UTILITY OF HIGH RESOLUTION SATELLITE DATA FOR DIGITAL SUB-DIVISIONS OF FIELD MEASUREMENT BOOKS - A CASE STUDY OF SELECTED VILLAGES IN ANDHRA PRADESH

*K.V.Ramana, Ch. Tata Babu, M. Hari Krishna, Ch. Praveen Kumar

Andhra Pradesh Space Applications Centre, Planning Department,
Govt. of Andhra Pradesh, Vijayawada, 520010, Andhra Pradesh

*Corresponding Author Email: ramanakv.apsac@gmail.com

ABSTRACT

The individual survey number sketches are maintained as Field Measurement Book (FMB). It is a description of systematically organised land parcels in an area describing any individual land properties. It provides spatial integrity and unique identification of each and every land sub-division. It is required to maintain adequate, accurate and up-to-date data and easily retrievable land records for establishing the ownership rights. The main objective of the study is to regenerate a spatially accurate, legally supportive and operationally efficient sub divisional cadastral database and assess the accuracy of sub-division parcels of selected three villages of Guntur district in Andhra Pradesh. To achieve this, village cadastral maps, FMBs, Record of Rights (RoR) and Adangal records have been used. This study mainly focuses to evaluate the method of digital sub-divisions by using High Resolution Satellite Imagery (HRSI) and Global Positional System (GPS). The comparisons show that 70% of the sub divisions and 90% of the sub divisional area can be derived from high resolution satellite imagery with acceptable accuracy and precision meeting the standards of cadastral survey. The result shows that the use of very high resolution satellite imageries can reduce the cost, time and human resources as compared to the other survey methods. Large deviations in sub-division areas were due to unclear boundaries or measurements of the sketches.

KEYWORDS: cadastral maps, sub divisions, adangal, field measurement book, HRSI, RoR

INTRODUCTION

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. 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 (Mishra and Pal, 2000). 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. The information revolution has a great potential to support the complex decision making demands of sustainable development. A cadastral map shows the relative location of all parcels in a given village (Kumar et al, 2013). Information on sub-divisions 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.

FMBs along with cadastral maps are vital tool for the administration in dealing with day to day revenue and development activities in the state. Any current or future property registration system must be viewed within the larger context of land rights and should be designed to support the massive transfer of land from state to private ownership. This transfer defines the most immediate needs in terms of sub-parcel demarcation, delineation and registration. The implementation and modernization of field measured books and registration systems have been key components in a number of economic development projects in many parts of the country. The land hub system is providing a core of information for a multipurpose usage by a variety of users without directly involved in the cadastral system or land administration. Computerization of FMBs along with RoR data can enhance the capability to manage, analyze, summarize, display, and disseminate geographically referenced information (Padma et al, 2015). Working with digital FMBs and tabular related data in a GIS, users can selectively retrieve and manipulate layers of parcel and spatial information to produce composite maps as per their need.

REVIEW OF LITERATURE

APSAC, (2016) described the procedure for reproducing Field Measurement Books by using CollabLand software. The idea of using High Resolution Satellite Imagery (HRSI) for the purpose of cadastral and sub-division mapping is described by different authors at different times. Padma et al., (2015) demonstrated updation of approximate sub-divisional parcel boundaries of a cadastral map by using World View-2 satellite 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. Rao et al., (2014) underlines the importance of HRSI in cadastral survey by comparing the perimeter area and position of parcel boundaries with the results from global positioning system (GPS) and Electronic Total Stations (ETS). One of the motivations behind their work was modernization of land records management to improve transparency and minimize land disputes.

Kumar et. al., (2013) demonstrated updation of cadastral maps using high resolution remotely sensed data. Ali et. al., (2012) described the use of remote sensing data for updation of cadastral maps. 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. Greenfield (2001) evaluated the accuracy of digital orthophoto quadrangle in the context of parcel based GIS. Singh (1998) discussed different issues associated with Land Records and modernization of the same. Rao et al., (1996) demonstrated overlaying of cadastral maps over the merged product of IRS 1C PAN and LISS III data. The above authors justified satellite image based mapping with manual digitization is advantageous in terms of cost and time over the conventional cadastral surveying approaches. Thus an attempt has been made to compare the sub-division areas obtained from RoR, CollabLand and HRSI.

