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Digital Cartography for Land Record Modernisation in India

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Distinguished members of INCA, my dear young cartographers committed to contribute in furtherance of vision for new dimensions and application of cartography, my colleagues, students, friends, Ladies, Gentlemen and friends from Media. It is a great honour for me to be addressing such an august audience for the Todar Mal Lecture series which is a prestigious event by itself with the INCA International Congress every year.



Lt. Gen. Girish Kumar, VSM (Retd.) while delivering the Todar Mal Memorial Lecture, 43rd INCA International Conference, Jodhpur (Dt. 06 Nov. 2023).

Cadastral surveys in India have a rich and complex history, reflecting the country's diverse administrative and land management systems. The term 'cadastral' comes from the Latin base term 'Cadastré', referring to a registry of lands using a cadastral survey or cadastral map. It is a field-by-field survey of a Revenue Village or an estate undertaken by Government, to ascertain the position of boundaries, area and quality of each field. It

provides the data for the settlement of Land Revenue and the preparation and maintenance of Record of Rights. Thus, a cadastral survey is a comprehensive land recording of the land and real estate by metes-and-bound of a country and is executed to determine and define the land ownership and boundaries.

History of Cadastral Surveys:

In India, there is a reference to maps and diagrams even from the days of the Mahabharata 3100 B.C. The origin of Cadastral Survey in India can be traced to the pre-Mauryan and Mauryan period i.e. 3rd Century BCE. Though the Arthashastra of Kautilya shows how maps were used to show the extent of the Mauryan Empire

During First Century B.C., the institution of a village accountant known as Gopa had come into being. He looked into the accounts, statistics of a group of villages and recorded and numbered plots with details. He fixed the boundary of villages, fields, forests, roads etc., charities and remission of taxes regarding fields.

Cartography has a 2000-year written history from the time of Plato in the Western world. The Mughal Empire, for example, had a detailed land revenue system, including measurement practices, though it was not as formalized as modern cadastral surveys. Written Cadastral records were prepared, Survey of Land and Revenue Settlement is usually dated to Sher Shah Suri (1472-1545 A.D.)

Todar Mal:

Raja Todar Mal Introduced standard weights and land measurement systems. He also standardized unit of measurement to *Ilahi Gaj*, which was equivalent to 41 fingers (29-32 inches). A *Bigha* was made of 3600 *Ilahi Gaj*, which is roughly half of modern acre.

Lead measuring rope, called *Tenab*, was also standardized by joining pieces of Bamboo with iron rings so that the length of *Tenab* did not vary with seasonal changes. He also initiated land survey based on this measurement system and demarcated Revenue Districts.

He established the village level revenue officials/in-charge like *Lekhpal*, the Village Accountant. Started the system of Revenue officers and *Patwaris*. The *Khasra* system of survey in North India owes its origin to Raja Todar Mal. This system of maintenance by *Patwari* is still used in Indian Subcontinent which was improved during British Raj and by Government of India.

Great Trigonometrical Survey - 1802-54:

Survey of India commenced a comprehensive survey of the country, including cadastral surveys, to map and measure land accurately after establishment of ground control/reference frame work under Great Trigonometric Survey (GTS) in India from 1802-1854. These GTS stations and GT Benchmarks (BMs) were used for preparing accurate cadastral maps. This marked the beginning of scientific surveys in India

Mahalwari Settlement (1822) and *Ryotwari Settlement* (1820s) focused on individual landholdings rather than collective village-based systems. This required detailed cadastral surveys to assess individual landholdings and their revenue assessments.

Technological Advancements:

The use of drones and advanced GIS tools continues to evolve, offering new possibilities for cadastral surveys. Overall, the history of cadastral surveys in India reflects the evolution of land management practices from traditional methods to modern, technology-driven approaches.

Collaborative Space & Positioning Infrastructure and Geospatial Value Chain:

In today's digital world, space services and geospatial data impact our daily lives. The power of 'Where', enabled through space and spatial, is the record of what we do, when and where we do it, and in what environment - because very thing happens somewhere.

