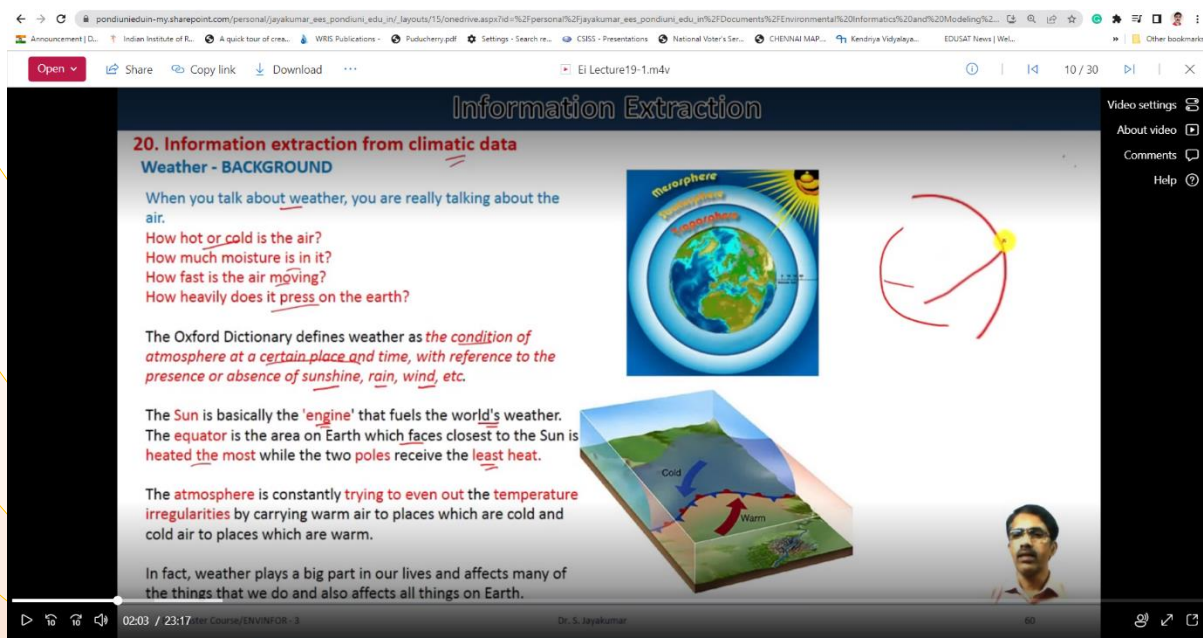


19. Topographical maps – Information extraction

- Multi-thematic maps ✓
- Provides land cover and land use
- Information extraction is by means of manual digitization
- Digital topographic maps are very handy - easy to extract thematic information
- Details available,
 - Transport network (All types of roads and path)
 - Drainage networks (Rivers, various drainage orders)
 - Settlements
 - Post office, Police station, PWD offices, Telegraph office,
 - Power lines, Telephone lines,
 - Forest area – reserved forest, reserved lands, types of forest
 - Wells, bore wells, tanks, reservoirs
 - Agriculture – crop type, and so on

Handwritten notes in red: Road / Tr, 2 HG, 20 min network, Air, PWD, FP, wing and

Information extraction from climatic data



20. Information extraction from climatic data

Weather - BACKGROUND

When you talk about weather, you are really talking about the air.

How hot or cold is the air?
How much moisture is in it?
How fast is the air moving?
How heavily does it press on the earth?

The Oxford Dictionary defines weather as *the condition of atmosphere at a certain place and time, with reference to the presence or absence of sunshine, rain, wind, etc.*

The Sun is basically the 'engine' that fuels the world's weather. The equator is the area on Earth which faces closest to the Sun is heated the most while the two poles receive the least heat.

The atmosphere is constantly trying to even out the temperature irregularities by carrying warm air to places which are cold and cold air to places which are warm.