STUDY AREA

The study area comprises of Inavolu and Dondapadu villages in Thullur mandal and Penumaka village in Tadepalli mandal of Guntur district, which constitute a part of the capital core area of the Andhra Pradesh. The total FMB's against the FMBs digitized, mosaiced and sub division wise area compared are presented below of three selected villages. The study area is shown in Figure-1 and total FMB's against the FMBs digitized, mosaiced and no. of sub divisions are presented below of three selected villages (Table-1).

Table-1. Details of available FMBs and Digitized of three villages

S. No	Mandal Name	Village Name	Total FMBs	Total Sub Divisions	Digitized	Mosaiced	Geo-referenced	Remarks
1	Thullur	Dondapadu	64	135	63	63	63	1 FMB Not available
2	Thullur	Ainavolu	162	670	161	161	161	1 FMB Not available
3	Tadepalli	Penumaka	342	752	339	339	339	3 FMBs are Not available

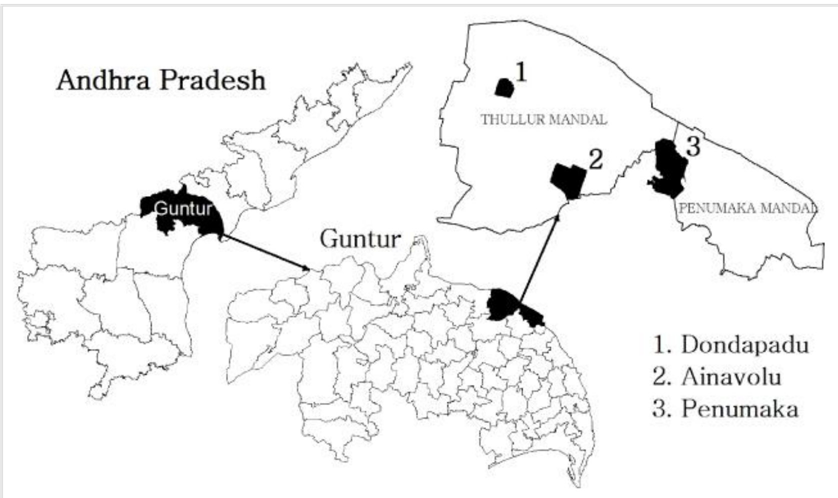

Figure 1. Location map

OBJECTIVES

The study is aimed at assessing the utility of high resolution satellite data for developing comprehensive land database upto sub-division levels of field measurements books.

DATABASE

The FMB sketches and RoR areas were collected from SS&LR department and CollabLand software v 2.5 developed by NIC, is used to reconstruct the digital sketches and generated village mosaics. High resolution World View-2 satellite data of PAN (0.5m) and Multispectral (2m) were acquired on 15th January, 2015 over the study area. These maps were geo-referenced and overlaid on the satellite imagery for further use. GPS was used for Ground Control Points (GCPs) collection in the study area.

METHODOLOGY

The available FMB sketches of the selected three villages are reproduced using CollabLand software based on the ladder (survey) data. 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 village mosaics were generated in the CollabLand s/w based on adjacency and boundary lines of the FMB. World view-2 multispectral image was ortho rectified using the Carto DEM and the ground control points. After the finalization of satellite data, the village wise mosaic FMBs were overlaid and transformed on satellite data by using affine method of transformation tool in the GIS environment (NRSC, 2011). The sub-division wise area have been compared and also compared with respect to ownership. The comprehensive methodology presented in Figure-2.

