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Geo-spatial approach for mapping of field measurement books in Andhra Pradesh: a case study

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Abstract: An effective and secure transaction of landed properties is essential for the welfare of any country's economy. Governments at all levels require accurate, easily retrievable land records for establishing the ownership rights. A Field measurement Book (FMB) provides data about land and ownership. It is the base for legal aspects like ownership as well as fiscal aspects like taxation of land. The main objective of the study is to regenerate a spatially accurate, legally supportive and operationally efficient sub divisional cadastral database. The definition and compilation of an accurate database is based on an analytical reconstruction of sub-division boundaries rather than the conventional field reconstruction process by using Collabland software. To attain this, village cadastral maps, Field Measurement Books and Adangal records have been used. This study mainly elaborates the methods used for producing and updating the FMB map. It investigates the use of High Resolution Satellite Imagery (HRSI) and Global Positional System (GPS) which are vital elements in timely maintaining many of the cadastral maps in GIS. The abilities of remote sensing imageries in sub parcel mapping are evaluated using World View-2 satellite data. The study reveals that the sub-parcel wise information serves the administrative mandates, maintaining up to date database, assigning values for taxation, addressing rural development, management and services to citizens. The study indicates that the adopted technology can be extended to other areas of the State and updation work can be done in a limited time.

Keywords: cadastral mapping, adangal, FMB, HRSI, GIS, Collabland

1. Introduction

The dynamically changing relationship of humankind to land has a great influence on the development of land administration systems. The individual survey number sketches are maintained as Field Measurement Book (FMB). It illustrates the dimensions of each field boundary of the sub-divisions in the particular FMB. Each sub-division number is owned by a property owner. Land records originated from Mughal period and later during British period, scientific cadastral surveys were conducted to determine boundaries and extent of each individual landholding. Now a day the land information in India is maintained at Block/Taluka/Mandal offices. Map data is stored in Field measurement book, Jamabandi, Khasra Girdawari, Adangal, Padigree Sheets etc. and land ownership detail is maintained using various registers (Mishra and Pal, 2000). Updating and searching for any land information in this type of system is very tedious work. Sub-division based information presents an accurate picture of land holdings, geographic location and their boundaries, make relevance, reliable, accurate, and up to date spatial land parcel data and information continuously available to the government, land authorities and communities. It provides consistency in reporting, reduce cost through the sharing of information technology, facilitate citizens, professionals, research, and build the land market.

1.1 About Field Measurement Book (FMB)

It contains pictorial representation of the survey fields and sub-divisions recorded in the Adangal Register. It depicts measurements of individual fields with sub-divisions at a scale of 1:1000 or 1:2000. Each survey number is divided into several sub-divisions. Each sub division is owned by an owner. Three copies are prepared by the Survey department. Original copy is preserved in State Archives, duplicate copy is supplied to Tahsildar office and triplicate copy is supplied to the Village functionary. A sample of FMB sketch is presented in Figure-1.

G-line (Guess): This is an imaginary line which converts the map into various sizes of triangles in order to accurately fix the boundary lines and various points in the map. This line is the foundation on which the entire map is built. Any error in a G-line will affect all calculations based on that G-line.

F-line / Boundary line: It is the outer boundary line in a sketch, which signifies the actual field boundaries of the sketch. The F-line points are fixed with reference to its offset distance from the G-line.

Sub-division lines: These lines demarcate a small parcel of land within a survey number. A sub-divisional polygon's extent is directly correlated to the extent found for the particular sub division. The sub division lines are generally defined through a ladder etc., except for the graphical representation in the FMB.

Ladder: The field line points are defined with reference to an offset distance from the G-line. The offset distance may be to the left or right side of the G-line. This left or right angle deviation (offset) is depicted by Ladder. By converting the ladder details into electronic data, one can produce the outline of the FMB sketch. The ladder details get attracted whenever there is a change in the field line, involving a bent.

Extension lines: Each survey number field is an integral part of the village map and hence other fields surround each sketch. The exact direction in which the subject field joins the neighbouring field is shown on the FMB as an extension line.

