NeLIS: System Architecture and Transparency

Suresh Manandhar[1], Susheel Dangol[1]
sureshmdhr@gmail.com, susheel.dangol@nepal.gov.np
[1]Survey Department

KEYWORDS

NeLIS, LIS, Transparency, Architecture

ABSTRACT

Land Information Systems (LIS) are critical tools for effective land administration, promoting efficiency, tenure security, and strategic urban planning. This paper examines the development and implementation of the Nepal Land Information System (NeLIS) and its public portal, MeroKitta. We detail NeLIS's system, business, and information architectures, which utilize a modified three-tier client-server model to securely separate internal cadastral operations from external citizen services. Transitioning to this centralized architecture required rigorous spatial and attribute data harmonization to resolve topological errors, schema drift, and linguistic variations in legacy decentralized databases. Furthermore, the study highlights how NeLIS enhances functional transparency and accountability. Through real-time transaction tracking, Lead Time Velocity monitoring, automated SMS notifications, and integration with the Revenue Management Information System (RMIS), the system clarifies responsibilities and reduces bottlenecks. Ultimately, this standardized LIS architecture streamlines workflows, secures land records, and empowers citizens with accessible, trustworthy information, laying the groundwork for sustainable land governance.

1. LAND INFORMATION SYSTEM (LIS)

Information System (IS) is the set of components to collect, analyze and disseminate information to the user which is discussed as the interaction between people, processes, data and technology in general (Gupta, 2013). Land Information System (LIS) is the special type of IS which capture, process, store, analyze disseminate and share information about the land. It is designed to collect, store, reference, process, and retrieve land-related information, comprising four key components: data, processes, technology, and human resources.

"The International Federation of Surveyors (FIG) defined a land information system as a tool for legal, administrative and economic decision-making and an aid for planning and development. A land information system consists of a database containing spatially referenced land-related data for a defined area including procedures and techniques for the systematic collection, updating, processing and distribution of the data" (UN, 2005). LIS supports cadaster and land registration activities as well as land use planning, land valuation, and broader land resource management. (Tuan, 2006).

DOI: https://doi.org/10.3126/njg.v25i1.95092

An LIS consists of a spatially referenced land-related database for a defined area, along with procedures and techniques for the systematic collection, updating, processing, and dissemination of data (Tuan, 2006). More specifically, an LIS comprises essential components that support land transactions, namely data sets, processes or functions, hardware and software, and people (Tuladhar, 2005).

The cadaster, which acts as the comprehensive registry of individual land parcels, constitutes the primary component of an LIS (Dhal, 2002; Zhao, 2010). A LIS facilitates quick, reliable, and streamlined land transactions through a one-stop service, while also supporting urban planning, infrastructure development, land reform, dispute reduction, and related initiatives. Broadly, the advantages of a LIS can be examined in terms of efficiency, effectiveness, and the creation of competitive advantage.

LIS reduces labor demands, minimizes the need for physical storage of analog documents, enables automated control processes that facilitate data sharing, and ultimately delivers higher-quality services. It also supports land administration functions such as alienation, transfer, valuation, development, and utilization of land, while also enhancing land tenure security by delivering current and reliable information and services at the lowest possible cost (Tuladhar, 2004). *Figure 1* shows the concept of LIS and its components.

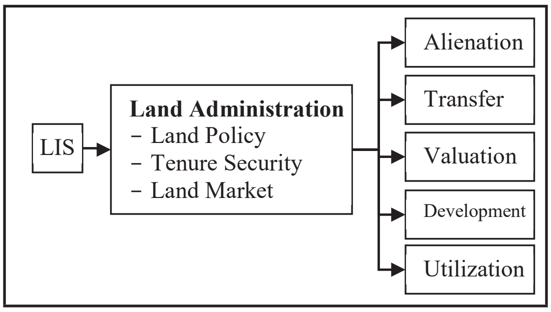

Figure 1: Land Information System.(Tuladhar, 2004)

To discuss some examples, The Korean Land Information System (KLIS) is an online application that provides electronic transaction services and essential information through kiosks. It comprises individual parcel maps digitized from paper records, continuous cadastral maps created by edge-matching individual parcels, and edited cadastral maps produced by transforming continuous cadastral maps to overlay on topographic maps (Kim & Lee, 2014). Landgate of Western Australia is the web-based LIS to provide information about land and property to the users (Kalantari et al., 2005). At the regional level, European Land Information System (EULIS) is the LIS which deals beyond the border in Europe which provide access to land information across the border and also support property market.