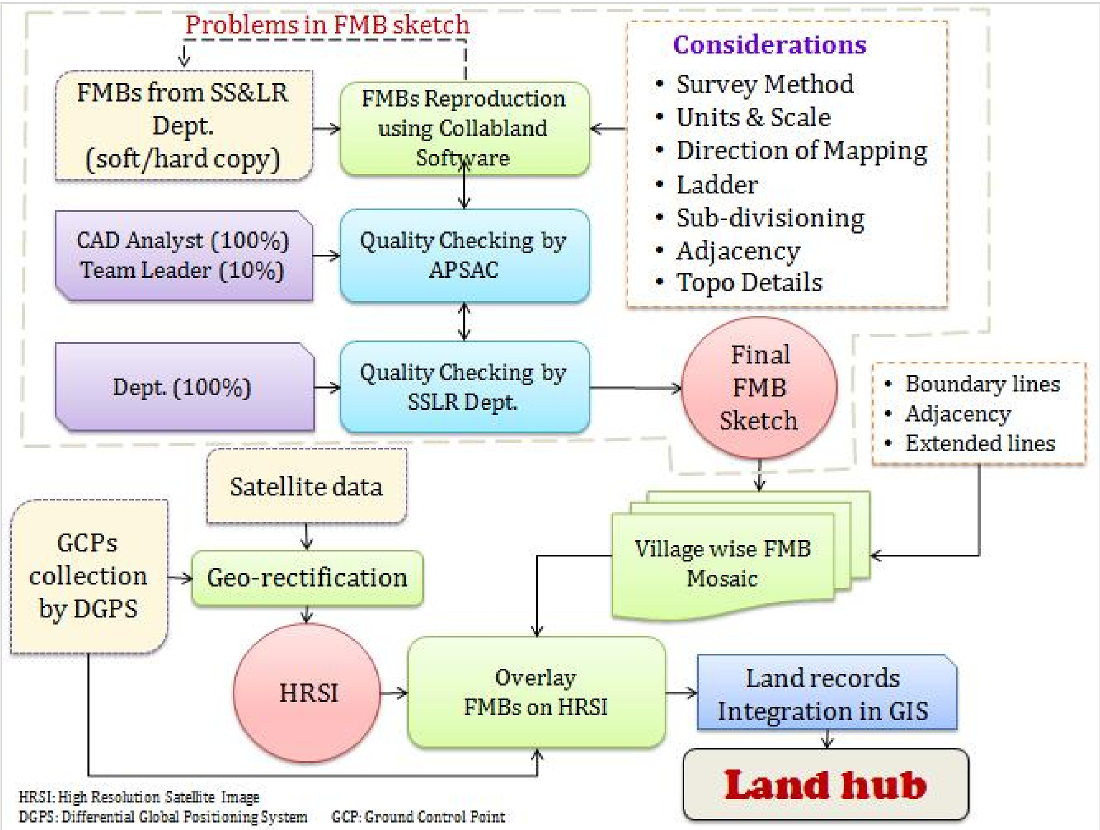

Figure 2. Methodology

RESULTS & DISCUSSIONS

The study has demonstrated that CollabLand software is capable of producing accurate computer aided field measurement book sketches. The modern cost-effective methodologies don't neglect the quality but focus more on required accuracy on the user point of view by using technical capacity and available equipment. The digital FMB mosaic maps have been geo-referenced to high resolution satellite data with 2nd order polynomial for more precision. During the geo-referencing, two modes of methodology are attempted for accuracy assessment in the process of geo-referencing of FMBs i.e. visual (quality) and numerical (quantitative). The visual assessment includes validation of geo-referenced FMBs and with adjacency or neighbourhood using the high-resolution satellite as the reference. The quantitative method includes transformation model assessment and positional and area accuracy (Murthy et al., 2003). Each polygon in the FMB (polygon) vector represents a sub parcel and it will have unique sub-parcel number or sub-survey number. Topology validation has been performed for creation of spatial relationship between the adjacent sub division boundaries. The methodology presented in this paper is useful to reproduce the FMBs with low to medium accuracy. The village wise FMB mosaic maps are presented in figure 3, 4 and 5.

