ASSESSING LARSI-INTEGRATED PARTICIPATION PROCEDURE FOR URBAN ADJUDICATION IN CHINA

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April, 2011

SUPERVISORS:
Prof. Zhimin Ma
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Prof. Weidong Luan
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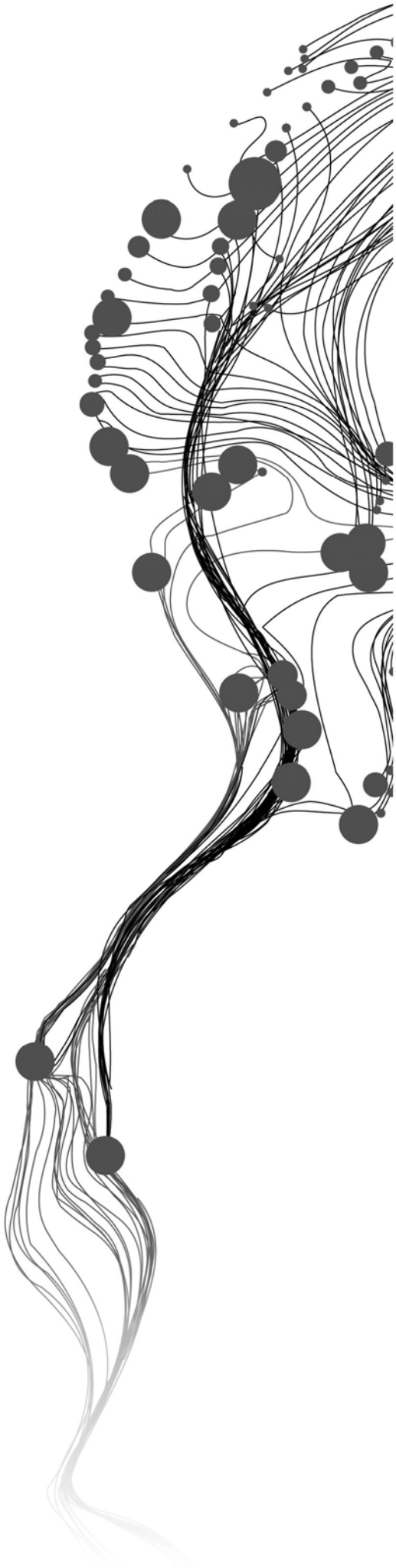

ASSESSING LARSI-INTEGRATED PARTICIPATION PROCEDURE FOR URBAN ADJUDICATION IN CHINA

YING JING
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Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Land administration

SUPERVISORS:
Prof. Zhimin Ma
Prof. Dr. J.A. Zevenbergen
Prof. Weidong Luan
Ir. M.C. Bronsveld

THESIS ASSESSMENT BOARD:
Chair: Prof. Dr. J.A. Zevenbergen
External examiner: Dr. A.M. Tuladhar
First Supervisor: Prof. Zhimin Ma, Prof. Dr. J.A. Zevenbergen
Second Supervisor: Prof Weidong Luan, Ir. M.C. Bronsveld

ABSTRACT

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 adjudication way 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) / photogrammetry into adjudication. The purpose of the study is to investigate the suitability of integrating Low Altitude Remote Sensing Imagery (LARSI) in urban adjudication. The specific aim was to analyze the current adjudication procedure, to design a new LARSI-integrated participation adjudication procedure, to test the new procedure in the field and to assess this procedure after establishing the assessment model consisting of four indicators - accuracy, efficiency, cost and law compliance.

The study included desk research and semi-structured interview for information on the detailed procedure, efficiency and cost of current adjudication. Fieldwork was conducted to test the new procedure. Finally, the new procedure was assessed by the assessment model. The results of the study show that the accuracy of the cadastral map made in the new procedure was 21 centimetres with 4.5% of time and 20% of cost consumed by the current procedure; the specific adjudication regulations are outdated and redundant.

The conclusion is that the designed procedure simplifies the current one, greatly enhances efficiency and effectively reduces costs. Even through the accuracy could not satisfy centimetre-degree requirement, the procedure is still promising to achieve efficient and pro-poor adjudication for large areas not yet adjudicated. Meanwhile, to apply the new procedure, the specific regulations should also be reorganized to be updated and unified.

Keywords: Adjudication, Low Altitude Remote Sensing (LARS), High Resolution Imagery, Assessment

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Sincerely,

Ying Jing

April 2011

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1. INTRODUCTION

1.1. Background

The term "adjudication" was first used in 1950's to describe systematic ascertainment of rights in land (Lawrence, 1985). Adjudication, 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).

According to the FIG definition,

"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, 2001), 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.

1.1.1. The first national land survey project

The First National Land Survey Project (FNLSP) in China started from 1984 and accomplished in 1997. Backward technology tools and insufficient fund lead to the long duration of the whole project. At that time, 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 maintenance form of the output was mainly paper format, which made it hard to modify, update and achieve data sharing (Xie & Li, 2007). Luochuan County is the case study area in this thesis. The cadastral data there was the same situation.

Land data has a dynamic character, which changes frequently (Ning, 2006). So till now, land-related information has changed a lot during the past 10 years. The output of the FNLS Project is outdated, which cannot satisfy the current social needs (land registration, land market, land use planning, other land administration purposes etc). It is imperative to acquire up-to-date, accurate and complete data for land management – 'State Council Notification on the Second National Land Survey (Council, 2006)'.

1.1.2. The second national land survey project

The Second National Land Survey Project (SNLSP) started on July 1st, 2007 and achieved in 2009 nationally. The SNLS Project includes urban cadastral survey, rural land use survey and basic farmland status survey. For the national urban cadastral survey, central government sponsors and disseminates the whole project to lower-levels. The SNLS Project aims to achieve integrated land information system at national, provincial, municipal and county levels (Council, 2006)'.

Adjudication in Luochuan Segment of the Second National Land Survey Project (SNLSP) finished in the end of 2009. Because of lack of original data - no coordinates and attributes, the nature of adjudication in Luochuan County belongs to first registration category. Compared with the First National Land Survey, great progress has been made. Economically, the government fund enough money. Technically, total station and Geographic Information System (GIS) were introduced to survey and record coordinates automatically, which reduced time and labour of manual calculation. However, cadastre is a parcel-based information system. Even this technique is much quicker compared with the First National Land Survey. It is still time-and -labour consuming, carried out parcel by parcel.

1.2. Research problem

Adjudication plays an important role in land registration. Adjudication is the first stage of land registration to formalize land through the procedure of land rights identification, demarcation, cadastral surveying and mapping (PF Dale & McLaughlin, 1999).The data quality (accuracy, completeness and currency) and working efficiency of adjudication has direct impact on land registration. Efficient data acquisition process can help speed up the land registration process (land transaction, subdivision and conflicts resolution) and help government to make effective decisions and also ensure citizens' tenure security. With the rapid land information change, the interval of land renewal is also becoming more frequent. So land adjudication also tends to be more frequent and important (Li, He, & Wang, 2007).

Adjudication includes both technical and legal perspective. From the technical perspective, the conventional way of cadastral surveying is full ground survey. The advantage of this way is high accuracy, but the working process was complicated, slow, labor-intensive and expensive. It is necessary to improve the effectiveness and efficiency of adjudication, especially for countries with large-territory to be adjudicated (e.g. China).

With the development of Geo-information technologies (GIT), remote sensing (RS)/photogrammetry is becoming a good technique to acquire data for large terrain. In this aspect, there is a great opportunity of integrating this technique into adjudication to improve working efficiency and effectiveness (Tuladhar, 2005).

High Resolution Satellite Imagery (HRSI) has been successfully used into some African countries, like Ethiopia (Lemmen et al.) or Kenya using QuickBird (0.6m resolution) or Ikonos images, for general boundary surveying in rural areas where accuracy requirement is not high (D. & Kenya, 2006). 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, 2008b). But after testing the HRSI' measurement after digitizing in Turkey, the result of root mean square error (RMSE) is around 0.5 m, which is far from the accuracy requirements (centimetre-degree) of urban boundary surveying (N.Ahin, S.Bakıcı, & B.Erkek, 2000).

Aerial photography is another common form of Remote Sensing (RS) applied in adjudication. The aerial photos can achieve much higher resolution (25-50cm) than satellite images. Successful cases of integrating this technique are from Namibia and Thailand. But in Namibia, the aerial photo is only used for rural areas where the accuracy requirement is not high (Meijs, Kapitango, & Witmer, 2010). In Thailand, the aerial photo is used in urban adjudication, and the cadastral map is made by delineating boundaries on the orthophoto directly. But this way neither can satisfy the centimetre-degree accuracy. The output accuracy is low, which cannot satisfy the urban centimetre-degree accuracy requirements. But making cadastral map by delineating boundaries directly on airplane-platform photos can achieve higher accuracy than on HRSI.

Bear in mind that the higher resolution of the images/photos are, the more accurate cadastral map can be generated by delineating boundaries directly on the map after identifying land rights. The Low Altitude Remote Sensing Imagery (LARSI) provides a potential chance to enhance the conventional adjudication and improve the efficiency of establishing or refreshing cadastre. Based on the LARSI, on one hand, the output is more possible to meet the urban adjudication's accuracy needs. On the other hand, this way can greatly reduce ground measurement.

1.3. Research objective

1.3.1. General objective

To assess the new LARSI-integrated procedure's suitability in urban adjudication

1.3.2. Specific objective

- To analyze the current conventional adjudication procedure
- To design a new LARSI-integrated participation adjudication procedure
- To test the new procedure in the field
- To assess the new procedure
    - Accuracy
    - Efficiency (time)
    - Cost (Tech-tools, labor etc.)
    - Compliance with laws, standards and regulations

Table 1-1, Research Design Matrix

Research Objective	Research Question	Research Method	Research Approach	Research Data
1.To analyze the current conventional adjudication procedure	Q1: What is the current procedure of adjudication in Luochuan County? Q2: What are advantages and disadvantages of the procedure?	Literature Review &Interview	● Desk research ● Comparison ● Interview staff	● Local documents ● Journal articles ● Questionnaires
2. To design a new LARSI-integrated PGIS adjudication procedure	Q3: What are the features of LARSI? Q4: What is the new procedure of adjudication?	Literature Review	● Desk research	● Literature on adjudication method development
3. To test the new procedure in the field	Q5: Where are the pilot areas? Q6: What are the features of the pilot areas? Q7: What is the practical plan to test the procedure?	Literature Review & Fieldwork	● Pre-fieldwork ● Fieldwork (PGIS in the workshop) ● Post-fieldwork (Cadastral mapping & analysis)	● LARS Imagery ● Old cadastral forms ● Pen for delineation
4. To assess the new procedure **- Data Quality (Accuracy)** **- Efficiency (time)** **- Cost (Tech-tools, labor etc.)** **- Compliance with the law**	Q8: What is the output of the pilot practice? Q9: What are the indicators to assess the new procedure? Q10: To what degree does the new procedure enhance the current one?	Literature Review, Interview & Output analysis	● **Data Quality** (Accuracy) --RMSE Algorithm ● **Efficiency** (time) Calculation &Comparison ● **Cost** Comparison ● **Law compliance** (Desk Research)	● All the output after fieldwork ● The adjudication-related legal materials ● Literature on assessment

1.4. Research methodology

1.4.1. Literature review

This method aims to comprehensively review the previous work and forms the research problem, research objective and research questions. The answers to the research questions will be based on literature review, and the methods will be found too. In this thesis, the main focuses are as follows:

- Adjudication Definition
- Adjudication Approach (especially, photogrammetric application in adjudication)
- PGIS (Participatory Geographic Information System)
- Cadastral standards, rules, regulations and laws
- Accuracy assessment methods
- Cost assessment methods

1.4.2. Pre-fieldwork

- Literature review and interview

In the phase, the researcher will analyze the current adjudication procedure. The analysis is based on documents, standards, regulations, laws, journal articles and interviewing the staff who took part in the current adjudication process (SNLS). The previous other adjudication methods will be also reviewed, especially photogrammetric application integrated into adjudication. Based on the above, the new adjudication procedure will be designed.

- Data preparation

Table 1-2, Pre-field Prepared Data

Geometric Data	Textual Data
Low Altitude Remote Sensing Imagery (LARSI)	Cadastral Forms Printouts
The Original Cadastral Index Map	

Among them, low altitude remote sensing imagery is ortho-rectified when used in the testing process - land right identification, cadastral surveying and mapping. Notice letters, application forms and cadastral forms are printed out. Actually, notice letters are not used, for land obligees are informed directly by telephone when the telephone number is already accessible in the Luochuan adjudication project team.

1.4.3. Literature review

This phase tests the newly-designed adjudication procedure. Complete geometry and attribute data of the pilot is collected. The pilot is chosen from blocks in Luochuan County, Yan'an City, Shaanxi Province, China. Land obligees in the test area and land administrators are participants.

- Inform the land obligees

Inform land obligees the exact date to adjudicate land. The materials brought to the workshop are identification card, land certificate and building property certificate. If the land obligee cannot be present that day, the consignor can represent the obligee with a certificate of entrustment.

- Test in one workshop

On the adjudicated date, when people get together, the land administrator will explain the detailed requirements and monitor the participatory adjudication process.

In the workshop, land obligees will make an agreement, delineate boundaries by themselves on the map according to the records of land certificates, sign the name on their parcel(s), fill the cadastral forms and submit the copies of identification card, land certificate and building property certificate.

1.4.4. Post-fieldwork

This phase is mainly cadastral mapping and new method assessment. The output is below.