In context of Nepal, Nepal Land Information System (NeLIS) is the web-based application for the management of cadastral data and perform all the cadastral data related operations for land administration services and also, it maintains all the cadastral data at centralized database system considering security of the data while considering the fast, reliable and effective service delivery (Karmacharya et al., 2022). Complementing this spatial framework, the complete Nepal's LIS also constitutes the Land Records Information Management System (LRIMS), which manages textual ownership records and deed registrations.

2. INFORMATION SYSTEM ARCHITECTURE

Architecture represents a system by defining its components, the relationships among them, and the resulting product. It should be designed in a manner that ensures adoption by both government organizations and citizens. The components of the architecture must be interconnected, the data utilized should be interoperable, and the mechanisms for delivering information need to be clearly established. Effective information sharing among organizations is essential for enhancing efficiency and service quality, reducing labor costs, and minimizing data redundancy (Hobson et al., 2011). Moreover, it contributes to greater transparency in service delivery.

Among different architectures, The Open Group Architecture Framework (TOGAF) provides a complete framework for development of architecture discussed under four different vies as business, data, system and technical architecture (Jin et al., 2010). According to Jin et al. (2010), business architecture identifies the functions, process, and information flow for accomplishing the task of organization, data architecture defines structure of data being used by the system, system architecture is the factor which determine the adoption of the system by users and technology architecture defines how different systems within the system are connected with each other.

2.1. NeLIS system architecture

Dangol (2012) has proposed business architecture, information architecture, and system architecture for the development of e-government-based LIS for Nepal. The proposed system architecture was three-tier client server concept with application server, web server and database server. The same architecture concept was adopted to develop the NeLIS with some modification in connectivity (Figure 2).

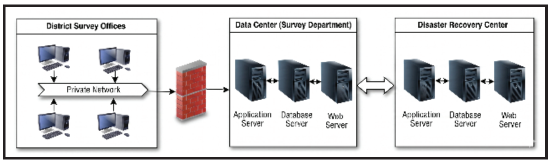

Figure 2: NeLIS system architecture (Modified) (Dangol et al., 2021))

The system architecture was slightly modified with separate web server for providing online map printing services for the customers through *MeroKitta* system. All the three servers are hosted at the Data Center (DC) of Survey Department. District survey offices connect to the DC through the private network with restriction through web access. All the servers are collocated at the Disaster Recovery (DR) center maintained at Hetauda by Integrated Data Management Center (IDMC), Government of Nepal. All the transactions are simultaneously updated and backed up at the DR site.

2.2. NeLIS business and information architecture

For the land transaction services and information delivery, two categories of users are maintained. The internal users are the NeLIS system users at district survey office and Survey Department. Internal users from the department use the system to monitor the system, provide technical support to the district offices and managing administration of the system. Internal users at the survey office use the system to provide all cadastral related services of the land administration services at the district level.

The external users are the individual persons and institutional users like financial organizations and the local level municipalities. The external users can get the cadastral services like map print, fieldbook/ plot register print, request for field survey and also pay the revenue for the services through the e-payment gateways. These services are provided through the *Merokitta* system. This is the web-based system; however, it does not have direct connection with the database server to ensure the security of the NeLIS (Figure 3).

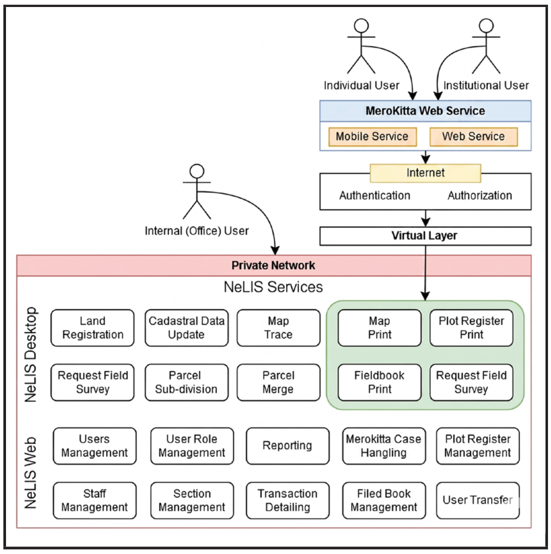

Figure 3: Business and information architecture.

