Assessing LARSI-integrated Participation Procedure in Urban Adjudication in China

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Key words: Urban adjudication, Low altitude remote sensing, High resolution imagery, Assessment

SUMMARY

Adjudication plays an important role in land registration. Adjudication is the first stage of land registration which can help government to make effective decisions and also ensure citizens' tenure security. The conventional way of cadastral surveying is full ground survey. The working process is complicated, slow, labor-intensive and expensive.
With the development of Geo-information technologies (GIT), there is a great opportunity of integrating Remote Sensing (RS) or photogrammetry into adjudication (Tuladhar, 2005). High Resolution Satellite Imagery (HRSI) has been successfully used into some African countries, like Ethiopia (Lemmen et al, 2010) or Kenya using QuickBird images with sub meter resolution (0.6 m), for general boundary surveying in rural areas where accuracy requirement is not high (D. & Kenya, 2006). For urban fixed boundary surveying, the HRSI measurement after digitizing in Turkey shows 0.5 m root mean square error (RMSE), which is far from accuracy requirements (centimetre-degree) (N.Ahin, S.Bak & B.Erkek, 2000). The aerial photos can achieve much higher resolution (25-50 cm) than satellite images. Successful case of integrating of this technique is from Thailand. But this way can still not satisfy the urban centimetre-degree accuracy requirements. What could be the next step?
Low Altitude Remote Sensing Imagery (LARSI) provides a potential chance to enhance the conventional adjudication. This kind of images is easier to be interpreted and can achieve higher accuracy when digitizing compared with satellite or aerial photos. A case study with an approach based on five centimeter resolution imagery has been done in Luochuan County, Yan'an City in China. This article introduces the integration of LARSI into the adjudication procedure to assess the newly-designed procedure with regard to four aspects- accuracy, efficiency, cost, compliance with law. The new procedure is designed and formulated, as well as an assessment model for the new method is built up.
The result shows the procedure greatly streamlines process and reduces fieldwork so that cost and labor are greatly reduced. Even through the accuracy of the cadastral map is 21 cm which doesn't satisfy the urban accuracy requirement (5 cm) in China, the method is still promising. For other countries (e.g. Germany, North America and large rural area in China) where the accuracy requirement is not high, this new procedure could be applied, the method can satisfy the accuracy needs and also reduce the cost, improve the efficiency. With the development of LARSI and data processing technology, the accuracy of a digitally generated cadastral map tends to be more and more accurate.

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1. INTRODUCTION

1.1 Adjudication

The term "adjudication" was first used in 1950's to describe systematic ascertainment of rights in land (Lawrence, 1985). Adjudication, also called first registration or land titling, deals with the initial compilation of the registers. It happened in two cases where no earlier register information is available or where the 'old' information has a very limited or bad quality. During adjudication, particulars of all rights and liabilities in a parcel must be ascertained and determined conclusively (Larsson, 1991).

The FIG definition is,

"Adjudication is the formalization of unwritten evidence of ownership into sworn written statements to be legally recognized as documentary proof of ownership (FIG, 1996)." It is the first stage in the registration of title to land (Dale & McLaughlin, 1999).

According to (Zevenbergen, 2002), adjudication is the procedure to formalize land through land rights identification, demarcation, cadastral surveying and mapping. Adjudication is the first step and one function of land registration. It occurs when first registration starts. When virtually no written documentation is available, a careful procedure to investigate all relevant interests that exist is called adjudication.

1.2 Status of Integrating HRSI into Adjudication

With the development of geo-information technology, according to (Raju & Ghosh, 2003), High Resolution Satellite Imagery (HRSI) plays a very significant role in generating large scale maps for natural resources or other applications, which indicates the potential utility of integrating HRSI in cadastral mapping (Raju & Ghosh, 2003). Because when the outline of features can be interpreted, boundaries can be identified and traced with great ease and economy. For urban fixed boundary surveying, it has been suggested to do research on the cost, efficiency and time assessment between high resolution images, and field measurement (Leksono & Susilowati, 2008). During the past decade the interest in the application of photogrammetric techniques is increasing (Vassilopoulou et al., 2002). Photogrammetric method to identify land parcel boundaries is considered to be an alternative to ground-based survey and has been adopted by different countries in different ways (Muller et al., 1998).

