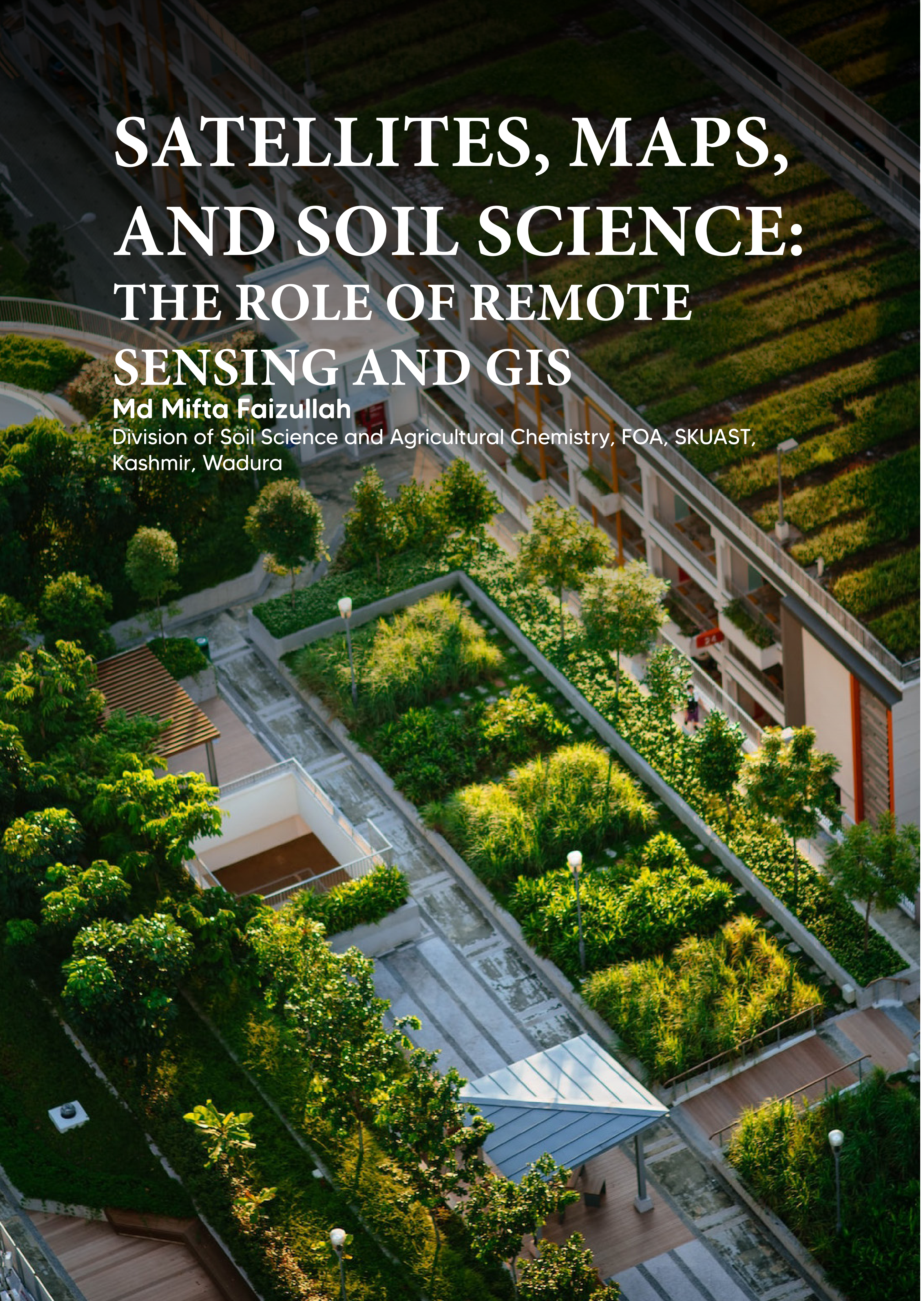

SATELLITES, MAPS, AND SOIL SCIENCE:

THE ROLE OF REMOTE SENSING AND GIS

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REMOTE SENSING (RS)

Remote sensing involves drawing conclusions about soil surface properties through measurements of electromagnetic radiation either emitted or reflected from the land surface. The characteristics of this radiation vary based on the physical and chemical attributes of the soil. As a result, analyzing the measured radiation allows for the study of soil properties and processes, enabling differentiation between different types of soils.