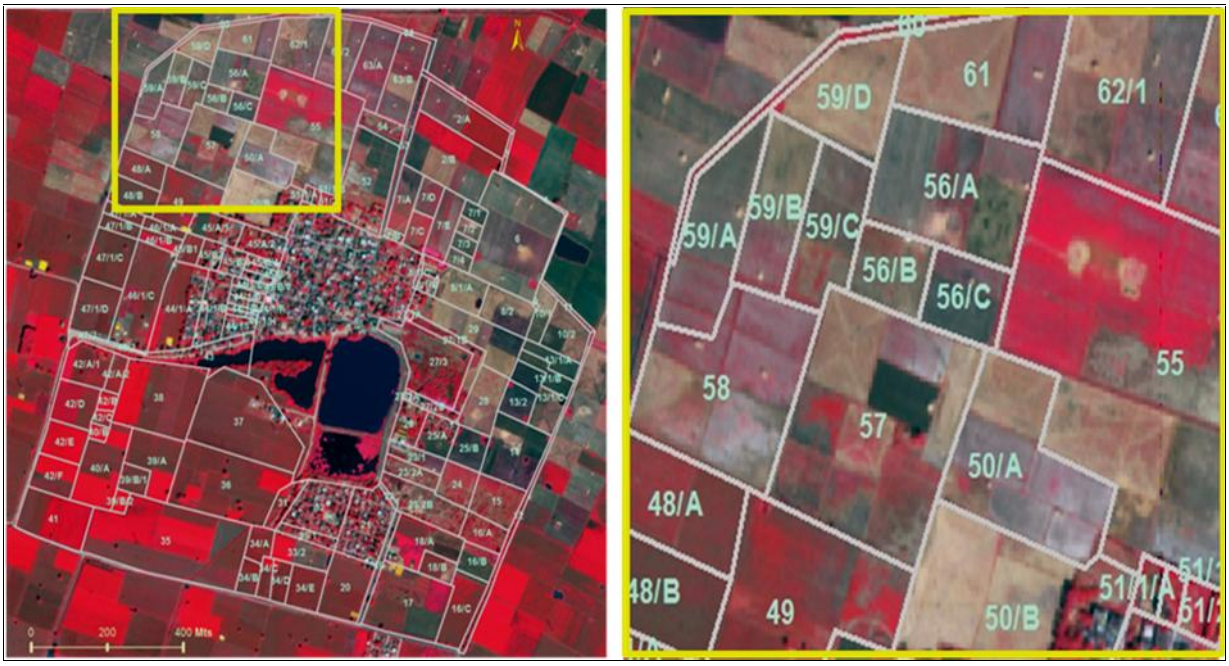

Figure 3. Sub-divisions (FMBs) of Dondapadu Village

Figure 4. Sub-divisions (FMBs) of Ainavolu Village

Figure 5. Sub-divisions (FMBs) of PenumakaVillage

Comparison of Village Area

The sub divisions derived from CollabLand and HRSI were used for analysis and compared with the original ROR records, that are obtained from AP Survey department and used as reference area for the comparison. A total of 1557 sub-divisions are reproduced, mosaiced and overlaid on HRSI and used for analysis. The comparison of area for selected 3 villages is shown in Table-2. The extent of village area generated from CollabLand s/w is more or less matching with the ROR data while with HRSI data, the maximum is found to be around 1.6 %.

Table 2. Comparison of total village area (Acres)

S No	Village Name	No of FMB Sub Div	Village Area (ROR)	Village Area (CollabLand)	Village Area (Satellite data)
1	Ainavolu	670	1182.88	1189.81	1186.1
2	Dondapadu	135	334.29	332.63	334.61
3	Penumaka	752	1874.55	1885.16	1907.88

Comparison between RoR Records and CollabLand

The comparative study of the sub division area derived from CollabLand and HR Satellite image were compared with the reference data (ROR data). The deviation of area is categorised into four categories (0-1, 1-3, 3-5 and > 5 % deviation). The comparison of % error for number of subdivisions between RoR and CollabLand is presented in Table-3. From Table 3, it can be seen that about 1064 sub-divisions have less than 5% error in CollabLand area. About 48% of the parcels have error between 3% and 5% which implies a moderate deviation in record values. Around 20% (310 sub divisions) of the sub divisions had an area deviation between 0-1%. 32% of sub-divisions were in the error range of 1-3%. In Ainavolu village, 90% of sub-divisions were having the area within acceptance error i.e. 5%, whereas Dondapadu village is about 77% and Penumaka village is about 84%. It can be stated that approximately 68 % of the parcels can be marked with less than 5% error using CollabLand software. The comparison of % error in number of subdivisions and area between RoR and CollabLand is shown in Figure-6.