Table 1-3, Data Generated in the Field

Geometric data	Attribute data
Delineated Ortho-Imagery	Cadastral Forms

IT staff extract parcel boundaries digitally on the delineated orthophoto using ArcGIS software. Cadastral forms are the basis for IT staff to complete attributes data recording in the database.

- Cadastral mapping

In this phase, IT staff will delineate the boundaries on computer according to the delineated orthophoto by pen. And they will also import attribute data (land obligee name, land use type, land use duration etc.)

- Assessment of the new procedure

In this phase, assessment is carried on from four aspects – accuracy, time, cost and compliance with the law. Based on literature review and fieldwork output, the assessment methods are RMSE (root mean square error) analysis, time calculation, cost-effective analysis and literature review analysis.

1.5. Materials

a. Software (ArcGIS, EA / Visio, Excel)
b. Literature concerning the subject area (theses, reports, journal articles, conference proceedings, adjudication specifications etc.)
c. Cadastral new map surveyed by total station in the Second National Land Survey Project (SNLSP)
d. Pens and Ortho-rectified Low-Altitude Remote Sensing Imagery with 5 cm resolution
e. Cadastral forms Printouts

1.6. Conventional and innovative adjudication procedures

They are shown in Figure 3.5 and Figure 4.1.

1.7. Selection of research area

The case study area is Luochuan County in Yan'an City, Shaanxi Province, China. It locates in the south part of Yan'an City and the middle part of Shaanxi Province in China (E: 109°13'14″ -109°45'47″ , N:35°26'29″ -36°04'12″). This county dominates seven townships and nine villages. Its area is 1886 km2 and the population is 200,000 people.

This county was adjudicated in the First National Land Survey, and the data is available but out of date (the old cadastral map only with parcel ID and land obligees' names). This county has recently been surveyed using total station in 2009 and the output has been validated and met the accuracy requirement. Low Altitude Remote Sensing Imagery (LARSI) is available here - based on Unmanned Aerial Vehicle (UAV) and airship platforms. The terrain is flat, so LARSI is with less relief error.

1.8. Cencetual framework

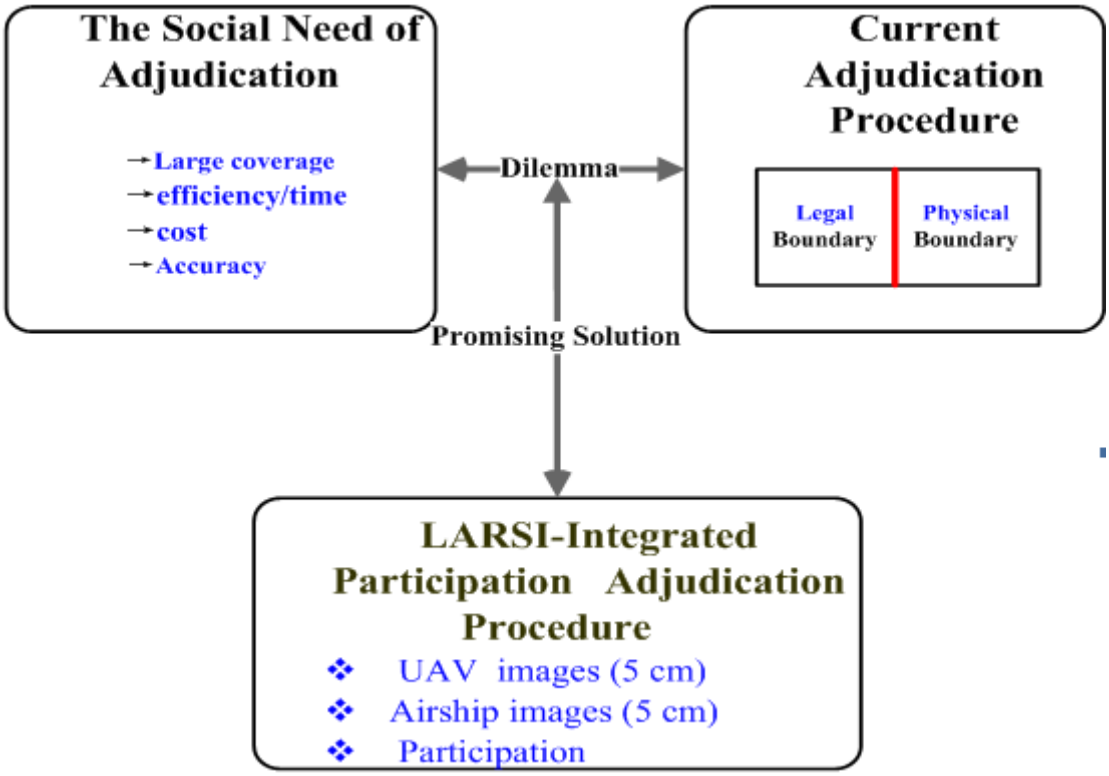

Figure 1-1, Conceptual Framework

The conceptual framework is composed of three elements - the social need of adjudication, current adjudication procedure and LARSI-integrated participation adjudication procedure.

The social requirements of adjudication are as follows:

- Larger coverage registered
- Accurate
- High efficiency
- Low cost (Pro-poor)

But the situation of the current adjudication procedure is below:

- Large coverage land remains to be adjudicated, e.g. China
- Not accurate in some area, e.g. African countries
- Inefficiency
- High Cost

To identify the legal and physical boundaries in the current procedure, the fieldwork is always inefficient, high-cost. Even accuracy standards are different in various countries, but the requirement of cadastral map tends to be more and more accurate.

There is a dilemma between the social need and the current adjudication procedure. Low Altitude Remote Sensing Imagery (LARSI) is a potential tool to solve the dilemma. Low Altitude Remote Sensing has two platforms - UAV and airship, and both can fly low and flexible, so the high resolution (eg.5 cm) imagery can be acquired. The boundary on the imagery can be clearly interpreted, which makes it feasible to identify legal boundaries by gathering people together in one workshop. Then based on the output of the workshop, cartographers will survey parcel point coordinates and make cadastral map by digitizing. In this way, fieldwork can greatly reduced so that efficiency can be improved, and meanwhile cost is reduced with less labor.

This thesis focuses on researching the suitability of LARSI-integrated participation procedure. After literature review, fieldwork (test procedure) and assessment modeling and assessment, the conclusion will be made.

1.9. Theis structure

Chapter 1 ： Introduction

In this chapter, research background, research problem, research objectives, research questions and the methodology are addressed.

Chapter 2：Theoretical concepts and Literature Review

This chapter presents literature overview on the problem related to this research. There are six main aspects to discuss: adjudication definition, adjudication approach (especially, photogrammetric application in adjudication), and Low Altitude Remote Sensing Imagery (LARSI) characteristics.

Chapter 3：Current Situation of adjudication procedure

The chapter analyzes the current adjudication procedure of Luochuan County. The advantages and disadvantages of this procedure will be presented.

Chapter 4：Design adjudication procedure and Test procedure

In this chapter, an LARSI – integrated participation adjudication procedure is designed and tested in the pilot area.

Chapter 5：Assess the new adjudication procedure

This chapter assesses the new adjudication procedure of Luochuan County, based on the test process output and literature review.

Chapter 6：Discussion, conclusion and recommendation

The discussion, conclusions and recommendations are presented. The limitation of the research is also addressed.

2. THEORETICAL CONCEPTS AND LITERATURE REVIEW

2.1. Introduction

The previous chapter introduced the national land survey projects, the general current urban adjudication procedure in China, the existing problems and potential techniques to enhance urban adjudication.

This chapter introduces the adjudication-related terms and adjudication technique review. Section 2.2 explains the adjudication-related terms (cadastre, registration, adjudication, parcel and boundary) and what they mean in China. Section 2.3 is literature review on adjudication techniques. Concluding remarks are made in Section 2.4.

2.2. Theoretical Concepts

2.2.1. Cadastre

The meaning of the term *"Cadastre"* varies in different regions of the world as to the different histories. Understanding "cadastre" globally helps to know the context of "adjudication" and to design an adjudication procedure integrated with Low Altitude Remote Sensing Imagery (LARSI).

FIG defines cadastre as,

"*Normally a parcel based and up-to-date land information system containing a record of interests in the land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements."* (FIG, 1995)

The opinion of (Henssen & Williamson, 1990) is as below,

"Cadastre is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. Such properties are systematically identified by means of some separate designation. The outlines or boundaries of the property and the parcel identifier are normally shown on large scale maps which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel."

Cadastre is a systematic and up-to-date national public register controlled by the central government, recording the quantity and quality of parcels. Basically, cadastre is a record which ascertains the individual or public land properties which aims to taxation or security of land rights (Enemark, 2003). Currently, cadastre is advancing into a broader land administrative system which addresses more issues and meanwhile supports sustainable development besides land ownership, land markets (Steudler & Williamson, 2002).

In brief, cadastre has these elements in common:

- Records of land-related information

- People who have interests in parcels of land;
- Land interests (e.g. nature and duration of rights, restrictions, and responsibilities);
- Parcels (e.g. location, size, improvements or value).

❖ Based on cadastral maps linking with text records

- Maps are typically cadastral maps/plans which record the precise locations and extents of property boundaries measured by suitable survey methods;
- Text records describe the relevant attributes of the land.

❖ Optional functions:

- Fiscal (e.g. Valuation and equitable taxation),
- Legal (e.g. Conveyancing),
- Other administrative purposes (e.g. land use planning)

Each country has different requirements for cadastre due to their specific social, legal, cultural, economic, institutional and administrative circumstances (I. Williamson, 2000) **.** Many developing countries are just establishing more formal cadastral records for fiscal or other purposes. While western nations advance in creating the multi-purpose cadastre that approaches to sustainable development (Steudler & Williamson, 2002).

2.2.2. Definition of registration and adjudication

- **Registration**

Land registration (the legal focus) and cadastre itself (the spatial focus) consist of one cadastral system (Bogaerts & Zevenbergen, 2001). From the view of (McLaughlin & Nichols, 1989), registration is the process of recording legally recognized interests in land. Land registration can be illustrated by static and dynamic models (Zevenbergen, 2002).

The static model is simple and direct. Its simple version is figure 2-1 (Hessen, 1995). The owner represents an individual or a group of individuals, which gives the answer to the question 'who'. The parcel here represents a certain plot and answers 'where' and 'how much'. The right or title, representing a certain legal relation (ownership, leasehold and other form of tenure) gives the answer to the question 'how'. Each of these three entities has to be identified correctly and unambiguously so that each of them has a unique identifier.

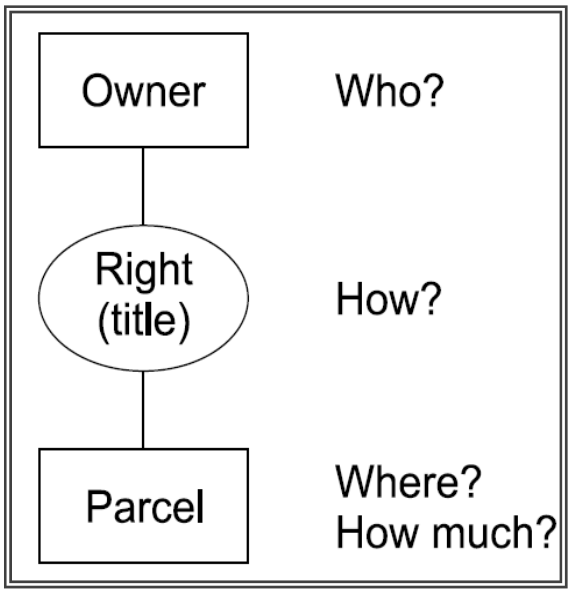

Figure 2-1, Core Entities Connected

The below mushroom diagram depicts registration in a dynamic way.

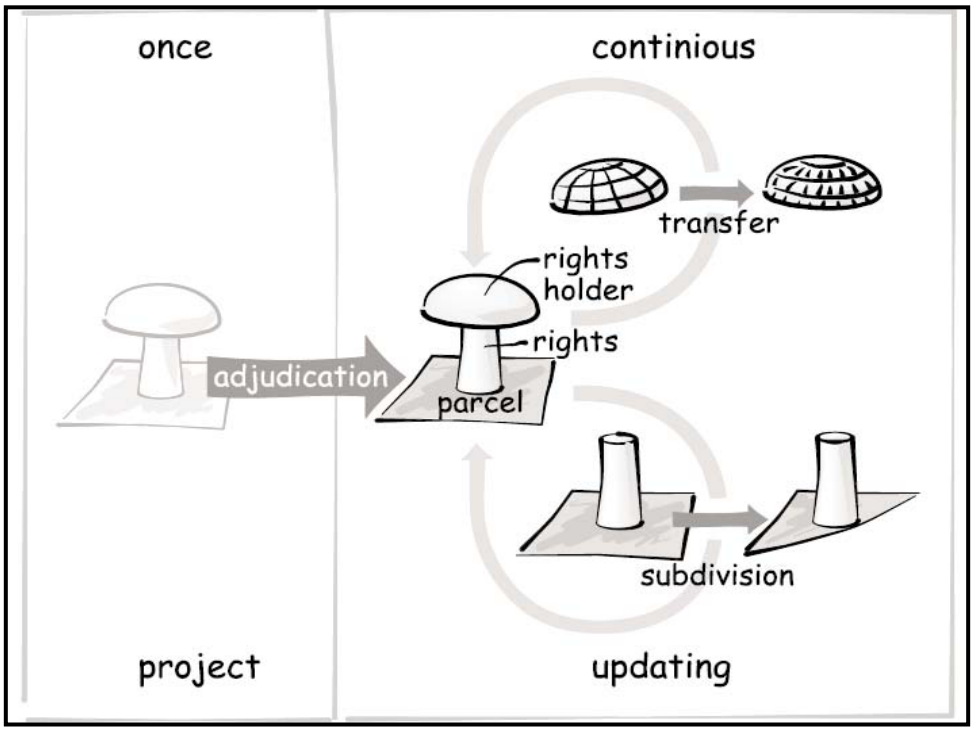

Figure 2-2, Dynamic Model of the System of Land Registration

As seen from figure 2-2 from (Zevenbergen, 2002), registration dynamic model includes three main functions: adjudication, transfer and subdivision. The static system is represented by the mushroom. The figure also deals with a change in the part of the continuum that is regarded as one parcel. Subdivision (or consolidation) is less common, but also of great importance. Transfer is the most common procedure which deals with the transfer of an existing property (parcel), in most cases due to a sale.