Remote sensing systems can be categorized as passive or active depending on the light source employed. Passive remote sensing, exemplified by imaging spectrometers and multispectral instruments, utilizes various segments of the electromagnetic (EM) spectrum, including Visible near infrared (VNIR), shortwave infrared (SWIR), thermal infrared (TIR), and microwave wavelengths. Conversely, active sensors predominantly utilize the microwave portion of the EM spectrum. Passive remote sensing encompasses four sensor types: optical multispectral sensors (applied in land use and mineralogical studies), optical imaging spectroscopy sensors (employed for retrieving soil properties like mineral composition, Fe-oxides, and organic matter), optical TIR sensors (used for estimating soil temperature), and passive microwave sensors (applied in soil moisture estimation). Active remote sensing involves synthetic aperture radar (SAR) sensors (utilized for estimating soil moisture, texture, and salinity), radar scatter meter sensors (employed in soil moisture estimation), and LiDAR sensors (utilized for terrain analysis).

Based on platform, remote sensing (RS) can be conducted via ground-based, air-borne, or space-borne methods. Air-borne and space-borne sensors offer broader geographical coverage in contrast to ground-based sensors. Radar and passive microwave systems primarily offer soil-related information on a regional or catchment scale. Airborne systems such as LiDAR, multi-spectral, and hyperspectral instruments have the capability to achieve higher spatial resolutions. Additionally, they can discern variables like mineral composition, moisture content, and elevation, among others.

Recent years have witnessed significant advancements in both optical and microwave remote sensing techniques. These breakthroughs have enabled the comprehensive study of numerous soil parameters, including mineralogical composition, soil texture, soil moisture, organic carbon content, soil salinity, iron content, carbonates, erosion, and digital soil mapping (DSM). Effective land use planning requires soil maps at various scales, each catering to different levels of detail. As the scale increases, the availability of information also expands. For soil maps at scales of 1:250,000 or smaller, coarse-resolution data from sensors like IRS LISS-I, AWiFs, and LANDSAT MSS can be employed. Medium-resolution data from satellites such as LANDSAT TM, IRS LISS-II, and SPOT-MLA are useful for generating soil maps at a scale of 1:50,000. Detailed soil resource characterization at a scale of 1:10,000 or larger can be achieved using data from satellites like IRS-P6 (LISS-IV sensor), Cartosat-1, Cartosat-2, and IKONOS.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS can be defined as a suite of tools designed for the purpose of collecting, storing, retrieving, transforming, and visually representing spatial data derived from the real world, all according to predefined objectives. This encompasses four core software functions: input, storage, manipulation, and output of spatial information. The architecture of a GIS system is such that it can efficiently accommodate vast quantities of spatially distributed data originating from diverse sources. This includes information obtained from sources like satellite data and topographical maps. By utilizing GIS, the process of handling both spatial and non-spatial data is streamlined, facilitating tasks such as soil mapping and characterization. Through the use of GIS, challenges linked to data integration stemming from differing geographic units across various datasets can be mitigated.

The primary aim of GIS is to convert raw data into novel insights via methods like overlay and other operations, thereby furnishing support for informed decision-making. The utilization of GIS has witnessed a considerable surge in recent times. Its applications have rapidly expanded in conjunction with advancements in remote sensing, providing a robust framework for tackling intricate spatial issues in more effective ways.