Neighbouring field survey numbers: As mentioned earlier, each survey sketch is surrounded by other fields. These surrounding field numbers are marked around each FMB. This enables mosaicing of FMBs into D-sketches, village maps and so on.

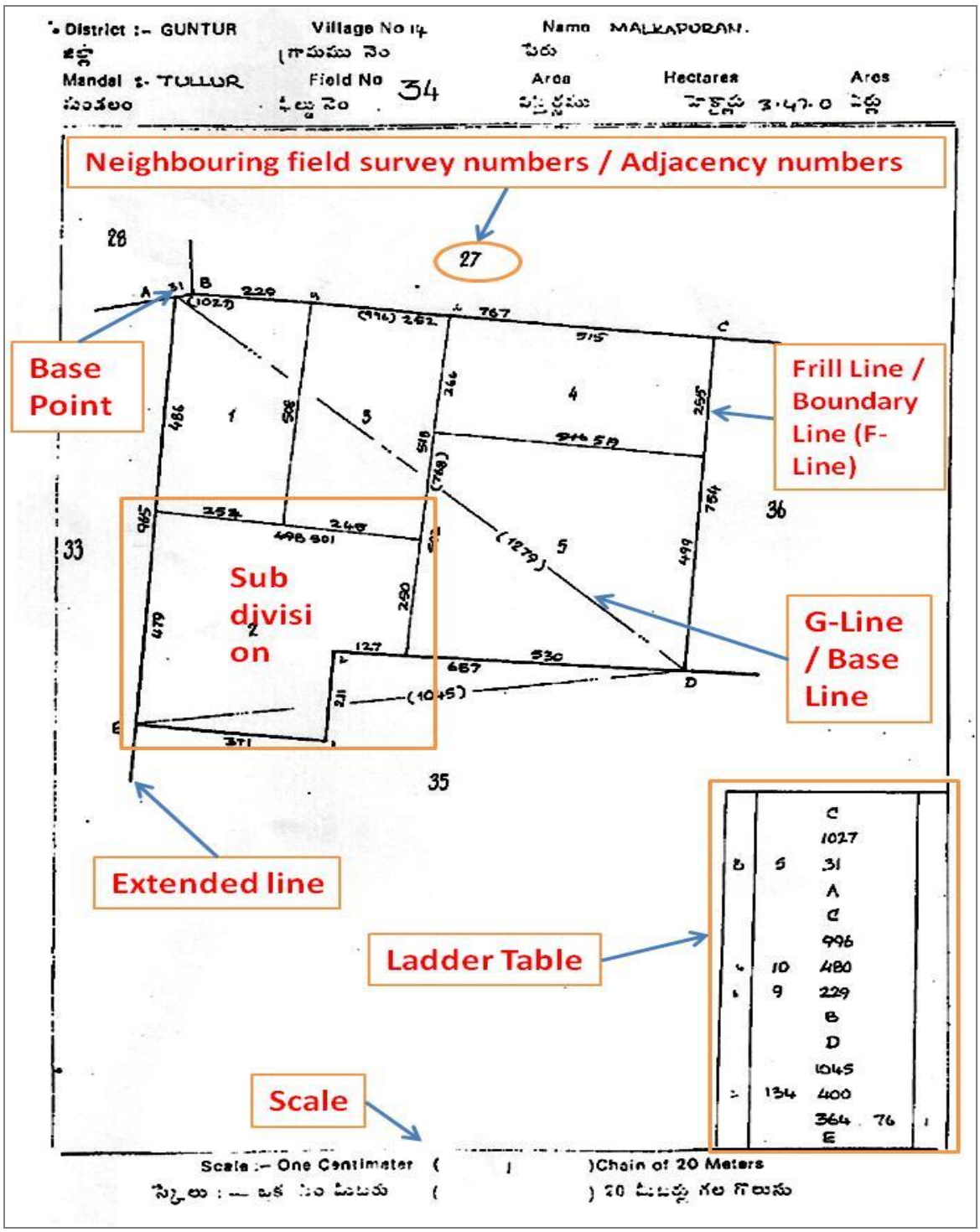

Figure 1: A Sample FMB sketch

1.2 FMB Scenario in Andhra Pradesh

The FMBs were surveyed during the period of Mughal and it reached its scientific form during the British rule. In Andhra Pradesh, during the initial survey, different survey systems were adopted such as Paimash system, Khasra method, Simple triangulation, Plane table, Block map, Punganur System and Diagonal and Offset (D&O) system (GoAP, 1980). The method of measurement of individual properties and holdings underwent several changes as the survey progressed. More than 96% of FMBs were surveyed by using D&O system in the state. Along with D&O system, Plane table and Block maps are found in Anantapuramu district. The available FMBs in Andhra Pradesh are either in Gunter Links or in Metric Links.