High Resolution Satellite Imagery (HRSI) has been successfully used into some African

countries, like Ethiopia (Lemmen et al, 2010) or Kenya using QuickBird images with sub meter resolution (0.6 m), for general boundary surveying in rural areas where accuracy requirement is not high (D. & Kenya, 2006). For urban fixed boundary surveying, the HRSI measurement after digitizing in Turkey shows 0.5 m root mean square error (RMSE), which is far from accuracy requirements (centimetre-degree) (N.Ahin, S.Bak & B.Erkek, 2000). The aerial photos can achieve much higher resolution (25-50 cm) than satellite images. Successful case of integrating of this technique is from Thailand. But this way can still not satisfy the urban centimetre-degree accuracy requirements. What could be the next step?

1.3 Low Altitude Remote Sensing Imagery (LARSI)

Low Altitude Remote Sensing Imagery (LARSI) becomes a potential tool to enhance the conventional adjudication. This kind of images is easier to be interpreted with centimeter resolution and can achieve higher accuracy when digitizing compared with satellite or aerial photos.

For LARSI, there are two types of platforms to acquire this kind of data:

- Unmanned Aerial Vehicle (UAV)
- Airship

The two kinds of LARSI are the same in essence on different platforms (5 cm resolution and current), applicable to the newly-designed adjudication procedure after being ortho-rectified. Low Altitude Remote Sensing (LARS) takes advantage over the common aerial system (Commerce Department of China, 2009).

- Low Cost
- Fly slow (>=10 m/s)
- Low altitude (>=100 m)
- High resolution
- Easy to take off regardless of weather and flight permission
- Suitable for mapping in large scale
- Flexible to provide current data for small and discrete areas (<=20 km2)
- But attributes cannot be defined

1.4 Adjudication Situation in China

The First National Land Survey Project (FNLSP) started from 1984 and was completed in 1997. Surveying tools were theodolites, levels which were used to survey the parcel points and boundaries, and plane-tablets for cadastral mapping by pencil, compass and protractor manually. The output quality greatly depended on the skills of the surveyors and cartographers, and the procedure was time-consuming. The computer was not widely

promoted, so the output was mainly maintained in paper format, which made it hard to modify, update and achieve data sharing (Xie & Li, 2007).

The Second National Land Survey Project (SNLSP) started on July 1st, 2007 and was achieved nationally in 2009. Technical tools like GPS RTK, total station and Geographic Information System (GIS) were introduced to survey and record coordinates automatically, which reduced time and labour of manual calculation. Although the technique in the SNLSP is much quicker compared with the FNLSP, it is still time-and-labor consuming in SNLSP, since the cadastre is carried out parcel by parcel in the field.

The current adjudication in China is still groundwork which is slow, labor-intensive and costly. With the development of Remote Sensing (RS), Low Altitude Remote Sensing Imagery (LARSI) is becoming feasible to gather people together and implement adjudication in one workshop, replacing most fieldwork in order to increase efficiency, save labor and probably reduce cost and possibly satisfy the accuracy needs.

LARSI and coordinates measured by total station in SNLSP are available in Luochuan County, so Luochuan County is chosen as the study area. UAV imagery of one pilot of 17 parcels is chosen as the imagery to be tested (see Jing 2011).