Registration tends to be slow and expensive (Zevenbergen, 2002). Registration supports conveyance and property taxation. To meet new demands for information, land transactions, and cost reduction, in some cases, a new system of land registration can be introduced to replace existing systems or informal arrangements (FIG, 1995).

- **Adjudication**

The term "adjudication" was first used in 1950's to describe systematic ascertainment of rights in land (Lawrence, 1985). Adjudication, 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).

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According to (Zevenbergen, 2001), 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.

- **Parcel**

A parcel is always understood as a basic special unit, basic register unit, or the minimum cell for land survey. Actually no commonly accepted international terms or definitions exist. There are some synonyms for "parcel" from various UN agencies:

Table 2-1, Synonyms for "Parcel" From UN Agencies

Parcel	*A single area of land, or more particularly a volume of space, under homogeneous real property rights and unique ownership.*
Land parcel	*The same as parcel*
Plot	*A component of a land parcel (see above) normally defined by the way in which the land is used and capable of being plotted on a map.*
Basic property unit	*A land parcel or group of land parcels in one ownership.*

The definition is flexible and adapts itself to the cadastral system for specific needs. In some situations, larger parcels can be theoretically defined as one parcel when representing common interest; Formal or informal boundaries can demarcate plots held by individuals or communities (e.g. families, corporations, or other communal groups) (FIG, 1995).

- Boundary

Boundary is an imaginary line which marks the limits of two adjacent pieces of real property ("Halsbury's 4th edition of the Laws of England," 2002).

In ("Boundaries and Surveys," 2009), boundary means a physical object that serves as a limit of property, natural, (e.g. waters) or artificial/man-made (e.g. party walls, fences and survey monuments).

Boundaries can be classified into fixed and general boundaries. Both of them can be viewed as the line to divide two adjacent parcels. The table below shows their differences (Zevenbergen, 2002).

Table 2-2, Comparison between Fixed Boundary and General Boundary

Fixed Boundary	General Boundary
◆ Accurately surveyed ◆ Boundary corners are usually monumented and coordinated. ◆ Determined after agreement of the land oblige and their neighbors. ◆ Documented and could not changed without legal justification ◆ It is easy to retrace the boundary.	◆ Not surveyed, approximately. ◆ Boundary corners are usually not monumented. ◆ Demarcated by physical features (walls, fences, hedges and etc.) ◆ Not documented and usually in the verbal form. ◆ It is difficult to trace in case of dispute

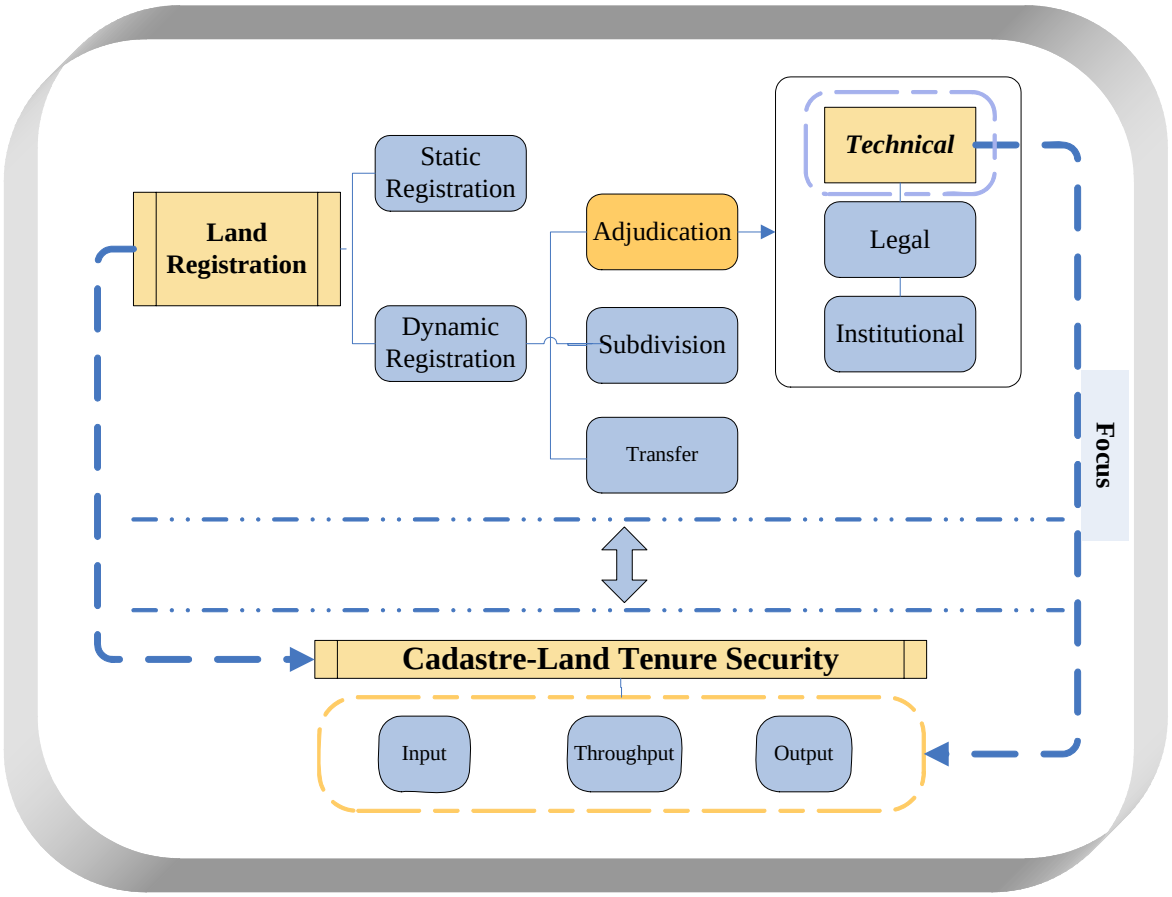


Figure 2-3, Land Elements Relationship Diagram

According to a wide range of publications concerning with cadastre, land registration, land adjudication, parcel and boundaries, Figure 2-3 diagram is drawn. Land registration is divided into Static and Dynamic registration, and the dynamic registration includes static type which is already reflected in Mushroom Diagram (Figure 2-2). Adjudication is multifaceted term including technical, legal and Institutional aspects. Through data input, throughput and output, the whole land registration is for cadastre building and renewing to secure land tenure. In turn, existing cadastre materials helps to update itself as reference by adjudication and registration.

The focus of the thesis is technical aspect of adjudication. LARSI is a new technical tool contributing to adjudication and it is introduced in Chapter 4. A model is also designed to assess the suitability of new adjudication procedure integrated this technical tool. The model consists of four indicators - efficiency, cost, accuracy and law compliance.

2.3. Adjudication techniques

The general steps of adjudication are globally similar,

→Boundary identification by agreement
→Surveying and mapping
→Output Verification (Kaufmann & Steudler, 1998)

Cadastre is established and refreshed through adjudication and registration (Province, 2007). But adjudication techniques are different in various countries during different periods of time. From the technical perspective, there are two ways with different techniques/tools to carry on adjudication from primary sources，

→Ground survey
(Theodolite, Plane-tablet, Total Station and GPS etc.)
→Surveying using remote sensing imagery/ aerial photographs
(Ikonos, Quickbird, Worldview, Geoeye and Aerial photos etc.)

The classic technique of the first way is using the theodolite and plane-tablet (Vachher & Srivastava, 2007). This technique is still used in Thailand to undertake adjudication and produce cadastral maps for higher-class accuracy requirement in registration (Valentin et al., 2008). With the advent of GPS and total station, data acquisition has become more automatic and flexible (Vachher & Srivastava, 2007), e.g. Nepal and Indonesia, the technique is with total stations to survey and relevant geo-information software to process data (LEKSONO & SUSILOWATI, 2008a; Paudyal & Sharma, 2006).

But with rapid change of land use situation and rights attached on land, land records need renewing frequently to satisfy the user community's demands - current, complete, consistent, validated and accurate data (General).

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, 2008b). 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 surveys and has been adopted by different countries in different ways (Muller et al., 1998).

There are the following ways to apply imagery:

(1) Simply enlarged.

Kenya is a successful example which has prepared so-called Preliminary Index Diagrams (PIDs) in this technique. But PIDs are approximate and results in the lowest positional accuracy (Mwenda, 2001).

(2) Rectified and enlarged.

Thailand, Botswana, England and Wales are cases (Dale, 1979), as well as Ethiopia (Lemmen, et al.) and Turkey (KANSU & GAZİOĞLU, 2006). The enlargements are only used as backdrop or the outlines are delineated, but they do not meet the urban accuracy needs. In the case of Turkey, after comparing extracted maps from (High Resolution Satellite Imagery) HRSI and terrestrial surveying map, the result of 3 m positional accuracy means impossibility of obtaining high level accuracy cadastral map with satellite images. Accuracy is the most important thing for cadastral maps to clarify the adjacent land owner, because urban land is dense and value is high. High geometric accuracy helps to clarify land tenures.

(3) Ortho-rectified and enlarged.

Georeferenced orthophotos recently open a new avenue for geospatial information acquisition (Abdulla, 2007) and to carry out metric surveys (Heritage, 2000). Palestine (K. Mikkonen & I., 2000), Australia and Canada (P. Dale, 1979), Namibia (Meijs, et al., 2010) are cases of integrating this technique to adjudication. And the renewal of cadastral maps is also currently being considered in a number of countries (Al-Ruzouq & Dimitrova, 2006).

The ortho-rectified aerial photo is tested in Namibia for rural adjudication recently (Meijs, et al., 2010), which can not satisfy the urban centimetre-degree accuracy requirements. Even so, the development of integrating this technique is quite promising. It tends to survey in centimeter degree accuracy. Take Palestine for example, orthophotos (15 cm resolution) used in adjudication can achieve the result with the positional accuracy of better than 50 centimeters (K Mikkonen & Corker, 2000).

Take it in mind that the higher the resolution of the imagery is, the higher accurate cadastral maps can be generated by tracing boundaries directly on the orthophotos after identifying land rights. With the rapid development of the geo-spatial technology, then what could be the next step?

Low Attitude Remote Sensing Imagery (LARSI) provides a potential chance to greatly enhance the conventional adjudication by replacing fieldwork. This kind of imagery is mainly based on two platforms:

- Unmanned Aerial Vehicle (UAV)
- Airship

The third technique of "ortho-rectified and enlarged imagery" benefits adjudication. From legal perspective, land right boundaries can be identified through gathering land obligees together in one workshop; from technical perspective, delineating directly on the images can also satisfy higher accuracy requirement. In this way, fieldwork can be greatly reduced with enhancing efficiency and also satisfying high accuracy needs. This way can streamline working procedure and possibly reduce cost effectively.

There are two types of platforms to acquire LARSI:

- Unmanned Aerial Vehicle (UAV)
- Airship

Table 2-3, Similarities and Differences of Two Types of LARSI

LARSI	Difference	Similarity
UAV Imagery	❖ Platform： Unmanned Aerial Vehicle (UAV)	❖ Low Altitude ❖ High Resolution--5 cm Resolution ❖ Flexible to acquire ❖ Current
Airship Imagery	❖ Platform: 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 (Technical Channel, 2008)

- ❖ 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

LARSI also has advantages over satellite images and aerial photos to facilitate adjudication procedure (imagery with 5 cm resolution is available in Xi'an). The following aspects:

(1) Easier to interpret and distinguish boundaries of features
(2) Potential to meet high precision specifications of cadastral surveying and mapping
(3) Less fieldwork is required to supplement the photo-interpreted information (Siriba, 2009)

2.4. Cadastre in China

The cadastre origins from 1930s and serves two purposes (taxes and ownerip) in China where Land ownership is separated from land use right (Congress, 1999). Understanding land tenure system in China is the basis to understand cadastre in China.

China has dual land tenure system - land ownership and land use right. Both are separate from each other. Land ownership includes state-owned land ownership (urban areas) and collective-owned land ownership (rural areas). Land use right includes state-owned land use right and collective-owned land use right. 'Other Rights' means all the other rights which are related to land rights except land ownership and land use right. The above is stipulated under Article 8 of Chapter 2 of Land Administration Law of People's Republic of China (Congress, 1999).