As per the records of Survey Settlements and Land Records (SS&LR) Department, Andhra Pradesh is having about 49 Lakh FMBs with different survey methods. Recently, state government has launched "MeeBhoomi" project which contains all land details along with Adangal/Pahani and 1-B/Record of Revenue (RoR) of the state. Government has made it available to the public for checking their land details online in the official website of MeeBhoomi anywhere/ anytime. MeeBhoomi portal contains the details of land owners, area, assessment, soil

type, water resources, and nature of possession of the land, liabilities and crops grown. It is very useful for land owners, tenants, administrators, etc.

Different systems of survey in Andhra Pradesh

Paimash system: It was started in first quarter of 19th century, in which, each land holding (plot) was numbered and named in this system. Measurements were taken from north to south and then east to west. Areas and boundaries were generally taken with a 24 feet chain at that time. This method underwent several changes as the survey techniques advanced.

Khasra method (1858-65): If the field was quadrilateral, four sides were measured in this method. All irregular fields were divided into quadrilateral or triangular portions called as taks and the field itself could be plotted only by piecing of taks. The areas were worked out by multiplying the means of lengths by the means of breadths. But no serious attempt was made for mapping of the details on ground.

Simple triangulation (1866-77): Triangulation is a surveying method that measures the angles in a triangle formed by three survey control points. Using trigonometry and the measured length of just one side, the other distances in the triangle are calculated. The shape of the triangles is important as there is a lot of inaccuracy in a long skinny triangle, but one with base angles of about 45 degrees is ideal. In triangulation, entire area to be surveyed is covered with a framework of triangles. For the triangle, the length of the first line, which is measured precisely, is known as Base line. The other two computed sides are used as new baselines for two other triangles interconnected with the first triangle. Each of the calculated distances is then used as one side in another triangle to calculate the distances to another point, which in turn can start another triangle. Triangulation with offsets method survey was used during 1878-1886.

Plane table (1887-91): Plane Table surveying is a graphical method of survey in which the field observations and plotting are done simultaneously. The plan is drawn by the surveyor in the field, while the area to be surveyed is before his eyes. Therefore, there is no possibility of omitting the necessary measurements. Under this system, the maximum area of survey fields was taken to be 6 acres in wetland and 12 acres in dry land.

Block map system (1892-96): In this method, the block was divided into large triangles and all survey fields and sub-divisions were correctly plotted by offsets from the sides of these triangles. Only a few stations of these triangles were theodolite stations, the rest being fieldstones or peg stations. This method was extremely cheap but results were inaccurate and the system was not suitable for maintenance.

Punganur system (1918-20): The system was first adopted in the Punganur zamindari of Chittoor district and then followed in Repalli taluk of Guntur district and Venkatagiri zamindari of Nellore district. Under this system, all points on the boundary of a field are offset from G-Line and field boundaries are not measured but computed.

Diagonal and Offset (D&O): This is the latest method and is being adopted for survey since 1902. Each field tri-junction is connected with the next field by a line called G-line and selecting convenient diagonals completes the triangles. Independent framework is provided for each survey field. Field and subdivision bends are offset on the G-lines and diagonals. The diagonal and offset system affords an independent check of a substantial amount of fieldwork done by the surveyor. The up-to-date diagonal and offset system is more accurate, less costly and quite easy for maintenance of framework of survey and land records.