2. DESIGN AND TEST THE NEW ADJUDICATION PROCEDURE

2.1 The Current Adjudication Procedure

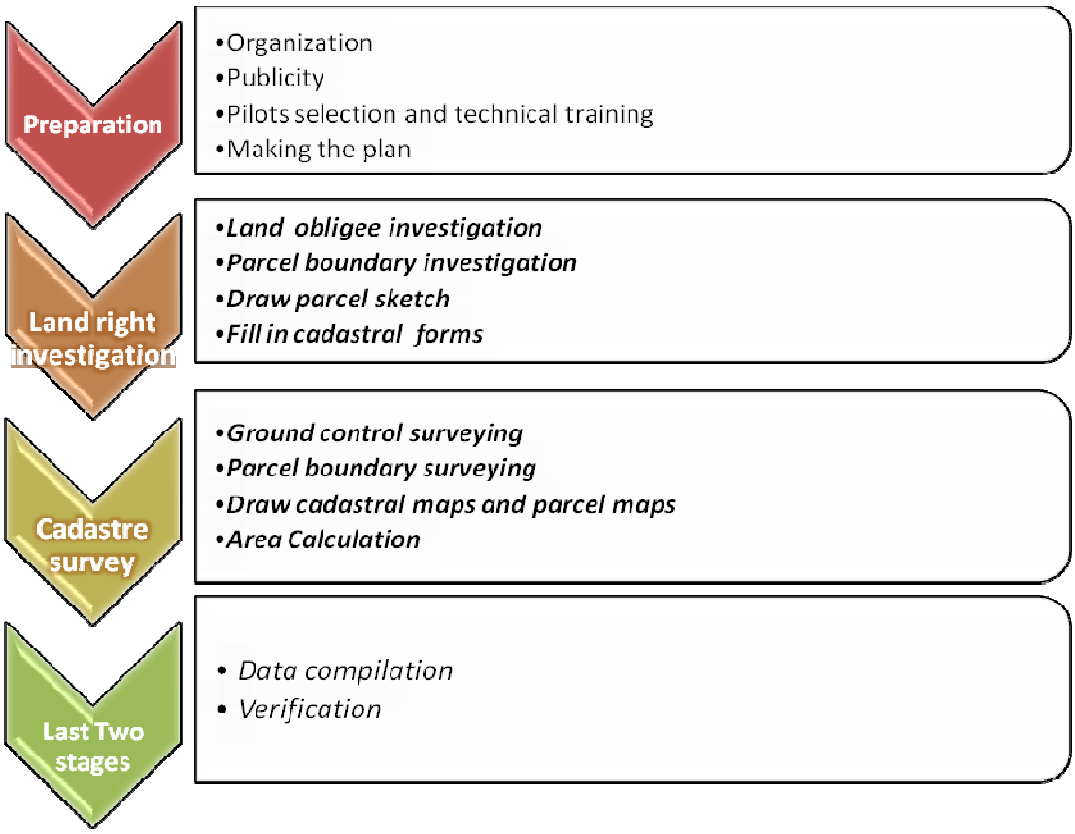


Figure 2, Adjudication Procedure in China (Jing, 2011)

In China, the adjudication procedure includes five stages. Among them, land right investigation and cadastral surveying are the two most important parts in the whole adjudication procedure.

For preparation, land department organizes land staff at local level, inform land obligee via publicity, select pilots for technical training and make the plan for detailed work in the fieldwork.

For land right investigation, land obligees and land staff are together to identify boundary point and measure length in the field. For three land staff per team, two land staff demarcate parcel corner points and measure the length of boundaries. The third one is responsible for filling in the cadastral forms, drawing parcel sketch. Land obligee and neighbors make an agreement, sign their names in the cadastral form and mark boundary points together with land staff.

For cadastral survey per team, one land staff is responsible for prism holder, one is in charge

of Total Station and the third one is to draw field sketch. Based on the parcel corners marked by the first three teams, the surveyors survey every point by total station, draw the parcel sketch and export the data to compute for cadastral mapping by digital delineating.

For the last two stages, data acquired in land right investigation and cadastral surveying, will be complied by coding and then submitted to land department at higher level for verification.