- Space Services, Positional Infrastructure and Geospatial Complement each other, create value individually however, collaboration can lead to significant benefits.
- These are making a critical contribution to digital transformation and are important for the Future Growth & Prosperity of countries.
- Position can be used by Govt., Industry & Individuals to connect data and work to make decisions that have positive impact on economies, environment and society in general
- Integration of space and spatial sectors will:
- Increase productivity in key sectors including agriculture, mining, transportation, construction and energy etc., smart city planning and management etc.
- Support national defence & security disaster mitigation & management, environmental monitoring & management Positioning Infrastructure like GNSS (Space technology) - GPS, GALILIO, GLONASS, BEIDOU AND NAVIC.

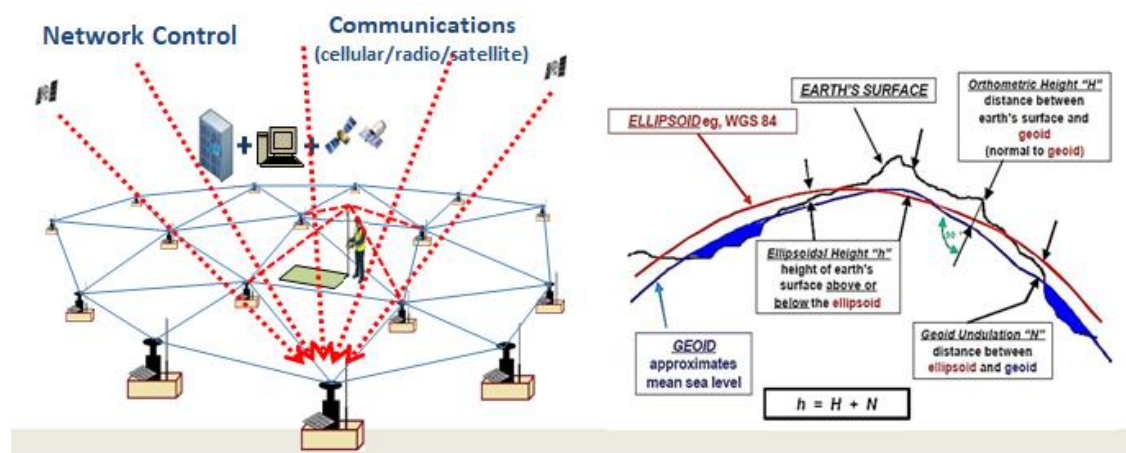


Fig. 2 Illustration of positioning infrastructure.

GNSS Accuracies:

- Stand Alone Positional Accuracy is around 7 m
- Post Processing accuracy about centimetre is achieved by collecting data for minimum 24 hours and further processing time is required
- Real Time accuracy can be achieved up to 5 cm using Differential GPS station using RTK technique with a limitation of maximum 10 kms
- To achieve Higher accuracy Reference stations are established at a distance of around 50 kms for network RTK

Continuous Operating Reference Stations (CORS) network is a Positioning infrastructure created by establishing CORS stations at a distance of 50-80 Kms. It is a network of RTK base stations that broadcast corrections, usually over an Internet connection. These networked

CORS stations (or GNSS receivers) are permanent installations and continuously stream satellite observations to a Central Server known as Control Centre. The entire setup of Reference Stations and Central Server is known as Continuous Operating Reference Station (CORS) Network. The Control Centre process the data received from these CORS stations to further refine the rover position by sending Network Real-Time Kinematic (NRTK) corrections to the rover. This would help in benchmarking the location and provides 5 cms level accuracy. It supports in accurate Geo-referencing, ground truthing and demarcation of lands which can be used to replace the chain surveys practiced in several States.

The CORS once established could be used by any State agency / Department viz. Revenue Department, Gram Panchayat (GP), Public Works Department, Rural Development Department, Agriculture, Drainage & Canal, Education, Electricity, Water, Health etc. for the survey and implementing/using GIS based applications. The CORS network is available 24 hours per day, 7 days a week and 365 days a year. However, it depends on the communication service provider and satellite availability. Data streaming is supported in real-time and users can also retrieve stored GNSS data from the control Centre via the internet for post-processing. Users can also submit static survey GNSS data for online processing. More than 1000 CORS stations have already been established in India and most of them are connected to the Control Centre. Some states are also in the process of establishing their own Control Centre for effective utilization of the Positioning Infrastructure.