1.3 Review of Literature

Rao et. al., (1996) demonstrated overlaying of cadastral maps over the merged product of IRS 1C PAN and LISS III data. Singh (1998) discussed different issues associated with Land Records and modernization of the same. Greenfield (2001) evaluated the accuracy of digital orthophoto quadrangle in the context of parcel based GIS. Similar study has been carried out by Raju et. al., (2008) who stated that the potential of very high resolution satellite data is high in urban cadastral mapping. Ali et. al., (2012) described the use of remote sensing data for updation of cadastral maps. Kumar et. al., (2013) demonstrated updation of cadastral maps using high resolution remotely sensed data. Kemiki et. al., (2015) discussed possibilities of implementation of cadastral information system and stated that it as useful for property valuation, resident's inventory and property leasing analysis. Padma et al, (2015) demonstrated updation of approximate sub-divisional parcel boundaries of a cadastral map by using World View-2 satellite data.

1.4 Objectives

The study is aimed at developing comprehensive landed database for sustainable development of the state with the following objectives.

- To reproduce the field measurement book sketches using Collabland software
- To develop comprehensive sub-division wise database of the State

2. Data Used

High resolution World View-2 satellite data of PAN (0.5m) and Multispectral (2m) were acquired on 15th January, 2015 over the study area. The FMB sketches were collected from SS&LR department and used to produce the digital sketches using Collabland software and generate village wise mosaics. These maps were geo-referenced and overlaid on the satellite imagery for further use. The study area comprises of Malkapuram village, which is located in Guntur District of Andhra Pradesh. GPS was used for Ground Control Points (GCPs) collection in the study area.

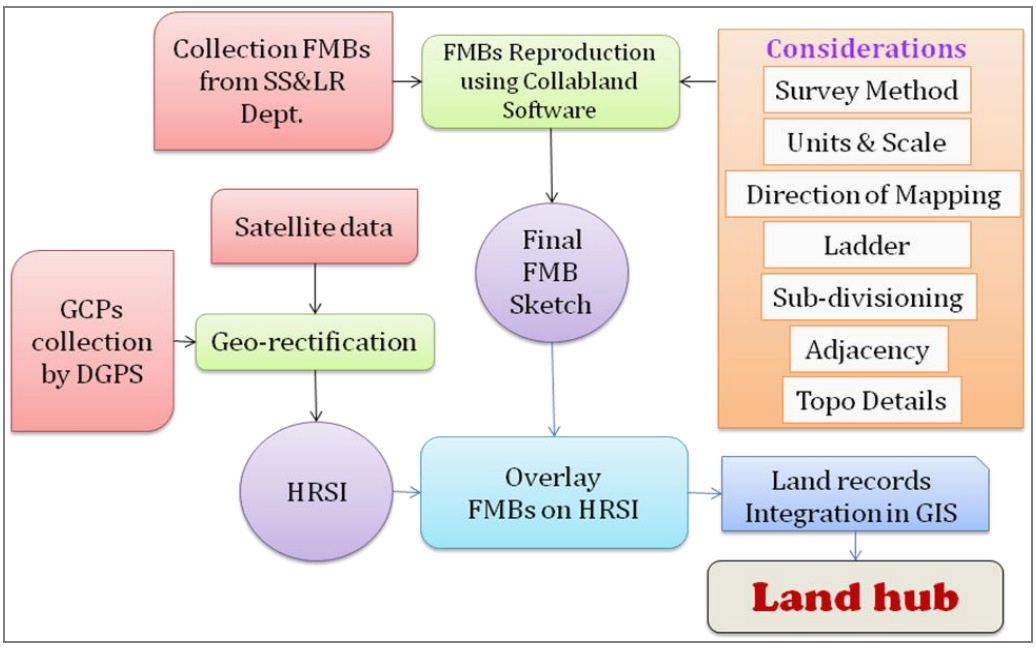

Figure 2: Methodology

3. Study Area

The study area comprises of Malkapuram village, which is situated on the Vijayawada - Amaravathi main road. It is located 31kms towards north from district headquarters. The study area lies to the north of Guntur district between 16º 29' - 16º 32' N latitudes and 80º 30' - 80º 32' E longitudes. This place is associated with the ancient historic culture of Kakatiyas and Golkonda Kings.