Only major services are shown in the NeLIS services. NeLIS has two modules: NeLIS desktop and NeLIS web. The desktop module conducts all core land administration activities, which involves directly editing, updating, and processing the spatial and attribute data of the cadaster. In contrast, the NeLIS web module focuses primarily on overarching system administration and monitoring.

Merokitta provides online platform for the external users for requesting services like map print, field book/plot register print, field survey request. This platform is connected with Revenue Management Information System (RMIS) for online revenue payment by the users. The virtual layer is created for restricting direct access to the cadastral database by the external users.

3. NELIS SUPPORT MECHANISM

3.1. System implementation

The existing cadastral geodatabase of the district offices are the base of the cadastral data in NeLIS. Those databases are migrated to the NeLIS database with necessary data cleaning and harmonization.

3.2. Attribute data cleaning

The existing geodatabases are checked for how effectively the attributes align with the NeLIS database framework. These legacy databases were created using the Spatial Application Extension (SAEx), a decentralized digital cadastral service delivery tool used in Nepal for the past two decades. Over time, these SAEx databases have exhibited significant schema drift, such as missing columns, renamed fields, and non-standard data types (Paudyal, 2007). Required fields in parcel layer of the geodatabase including DISTRICT, VDC, WARDNO, GRIDS1, PARCELTY, and PARCELNO must be present and properly structured.

The 9-digit geocode (GRIDS1) must be generated for the free sheet maps and validated for all parcels. The NeLIS geocode format (Prefix + Scale + Ward + Sheet + Part) is specific to Nepal's administrative hierarchy.

Nepal's cadastral maps use Devanagari script for sheet identification, with transliterations varying significantly across survey offices. These linguistic variations need to be normalized and mapped to the standardized NeLIS geocoding schema (Karmacharya et al., 2022).

Attribute validation must be performed to ensure data integrity. District codes must be present and within valid range (1-77). VDC codes, ward numbers, and parcel numbers must be valid and within appropriate ranges. Sheet number mismatches between folder names and database entries need correction. Parcel type fields must be verified for correct entries. Legacy data often has incomplete attribute information that needs to be identified and filled from available sources (Tuladhar, 2004).

Database-level checks are also essential. Database version conflicts may exist where multiple databases of the same location contain different branching edits. Database fragmentation from accumulated scratch layers increases file size and slows loading time, requiring compaction (A. M. Tuladhar, 2005). Cross-boundary databases in trig sheet areas may contain parcels from multiple wards, causing data duplication during migration (Dangol et al., 2021).

3.3. Spatial data cleaning

Spatial properties of the geodatabase are also checked with different specified rules. The topological integrity of cadastral data is the foundation of any Land Information System (LIS) (Lemmen et al., 2015). A topologically correct cadastral map must satisfy two fundamental rules: (1) No Overlaps—the intersection of the interiors of any two distinct parcel polygons must be empty, and (2) No Gaps—the union of all parcel polygons in a continuous block must form a seamless surface without unintended voids.

Existing data digitized using the Spatial Application Extension (SAEx) often violates these rules due to manual digitization errors, "double-digitizing" of shared boundaries, and floating-point precision errors (Paudyal, 2007). Micro-gaps and sliver overlaps must be resolved. Sliver polygons, which are thin unwanted polygons created during digitization, can be identified using the Circularity Index ($4\pi A/P^2$) combined with area thresholds. Geometry validity must be verified where self-intersecting polygons, unclosed rings, and null geometries must be corrected.