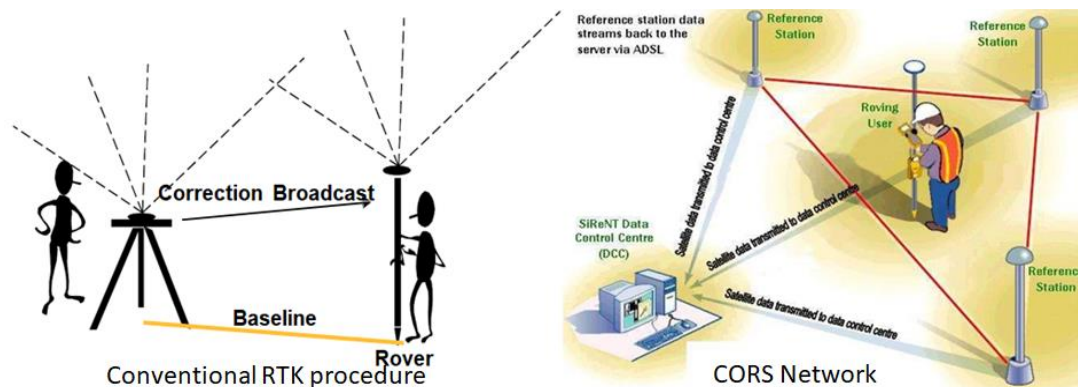


Fig. 3 Difference between the conventional RTK based survey and CORS Network.

Survey of Villages and Mapping with Improved Technology in Village Areas (SVAMITVA) Scheme:

SVAMITVA, a Central Sector Scheme of Ministry of Panchayati Raj which launched by the Hon'ble Prime Minister on National Panchayati Raj Day, 24th April 2020 for 6 pilot states. The scheme was launched Pan India in 2021 after successful completion of pilot phase of scheme (2020-2021). Scheme is a reformative step towards establishment of clear ownership of property in rural inhabited ("Abadi") areas, by mapping of land parcels using drone technology and providing 'Record of Rights' to village household owners with issuance of legal ownership cards (Property cards/Title deeds) to the property owners. The Scheme is implemented with the collaborative efforts of the Ministry of Panchayati Raj, State Revenue Department, State Panchayati Raj Department and Survey of India. The scheme covers

multifarious aspects viz. facilitating monetisation of properties and enabling bank loan; reducing property related disputes; comprehensive village level planning, would be the stepping-stone towards achieving Gram Swaraj in true sense and making rural India Atmanirbhar.

The scheme seeks to achieve the following objectives: -

- i. Creation of accurate land records for rural planning and reduce property related disputes.
- ii. To bring financial stability to the citizens in rural India by enabling them to use their property as a financial asset for taking loans and other financial benefits.
- iii. Determination of property tax, which would accrue to the GPs directly in States where it is devolved or else, add to the State exchequer.
- iv. Creation of survey infrastructure and GIS maps that can be leveraged by any department for their use.
- v. To support in preparation of better-quality Gram Panchayat Development Plan (GPD) by making use of GIS maps

Why SVAMITVA?

- No property ownership Record of Right for residents of Lal Doras.
- Monetary value of properties was locked- not recognized by Banks for loan.
- Proper demarcation of each parcel was not available thus, leading to encroachments even on public places, playgrounds, ponds, drains etc.