4. Methodology

An attempt has been made to reproduce the FMB sketches using Collabland software, which is developed by National Informatics Centre (NIC), Government of India. It is a software for digitization and mosaicing of survey maps for computerization of land records. It allows a variety of survey systems, extending from the conventional Chain and Theodolite method to the modern Electronic Total Station (ETS) system (APSAC, 2016). The software also supports in regional language and the interface sample in Telugu is given in the Figure 3. World view-2 multispectral image was geometrically corrected using the ground control points. Village wise FMB sketch mosaics were generated in Collabland software based on adjacency and boundary lines of the FMB. The high-resolution satellite images were rectified using collected Ground Control Points (GCPs). After the finalization of satellite data, the village wise mosaic FMBs were transformed on satellite data by using affine method of transformation tool in the GIS environment (NRSC, 2011). The comprehensive methodology used in the present study is shown in Figure-2.

5. Results & Discussion

The study has demonstrated that collabland software is capable of producing accurate computer aided field measurement book sketches. Traditionally, the surveyors in developing countries have given priority to implement accurate cadastral field surveys without giving much attention to the cost but since the turn of the new millennium, more cost-effective and flexible methodologies were utilized. However, modern cost-effective methodologies do not neglect the quality but focus more on required accuracy on the user point of view by using technical capacity and available equipment. In many developing countries the use of very high resolution satellite data with possible combination of different survey methodology depending on local quality requirements and characteristics of the land is implemented.

5.1 FMB Reproducing

To attain this, the FMBs have been collected from survey department in the form of hard copy. Collabland software has been used for digitization/reproduction of the FMB. It allows different survey maps for digitization and mosaicing of land survey maps. Initially, the FMB sketches were examined by the draughtsman/digitizer for reproduction; with respect to method of survey, scale, traverse direction, base distances, units, etc. Once confined with all these parameters, the input values (survey measurements) have been entered into the Collabland software in the form of tables i.e. Ladder, Boundary, Adjacency and Extended. The ladder table is very crucial for the reproduction of a field sketch and has all the survey details of FMB sketch. The adjacency and boundary tables have been used for demarcation of the adjoining field boundary and survey numbers of the FMB sketch. The sub-division points have been joined for sub-dividing the FMB sketch and titled in order to assign numbers for each individual sub-division. The extended table has been used as extension of ladder table. The topological details like Building, Culvert and Bridge, Sluice, Thatched house, River, Canal, Aqueduct, River flow direction, etc. have been drawn on the FMB sketch as per the specification on the original FMB. The digitized FMB sketch has been saved by selecting

corresponding district, mandal, village name, which are pre-defined in the software with regional language and is stored in the database with corresponding survey number. The quality assurance has been abided for reproduction of FMB in terms of measurements, tables, adjacency, sub-divisions, scale, title, completeness, etc. Cross verification has been made frequently for ensuring coherent consistency of the FMB. Thus, village level mosaic has been generated to piecing of individual FMBs by using mosaic tool in the software. Edge matching is done by fetching two different FMB sketches of the same village into the same file and matching their edges with reference to the adjacency, boundary and base lines. On-screen checking has been performed for checking the common edge between the sketches. The reproduced FMB map is presented in Figure-3 and village mosaic is presented in Figure-4.