Multi-polygons, which are parcel features consisting of multiple disconnected parts, are not supported in NeLIS and must be separated into individual features. Spatially displaced sheets, where database corners are digitized in wrong locations, can be identified using background satellite imagery. Sheet extent mismatches, where adjacent sheet corners do not align, require geometric adjustment. Residual parcels, which are remaining areas left as single features during digitization, should be identified and removed. Roads that continue across sheet or ward boundaries must be properly segmented (Sapkota, 2012).

Duplicate features must be removed as they cause topological errors and database bloat. Attribute-geometry linkage must be preserved during any spatial correction to maintain cadastral integrity (Enemark et al., 2014). A review mechanism must be established for complex cases as large overlaps may indicate genuine boundary disputes requiring human judgment.

3.4. Service delivery support

Technical support mechanism through different medium is adopted to provide continuous support to ensure efficient service delivery at district survey offices (Koroso et al., 2013). The central Survey Department provides constant phone support to address technical issues faced by district offices. Remote desktop support using VNC and Any Desk software enables technical staff to directly troubleshoot problems on district office computers, reducing the need for physical visits and minimizing service disruption.

Training programs are conducted regularly to enhance the technical capacity of survey office staff (Karmacharya et al., 2022). These programs cover system operation, data management procedures, and troubleshooting techniques, ensuring that local staff can handle routine issues independently while complex problems are escalated to the central support team.

Network monitoring is essential for uninterrupted connectivity between district offices and the central data center. All district offices are connected through redundant private networks to ensure continuous service availability (Dangol et al., 2021). Continuous monitoring systems track network performance and alert administrators to potential issues before they affect service delivery.

System monitoring is implemented to track the health and performance of NeLIS servers and applications. Real-time monitoring of server resources, database performance, and application response times helps identify and resolve issues proactively (Cheng, 2013). This ensures high availability of the system for both internal users at survey offices and external users accessing services through *MeroKitta*.

Continuous updates to the system and software are deployed to improve functionality, security, and user experience. Regular software updates address bug fixes, introduce new features, and enhance system performance based on user feedback and operational requirements (Arshad et al., 2025). These updates are managed centrally to ensure consistency across all district offices while minimizing disruption to ongoing services.

3.5. Network monitoring

All district offices are connected to the DC with two separate private networks so that even if one network fails to work, then next one will continue the service. In spite of redundant private network, continuous monitoring of the network is essential for uninterrupted connectivity (Karmacharya et al., 2022).

4. FUNCTIONALITY FOR TRANSPARENCY

Transparency is one of the keywords of contemporary governance which implies to access to public information and hence, it is often assumed that increase in transparency leads to increased citizens trust in government (Erkkilä, 2020). Access to information is one of the major elements of transparency along with public participation and institutional reforms (TI, 2004). From a functional perspective, transparency focuses on the clarity of information—specifically addressing questions such as: Who does what? Who is responsible for what? Who processes applications? and Who makes decisions? (Cheng, 2013). Ontime information during land transaction supports in effective and efficient service delivery (Koroso et al., 2013).

To enhance the transparency in service delivery through NeLIS and *MeroKitta* system, different ways for providing information regarding land transaction has been developed.

4.1. Administrative monitoring and accountability

Figure 4 illustrates the Lead Time Velocity Timeline, which provides a granular breakdown of the time elapsed between each stage of a *MeroKitta* transaction. This visualization serves as a critical monitoring tool for the department, enabling administrators to identify specific bottlenecks and outliers in real-time. By analyzing these data points, the central authority can proactively intervene in cases exceeding standard processing times, requesting justifications from the respective survey offices to ensure accountability and maintain a high standard of service delivery.

Figure 4: Lead time velocity timeline for MeroKitta transaction processing

4.2. Real-time transaction tracking

To provide clarity to the public, Figure 5 shows the current status of the transaction in NeLIS. CaseID is the unique number of every transaction in NeLIS all over the country. Concerned landowner with this ID can check the status of the transaction online. Transaction status is shown for every step completed at the survey office. For each step, whether it is initiated, checked or approved is shown with date and time stamp and the staff of the survey office who conducted the specific step of the transaction.