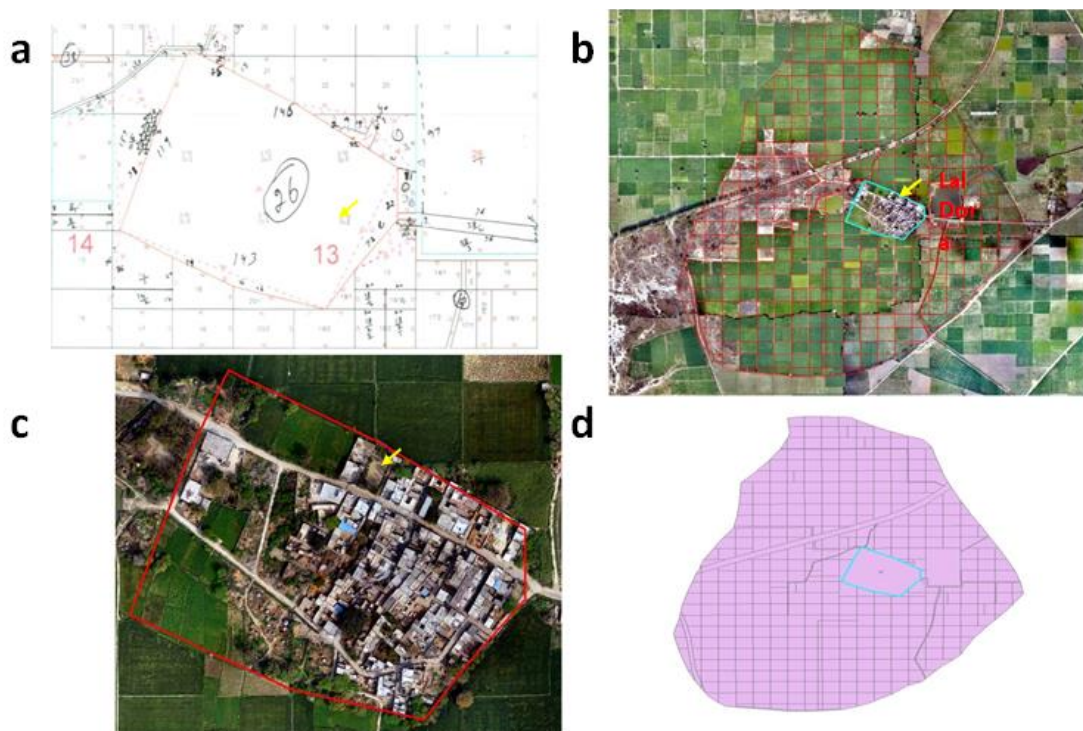


Fig. 4 Concept illustration of land records modernization under SVAMITVA scheme. (a) Land records (Mussavies) of Chatia Deva village. (b) A drone imagery of the Chaita Devi village. (c) Lal Dora overlaid on the drone imagery. (d) Digital land record of Chaita Deva village.

Modernisation of Land Records:

In most of the States these cadastral maps are very old and have never been updated. Over a period of time the attribute information in the form of parcels through registration etc.

are being updated using online Jamabandi program for updation of the textual/tabular data but the maps were not updated. It means that if a parcel has been subdivided amongst a number of new owners, then their share is shown as 1/1 and 1/2 and so on but the geographical locations of these parcels have not been updated.

During 1990s, Government of India launched Computerization of Land Records Program (CMP). That is to scan the existing land records, digitized them and upload them on a server. But again, the lacuna was that most of the maps were not geo referenced. Since maps were not updated, resulting in large number of court cases, as these maps were not representing the true ownership of the parcels of the ground. Government of India launched National Land Record Modernization Program in 2008.