2.2 The Newly-Designed Procedure

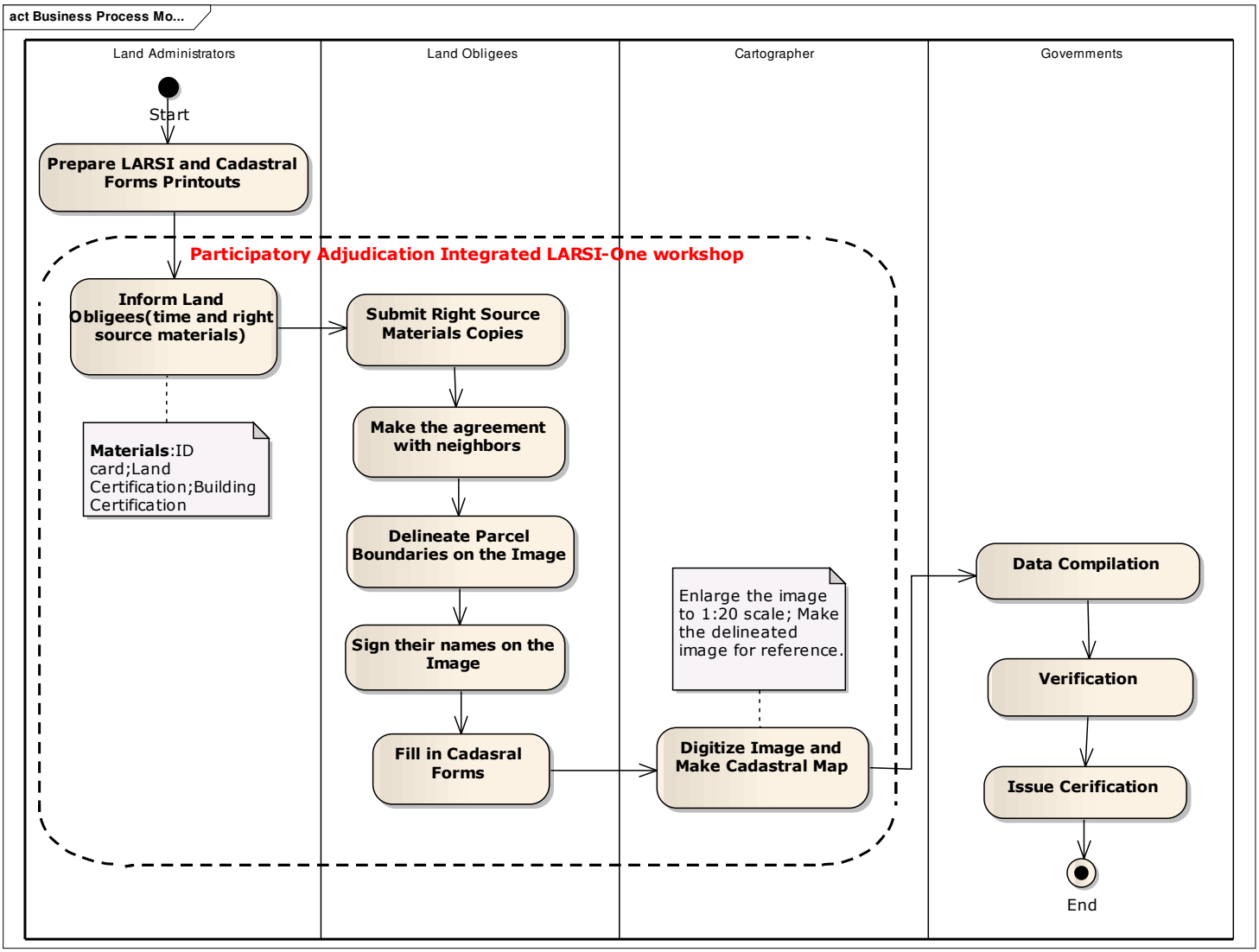


Figure 3, the Newly-Designed Adjudication Procedure (Jing 2011)

The new procedure aims to combine land right investigation and cadastral surveying into one workshop (indoor) in order to replace most fieldwork, improve efficiency, save labor and probably reduce cost.

For land right investigation, one land administrator (the author in the test procedure) introduces the requirement, assists land obligees to identify parcels and delineates boundaries on the image. After land obligees and their neighbors make agreement and sign their names on the imagery, the following work is to fill in cadastral forms under the surveillance of the other land administrator. Cadastral forms are used to record land attribute data (land obligee name and nature, land use type, land right type, etc.).

For cadastral surveying, the cartographer makes the cadastral map and input attribute data based on delineated orthophotos and cadastral forms. Coordinates are measured in ArcGIS software after generating cadastral maps by digitization.