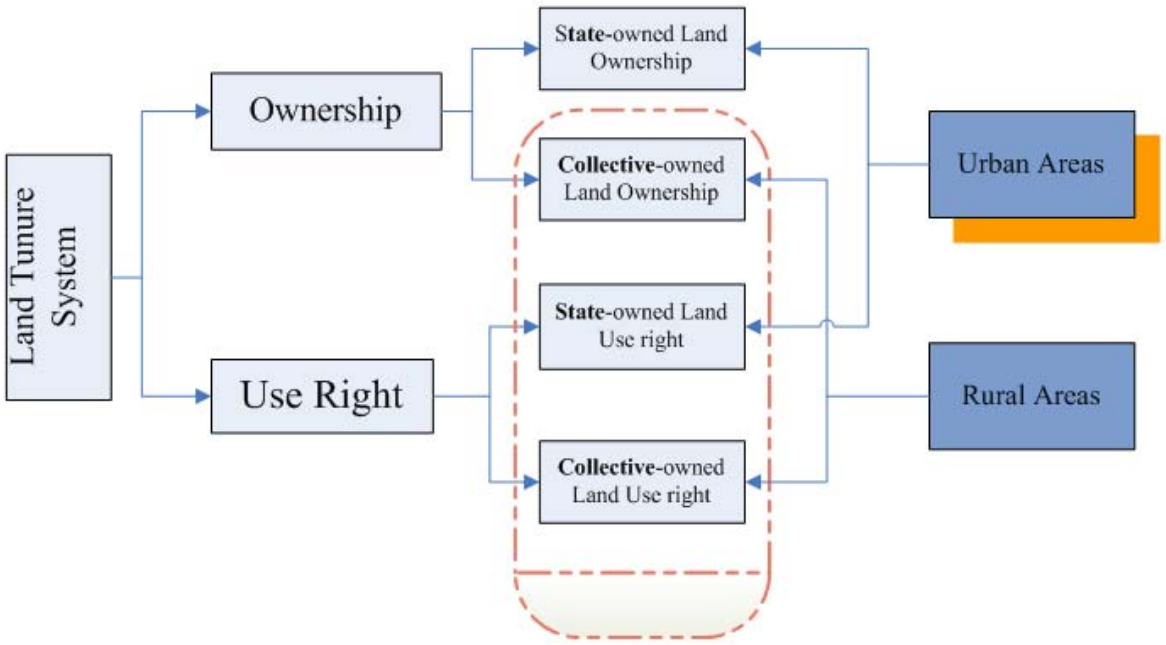


Figure 2-4, Land Tenure System Framework in China

Often the existing rights that will be registered after adjudication have not been completely defined. Their exact meaning might be vague (J. A. Zevenbergen, 2002). In China, there are mainly three kinds of land rights in adjudication process, based on the dual land tenure system. They are state-owned land use right, collective-owned land ownership and collective-owned land use right. That means, for urban areas, only land use right needs to be adjudicated by land administration department in China. State-owned land use right certification will be issued after adjudication which doesn't include ownership identification according to Article 11, Chapter 2 of Land Administration Law of People's Republic of China ("Land Administration Law of People's Republic of China," 2004).

The specialties of cadastre in China are below,

Table 2-4, Specialties of Cadastre in China

Records of land-related information	● Rights mainly land use right and community ownership
Based on cadastral maps linking with text records	● Rural cadastre Lot-based (spatial unit with the same use type) (Survey, 2007) Community land ownership & community land use right Land use map (1:10000 scale) No parcel based cadastral map ● Urban cadastre Parcel-based State land use right Cadastral map (1:500)
Optional functions	● Tenure ● Tax

2.4.1. Adjudication in China

There are two main categories of adjudication in China - urban land adjudication and rural land adjudication. For urban land, adjudication means identifying land use right boundaries; for rural land, adjudication means ascertaining community ownership. Up till now, rural land adjudication has not been implemented in parcel unit in China.

Luochuan County falls into urban land category. This area was adjudicated in 1986 during the FNLSP. SNLSP in 2007 is implemented in this area as well to update data.

Unlike UN Agencies, parcel is the term defining the basic unit of urban region closed by land right boundary in China. The term is flexible in some situations:

(1) One parcel with several land obligees is defined as Shared Parcel.
(2) One large enough parcel belonging to one land obligee with different surface features, can be divided into several isolated parcels according to the surface features (Province, 2007).

2.4.2. Boundary in China

Boundary only refers to fixed boundary. It should satisfy the following requirements (Congress, 1999):

(1) Neighbors and the land obligees should together identify parcel boundaries and points.
(2) For community land, community land ownership boundary is adjudicated. For individual land, land use right is adjudicated.
(3) Every boundary point should be physically demarcated and surveyed accurately.
(4) Once verified, the boundary has legal effect.

2.4.3. Adjudication techniques in China

The First National Land Survey Project (FNLSP) was initiated in several relatively well-developed regions in 1986 in China. Its main objective was to acquire and record the basic data and attributes of every parcel (area, classification, boundary, ownership, use right, use type, attachments to land etc.) (Guo, 2003).

But the adjudication technical 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 procedure was time-and-labor consuming. The computer was not widely promoted, so maintenance form of the output was mainly 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 finished nationally in 2009. The technical tools were GPS RTK and Total Station for point surveying, which greatly improved the efficiency and data quality. Cadastral maps were generated by exporting surveyed points into computers and making digitization. Even though SNLSP made progress in technical tools, efficiency, data quality and etc, but the time-and-cost consuming still exists.

The Ortho-rectified LARSI has been applied into the test area for urban adjudication in Luochuan County, Yan'an City, Shaanxi Province in China. This solves the time-and-cost consuming issue theoretically.

2.5. Concluding remarks

Adjudication plays an important role in land registration. As the first stage of land registration, adjudication is to formalize land through the procedure of land rights identification, parcel points demarcation, cadastral surveying and mapping (PF Dale & McLaughlin, 1999).

While adjudication is slow and expensive (Zevenbergen, 2001).With the advent of various technical tools (total station, GPS RTK, software etc.), adjudication (cadastral surveying and mapping) has already been enhanced greatly. As for ground survey from technical perspective, the problem of time-and-cost consuming still exists.

This chapter introduces the adjudication-related terms (cadastre, registration, adjudication, parcel and boundary) and what these terms mean exactly in China's land tenure system. Literature review on adjudication techniques of orthophoto focuses on three categories.

- Simply enlarged
- Rectified and enlarged
- Ortho-rectified and enlarged

According to a wide range of publications concerning this field, the third one is a potential tool to be used in adjudication process for cadastral surveying and mapping with high accuracy requirement.

As an alternative way of ground survey, high resolution orthophoto can achieve promising benefits. Low Altitude Remote Sensing provides flexible flight, even below clouds. So Low Altitude Remote Sensing Imagery tends to be very accurate and current (Government of Chongqin City, 2010).

3. CURRENT SITUATION OF URBAN ADJUDICATION PROCEDURE IN CHINA

3.1. Introduction

Chapter Two reviews adjudication-related terms and adjudication techniques. This chapter introduces the current urban adjudication procedure in China. According to (Survey, 2007), adjudication in the whole China obeys the requirement in the book. So Luochuan County is taken as a case to illustrate the present adjudication status in China.

Section 3.2 describes the preparation stage of urban adjudication from the national view based on the regulations and specifications. Section 3.3 introduces the land right investigation stage in Luochuan County. Section 3.4 introduces the cadastre survey stage of urban adjudication and Section 3.5 summarizes data compilation and verification stages of urban adjudication in Luochuan County.

This chapter answers research questions 1 and 2.

3.1.1. Basic situation in Luochuan County

Luochuan County locates in Middle part of Shaanxi Province of China (East longitude: 109°13'14"-109°45'47", North Latitude: 35°26'29"-36°04'12"). The total area is 1,886 square kilometers with the population of 200,000. Luochuan County belongs to street administrative level and consists of 13 neighborhoods and 3201 parcels.

Figure 3-1, Luochuan County of Shaanxi Province in China

Urban adjudication in Luochuan county is one segment of the SNLSP. The data quality has been verified by Land Administration Department (LAD). So the complete, current and accurate cadastral data is available. Data can be used as reference data when making comparisons with the output of newly-designed procedure.

3.1.2. Adjudication procedure

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

The details can be seen obviously as below:

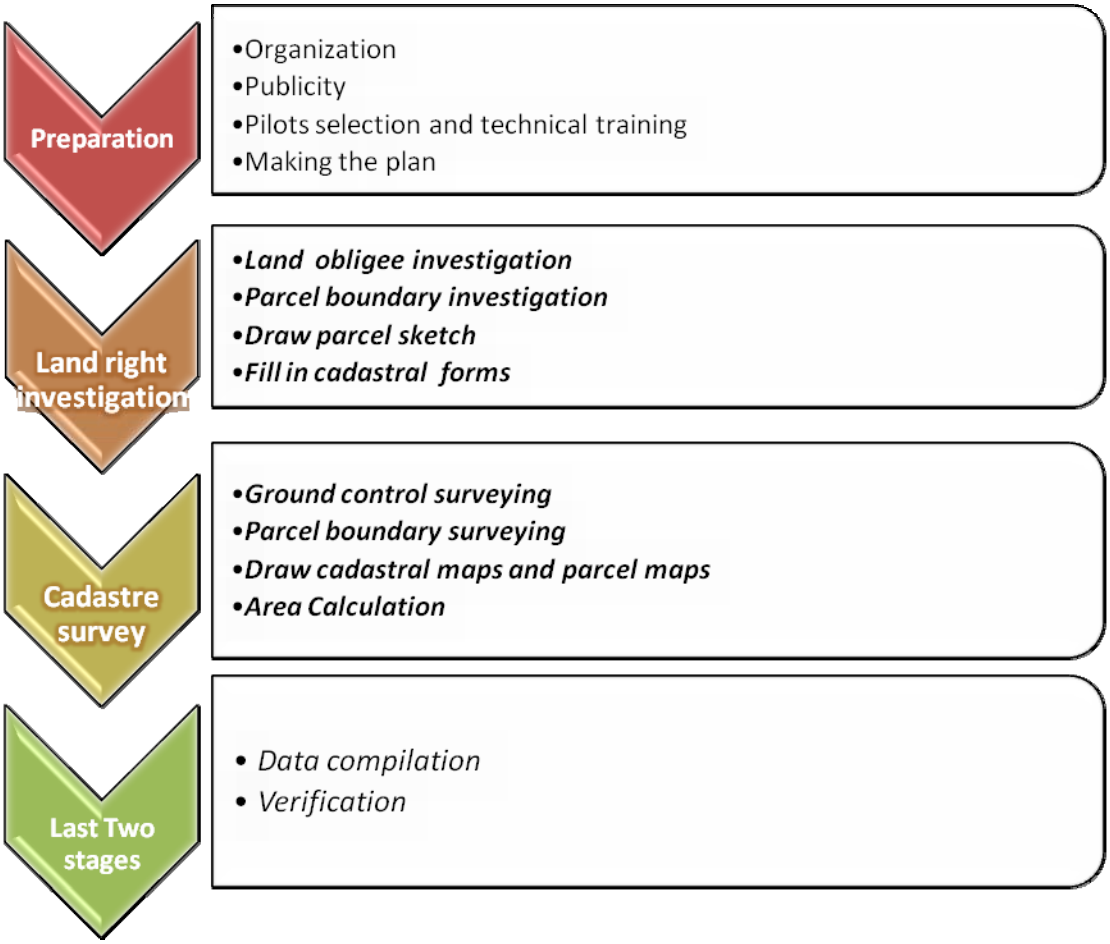


Figure 3-2, Adjudication Procedure in China

3.2. Preparation

Adjudication procedure is long and complicated, and it tends to be slow and expensive (Zevenbergen, 2004). Before adjudication, adequate preparation can lay a solid foundation for the smoothness of the whole adjudication progress. Preparation includes the following aspects.

3.2.1. Organization

Local land survey offices sponsor and arrange urban adjudication, establish the leadership institute and arrange investigation project teams. The leadership institute guides the adjudication of different teams. Adjudication team members are composed of land administrators, surveyors and cartographers.

The plan involves adjudication geographic scope, time, expense, method, labor and procedure.

3.2.2. Publicity

Adjudication is a task covering large area, so it is necessary to ensure every land obligee informed of urban adjudication (its significance, time and essential material to be prepared). The methods of publicity are:

(1) Send directly by registered mail/land staff to every house
(2) Posting notices
(3) Telephone
(4) Broadcast/Television

3.2.3. Pilot selection and technical training

The purpose of selecting pilots is to test and then make the reasonable plan for cadastral adjudication of the whole local region. The pilot selection principles are as follows:

(1) One neighborhood or one district covering an area of one square kilometer
(2) Able to represent the local land characteristics
(3) Land types as rich as possible

Training is carried on theoretically and practically. Land administrators at city level train land right investigators, land surveyors and land cartographers in two aspects:

(1) Legal training
(2) Technical training

3.2.4. Making plan

After preparation, the proper plan will be designed. The items in one plan are shown in the table:

Table 3- 1, Items of the Adjudication Plan

ITEMS	DETAILS
1. Basic information of pilot area	(1) Geographic scope (2) Staff arrangements (3) Procedure, time schedule (4) Funding arrangements
2. Land right survey plan	(1) Adjudication-related law system (2) Index map (3) Division of research area (4) Cadastral numbering (5) Approach of adjudication, demarcation and parcel corner marking; cadastral sketch and measurement requirement
3. Cadastral survey plan	(1) Original data (GCP etc.) analysis (2) GCP coordinate system (3) Control point network (4) Software (5) Method of surveying parcel corner; Determine the accuracy requirement (6) Method of drawing cadastral map
4. List of expected outputs	❖ Text report and technical report ❖ Cadastral forms ❖ Digital Cadastral Map and Parcel Map ❖ Analytical parcel point form ❖ Cadastral map, parcel map and parcel sketch ❖ Area forms of land use type

In Luochuan County, local urban adjudication office is responsible for the local urban adjudication. The adjudication teams are working on Jingyuan Digital Surveying Company. There are GPS RKT, total stations, Computers installed relative software, index maps and cadastre forms. There are totally 14 teams for land right investigation; 6 teams for cadastral survey. Every team is composed of three persons.