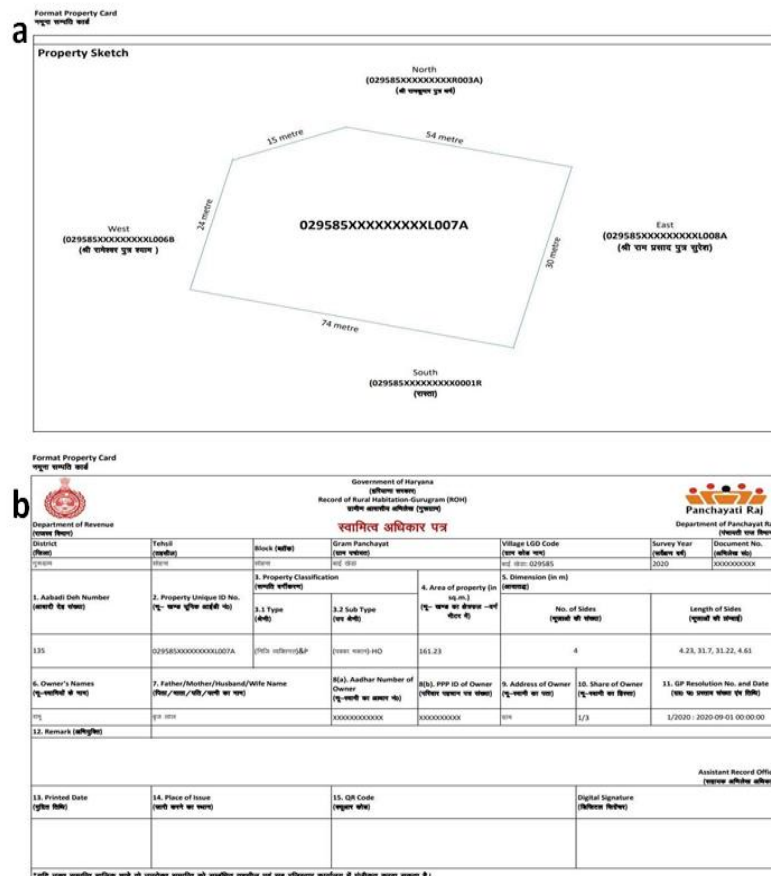


Fig. 5 A typical property card. (a) Sketch diagram of the property sketch as printed on the backside of the property card. (b) Details of location and ownership of the property as printed on the front side of the property card.

The main objective of the NLRMP was to develop a modern, comprehensive and transparent land records management system in the country with the aim to implement the conclusive land-titling system with title guarantee, which will be based on four basic principles, i.e., (i) a single window to handle land records (including the maintenance and updating of textual records, maps, survey and settlement operations and registration of immovable property), (ii) the mirror principle, which refers to the fact that cadastral records mirror the ground reality, (iii) the curtain principle which indicates that the record of title is a true depiction of the ownership status, mutation is automated and automatic following registration and the reference to past records is not necessary, and (iv) title insurance, which guarantees the title for its correctness and indemnifies the title holder against loss arising on account of any defect therein.