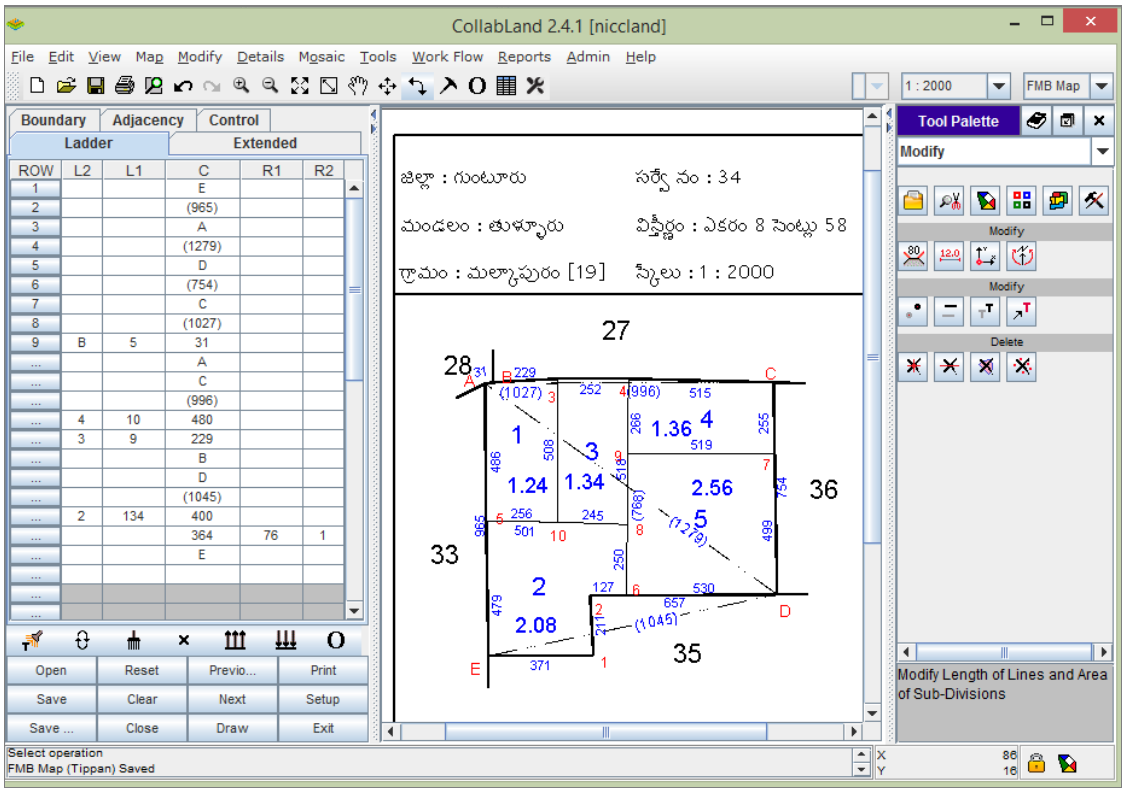

Figure 3: Reproducing FMB sketch in Collabland software

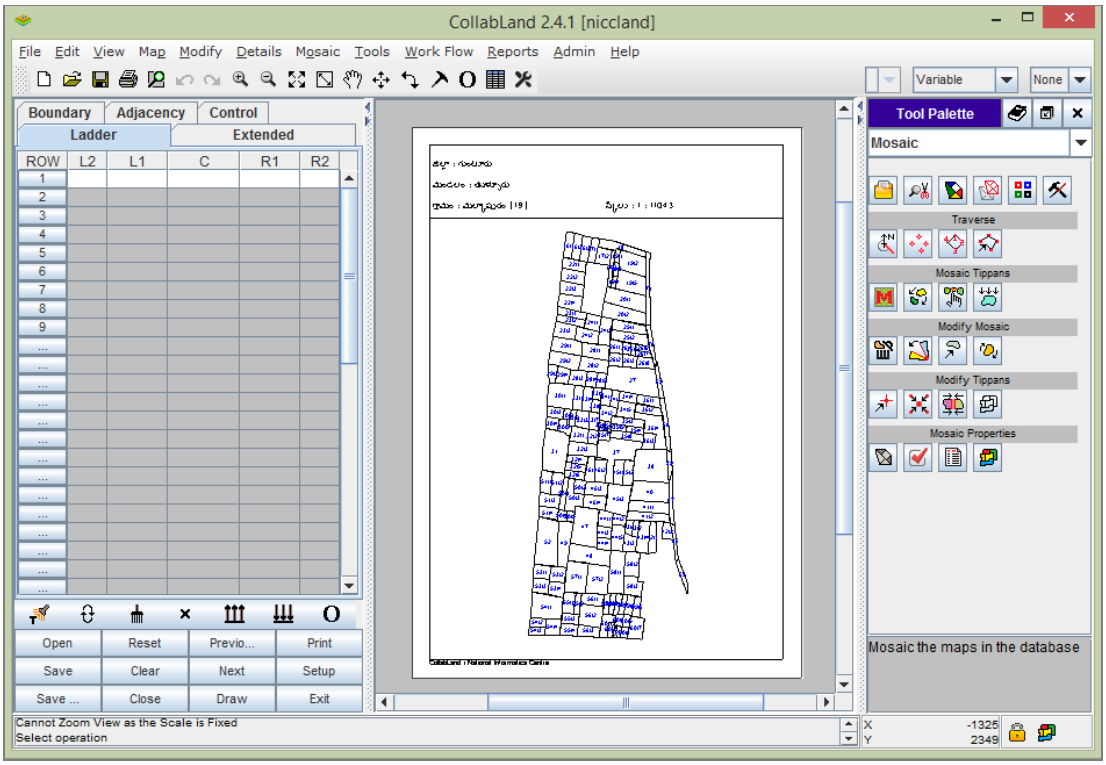

Figure 4: Village Mosaic of FMBs in Collabland software

Figure 5: Village mosaic overlaid on HRSI

5.2 Overlay on High Resolution Satellite Imagery (HRSI)

High resolution satellite images are considered as source of information to solve socio-economic problems in many contemporary fields of study. These images, together with remote sensing and GIS techniques support decision making in many ways. HRSI provides an alternative data for acquisition of spatial data by providing remote and inaccessible area survey details. World View-2 PAN & MSS images were acquired and separately geo-rectified with collected GCP's in conjunction with Digital Elevation Model (DEM). These two images were geo-rectified separately and merged for final fusion product generation using ERDAS Imagine software. After the finalization of satellite data, the digitized