Before land right investigation, one team with three persons is responsible for sending notification forms directly to every land obligee, recording their signatures. Collect copies of land right proof material - ID card, land certification, building property certification.

3.3. Land right investigation

Land right survey is the investigation of items: land obligee name and nature, land right type, land use type, land location, boundaries points marking, boundary length measurement etc. It provides the proof of issuing land registration certification.

The relationship between urban adjudication, land right investigation and boundary investigation is shown in the below figure,

- ✓ (A) is the core of (B)
- ✓ (B) is the core of (C)

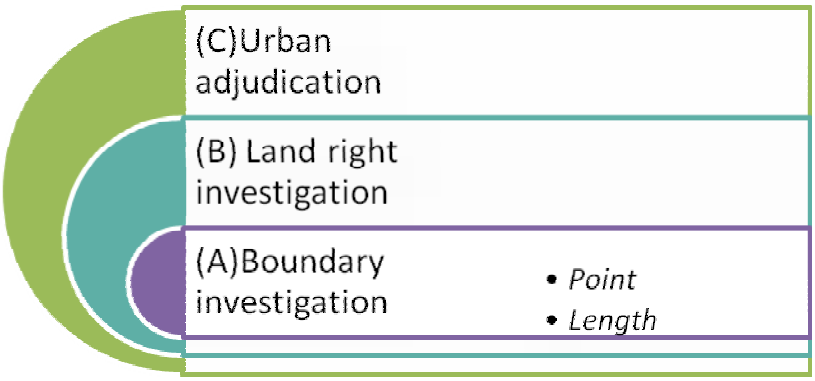


Figure 3-3, Relationship between Three Concepts

3.3.1. Determine the scope of investigation

- ✓ Urban area
- ✓ Urban fringe area to be developed in Land Use Planning

3.3.2. Divide districts

Every region to be adjudicated is divided at three levels- street, neighborhood and parcel.

Street is the top level of adjudication district division. It refers to areas closed by street administrative boundaries which are main roads, main rivers, ditches or other linear features.

Neighborhood is sub-level of adjudication division.

It refers to blocks closed by crossed roads, rivers etc.

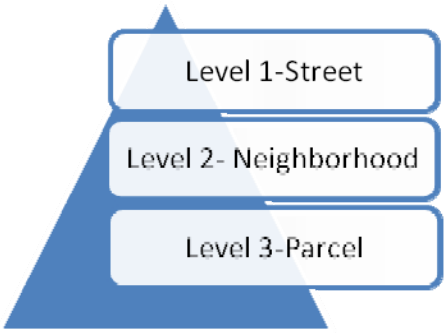


Figure 3-4, Adjudication Districts Division

(1) When the area of several neighborhoods is very small, then several physical neighborhoods can be integrated into one neighborhood unit from cadastral perspective.
(2) When one neighborhood is large, then the neighborhood can be divided into several isolated neighborhoods.

Parcel is basic unit of survey region division closed by land right boundary.

(1) If one parcel is used by several land obligees, then the parcel is defined as Shared Parcel.
(2) If one large parcel belongs to one land obligee with different surface features, then the parcel can be divided into several isolated parcels by the surface features.

3.3.3. Pre-numbering

The principle is "From west to east, from north to south" on the map. The unified pre-numbers are written on both cadastre forms and cadastre application forms which are distributed to adjudication teams.

Take "410000-004-012-0115" for example, "410000" represents the code of Province. "004" is Street Level Code, and "012" stands for the Neighborhood Level Code. "0115" means Parcel Level Code.

3.3.4. Publicity

Publicity is to ensure land obligee informed of adjudication. The form of publicity in Luochuan County is sending notification letters to every land oblige by land staff. After land obligees' signature, the notice letter is also kept as counterfoil for land obligees.

3.3.5. Land right investigation

There are twenty teams to do adjudication and the duration is five months. One team consists of four persons in Luochuan County. Two members demarcate parcel corner and measure the length of boundaries. The third one is responsible for filling in the cadastral forms, drawing parcel sketch.

First, Land obligees and neighbors are together to identify boundary point and measure length. Land obligees also provide three kinds of land right proof material: 1) Identification Card, 2) Land Certification, And 3) Building Property Certification.

Then, the adjudication team fills in the cadastral form and draw parcel sketch. Land obligee and neighbors make an agreement, sign their names in the cadastral form and mark boundary points together with adjudication team. In the next round, surveying team measures parcel points and boundary length.

3.4. Cadastral survey

There are six teams for cadastral surveying, and every team composes three people. One is responsible for prism holder, one is in charge of Total Station Operation 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 computers for cadastral mapping by digital delineating.

Table 3-2, Parcel Points Coordinates Accuracy Standard

Category	Boundary Points (cm)		Boundary Line (cm)	Applicable Scope
	RMSE	Tolerance	Tolerance	
一	±5	±10	±10	Obvious Boundary Points
二	±7.5	±15	±15	Hidden Boundary Points

Note: RMSE=root mean square error *From:(Province, 2007)*

This table illustrates parcel points coordinates accuracy requirement. For obvious boundary, the Root Mean Square Error (RMSE) of boundary points is ± 5 cm, while the tolerance of boundary points and length is ± 10 cm. For hidden boundary points which cannot be surveyed directly, the Root Mean Square Error (RMSE) of boundary length is ± 7.5 cm, while the tolerance of boundary points and length is ± 15 cm.

3.5. The last two stages

Land right investigation and cadastre survey are the most important stages of urban adjudication. After that, the last two stages are:

- Data compilation
- Verification

Data compilation includes 1) Technical design report, work summary report, 2) Picture of ground control points network, cadastral sketch, and 3) Cadastral map, cadastral forms. Then all those outputs have to be submitted to land related departments at higher level and finally Ministry of National Land Resource for verification.

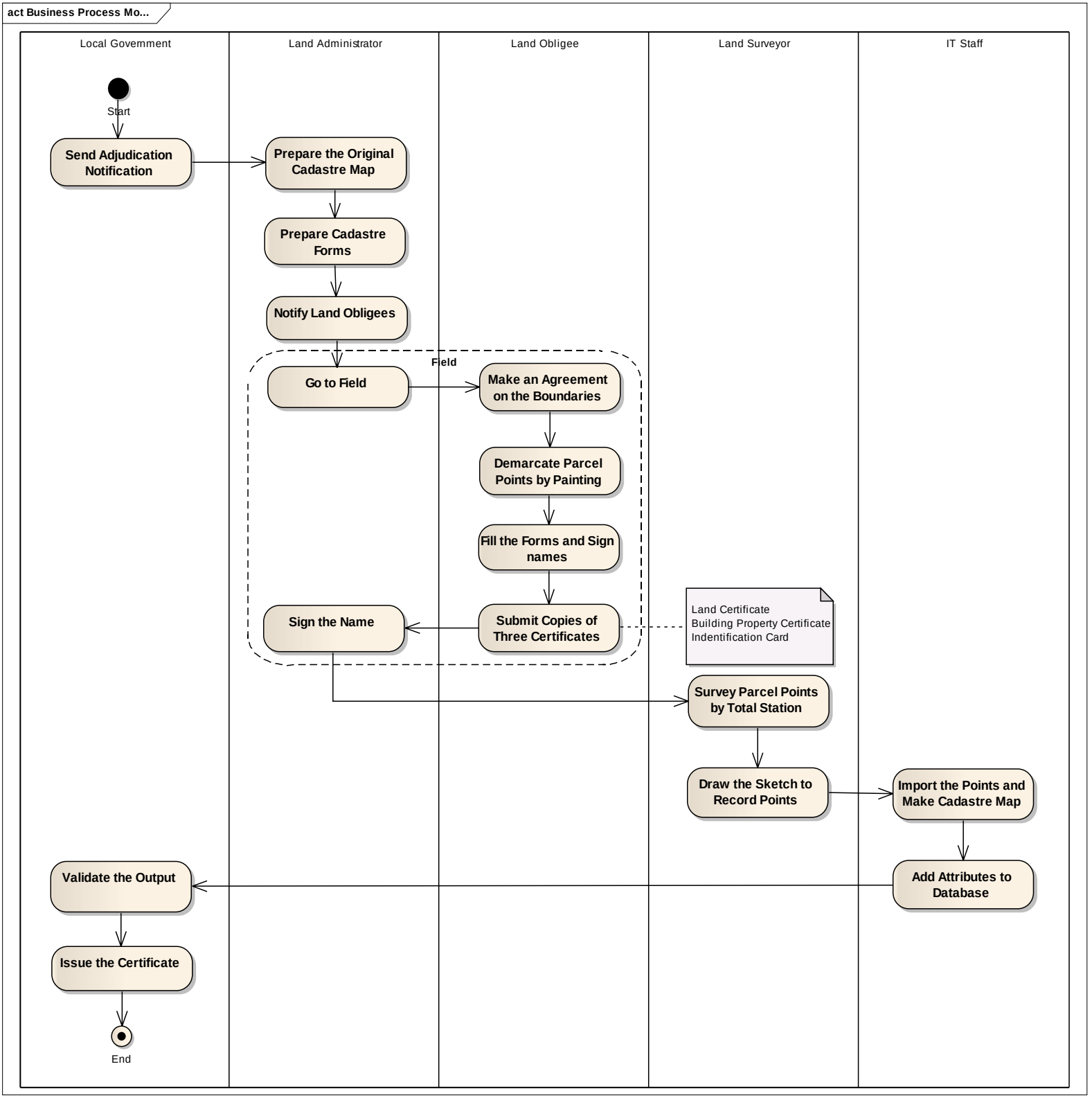


Figure 3-5, Activity Diagram of Current Procedure

Generally speaking, current adjudication procedure can be shown in the above activity diagram. Local

government makes adjudication notification. Land administrators send notices to land obligees and prepare materials (the original cadastral map and cadastral forms for land right investigation). On the adjudication date, land obligees and land administrators together ascertain land right in the field: Land obligees and their neighbors make agreement, demarcate parcels, fill cadastral forms and sign their signatures and then land administrators sign their names; In the end of land right investigation, obligees submit three copies of proof materials (Identification card, land certification and building property certification) to land administrators for records. Then the following work is cadastral survey: Land surveyors survey parcel points by total station on the basis of land right investigation and draw the sketch at the same time. After collecting attribute data on cadastral forms and geometry data (coordinates and sketches), IT staff will import the coordinate values from total station to computers, make cadastral map and add attributes to database according to cadastral forms. Local government verifies the quality of the output.

3.6. Concluding remarks

Land adjudication acts as a facilitator in protecting tenure security of land obligees. Adjudication in Luochuan County is finished in SNLS Project; the current progress is to issue land right certifications to land obligees.

This chapter introduces current adjudication procedure in Luochuan County in China Experiences and deficiencies could be concluded as below:

Experiences:

- ✓ From Legal perspective, land right survey teams are responsibility for collecting proof and fill in the cadastral form. In the process, parcels with disputes exclude in the scope for the time being. Those disputes will be solved later by other specific land administrators.

- ✓ From technical perspective, the current procedure is more automatic by using new technologies compared with the First National Land Survey. GPS RTK sets up control network with less time, cost and labor; Total Station is used to survey parcel corner coordinates. Cadastral sketch must record parcel points code clearly and completely in case of resurveying; Software such as ArcGIS, SQL server etc. is used to process data and produce cadastral maps.

- ✓ The data is completed, accurate, current and is verified and submitted to county, city, provincial and national level. This provides platforms for other administrative utilities.

- ✓ From administrative (organizational) perspective, the work is coordinated well and fund is enough.

Deficiency:

- ✓ From legal perspective, land disputes are still a problem in land adjudication.
- ✓ From technical perspective, even great progress has been made, but it is still time and money consuming, which should be enhanced. The cost of the equipments is also high.
- ✓ Participation is still waiting to be strengthened to make the citizens participate more.

Totally speaking, land adjudication is not only technical, legal or administrative aspects. Its process smoothness is completely depending a lot aspects, organization and schedule and training and quality of

the staff are intercommunication of different parties are all the necessary elements of the whole process, any element is broken, the system is just like link, the link will be broken. Urban adjudication is a long and complicated administrative activity. There are five stages of urban adjudication. Any stage can have impact on the adjudication efficiency and effectiveness.

Among the five stages, land right investigation and cadastre survey are the most important parts. Enhancing adjudication greatly concerns the land right investigation and cadastre survey part.

c

4. DESIGN ADJUDICATION PROCEDURE AND TEST THE PROCEDURE

4.1. Introduction

In Chapter Two, various adjudication techniques have been reviewed. With the rapid progress of Geo-information technology, images with higher resolution can achieve more accurate cadastral maps by delineation. Chapter Three introduces current urban adjudication procedure in China. Through great progress has been made, the problem of the current procedure still exists: time -and-cost consuming with much labor.