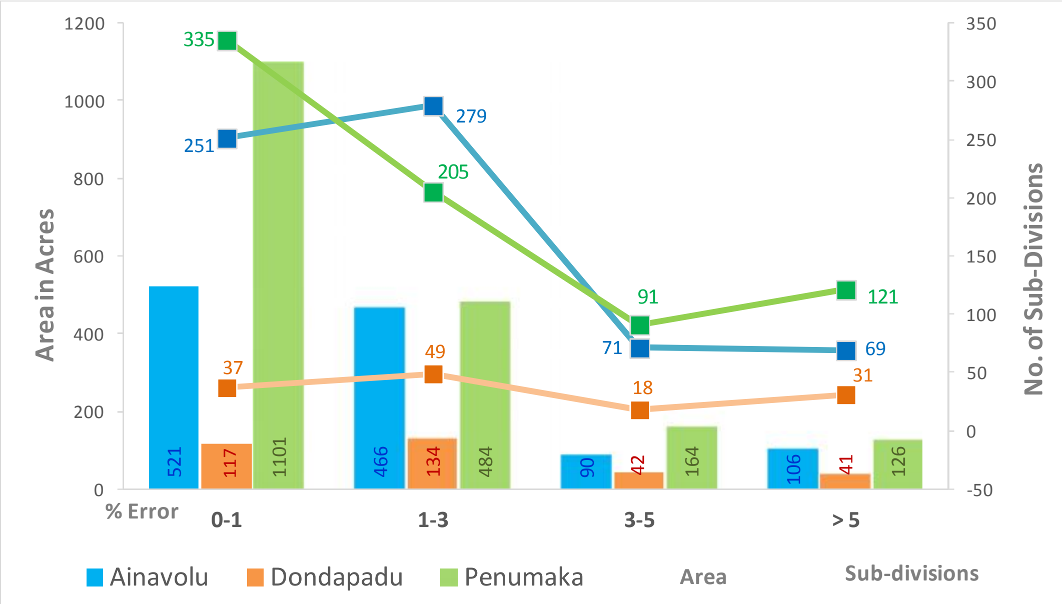

Figure 6. Comparison of % error in number of subdivisions and area between RoR and CollabLand

Table-3. % error comparison for number of subdivisions between RoR and CollabLand

% Error	Ainavolu		Dondapadu		Penumaka		Total	% to Total
	No. of Sub Divisions	% to Sub Div.	No. of Sub Divisions	% to Sub Div.	No. of Sub Divisions	% to Sub Div.		
0-1	251	37.46	37	27.41	335	44.55	310	19.91
1-3	279	41.64	49	36.30	205	27.26	497	31.92
3-5	71	10.60	18	13.33	91	12.10	257	16.51
> 5	69	10.30	31	22.96	121	16.09	493	31.66
Total	**670**	**100**	**135**	**100**	**752**	**100**	**1557**	**100**

Table-4 shows village wise % error comparison for area of subdivisions between RoR and CollabLand. It is observed that 92% of the area is under acceptable within a range of 0-5% which shows minimum deviation. Around 51% of the area is within the error range of 0-1% which shows accurate area in FMBs. 32% of the area has error between 1-3% which implies minimum deviation. 9% of the areas have error between 305% which implies a

Table-4. % error comparison for area of subdivisions between RoR and CollabLand

% Error	Ainavolu		Dondapadu		Penumaka		Total	% to Total
	Area in Acre	% Area	Area in Acre	% Area	Area in Acre	% Area		
0-1	521.01	44.05	117.32	35.10	1100.6	58.71	1738.93	51.27
1-3	466.36	39.43	133.51	39.94	484.28	25.83	1084.15	31.96
3-5	89.62	7.58	42.03	12.57	163.54	8.72	295.19	8.70
> 5	105.89	8.95	41.43	12.39	126.13	6.73	273.45	8.06
Total	**1182.88**	**100**	**334.29**	**100**	**1874.55**	**100**	**3391.72**	**100**

moderate deviation in recorded values. About 60% of the area is in the range of 0-1% error in Penumaka village. It is found that, the error range of 3-5 and >5 are more are less same in all the three villages.

Comparision between RoR Records and HRSI

The number of subdivisons and the proportion of area with in the error margin of 0-1, 1-3 and 3-5 % were compared between the measurements of CollabLand and HRSI. In this case, about 70% of the sub-divisions 70% in error range of 0% to 5%. Of which 20% of the sub-divisions have mached between the RoR record area and HRSI area. As in Table 4, 32% of the sub-divisions are in error range of 1-3% which shows minimum deviation. 32% of the sub-divisions have error greater than 5% which shows moderate deviation in recorded values. The village wise % error comparison for number of subdivisions between RoR and HRSI are presente in Table-5 and comparison of % error in number of subdivisions and area between RoR and HRSI shown in Figure-7.

Table-5. % error comparison for number of subdivisions between RoR and HRSI

% Error	Ainavolu		Dondapadu		Penumaka		Total	% to Total
	No. of Sub Divisions	% to Sub Div.	No. of Sub Divisions	% to Sub Div.	No. of Sub Divisions	% to Sub Div.		
0-1	138	20.60	19	14.07	153	20.35	310	19.91
1-3	212	31.64	26	19.26	259	34.44	497	31.92
3-5	107	15.97	21	15.56	129	17.15	257	16.51
> 5	213	31.79	69	51.11	211	28.06	493	31.66
Total	**670**	**100**	**135**	**100**	**752**	**100**	**1557**	**100**