vector sub-divisions were geo-referenced by using GCP's and transformed on satellite data by using affine method of transformation tool in the GIS environment. Thus, the FMB village mosaics are overlaid on HRSI and it can be used for updating the sub-divisions, transferring the land ownership details easily and precisely. The village mosaic overlaid on HRSI is shown in Figure-5 and sub-divisions of the survey number 34 are presented in Figure-6.

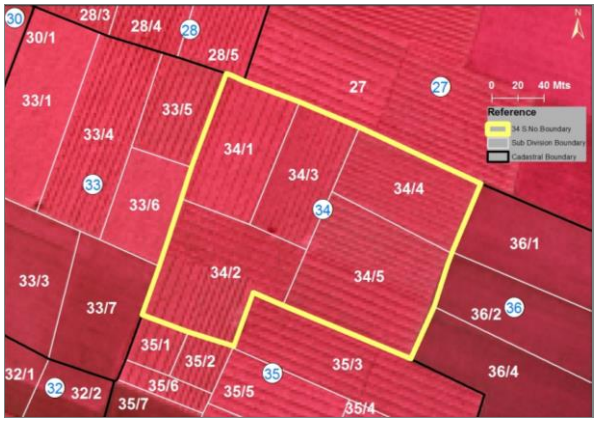

Figure 6: Survey number 34 is overlaid on HRSI

The Resurvey Settlement Records (RSR) data can be integrated with individual land holdings and make it as information system. This will serve the administrators in maintaining an up to date database, assigning values for taxation, calculating subsidies, addressing rural development and management and providing products and services to citizens and companies. The individual land holdings data (RSR) of survey number 34 is illustrated in Figure-7.