This chapter designs a new adjudication procedure integrating LARSI (5 cm resolution) technique. The new procedure aims to achieve land right investigation and cadastral surveying in one workshop, which can improve efficiency, reduce cost and save labor by replacing much fieldwork.

This chapter answers research questions 3 to 7.

4.2. Design and test the procedure

Adjudication is composed of five main phases in China: 1) Preparation, 2) Land Right Investigation, 3) Cadastral Survey, 4) Data Compilation, and 5) Verification. The newly-designed procedure integrates the new tool (LARSI with 5 cm resolution) and consists in relative changes in the first three phases when collecting cadastral data.

The procedure is designed based on the features of Low Remote Sensing Images (LARSI), - 5 cm resolution, easy interpretation, clearly showing parcel points so that land obligees and land staff can do land right investigation and cadastral surveying based on the imagery in one workshop which can greatly replace much fieldwork and meanwhile possibly satisfy the accuracy of the cadastral map. "Workshop" is described as the place where land obligees and land staff participate in adjudication together instead of the field.

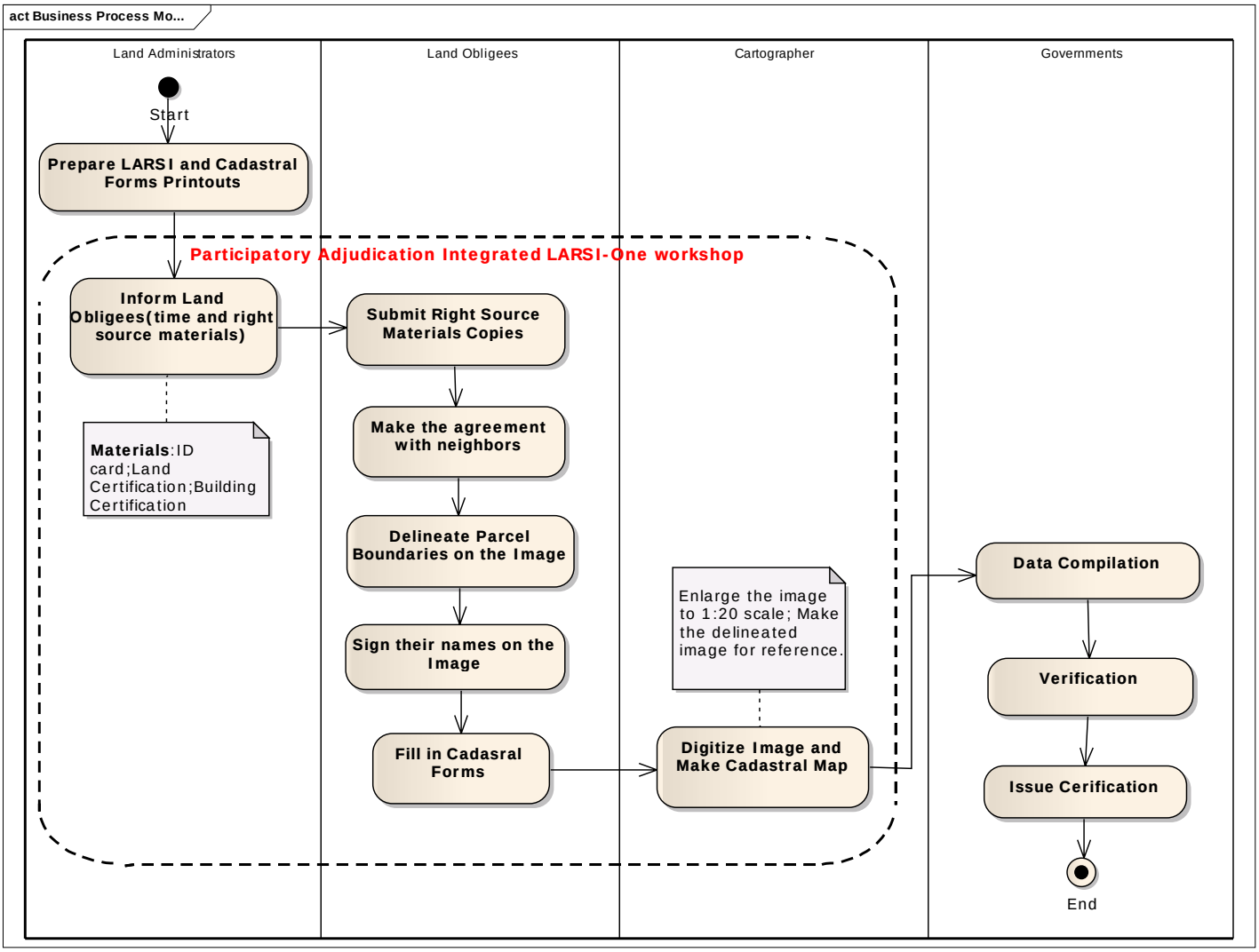


Figure 4-1, the Newly-Designed Adjudication Procedure

The first step of the newly-designed procedure is that land administrators prepare LARSI and cadastral forms printouts and that inform land obligees of adjudication date and necessary materials. On the adjudication date, after land obligees showing and providing the proof material copies, one land administrator (the author in the test procedure) will introduce the requirement, assist land obligees to identify parcels and delineate 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.).

As to cadastral surveying, the cartographer make cadastral maps and input attribute data based on delineated orthophotos and cadastral forms. Coordinates can be measured in ArcGIS software after generating cadastral maps by digitization. This produces the test dataset (boundary point coordinate) to be compared with SNLS dataset in Chapter 5.

The test procedure in detail is below.

4.2.1. Preparation

For **preparation**, the following data is needed:

- Low Altitude Remote Sensing Imagery (LARSI)
  --Ortho-rectified printout (90cm*90cm)

  --Cadastral forms printouts (At least seventeen copies)
- Dataset in the Second National Land Survey (SNLS)
  -- Adjudication Notice letter
  -- Boundary point coordinates
  -- Boundary length
  -- Cadastral forms

Low Altitude Remote Sensing Imagery (LARSI) is the most important tool in the new adjudication procedure. LARSI is 5 cm resolution and processed into orthophoto. The quality of processed LARSI has direct impact on the accuracy of cadastral mapping.

The higher resolution of the image is, the clearer the boundaries can be interpreted on the image. This makes it possible that people do land right investigation and cadastral surveying based on ortho-rectified imagery together in one workshop.

LARSI based on UAV and airship platforms are available-UAV imagery is provided by Surveying and Mapping Bureau of Shaanxi Province and airship imagery is acquired by Chang'an University. The two kind of imagery is on different platforms. Yet they are the same in essence - 5 cm high resolution applied to adjudication.

In the new procedure, UAV images were chosen as the tool in the test procedure. Because UAV images processed with better quality compared with airship images because of the elements of flight process and sensor quality. Pens with fine tips were prepared for delineation as well.

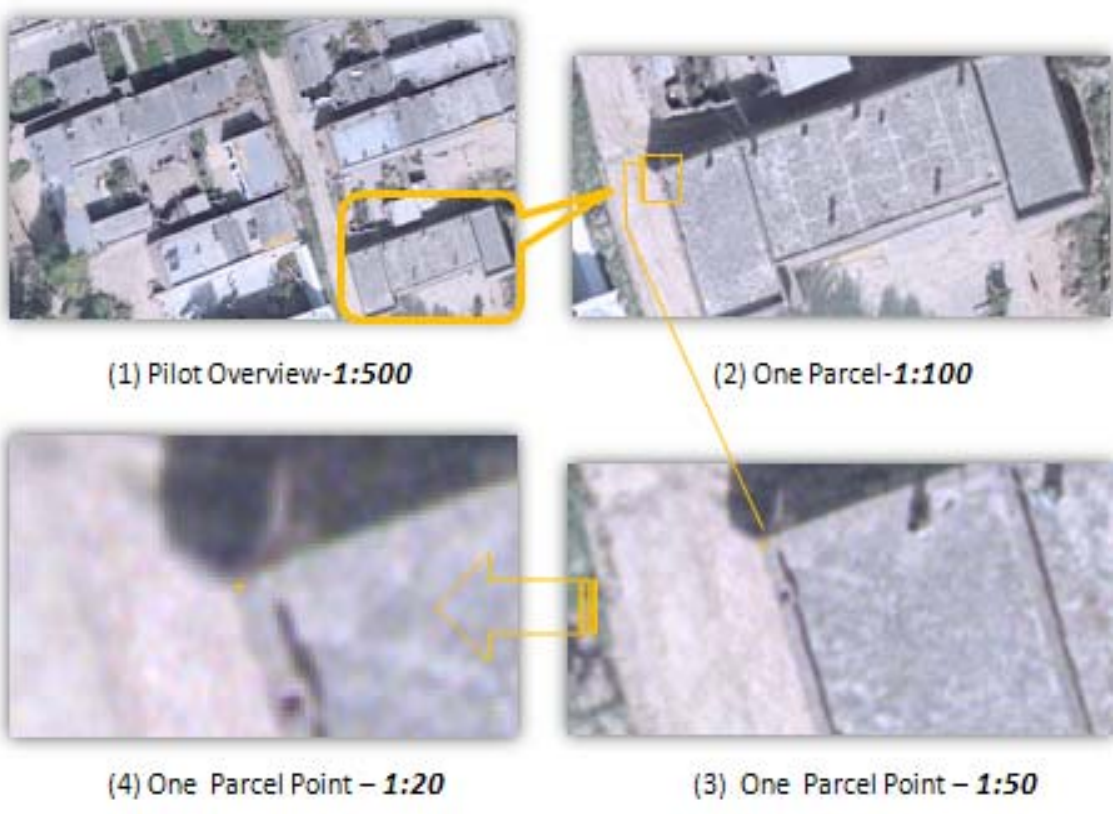


Figure 4-2, UAV Imagery with 5 cm Resolution

Four parts compose Figure 4-2, 1) Pilot area overview with the scale of 1:500, 2) One parcel in the pilot with the scale of 1:100 3) One part of the parcel with the scale of 1:50 4) One parcel Point with the scale of 1:20. From the figure, we can clearly see that even on the image enlarged to 1:20, the boundary and point can be still clearly interpreted. This lays a solid foundation for land obligees and land administrators to do land right investigation and cadastral surveying based on the image.

4.2.2. Land right investigation and cadastral surveying

Basic information of the test procedure is as below:

Table 4-1, Basic Information of Testing Procedure

Time	15th, November, 2010
Workshop	One SNLS office in Luochuan County
Participants	●Two land administrators & one cartographer ●Seventeen land obligees from Luochuan County
Imagery	Ortho-rectified UAV image (5 cm resolution)

First, all the land obligees provided their proof materials (land right certificate, house certificate and identification card) to show their legal identity and land legal status. Then land right investigation and cadastral surveying started in one workshop.

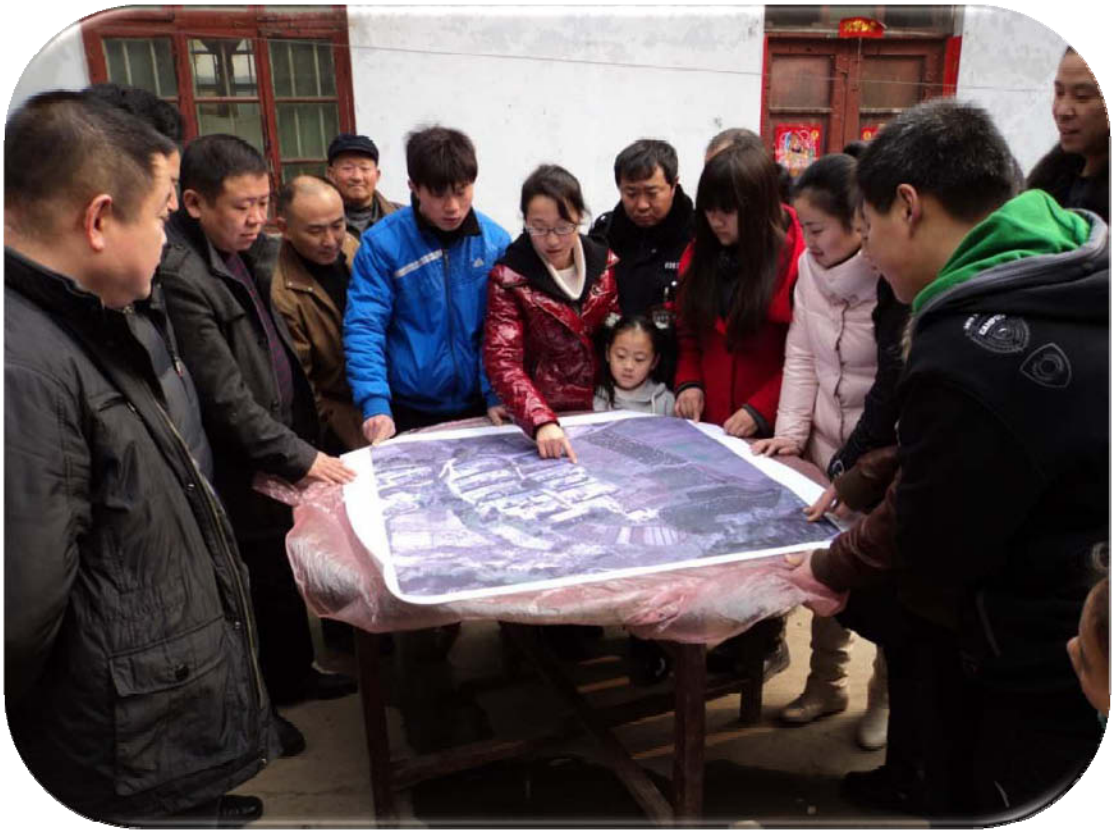


Figure 4-3, Participatory Adjudication Based on the LARSI

This figure shows the situation of land administrator illustrating the requirement to land obligees.