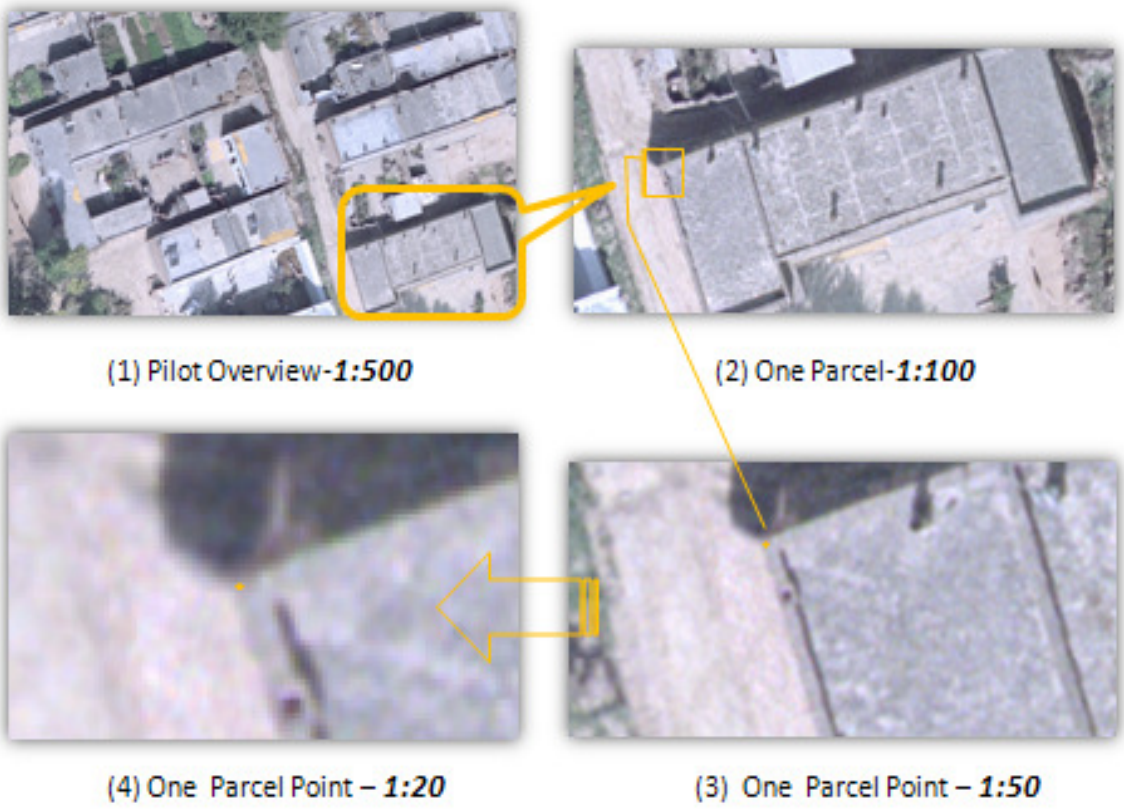


Figure 4, UAV Imagery with 5 cm Resolution

Figure 4 is LARSI with 5cm resolution enlarged to different scales-1:500, 1:100, 1:50, 1:20. From this diagram, we can clearly see that, the corner point can be still interpreted on the imagery enlarged to 1:20.

Figure 5, Delineated Image in Land Right Investigation

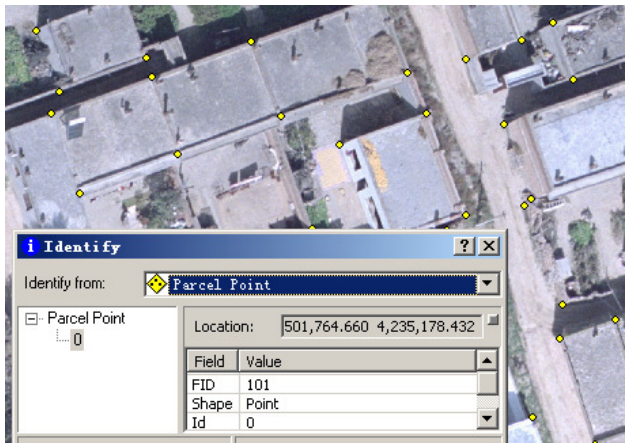


Figure 6, Parcel Point Measurement in ArcGIS

Figure 5 is the output of delineated imagery with signatures. Figure 6 shows coordinate extraction in ArcGIS which replaces cadastral surveying.

The coordinates extracted based on LARSI in ArcGIS will be compared with the reference coordinates measured by total station in the SNLSP. Then the accuracy of the new procedure will be gotten.

3. ASSESSMENT MODEL ESTABLISHMENT AND THE PROCEDURE ASSESSMENT BY THE MODEL

3.1 The Assessment Model

There is no accepted international model to evaluate the suitability of a land adjudication procedure. This paper develops a new model to measure the suitability of land adjudication. The model consists of four indicators - data quality, time/efficiency, cost, and law compliance.

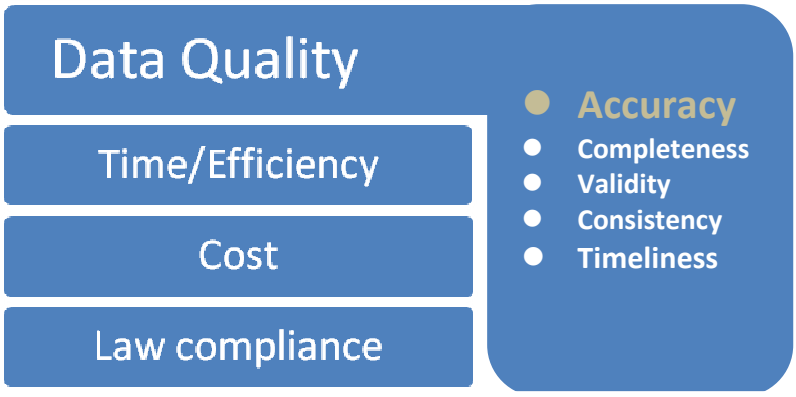


Figure 7, Assessment Model to the new Procedure (Jing 2011)

Data quality - Accuracy

Data quality consists of five aspects-accuracy, completeness, validity, consistency and timeliness (Lee, et al., 2002). Any aspect of data quality impacts the degree of data excellence. As for the output of the testing procedure, the data is complete: graphical data (cadastral map) and attribute data (filled cadastral form). Due to the temporal character of image acquisition, the current image secures the data currency. Validity secures data accuracy. Accuracy is an important element of data quality and the most important indicator to assess the adjudication output - cadastral map.

