Geographical Information Systems (GIS) Concepts and Applications

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What is GIS ?

- A system for capturing, storing, checking, integrating, manipulating and displaying data which are spatially referenced to the earth. This normally considered to involve a spatially referenced computer database and application software

A set of tools for

- Collecting
- Storing
- Manipulating
- Retrieving
- Transforming and display of spatial data from the real world

Components of GIS

- A working GIS consists of five key components:
- Computer hardware
- Software,
- Geographic data, that can be calculated in terms of Latitude and Longitude
- People, include users and GIS experts
- Methods software permits users to input data corresponding to a geographic location and create maps and other geographic displays to analyze and present information.
- The displays typically include points, lines, areas or raster images (from photos or scanned images).
- GIS mapping is the process of inputting data layers into GIS software to produce a map.
- Maps present users with legible information that raw data can't display on its own.
- Different kinds of data such as streets, buildings , vegetation.etc can be shown on one map

Applications of GIS in Agriculture

Pricision Farming

- Adoption of highly precise set of practices that uses technology to cater to the needs of individual plots and crops.
- Production cost and losses reduced and overall environmental impact minimized.
- Manages spatial information to make decisions by comparing multiple variables like soils, previous crop yield, elevation terrain specifics, organic matter content, pH, moisture, and soil nutrient levels to arrive at location specific recommendations for precise farming.
- Combine harvesters equipped with GPS tracking units can measure crop yields along with crop quality values like plant water content and chlorophyll levels in real time and at the exact location in the field from which they are harvested

Variable rate technology (VRT),

- Combines farm machinery, control systems, and application equipment to apply precise amounts of growing inputs at exact times and locations.
- Precision farming with VRT has both economic and environmental advantages.
- Applying fertilizer, nutrients, or pesticides only where and when they are needed.

Real-time mapping:

- Data from satellites, aircraft, drones, and sensors are used to construct images and connect them with maps displaying crop position and health status, topography, soil type, fertilization and other related information.
- Methods software and other technologies shape this data into information that is accessible and interpretable to make efficient and informed decisions for maximum yields
- Monitoring yields, applying nutrients, using precision water sensors and identifying critical areas
- Landsat imagery can collect real-time data on soil moisture from the Earth's surface to assess and monitor the condition of the land, Vegetation growth.
- Normalized difference vegetation index (NDVI), as well as a variety of other techniques, are used to help estimate crop productivity and monitor drought and flooding on a global scale (GIS Geography, 2018)

Drone technology

- **C**ollects local field data such as plant height and biomass, flora counts, disease and weed presence, nutrient values, elevation etc
- Replace time-consuming tasks, normally performed by field traversing on foot to assess qualities of the flora and vegetation.

Crop sown or crop average area estimation

- Plays a crucial role in mapping and monitoring various crops sown area estimation.
- Satellite data such as Sentinel-1, 2, Landsat-8, World View-3, LISS-IV provide precise crop sown area and helps in crop loss assessment due to various catastrophic disasters.

Normalized difference vegetation index (NDVI)

- Primarily used for the assessment of vegetation dynamics, particularly in determining the crop health status.
- Quantifies vegetation greenness and density by analyzing the difference between near-infrared and red light reflectance using mathematical calculations
- Helps in understanding the crop phenology as it explains the crop chronology and their relationship with weather and climate (season).

Crop diseases identification

- Provides information of spatial distribution of diseases and pests over a large area with relatively low cost.
- Use of satellite imagery and spatial analysis techniques, helps identification of areas having crops infected with pests like Mealy bug, Plant Hopper, and White Fly Soil Properties

Soil properties

- Characteristics like soil pH, soil organic matter, soil texture, soil moisture nutrient status and other properties can be inferred, mapped and related to crop growth.
- Change in farming system and land management impacts soil change which can also be monitored and appropriate strategies evolved

Flood impact

- Satellite imageries provides significant information on flood damages along with ground-based data collected from surveying teams, .
- Precise damage assessment of floods due to high rainfall, and the absence of proper drainage system causing inundation.
- Flood due to overflow ultimately forms small tributaries and joins the river, creating a situation of flood in the vicinity of river banks and river plains.
- The damage assessment of floods can significantly improve the role of land use planning in managing flood risk

NATCAT Modeling

- Natural Catastrophe modelling is a system to estimate the real-time or possible forecast of risk assessment, using the probabilistic approach to predict the outcome and behavior of natural hazards.

Drone image analysis for crop damage assessment

- Very useful in micro-level crop assessment for crop loss due to hailstorm, horticulture tree counting, diseases, and pest attak etc
- Accuracy of drone image data is directly related to the spatial resolution of the input imagery
- Spatial resolution is very high ranging from 50 cm and can be increased as per requirement.

Crop yield prediction

- Tentative yield of a crop can be assessed keeping in view the health of the crop using the colour image of High Resolution satellite data (HR).to the extent of 90 percent accuracy

Land Use Planning

- GIS can present combinations of map layers to address different agricultural problems.
- Land characteristics like slope, soil depth, erosion, average rainfall, elevation,
- soil properties can be shown in one map.
- Using these detailed maps, most efficient and cost-effective way to use their land for various purposes.

Water management

- Monitors rain water movement so as to evolve appropriate soil conservation measures to slow down water movement
- Improve water percolation to lower layers so as to minimize soil erosion
- In landscape depressions and level lands, measures to prevent water logging and improve internal drainage can be taken up

Crop suitability mapping

- Soil characteristic maps with several crop related themes such as salinity, internal drainage, pH and various other chemical and physical properties can be prepared
- and suitable crops based on soil properties can be assigned to different areas and crop suitability maps prepared.

Meeting global demands for food

- Current production of crops will need to double by 2050 in order to meet future needs for food (GIS Geography, 2018).
- GIS is not only being used for real-time analyses, but also to compare historical data.
- Landsat imagery can be used to assess historical trends of agricultural land use over time and plan for locating and extending arable land needed to supply food to the future population

Other Applications of GIS

- Geographic Information Systems are powerful decision-making tools for various areas affecting human life some impotent areas are enumerated

Forest management

- Assisting forest managers to evaluate and analyze the forest cover, species diversity, age and size of timber, timber density, and volume.

Urban planning

- Human side of urban expansion and assist in planning.

Navigation

- Map applications that are used on smartphones and in vehicles rely heavily on GIS data to keep their maps updated to the second for establishing and monitoring routes.

Environment mapping & Pollution control

- Using GIS, a single map could include sites that cause pollution, such as factories, and sites that are sensitive to pollution, such as wetlands and rivers.other hotspots for initiating reclamation measures
- Crime mapping
- Accidents and Hot Spot analysis

- Disaster management and Mitigation
- Management of telecom and network services
- Infrastructure mapping
- Transportation planning
- Municipal planning, assets management, maintenance
- Many other areas have also been identified.

References

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Thank You