

**DESIGNING AND COMPILING AN AGRICULTURAL MAPPING SYSTEM
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Abstract: This article presents a comprehensive approach to designing and compiling an agricultural mapping system for the Surkhondarya region of Uzbekistan. Leveraging Geographic Information Systems (GIS) and remote sensing technologies, the proposed system aims to enhance agricultural land management, optimize resource allocation, and support sustainable development in a region characterized by unique agro-climatic conditions and significant agricultural potential. The methodology integrates various data sources, including satellite imagery, cadastral records, and field observations, to create thematic maps for crop classification, soil analysis, irrigation network management, and land use dynamics. The system's architecture emphasizes data acquisition, processing, database design, and interactive visualization, providing a robust tool for decision-makers and agricultural specialists.

Key words: GIS compilation, agricultural mapping, spatial database, system architecture, digital cartography, remote sensing, satellite imagery, precision agriculture.

Agriculture plays a pivotal role in the economy and food security of Uzbekistan, with significant contributions from regions like Surkhondarya. Located in the southernmost part of the country, Surkhondarya is known for its diverse agricultural production, including strategic crops like cotton and wheat, as well as various horticultural products such as grapes, pomegranates, and subtropical fruits. However, the region faces challenges such as water scarcity, soil salinization, and land degradation, which necessitate efficient and data-driven approaches to agricultural management. The advent of Geographic Information Systems (GIS) and remote sensing (RS) technologies offers powerful tools for addressing these challenges by providing capabilities for spatial data acquisition, analysis, and

visualization. This article outlines the design and compilation of an agricultural mapping system specifically tailored for the Surkhondarya region. The objective is to develop a comprehensive, interactive, and user-friendly system that can support informed decision-making, optimize agricultural practices, and contribute to the sustainable development of the region's agricultural sector. Surkhondarya region's geography is diverse, ranging from mountainous areas to fertile river valleys, with a continental climate characterized by hot summers and mild winters.

Certain areas, particularly around Denau and Termez, benefit from a unique microclimate suitable for subtropical fruit cultivation. The primary agricultural activities revolve around cotton and wheat cultivation, which are central to national agricultural policies. Additionally, the region is a significant producer of table grapes, pomegranates, persimmons, and early vegetables. Livestock farming also thrives, utilizing extensive rangelands in the hilly terrains. Water resources are critical for agriculture in Surkhondarya, with major irrigation systems like the Amu-Zang Irrigation System and rivers such as Surkhandarya and Sherabaddarya supplying water to agricultural lands. The reliance on pumping stations for water distribution highlights the infrastructural complexities and the importance of efficient water management. Despite these resources, the region grapples with environmental issues, including soil salinization, reduced soil fertility, and land degradation, which are exacerbated by intensive irrigation practices and climate change. These factors underscore the urgent need for advanced mapping and monitoring systems to ensure sustainable agricultural development. Designing an effective agricultural mapping system for Surkhondarya involves a multi-faceted methodology that integrates GIS and remote sensing techniques. The process can be broadly categorized into data acquisition, preprocessing, classification and analysis, database design, and system integration. Data acquisition is the foundational step, involving the collection of various spatial and non-spatial datasets. Key data sources include:

- ❖ High-resolution imagery from Sentinel-2 (10m spatial resolution) is crucial for detailed land cover and crop type mapping. Landsat 8/9 provides historical data for change detection, while MODIS can be used for broader phenological studies. Commercial satellites like Planet offer very high-resolution data for specific areas if needed.
- ❖ Official land parcel information from the Chamber of State Cadastres of Uzbekistan provides essential boundaries and ownership details.

- ❖ Ground truth data collected through GPS-enabled field surveys are vital for calibrating remote sensing classifications and validating map accuracy.
- ❖ This includes topographic maps, soil maps, meteorological data, and socio-economic statistics relevant to agricultural production.

Raw satellite imagery and other spatial data require extensive preprocessing to ensure accuracy and consistency. This involves:

- ❖ Removing atmospheric effects from satellite images to obtain accurate surface reflectance values.
- ❖ Aligning all spatial datasets to a common coordinate system to ensure precise overlay and analysis.
- ❖ Techniques such as radiometric and spatial enhancement to improve image quality for visual interpretation and further analysis.
- ❖ This phase focuses on extracting meaningful agricultural information from the preprocessed data:
- ❖ Classifying the entire region into different land use and land cover categories, with a particular focus on agricultural lands. This can be achieved using supervised or unsupervised classification algorithms on satellite imagery.
- ❖ Identifying and mapping specific crop types (e.g., cotton, wheat, grapes) using time-series satellite data and phenological characteristics. Machine learning algorithms like Random Forest or Support Vector Machines (SVM) are highly effective for this purpose.
- ❖ Calculating indices such as Normalized Difference Vegetation Index (NDVI) for crop health monitoring, Enhanced Vegetation Index (EVI), and Normalized Difference Water Index (NDWI) for water stress assessment.
- ❖ Integrating existing soil maps with remote sensing data to identify soil types, assess soil moisture content, and monitor salinization levels.
- ❖ Digitizing and mapping the intricate network of irrigation canals, pumping stations, and drainage systems, crucial for water resource management.

A robust GIS database is central to the mapping system, enabling efficient storage, retrieval, and management of spatial and attribute data. A relational database management system (RDBMS) with spatial extensions, such as PostgreSQL with PostGIS, or Esri's File Geodatabase, can be utilized. The database schema should include thematic layers for:

- ❖ Agricultural land parcels with attributes like area, crop type, ownership, and irrigation source.
- ❖ Soil characteristics (e.g., texture, pH, salinity).
- ❖ Irrigation infrastructure (canals, pumps, drainage).
- ❖ Crop health and yield data.
- ❖ Administrative boundaries.

The final stage involves integrating all components into a cohesive system and developing interactive visualization tools. This includes:

- ❖ Developing a web-based GIS application that allows users to view, query, and analyze agricultural maps. Platforms like ArcGIS Online/Enterprise or open-source alternatives like GeoServer and OpenLayers can be used.
- ❖ Creating dashboards (e.g., using ArcGIS Dashboards) to present key agricultural indicators, trends, and alerts in an easily digestible format.
- ❖ Developing mobile apps for field data collection (e.g., ArcGIS Field Maps) and for providing real-time information to farmers and extension workers.

The proposed agricultural mapping system for Surkhondarya region would comprise several interconnected modules:

1. **Data Layer:** Consisting of raw and processed satellite imagery, cadastral data, field survey data, and other ancillary geographic information.
2. **GIS Server:** Hosting the spatial database and providing GIS functionalities through web services. This layer would handle spatial queries, analysis, and data dissemination.
3. **Application Layer:** Including web-based and mobile applications for various user groups (farmers, agricultural specialists, policymakers). These applications would offer functionalities such as interactive map viewing, data querying, reporting, and decision support tools.
4. **Analysis Module:** Incorporating advanced spatial analysis tools, remote sensing image processing algorithms, and machine learning models for crop classification, yield prediction, and environmental monitoring.

Conclusion

The design and compilation of an agricultural mapping system for the Surkhondarya region of Uzbekistan, utilizing GIS and remote sensing technologies, offers a transformative solution for enhancing agricultural productivity and

sustainability. By providing accurate, timely, and spatially explicit information on land use, crop types, soil conditions, and irrigation networks, the system empowers stakeholders to make informed decisions, optimize resource management, and mitigate environmental challenges. The proposed methodology and system architecture lay the groundwork for a robust and scalable platform that can significantly contribute to the region's agricultural development and resilience in the face of evolving environmental and economic pressures.

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