Table 6: % error comparison of area between RoR and HRSI

% Error	Ainavolu		Dondapadu		Penumaka		Total	% to Total
	Area in Acre	% Area	Area in Acre	% Area	Area in Acre	% Area		
0-1	293.37	24.80	131.9	39.46	1100.6	58.71	1738.93	51.27
1-3	299.47	25.32	61.84	18.50	484.28	25.83	1084.15	31.96
3-5	403.71	34.13	70.97	21.23	163.54	8.72	295.19	8.70
> 5	186.33	15.75	69.58	20.81	126.13	6.73	273.45	8.06
Total	**1182.88**	**100**	**334.29**	**100**	**1874.55**	**100**	**3391.72**	**100**

From Table-6, it was observed that 92% of the sub-division areas have lies within error range of 5%. 51% of the sub-division ares have the areas mached between the RoR recorded area and HRSI area. 32% of the sub-division areas are in error range of 1-3% which shows minimum deviation. 9% of the sub-division areas in error range of 3-5% which shows moderate deviation in recorded values. The village wise % error comparison for area of subdivisions between RoR and HRSI are presente in Table-6.

CONCLUSIONS

The availability of satellite data with very high spatial resolution has proved to be a boon in the field of land surveying for cadastral mapping with high accuracy, cost effective and time efficient manner. The overall results suggest that the FMB reconstructed by CollabLand s/w approach are 20% of sub-divisions and 51 % of the area were within <1 % as recorded in ROR, while 68 % of sub divisions and 91 % of the area is within 5 % error margin. This study found that the CollabLand software is effective in regenerating accurate FMB sketches.

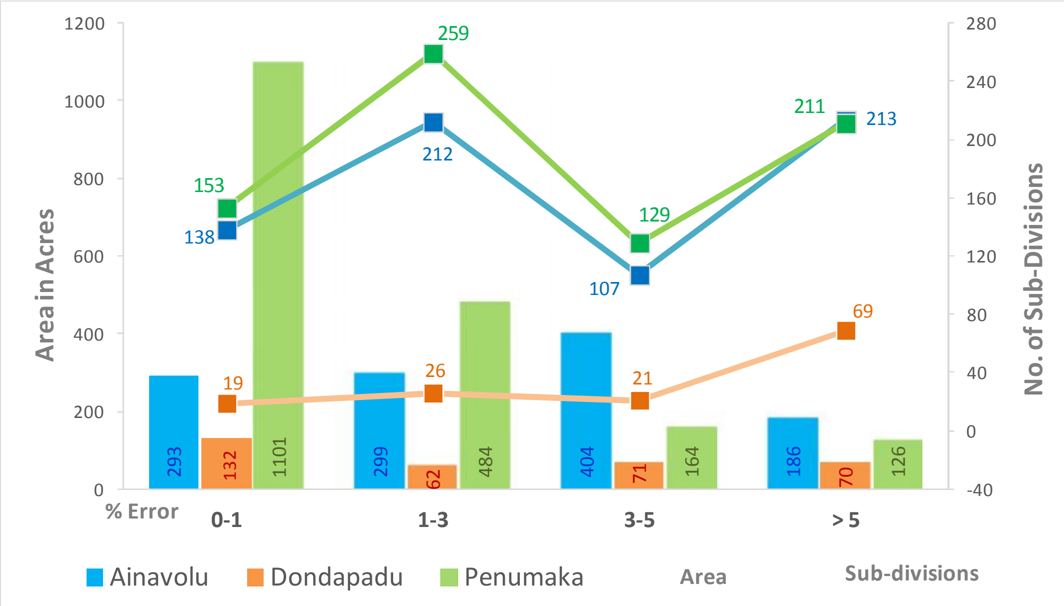

Figure 7. Comparison of % error in number of subdivisions and area between RoR and HRSI

From this study, the comparison of area between RORs, FMBs derived from CollabLand software and HRSI shows good potential of the later for Land hub project in Andhra Pradesh. The comparisons show that around 92% of the sub divisional parcel boundary with respect to area can be derived with acceptable accuracy and precision meeting the standards of cadastral survey. It is also found that about 70% of the sub-divisions are meeting the standards with respect to count of sub-divisions. The result shows that the use of very high resolution satellite imageries can reduce the cost, time and human resources as compared to the other survey methods. Large deviations in sub-division areas were due to unclear boundaries or measurements of the sketches. However, the study needs to be replicated in an undulating/hilly terrain for further validation. The integration of FMBs data with HRSI is more useful for successful implementation of land hub project in the State.

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