Accuracy requirements differ greatly in various countries due to different technical or social issues. Take three countries (Germany, England and the Netherlands) for examples. In Germany, the accuracy for boundary survey is very high and precise; In England, the prior field survey is not important but a graphical indication on a topographic map; while in the Netherlands, field surveying is required, but the accuracy on the map remains graphical (Van der Molen 2006). It is the society or community that decides how to value accuracy.

The accuracy requirement tends to be increasingly demanding. With the rapid economic development and land value soaring, higher accuracy is required to secure land tenure and meet land obligees' needs. In New Zealand, existing cadastre has been converted to a Survey-accurate Digital Cadastre (SADC) through upgrading the earlier database coordinates to higher accuracy (Haanen, Bevin, & Sutherland, 2002). So accuracy tends to be more important and is chosen as the first indicator to assess the suitability of the new procedure.

Efficiency

The land investigation must necessarily be 'quick and fast' in nature (Van der Molen, 2006). However, inefficiency is still the main problem of the current adjudication procedure. So efficiency is the second indicator to assess the suitability of the new procedure.

Cost

Cost is the third indicator to assess the new adjudication procedure. (FIG, 1995) mentioned the possibility of using images (e.g. orthophotos or enlarged photos) to reduce costs in special areas. With the technology development, higher and higher accuracy images can be acquired. When LARSI is applied to land adjudication, it is possible to reduce cost. (Leksono & Susilowati, 2008) suggested the necessity to do a research about cost comparison between images and field measurement.

Law Compliance

Adjudication is the comprehensive procedure of technical, administrative and legal aspects. The law system is the guidelines for adjudication, and whether the new procedure complies with the law or not is important and unknown. So law compliance is chosen as the fourth indicator to assess the new procedure.