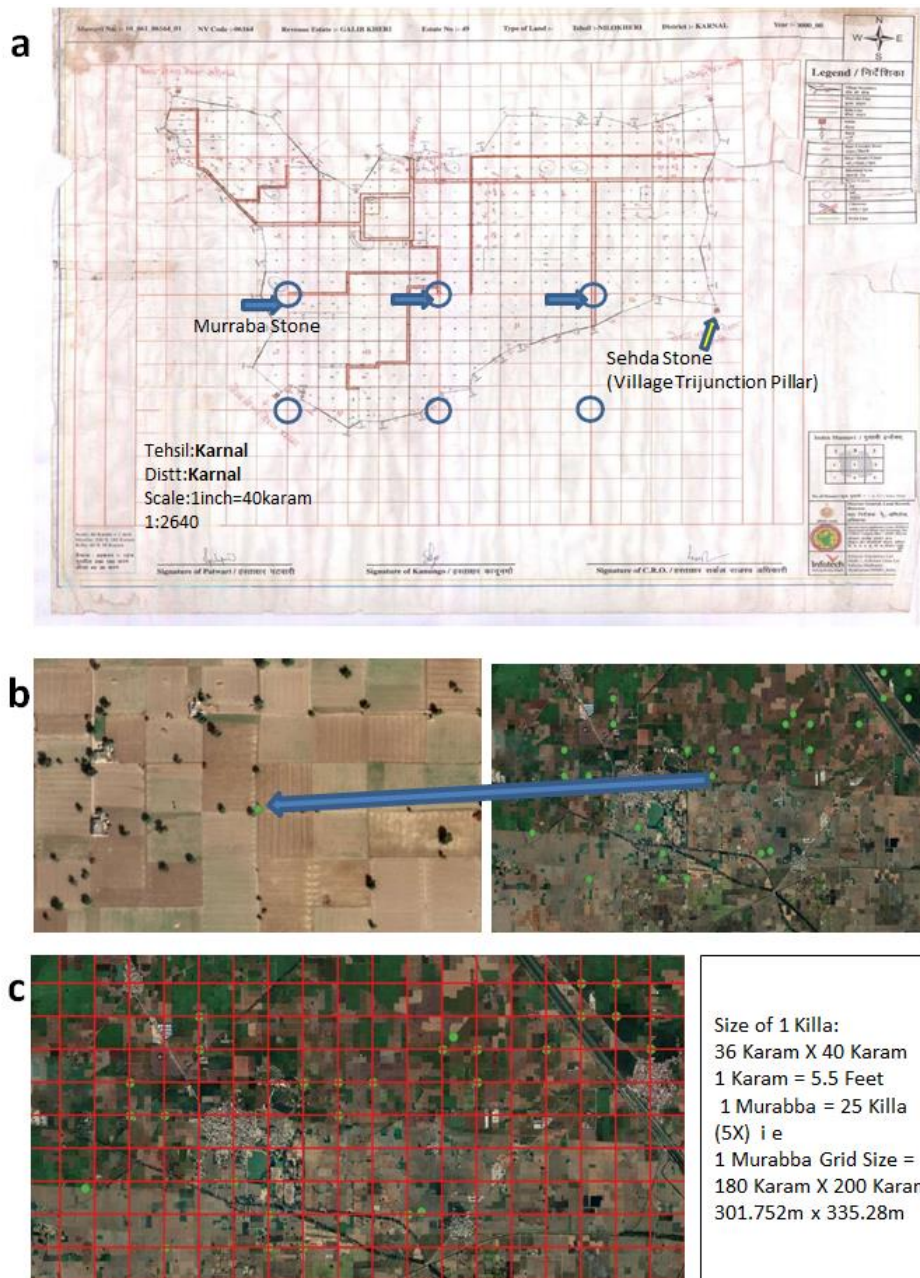


Fig. 6 (a) Original Land Record i.e. Mussavi of Village Gali Bakheri falling in Tehsil Karnal, Karnal District on a scale of 1 inch to 40 Karam. This map shows Murraba stone grid layout, Village Tri-junction pillars and parcel layout. (b) Murabba stone plotted on ORI shown in green dots. (c) Murabba grid reconstructed using existing Murabba stone shown in green dots.

This project was being implemented by the States and some States did achieve considerable success in modernising the land records using aerial photography, GPS and ground validation etc.

The NLRMP was approved as a Centrally Sponsored Scheme was revamped as the Digital India Land Records Modernization Programme (DILRMP) as a Central Sector Scheme with cent per cent Central funding with effect from 01st April 2016.

In 2018 trials of mapping using drone technology was undertaken by Survey of India and it was found to be meeting accuracy standards of a map of 1:500 scale. Accordingly, many States initiated programmes under DILRMP to modernise the land records using drone technology. Haryana was first State to take initiative to map the entire Haryana using drone technology with an accuracy of 12.5 cms. The project was being executed through Survey of

India and the ground validation being carried out by States Government. Under the program the existing cadastral maps known as Mussavis were scanned.

Survey of India and Govt. of Haryana signed an MoU in 2019 for modernization of the Land Records using latest technologies. Accuracy standards were decided as under.

- For Rural areas on 1:1000 scale with ORI at 10 cm GSD; ± 20 cm horizontal accuracy
- For Urban areas and Village Lal Dora/Abadion 1:500 and ORI at 5 cm GSD; ± 10 to 12.5 cm horizontal accuracy.
- Vertical Accuracy of 0.2 m for all areas.

In Haryana, these Mussavis were prepared in 1950s onwards and a grid of Murabba stones were established on the ground at a distance of 25 Acre. These Murabba stones were also depicted on the Mussavis. A systematic ground observation using Rovers and CORS network was carried out on the existing Murabba stone. Though 80% of the Murabba stones were found to be either missing or displaced. A grid of Murabba stones was reconstructed using existing Murabba stones and these cadastral maps, after following the procedure of scaling etc., were geo-referencing using this Murabba stone grid with an aim of maintaining shape and area of the each Murabba stone grid.