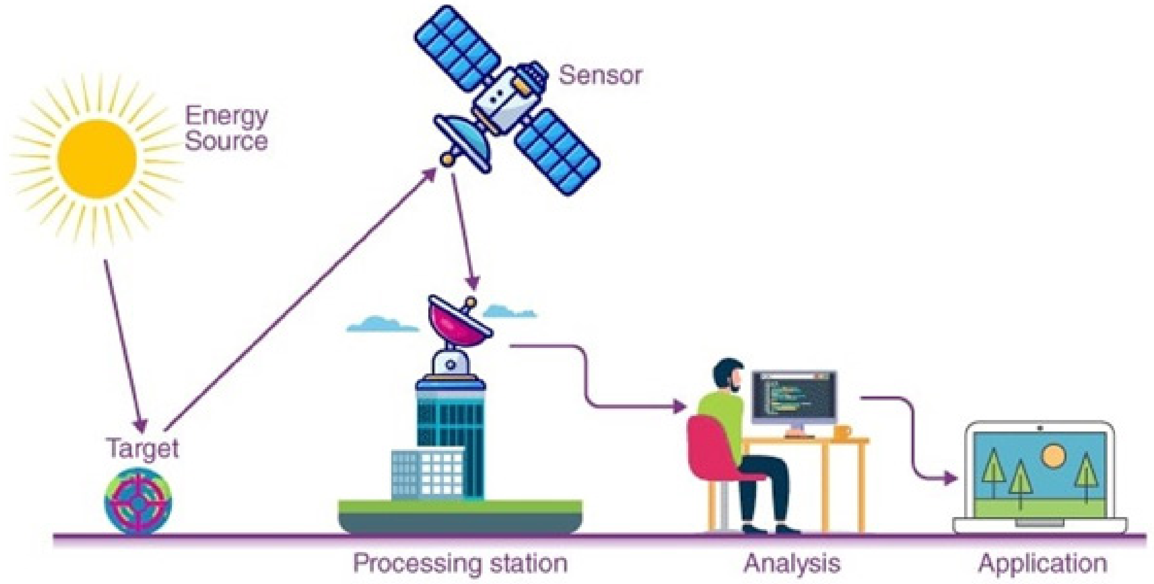

Figure 1: Schematic diagram of working principle of remote sensing

APPLICATIONS OF REMOTE SENSING AND GIS IN SOIL RELATED STUDIES

1. Soil Classification and Mapping:

Remote sensing data, such as satellite imagery and aerial photographs, can be used to classify and map different soil types based on their spectral signatures. This helps in creating detailed soil maps that provide valuable information for land use planning, agriculture, and environmental management.

2. Soil Erosion and Degradation Assessment:

Remote sensing can monitor soil erosion and degradation over time by capturing changes in land cover, vegetation, and topography. This information aids in identifying vulnerable areas and implementing erosion control measures.3

3. Soil Moisture Monitoring:

Remote sensing instruments can measure soil moisture content across large areas, providing valuable data for agricultural irrigation management, drought monitoring, and water resource planning.

4. Land Degradation Monitoring:

By analyzing remote sensing data, researchers can track land degradation processes such as desertification, salinization, and soil compaction. GIS tools help in quantifying the extent and severity of these issues.

5. Precision Agriculture:

Remote sensing data can assist in assessing crop health and nutrient status by analyzing vegetation indices derived from satellite imagery. This information enables farmers to make informed decisions about fertilization and irrigation.

6. Soil Fertility Mapping:

GIS can integrate soil data with other geospatial information to create soil fertility maps. These maps guide farmers

in optimizing nutrient management and improving crop yields.

7. Hydrological Modeling:

GIS facilitates the integration of soil data into hydrological models, enabling accurate simulations of water movement, infiltration, and runoff in watersheds. This is essential for managing water resources and predicting floods or droughts.

8. Soil Carbon Monitoring:

Remote sensing can contribute to monitoring soil carbon levels by assessing vegetation cover and land use changes, which impact carbon sequestration rates.

9. Urban Planning and Construction:

GIS tools aid in selecting suitable sites for construction projects by considering soil properties, stability, and drainage characteristics. This ensures sustainable urban development.

10. Environmental Impact Assessment:

Remote sensing and GIS support environmental impact assessments by analyzing soil conditions before and after human activities such as mining, construction, and deforestation.

11. Soil Contamination Detection:

Remote sensing can identify areas with potential soil contamination by detecting anomalies in land cover and vegetation health, guiding further soil sampling and analysis.

12. Wildfire and Disaster Management:

GIS and remote sensing aid in assessing soil susceptibility to erosion and landslides after wildfires or natural disasters, aiding in post-disaster rehabilitation planning.

CONCLUSION:

The conservation and utilization of resources, particularly soil and land, require not only protective and restorative measures but also a scientifically grounded approach for sustainable management. This approach ensures that proposed changes to meet developmental needs are enacted without compromising the potential for future utilization. By assessing the suitability of agro-ecological zones for various alternative uses through detailed information analysis, an optimal course of action can be recommended. This process takes into consideration both the socio-economic circumstances of the local farming community and the governing policies. An examination of the application of high-resolution remote sensing data in conjunction with GPS and GIS reveals that the mapping and characterization of soil resources can be achieved in a cost-effective and time-efficient manner. This approach enhances the efficient management and sustainable utilization of these resources. By integrating remote sensing data and GIS technologies, soil scientists, environmental researchers, and land managers can enhance their understanding of soil dynamics, make informed decisions, and contribute to sustainable land use practices.