3.2 Assessment of the New Procedure

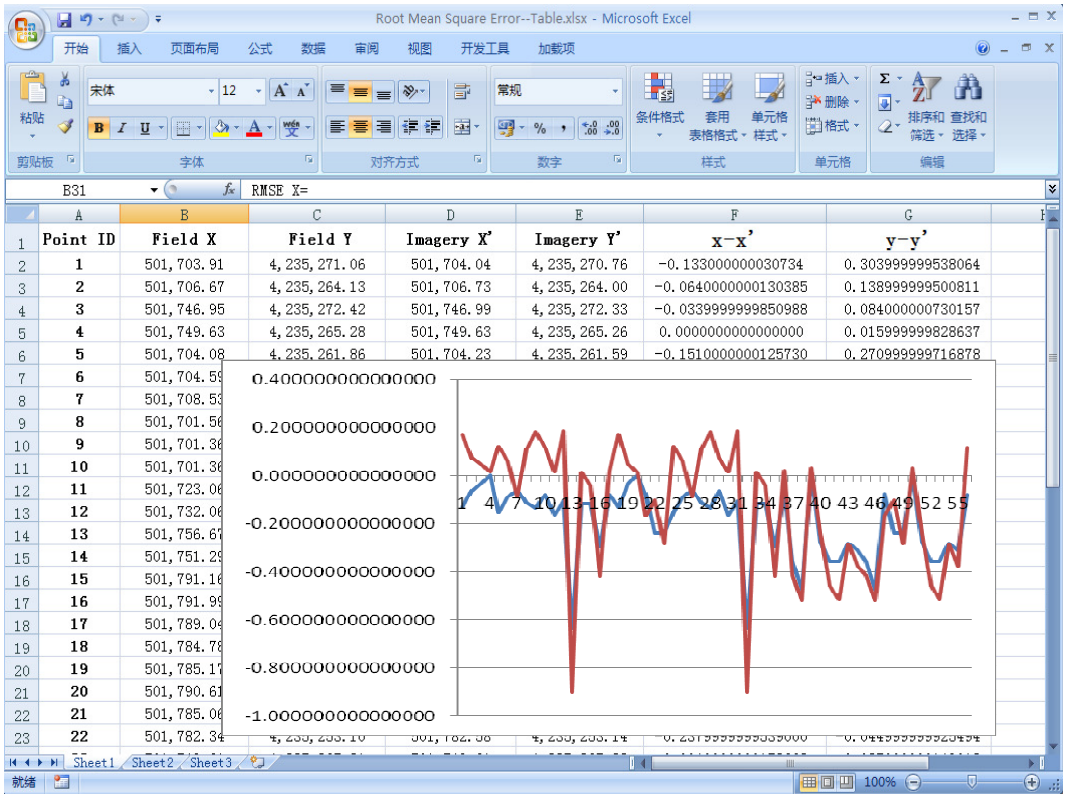
Accuracy

To assess accuracy, 56 parcel corner coordinates are extracted in ArcGIS, and the reference coordinates for comparison is from the measurement by total station and verified in the SNLSP.

Root Mean Square Error (RMSE) is the method to calculate the accuracy. It is an absolute measure of fit, and shows how close the test data points are to the field surveyed data points. It also indicates the standard deviation of the unexplained variance. Lower RMSE value means better fit. RMSE is a good measure for accuracy and the most important criterion for fit.

$$\text{RMSE} = \sqrt{\sum_{i=1}^{i=n} \frac{(xi - xi')^2}{n}} \quad \text{.....Equation (1)}$$

Table 1, Parcel Boundary Point Coordinates and the Difference Distribution



In this table, (X, Y) means the coordinate measured in the field in SNLS; (X', Y') is the coordinate acquired in the digitized ortho-rectified LARSI in ArcGIS; X-X' means the difference between measurement in the field and the ortho-rectified image.

The diagram illustrates the difference between coordinate measurement in the field and on the image. The red line stands for the Y value difference and the blue line is the X value difference. From the above diagram, we can clearly see the range of the difference. And after

calculation according to equation (1), RMSE result is 21 cm.

Efficiency / Time

Land right investigation and cadastral surveying can become efficient in one workshop, through replacing much fieldwork. The preparation, data compilation and data verification part are the same in the current procedure and the newly -designed procedure. So only the efficiency difference of land right investigation and cadastral surveying is compared.

Table 2, Efficiency/ Time Comparison between Current and Testing Procedure

Efficiency/Time Comparison	Field (Current procedure)	Workshop (Test procedure)
Land right investigation	Two days--Inform & delineate	Two hours (Two staff)
Cadastral surveying	One day (Two surveyors)	One hours (One Cartographer)

***Data sources**: The test procedure and interviewing the project manager, surveyors, and cartographers in SNLS.*

Test procedure (around 10% time of the field method) takes obvious advantages over the current procedure in efficiency even without extremely exact comparison. The prerequisites of making comparisons are:

- Time compared is for the test area (17 parcels), not the whole Luochuan County.
- Parcels with conflicts or with residents' long-term absence are excluded. Because those parcels will be left for land administrators to solve, not in the process of adjudication.

Cost

Through interviewing the relative staff - project chief and project manager, cost list in SNLSP is acquired (Table 3).

Table 3, Cost list in Luochun County in SNLSP

Process	The number of staff	Duration	Salary	House Rent	Food Subsidies	Tele-bill	Travel Fee	Total Station Rent	Total Cost
Land Right Investigation	3*14=42 *(14 teams & 3 persons per team)*	31days	￥50 *(per capital each day)*	￥20 *(per capital each day)*	￥50 *(per capital each day)*	￥5 *(per capital each day)*	￥200 *(each day)*	None	￥42*31*(50+20+50+5)+31*200 = ￥168950
Cadastral Surveying	3*6=18 *(6 teams & 3 persons per team)*	67 days	￥50 -- Prism Holder ￥70 -- *TS* Operator ￥150 -- Sketch Drawer					￥100 *(each day)*	￥18*67*(50+70+150)/3+18*67*(20+50+5)+200*67+100*67= ￥219090
Total	60 persons	98 days	￥40*31*50 + 18*67*(50+70+150)/3= ￥170540	￥42*31*20+18*67*20= ￥50160	￥50*42*31+50*18*67= ￥125400	￥5*42*31+5*18*67= ￥12540	￥200*(31+67)= ￥19600	￥100*67=￥6700	￥388040

Notice: 1. "￥" is the signal of RMB （Chinese Money）, currency unit of the table is Yuan. One Euro=8.92 Yuan.
2. "TS" is short for Total Station.
3. The duration of land right investigation includes two months for land obligees to submit three certifications to SNLS office.