For Land right investigation, it consists of boundary point identification, boundary length measurement, drawing parcel sketches and filling in cadastral forms (land obligee name and nature, land right type, land use type, parcel sketch, parcel points coordinates etc). The items "Land obligee name and nature", "land right type" and "land use type" were identified when land obligees provided the three proof materials-ID card, land and building certificates. Boundaries were delineated on high-resolution images. The delineated ortho-rectified image functioned as parcel sketch and was also the reference for cartographers to digitize and make cadastral map. Filling in cadastral forms was the next step for land obligees and land administrators to do (the last step of land right investigation) which is also easily achieved in the workshop instead of fieldwork.

For Cadastral surveying, it is made up of boundary points surveying, boundary length surveying, area calculation and cadastral mapping. In the newly-designed procedure, all those items were measured in ArcGIS software automatically based on land right investigation outputs (digitized cadastral map overlaid by LARSI)

Figure 4-4, Delineated Image after Land Right Investigation

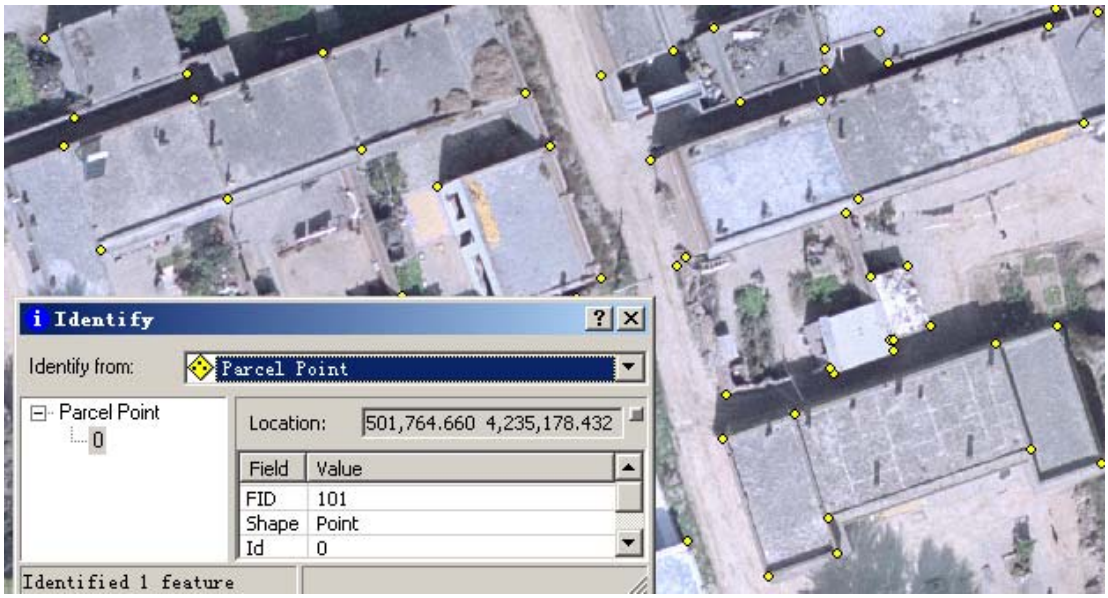


Figure 4-5, Parcel Point Measurement in ArcGIS

After creating the parcel point layer and marking every parcel point on the map according to the delineated map, parcel points were measured by the identification icon in ArcGIS. This point coordinate is

(501764.660, 4235178.432). Its accuracy will be compared with the reference dataset of SNLS in chapter five.

Figure 4-6, Digitized Cadastral Map Overlaid LARSI

This is the cadastral map through digitization overlaid LARSI using delineated ortho-image for reference. And the attributes of every parcel is recorded in SQL Server Database Software according to the cadastral forms.

4.2.3. Data compilation and verification

Data compilation and verification remained the same as the conventional procedure. So this chapter highlights the first three phases where both procedures are different.

4.3. Concluding remarks

This chapter designed and tested the participatory adjudication procedure integrated LARSI for urban areas. This method combines land right investigation and cadastral surveying in one workshop replacing much fieldwork. This way greatly improves the efficiency of adjudication. Land right investigation finished within two hours and cadastral surveying within one hour. For the old method, seventeen parcels in land right investigation take at least two days, and cadastral survey is one day (excluding the dispute lands).

The new way is advantageous but still has issues remaining to be solved:

Table 4-2, Advantages and Issues concerned with the New Procedure

Advantageous	Issues concerned
● High Efficiency ● Strengthen Transparency	● Whether accuracy satisfies the need or not ● Whether it is pro-poor or not ● Whether it complies with the law or not

The reference dataset of Luochuan County in SNLS is approved by the provincial and national land departments. Datasets of boundary points and length from SNLS are used to be the reference data for assessing the accuracy of new method in Chapter 5.

5. THE NEW PROCEDURE ASSESSMENT

5.1. Introduction

The first three chapters illustrate the current procedure and existing problems of adjudication in China - low efficiency, high cost and labor-consuming. The fourth chapter demonstrates the test procedure - participatory adjudication based on Low Altitude Remote Sensing Imagery (LARSI) with 5 cm resolution.

Based on the output of chapter 4, this chapter will identify the suitability of the new procedure through the assessment model consisting of four indicators - data quality, time/ efficiency, cost and law compliance.

This chapter answers the research questions 8, 9 and 10.

5.2. The Assessment Modeling of the New Procedure

After reading plenty of publications concerning with land adjudication, we can see that, currently, there is no model accepted internationally evaluating the suitability of land adjudication procedure. This chapter 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.

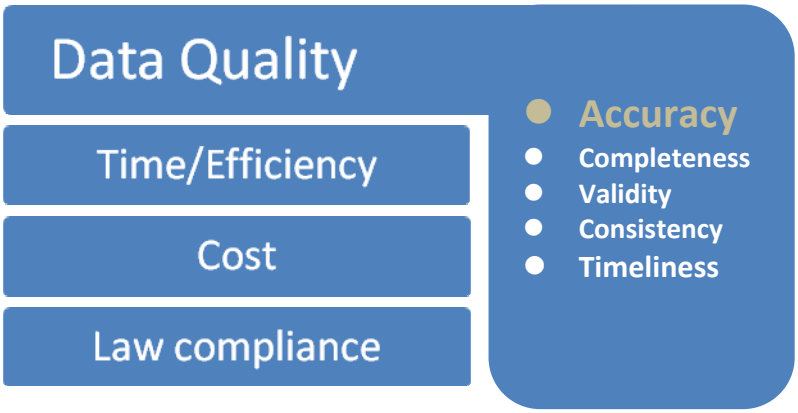


Figure 5-1, Assessment Model to the New Procedure

Data quality is the primary indicator of this model, because it bears on satisfying a given purpose which determines the requirement of the degrees of data excellence. Data quality is composed of five aspects - accuracy, completeness, validity, consistency and timeliness (Lee, Strong, Kahn, & Wang, 2002), among which accuracy is the most significant element to be assessed due to its legal effect.

Time/Efficiency is the second indicator to assess the new procedure. According to (VAN DER MOLEN), inefficiency is one main problem of the current adjudication procedure. So the efficiency of land adjudication procedure greatly reflects whether the land adjudication procedure is suitable or not.

Cost is the third indicator in the model. The reason is that, besides inefficiency, high cost is another challenge in land adjudication causing international experts' attention to do research on pro-poor projects, so the cost is third indicator to assess the suitability of one adjudication procedure (I. P. Williamson, 2000).

The fourth indicator is **law compliance**. The aim of law system is to provide guidelines for land administration and regulate adjudication activities legally and effectively, on the condition of the current economic development and social needs. The four indicators contribute to evaluating the newly-designed procedure and guide future research (Williamson, 2001).

5.3. The assessment of the new procedure

5.3.1. 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 testing procedure, the data is complete-graphical data (filled cadastral forms) and attribute data (cadastral map) for the test procedure. 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). 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).

In the latest land adjudication in the Second National Land Survey Project (SNLSP), the accuracy standard of Urban Cadastral Investigation Rule is nationally accepted. According to Cadastral Survey Regulation and Urban Cadastral Investigation Rule, the technical tools are GPS RTK for control points and Total Station for boundary points surveying. GPS RTK accuracy is within 2 cm and Total Station within millimeter. Both tools can satisfy the accuracy standard.

The accuracy assessment is to calculate the difference of parcel point coordinates through field surveying and digitizing. Root Mean Square Error (RMSE) algorithm is chosen as the approach to test whether the point coordinates acquired from digitized ortho-rectified LARSI can satisfy the accuracy demands.

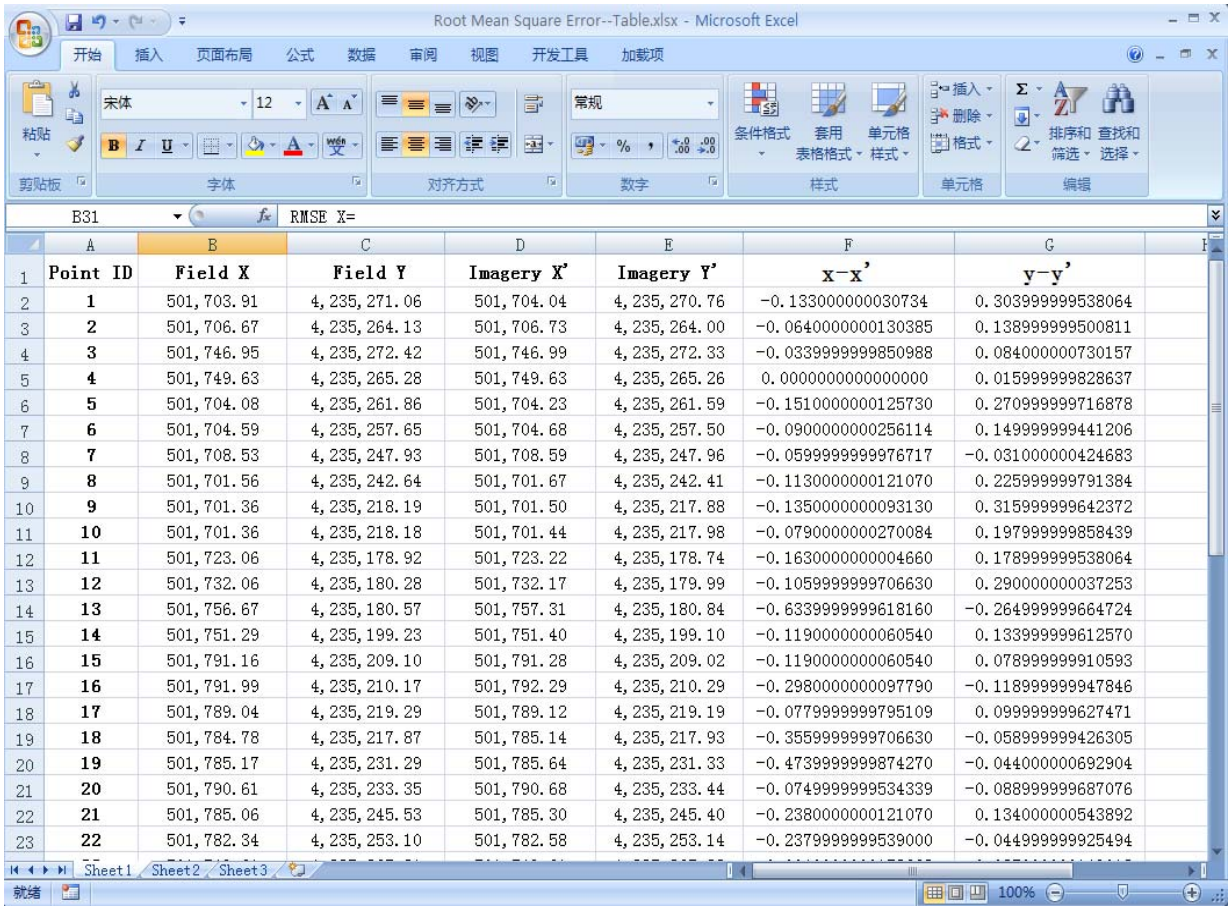
Table 5-1, Items of Assessing Data Quality (Accuracy)

The Dataset to assess	Boundary point coordinates set acquired through digitizing ortho-rectified Low Altitude Remote Sensing Imagery (LARSI)
The Reference Dataset	Boundary points by field surveying in the Second National Land Survey (SNLS)
The Software Tool	ArcGIS, Excel Software
The Assessment Algorithm	Root Mean Square Error (RMSE)

The dataset to assess is the set of boundary point coordinates through digitizing ortho-rectified Low Altitude Remote Sensing Imagery (LARSI) in the ArcGIS software. The reference dataset is the set of boundary points by field surveying in the Second National Land Survey (SNLS) and already validated by the central government. The whole process is to compare the difference of the two datasets. Root Mean Square Error (RMSE) is the algorithm chosen as the approach to calculate the difference of boundary points coordinates acquired by field surveying and the ortho-rectified LARSI digitizing.

Figure 5-2, Digitized LARSI for the Pilot Area

After being delineated by land obligees in one workshop, the above is digitized cadastral map overlaying the LARSI. Each line is drawn in the scale of 1:50 with red color and one bound width. 56 parcel point coordinates are collected and the result can be seen below.