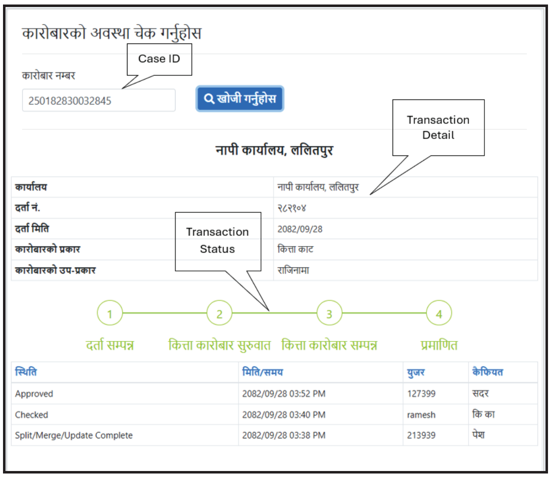

Figure 5: Live status of land transaction.

Additionally, Figure 6 shows the list of the transaction that is being handled at the survey office at the time. This shows the details of transaction with caseID, section, date, transaction detail, cadastral detail and the status of the transaction. This is displayed in the television screen connected with NeLIS to provide information about the transaction status to the customers at the waiting lobby.

Figure 6: Transaction status shown at TV.

4.3. Proactive citizen communication and e-services

Transparency is further enhanced through proactive updates. Figure 7 shows the information through SMS service regarding initiation of the service request through *MeroKitta* system. While requesting for the online services through the *MeroKitta*, One Time Password (OTP) is provided to the customer and he/she will get SMS for every process completed by the Survey Office.

Figure 7: Mobile message about map print initiated status for citizen.

Once the data for the online services is verified by the survey office, the customer will receive SMS for revenue payment. The message includes the total amount to be paid and the links for all compatible payment gateways (Figure 8). All these payment gateways are linked with the Revenue Management Information System (RMIS) through which the revenue is directly deposited to the central treasury.

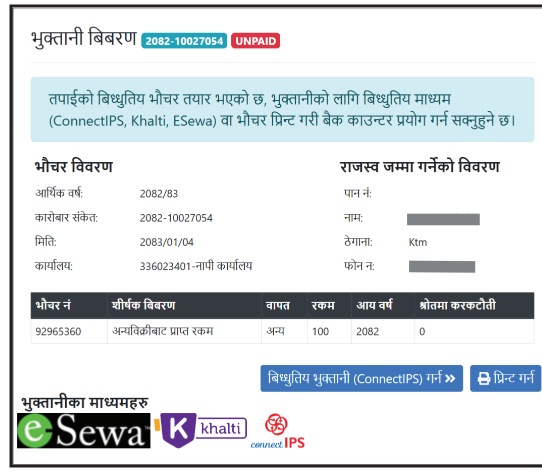

Figure 8: Online payment gateway options for revenue payment of map print.

Finally, once the customer completes the revenue payment, they will then receive the SMS for downloading the requested services (Figure 9). The customer can download the PDF version of the requested services, the link for download which will be available for fifteen days.

Figure 9: Final message for map download link.

5. CONCLUSION

Transparency has three main aspects as legal, structural and functional aspect. LIS explicitly supports in functional transparency. As the LIS is developed with some standard architecture and workflow, it supports in enhancing transparency and hence enhance efficiency and effectiveness in the land administration services. In the context of LIS in Nepal, NeLIS has also been developed and deployed with standard system architecture.

Further, the establishment of a LIS built upon a standard system architecture is a cornerstone for modern land governance. By ensuring interoperability, consistency, and reliability across processes, such a system enhances transparency in land records and transactions. Moreover, it streamlines workflows, reduces duplication, and supports efficient service delivery in land administration. Ultimately, adopting a standardized architecture not only strengthens institutional accountability but also empowers citizens with accessible, trustworthy, and timely land information—laying the foundation for sustainable and equitable land management.

REFERENCES

Arshad, N., Butt, T., & Iqbal, M. (2025). A comprehensive framework for Intelligent, Scalable, and Performance-Optimized software development. *IEEE Access*. 13, 74062-74077.

Cheng, B. (2013). *Workflow database modeling in a workflow management system for better land transaction transparency.* [MSC Thesis, University of Twente]. The Netherlands, Enschede.