Table 4, Newly-designed Adjudication Procedure Cost for the whole Luochuan City

Process	Number of Staff	Duration	Salary	Office Rent	Food Subsidy	Tele-bill	Total	
Land right investigation	2*14=28 *(2 persons per team &14 teams)*	3 days	￥50 *(per capita each day)*	￥40 *(each day)*	￥50 *(per capita each day)*	￥5 *(per capita each day)*	￥28*3*(50+50+5)+40*3=￥8940	
Cadastral Surveying	1*6=6 *(1 person per team & 6 teams)*	4 days	￥100 *(per capita each day)*				￥6*4*(100+50+5)+ 40*4=￥3880	
Total	34	7 days	￥50*28*3+100*6*4=￥6600	￥40*(3+4)=￥280	￥50*28*3+50*6*4=￥5400	￥5*28*3+5*6*4=￥540	UAV flight fee-￥80000	￥92820
							Airship flight fee-￥50000	￥62820

Note: 1. Cost of flying UAV once is ￥80000 and the airship is ￥50000. Flight once can cover the whole Luochuan County**.**

– To calculate the cost of the whole Luochuan County, two prerequisites are made: a) For Luochuan County, one day is enough to acquire the current imagery. b) There are also 14 teams for land right investigation and 6 teams for the

procedure.

Law Compliance

Specific Regulations of land adjudication illustrate concrete adjudication procedures- the standards on technical tools, steps, the accuracy requirement etc,

- Urban Cadastral Investigation Rules (UCIR)
- Specifications for Surveying and Mapping (SSM)

The accuracy requirement is contradictory. The *UCIR* accuracy requirement (25 cm) cannot satisfy the high needs of cadastral mapping and the legal proof to protect land tenure. The *SSM* requirement (5 cm) is accurate to be accepted as the standard to validate data in SNLSP.

The specific law system should be revised-the accuracy should be unified and the technical tools should meet the needs of the contemporary economic and technical development.

4. CONCLUSION

The objective of the paper is to assess the suitability of LARSI-integrated Participation Procedure for Urban Adjudication in China. In this paper, the conventional adjudication procedure investigation, the design and test procedure, assessment modeling and the suitability assessment, the result is gotten.

Table 5, Comparison between the Current and New adjudication

Comparison	The current procedure	The newly-designed procedure	The ratio
Cost	￥388040	￥6280 (Airship) ￥9280 (UAV)	Around 40:1
Time	5 months	7 days	Around 22:1
Labor amount	60 persons	34 persons	Around 2:1

Applying low altitude remote sensing can improve efficiency, around 5% time of the current method; save labor by reducing 24 persons so the cost is 2.5% of the before. And the accuracy of digitized ortho-image is 21 cm. The new procedure is non-compliance with the specific laws.

Even the accuracy 21 cm fails to satisfy the urban adjudication standards in China, it is still promising. Nationally, it can benefit china's rural area. China's cadastral surveying in rural area is not yet started and land right is changed rapidly. The RMSE result satisfies the rural standard according to Specifications for Surveying and Mapping. Globally, the result can

satisfy the urban standards for some countries like Germany. For African and south American area, where large land remains to be adjudicated, the method is also a good choice to achieve pro-poor and efficient systematic registration.

In future, this procedure tends to achieve higher accuracy which can satisfy the urban adjudication standards with the technical development.

5. LIMITATION OF THE RESEARCH AND RECOMMENDATIONS

This research is limited due to the non-availability of complete data and limited experience. So 1) the exact error accumulated in image processing is not discussed, 2) Only one pilot is selected to be tested and 3) Disputed land is not included in this paper.

Even with these limitations, still several recommendations can be made,

1. The suitability of the new procedure and the assessment model for other countries should be researched. Since land adjudication is not only a technical or administrative issue, but more a social and political issue, land adjudication in different countries varies due to different social regimes and technical situation. For the time being, the newly-designed procedure appears to be suitable for Germany and areas where large terrains remaining to be adjudicated.
2. Another topic that can be researched is: *What are the further developments in the new procedure*. Because of the following elements, the development of adjudication procedures tends to achieve one-stop service, more accurate, efficient, participatory, economic and intelligent.
    - LARSI can achieve higher accuracy
    - Tablet PC development and touch technology and fingerprint authentication
    - One Bigger Tablet PC showing the LARSI and achieve one-stop adjudication procedure.
3. A possible direction for investigation can be: *How to apply the newly-designed adjudication procedure to build a dynamic cadastral system with time series*. According to Cadastre 2014, it should convert 2D to 3D and modeling will replace the map, and dynamic can be achievable with images available of time series.

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BIOGRAPHICAL NOTES

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