In fact, weather plays a big part in our lives and affects many of the things that we do and also affects all things on Earth.

Diagrams: A globe showing the atmosphere and hydrosphere, and a 3D diagram of the atmosphere showing air circulation from warm to cold areas.

Surface temperature extraction from satellite data

Information Extraction

21. Air Temperature Information extraction from satellite data

Landsat Thematic Mapper

Thermal band

TM Band	Wavelength (um)	Band Name
6	10.4 - 12.5	Thermal Infrared
7	2.08 - 2.35	Shortwave Infrared
5	1.55 - 1.75	Shortwave Infrared
4	0.76 - 0.90	Near Infrared
3	0.63 - 0.69	Red
2	0.52 - 0.66	Green
1	0.45 - 0.52	Blue

Handwritten annotations on the thermal band image: "18010m", "1804m", "Band 6 = 30° ST".

PU/Master Course/ENVINFOR - 3 | Dr. S. Jayakumar | 68

Spatial database creation

Information Extraction

22. Spatial database creation

Symbolic Abstraction

Symbolize and Simplify

Video settings | About video | Comments | Help

20:17 / 25:29 | Dr. S. Jayakumar | 70

Spatial data analysis

27. SPATIAL ANALYSIS ✓

✓ Spatial analysis is a set of techniques for analyzing spatial data.

- The results of spatial analysis are dependent on the locations of the objects being analyzed.
- Software that implements spatial analysis requires access to both the locations of objects and their attributes.

```

    graph LR
      I1[Input] --> P((Process))
      I2[Input] --> P
      P --> O[Output]
  
```

02:54 / 18:52

Components of Information system

Components of Information system

- Computer hardware ✓
- Software ✓
- Databases ✓
- Human resources ✓
- Procedures ✓

- **Hardware:** The term hardware refers to machinery. This category includes the computer itself, which is often referred to as the central processing unit (CPU), and all of its support equipments. Among the support equipments are input and output devices, storage devices and communications devices.
- Different types of Hardware used for Computer Based Information System. **Input hardware** (Keyboard, mouse, etc.), **Processing hardware** (Processor, Memory, etc), **Output hardware** (Monitor, printer, etc) and **Storage hardware** (Disk drive, etc).

07:37 / 15:39

5. Course structure

5.c. In-class discussion

The main focus of discussion would be to understand the database management system, basic structure and function of information system

5.d. In-class assignments & field assignment

To understand information extraction from different data sources, basic framework of data collection, sampling, data quality standards

5.e. Reading and discussion of assigned papers for seminars

To understand the application of environmental informatics in various sectors, how do institutions make use of environmental informatics for better management of resources, how do people benefit of it, how to improve the information system more robust and user friendly.

5.f. Group project presentation

Ability to make presentation, effective communication, critical interpretation of data, response to audience

5. Course structure

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6. Course Assessment

Type of assessment	Percentage of Marks
In-class discussion	5
Assignment	5
Seminars	10
Group projects	10
Internal assessment test (MCQ types)	10
Final assessment	60
Total	100

7. References

1. Bungartz, HJ, Kranzlmuller D and Weinberg, V 2019. Advances and New Trends in Environmental Informatics: Managing Disruption, Big Data and Open Science Springer Publication. ISBN-13: 978-3030076191.
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4. Coronel, C., Morris, S., Rob, P., 2009. Database Systems: Design, Implementation and Management, 9th Ed., Course Technology, 700 pages, ISBN-13: 978-0538748841.
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6. Goodchild, M.F., Parks, B.O., Steyaert, L.T., (Eds.), 1993. Environmental Modeling with GIS (Spatial Information Systems) Oxford University Press, USA, 520 pages, ISBN-13: 978-0195080070.
7. Jorgensen, S. E., Chon, T-S., Recknage, F. A., 2009. Handbook of Ecological Modeling and Informatics, WIT Press, 448 pages, ISBN-13: 978-1845642075.