Dangol, S. (2012). *E-government based land information system architecture: A case of Nepal* A thesis submitted for the degree of Master of science in Geo-information Science and Earth Observation for Land Administration. ITC, The Netherlands, Enschede.

Dangol, S., Joshi, P., & Dahal, T.P. (2021). Online Service Delivery in Survey Offices: Step towards e-Land Administration. *Journal on Geoinformatics, Nepal*, 20(1), 67–74. https://doi.org/10.3126/njg.v20i1.39480

Dhal, N. (2002). Land Information System (LIS)-A Cae Study in Orissa. *Indian Cartographer*, *2*, 295–298.

Enemark, S., Bell, K. C., Lemmen, C., & McLaren, R. (2014). *Fit-for-purpose land administration*. International Federation of Surveyors (FIG).

Erkkilä, T. (2020). Transparency in public administration. In *Oxford research encyclopedia of politics*. Oxford University Press.

Gupta, E. (2013). Information system. In *Entrepreneurship and SMEs: Building Competencies* (pp. 97–102). Adhyayan Publishers & Distributors.

Hobson, S. F., Anand, R., Yang, J., & Lee, J. (2011). Towards Interoperability in Municipal Government: A Study of Information Sharing Practices. Conference Proceedings: IFIP Conference on Human-Computer Interaction, Portugal, September 5-9, 2011.

Jin, M., Kung, D., & Peng, W. (2010). Research of Information system Technology Architecture. Conference Proceedings: 2010 2nd International Conference on Industrial and Information Systems, Dalian, China 10 - 11 July 2010.

Kalantari, M., Rajabifard, A., Wallace, J., & Williamson, I. (2005). Toward e-land administration: Australian online land information services. Proceedings of SSC 2005 Spatial Intelligence, Innovation and Praxis: The national biennial Conference of the Spatial Sciences Institute, September, 2005. Melbourne.

Karmacharya, A., Pradhan, G., Niraula, P., Ghimire, P., Rajbhandari, S. P., Manandhar, S., Bhandari, S., & Dangol, S. (2022). Online Service Delivery in Survey Offices of Nepal. *Journal on Geoinformatics, Nepal*, 21(1), 43–50. https://doi.org/10.3126/njg.v21i1.50881

Kim, M., & Lee, K. H. (2014). *Korea Land Information System*. Korea Research Institute for Human Settlements (KRIHS).

Koroso, N. H., Van der Molen, P., Tuladhar, A. M., & Zevenbergen, J. A. (2013). Does the Chinese market for urban land use rights meet good governance principles? *Land use policy*, *30*(1), 417–426.

Lemmen, C., Van Oosterom, P., & Bennett, R. (2015). The land administration domain model. *Land use policy*, *49*, 535–545.

Paudyal, D. R. (2007). Assessment of the digital cadastre in Nepal from the cadastre 2014 vision. *Journal on Geoinformatics, Nepal*, 6(1), 9–15.

Sapkota, R. K. (2012). LIS Activities in Nepal: An Overview in prospect of DoLIA. *Journal on Geoinformatics, Nepal*, *11*, 23–28.

TI. (2004). *Tools to support transparency in local governance*. Transparency International, UN-HABITAT.

Tuan, V. A. (2006). *Reengineering of a land information system LIS for the Vietnamese land administration* [MSc Thesis, ITC]. Enschede, The Netherlands.

Tuladhar, A. (2005). Institutional and Technical Aspects of Cadastral Systems: Experiences and Reflections. In: Map India.

Tuladhar, A. M. (2004). Parcel-based geo-information system: concepts and guidelines.

Tuladhar, A. M. (2005). *Institutional and Technical Aspects of Cadastral Systems: Experiences and Reflections* Map India 2005,

UN. (2005). *Land Administration in the UNECE Region: Development trends and main principles*. United Nations.

Zhao, Y. (2010). "One Map"-Based Land Information System: Towards E-government for Land Management. Conference Proceedings: 2010 International Conference on E-Business and E-Government, Guangzhou, China, May, 2010.

Author's Information

Name	:	Suresh Manandhar
Academic Qualification	:	BE in Geomatics Engineering
Organization	:	Survey Department
Current Designation	:	Survey Officer