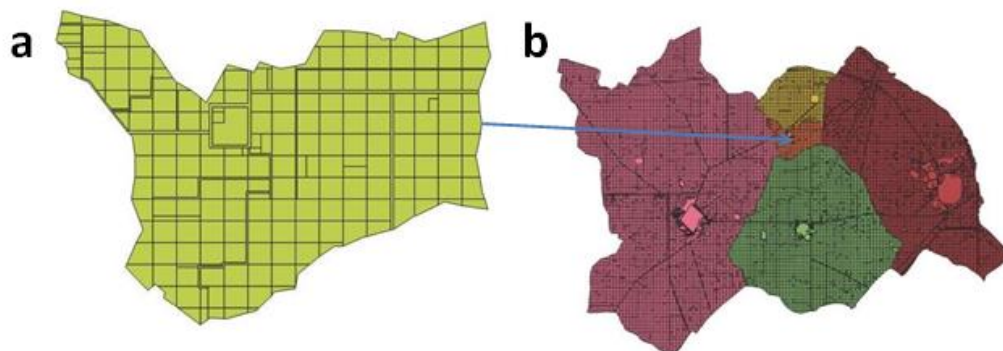


Fig. 7 (a) Digitized Mussavis of Galib Kheri Village. (b) Fixing and edge matching with Adjacent Villages.

Table 1 Area comparison.

S. No.	Name of the Village	Area as per Revenue (acres)	Area as per digital map (acres)	Difference	% variation
1	Hemda	407.775	407.8	0.025	0.0061
2	Sirsi	641.15	641.813	0.663	0.1034
3	Dadoopur Roran	775.36	774.6476	0.2876	0.0371
4	Chirao	1149.83	1149.1399	-0.6901	-0.06
5	Shahpur	1281.13	1280.23	-0.9	-0.0703

Geo-referenced Mussavis depict parcel information as it was at the time of preparation of these mussavis and it may be 50 to 80 years old but online Jamabandi data pertaining to the land record, which is current and updated, was linked with the old parcel information to establish a relationship between old cadastral map and the updated online Jamabandi data. During this exercise, we could establish the gap between the old parcel information and the new updated Jamabandi data and the parcels where the information needed to be updated were identified. This information was shared with the district administration to update the parcels.

In Haryana, this activity is called Tatima updation. We all know that the land record is maintained at the Patwari level. Each Patwari maintains a Sizra map (cloth mounted) which depicts the ground position also. Government of Haryana took initiative to transfer this

- Faster growth
- Multiple agencies
- Data Silos
- Jurisdictional Changes
- Higher Spatial accuracy

Major Problems in Urban Areas is land grabbing.

- Eyeing prime land.
- Protecting land asset is more challenging than buying it.
- Land-grabbers know the means of acquiring it or creating litigation through Fake documents. Making it impossible for the rightful owner to sell it or even enter it.

Unending Disputes:

- PRS Legislative Research indicates that ‘...land-related disputes account for two-thirds of all pending court cases in the country..’
- NITI Aayog...‘land disputes on average take about 20 years to be resolved’.
- Disputed or unclear land titles inhibit supply of capital and credit for agri.
<https://prsindia.org/policy/analytical-reports/landrecords-and-titles-india>

Land records in urban areas are not being maintained in most part of India except few states. The reason is that as and when any village adjacent to urban areas gets urbanised, either in part or may be full, the land record department in the State stopped updating these maps as it goes out of their jurisdiction to the urban local bodies. But these urban local bodies have no infrastructure to update these land records except in few states Maharashtra and Gujarat etc., where they have organised institutional arrangement of updating land records of urban areas. Because of lack of land records in urban areas the disputes related to property are being settled through the court of law as there is no grievance redressal mechanism in urban areas compared to the land records in rural areas. There is urgent need to undertake land record modernising and updation in urban areas not only in horizontal direction but also in the vertical due to many high-rise apartments being constructed in urban areas. It is learned that there is a proposal under consideration by the Government of India to initiate process of land record management in urban areas also.

Ladies and gentlemen, with this I conclude my talk that cartography has a very important role together with Geospatial and Space Technologies (Remote Sensing, GIS and GPS) in building a stronger nation to enable Governments to provide ease of living by launching Citizen Centric Programs such as Land Record Modernization in Rural and Urban areas to minimize property disputes and also better monetization of their assets.

Jai Hind.

Citation

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