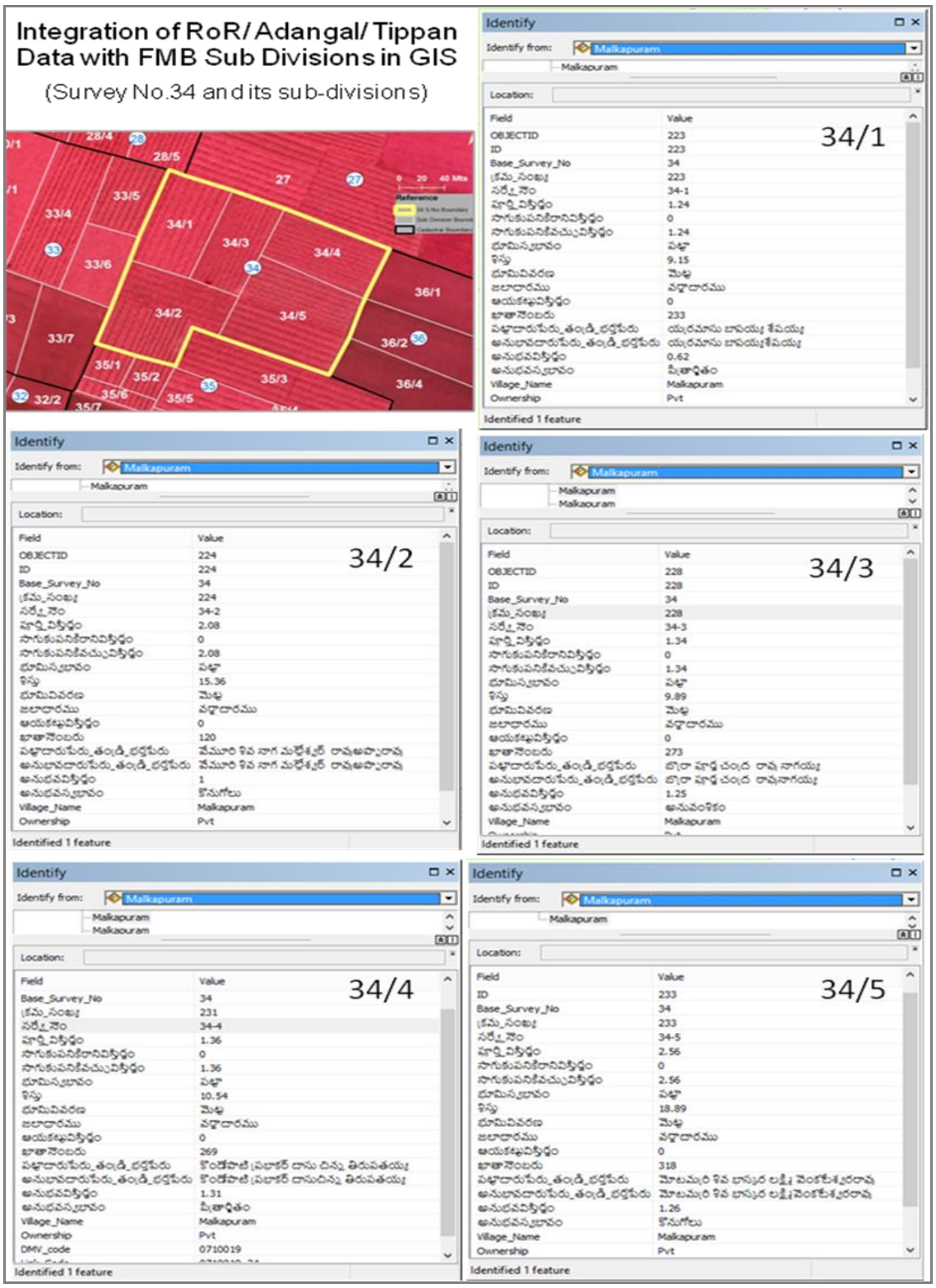

Figure 7: Integration of Adangal data with FMB sub-divisions from 34/1 to 34/5

6. Conclusions

The overall results suggest that the approach is more effective in reproducing FMBs by using survey measurements in the sketches. This study found that the CollabLand software is effective in regenerating accurate FMB sketches and has been adopted for Digital India Land Records Modernization Programme (DILRMP) project in the State of Andhra Pradesh. The FMBs are generally very old and need thorough updation as they have gone through various stages of manual settlement resulting in degradation of quality. The FMB sketches were perceived as a static, plain view of preselected areas, available at fixed scales, but due to the advances of the geospatial technology, it is now evolving into a dynamic, continually updated network of interrelated databases with volumes of geographically referenced information linked to a comprehensive digital land database. The integration of FMBs data with HRSI is more effective for further developmental planning and

management of the State. The village wise FMB maps have been overlaid on geometrically corrected image for development of applications in various sectors like urban planning, surveying, agriculture, property taxation, etc. This approach provided an effective technique for reproducing FMB data and facilitate to public dynamically. The FMB data can be easily updated, retrieved to do different calculations with less time and cost. This would be extended to the entire State in future. However, semi-automated procedure needs to be evolved for undertaking a gigantic task like digitization of all records pertaining to a State.

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