Root Mean Square Error--Table.xlsx - Microsoft Excel

RMSE X=

Point ID	Field X	Field Y	Imagery X'	Imagery Y'	x-x'	y-y'
1	501,703.91	4,235,271.06	501,704.04	4,235,270.76	-0.133000000030734	0.303999999538064
2	501,706.67	4,235,264.13	501,706.73	4,235,264.00	-0.0640000000130385	0.138999999500811
3	501,746.95	4,235,272.42	501,746.99	4,235,272.33	-0.0339999999850988	0.084000000730157
4	501,749.63	4,235,265.28	501,749.63	4,235,265.26	0.0000000000000000	0.015999999828637
5	501,704.08	4,235,261.86	501,704.23	4,235,261.59	-0.151000000125730	0.270999999716878
6	501,704.59	4,235,257.65	501,704.68	4,235,257.50	-0.0900000000256114	0.149999999441206
7	501,708.53	4,235,247.93	501,708.59	4,235,247.96	-0.0599999999976717	-0.031000000424683
8	501,701.56	4,235,242.64	501,701.67	4,235,242.41	-0.113000000121070	0.225999999791384
9	501,701.36	4,235,218.19	501,701.50	4,235,217.88	-0.135000000093130	0.315999999642372
10	501,701.36	4,235,218.18	501,701.44	4,235,217.98	-0.0790000000270084	0.197999999858439
11	501,723.06	4,235,178.92	501,723.22	4,235,178.74	-0.163000000004660	0.178999999538064
12	501,732.06	4,235,180.28	501,732.17	4,235,179.99	-0.105999999706630	0.290000000037253
13	501,756.67	4,235,180.57	501,757.31	4,235,180.84	-0.633999999618160	-0.264999999664724
14	501,751.29	4,235,199.23	501,751.40	4,235,199.10	-0.119000000060540	0.133999999612570
15	501,791.16	4,235,209.10	501,791.28	4,235,209.02	-0.119000000060540	0.078999999910593
16	501,791.99	4,235,210.17	501,792.29	4,235,210.29	-0.298000000097790	-0.118999999947846
17	501,789.04	4,235,219.29	501,789.12	4,235,219.19	-0.0779999999795109	0.099999999627471
18	501,784.78	4,235,217.87	501,785.14	4,235,217.93	-0.355999999706630	-0.058999999426305
19	501,785.17	4,235,231.29	501,785.64	4,235,231.33	-0.473999999874270	-0.044000000692904
20	501,790.61	4,235,233.35	501,790.68	4,235,233.44	-0.0749999999534339	-0.088999999687076
21	501,785.06	4,235,245.53	501,785.30	4,235,245.40	-0.238000000121070	0.134000000543892
22	501,782.34	4,235,253.10	501,782.58	4,235,253.14	-0.237999999539000	-0.044999999925494

Sheet1 Sheet2 Sheet3

就绪 100%

Figure 5-3, Parcel Boundary Point Coordinate Value List of the Pilot

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

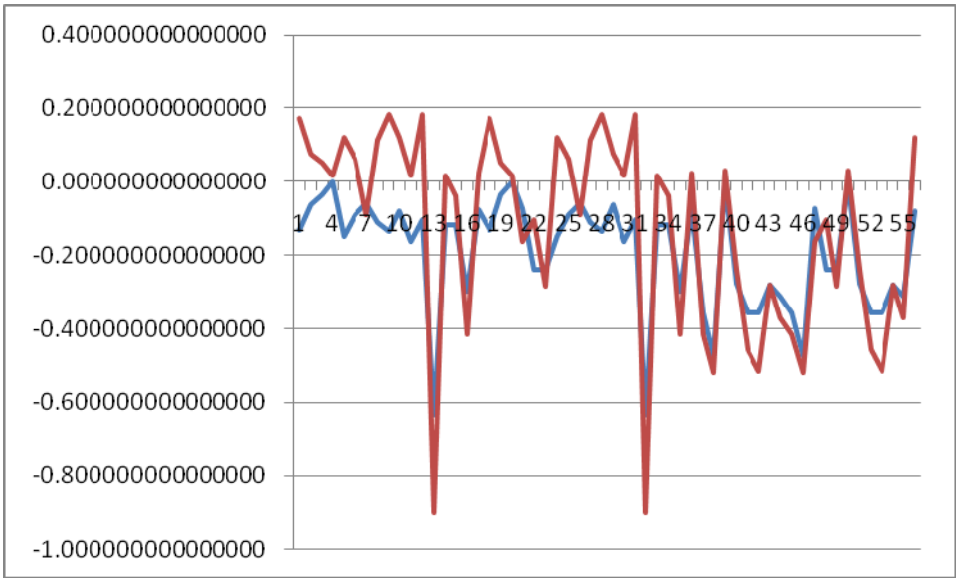


Figure 5-4, Difference Value Distribution

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.

R-squared analysis is a relative measure of fit. As the result of the analysis, a difference within 5 cm, the proportion is 11.1% for X values, and 18.5% for Y values. For a difference within 10 cm, the proportion is 44.4% for X values, and 37.1% for Y values. While extending the difference to 20 cm, the proportion is much larger-85.1% for X values and 66.7% for Y values.

Whereas Root Mean Square Error (RMSE) is an absolute measure of fit, it 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 values means better fit. RMSE is a good measure for accuracy and the most important criterion for fit.

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

Table 5-2, Output of RMSE Approach

RMSE X	RMSE Y	RMSE Point
0.24 m	**0.16 m**	**0.21 m**

Accuracy of the cadastral map is an accumulated result concerning with ground control points, imagery quality, image-interpreting skill, ortho-rectified process and cartographers' skills (Siriba, 2009). In this process, imagery has been processed into ortho-imagery and the accuracy 21 cm in the accumulated value.

Even through the RMSE result (21cm) fails to satisfy the urban adjudication accuracy requirement in China (SSM), it is still promising. Nationally, it can benefit china's rural area. China's cadastral surveying in rural area is not yet started and the 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.

5.3.2. Efficiency / Time

The land investigation must necessarily be 'quick and fast' in nature (VAN DER MOLEN). However, inefficiency is still the main problem of the current adjudication procedure. Land right investigation and cadastral surveying are carried on in the field, parcel by parcel.

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 5-3, 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.

5.3.3. Cost

Cost is the third indicator to assess the new adjudication procedure, causing international experts' attention to do research on pro-poor land adjudication projects.

(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, 2008b) suggested the necessity to do a research about cost comparison between images and field measurement.

Through interview the relative staff - project chief, project manager, and office manager (see Table 5-4).

Table 5-4 Interviewee List for Cost Information

Name	Occupation	Responsibility
Luan Weidong	Chief	Manage all the things
Zhao Bohui	Project manager	In charge of surveying in the field

Lian Heng	Office manager	Responsible for cadastral mapping in the office

Table 5-5, 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. The whole process should be 5 months. So the duration is actually 5 months. Every team for cadastral surveying is made up of three teammates -Prism holder, total station operator and sketch drawer.

For the Luochuan County, one day is enough to acquire the current imagery. After processing, ortho-rectified imagery can be used for land obligees to gather together with their proof materials and to identify their boundaries group by group in one workshop.

The area of Luochuan County is 1886 km2 and there are 3201 parcels in total. Supposing there are also 14 teams for land right investigation and 6 teams for cadastral surveying in the newly-designed procedure. And based on figure 5-4, time and cost can be calculated like the below.

Table 5-6, Newly-designed Adjudication Procedure Cost for the whole Luochuan County

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

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

2. In order to compare the cost of two different procedures, two prerequisites are made:
   - ❖ The number of teams in two procedures is same.
   - ❖ Every seventeen parcels in the new procedure need two hours for land right investigation and one hour for cadastral surveying, based on the table 5-3.
3. UAV flight fee and airship flight fee is acquired by interviewing the personnel in Surveying and Mapping Bureau of Shaanxi Province.

The duration is calculated as below:

(3201parcels /17 parcels /14 teams)*2 hours=24h=3 days

…….……Equation 2

(3201parcels/17 parcels /6 teams)*1hour=31h=4 days

…….……Equation 3

Equation (2) and (3) is acquired according to the regulation of China Labor Law: One workday is eight hours. Comparing the table 5-5 and table 5-6, we can conclude that,

Table 5-7, 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 reduced 24 persons so the cost is 2.5% of the before.

5.3.4. Law compliance

Law compliance is chosen as one indicator to assess the suitability of the newly-designed adjudication procedure. Land adjudication is a comprehensive process combining administrative, technical and legal perspectives. From legal perspective, the law system stipulates the responsibilities and obligations of land obligees and land administrators and provides the principles to guide land adjudication.

In China, the adjudication-related law system includes “Constitution Law of P. R. China”, ”Property Law of P.R. China”, ”Land Administration Law of P.R. China”, “Urban Cadastral Investigation Rule” and “Specifications for Surveying and Mapping”. Their hierarchical relationship is below.

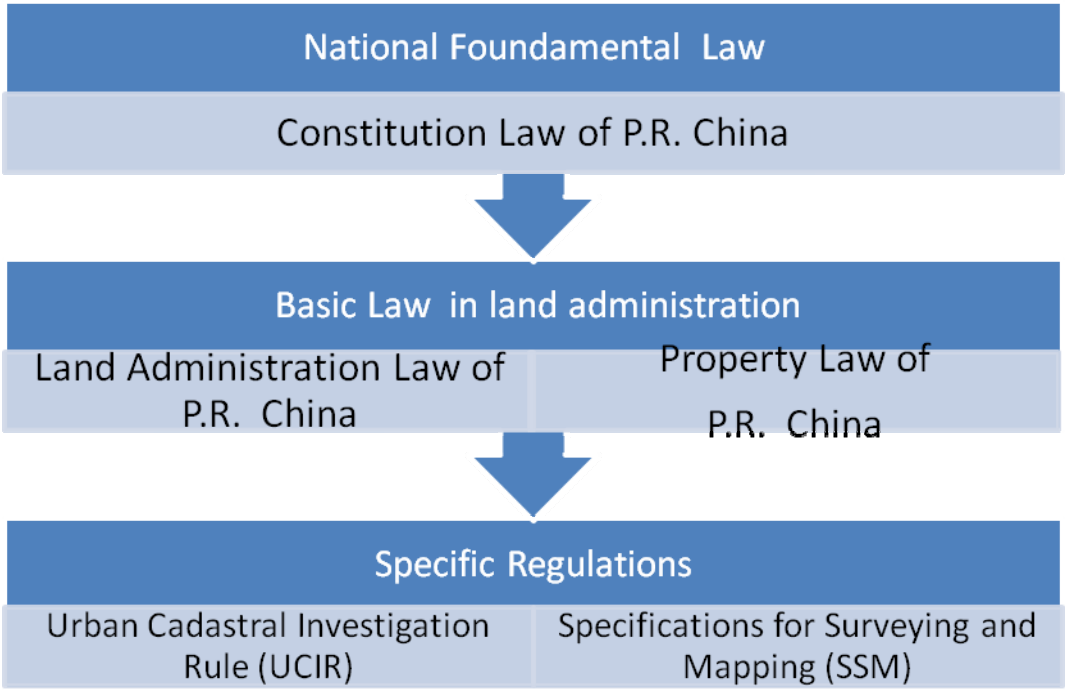


Figure 5-5, Land Adjudication - Related Law System Diagram

Constitution law of P.R. China is the fundamental law with the highest authority and concerning with all the aspects of the society. From land administration aspect, the law stipulates land tenure in China and the responsibilities and obligations of land obligees and land administrators.

Basic laws in land administration are:

- Land Administration Law of P.R. China.
- Property Law of P.R. China.

Land Administration Law is specifically enacted for land administration. It specifies and explores the Constitute law of P.R. China in land administration. It relates to land tenure security, land expropriation, land development, land reclamation, land use planning and land registration. The concrete land adjudication procedure is not stipulated. Property law is the latest law promulgated in the adjudication-related law system. Besides basic rights and duties of land obligees and land administrators, Property Law stipulates: once registered, land right can be set up, changed, transferred and canceled legally; State-owned land needn't registering; the nation is responsible for systematic registration.

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

- Urban Cadastral Investigation Rules
- Specifications for Surveying and Mapping

The newly-designed procedure aims to identify the land rights, secure land tenure and benefit the following land use planning and other activities, which complies with Constitute Law, Land Administration Law and Property law. However, there exists non-compliance between the newly-designed procedure and Urban Cadastral Investigation Rules & Specifications for Surveying and Mapping. Problems exist in the rules and specifications:

- ❖ Not unified for land adjudication accuracy requiremen
- ❖ Outdated in regulations for adjudication procedure and technical tools

According to Urban Cadastral Investigation Rule, the accuracy tolerance is 0.5 mm on the map. For the 1:500 urban cadastral map, the accuracy in the field is 0.5×500=250mm=25 cm; In Specifications for Surveying and Mapping the accuracy requirement in the field is 5 cm for the first class and 7.5 cm for the second class, which is similar to Germany and meets the needs of international standards.

Table 5-8, Comparison of the Two Specific Law

Specific Regulations	Urban Cadastral Investigation Rule (UCIR)	Specifications for Surveying and Mapping (SSM)
Accuracy	25 cm	5 cm -- first class 7.5cm-- second class
Scale	1:500	1:1000 or larger
Technical Tool	Theodolite & table tablet	Theodolite & table tablet
Adjudication Procedure	Introduced in chapter Three	The same in chapter Three

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 SNLS.

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

The specific law system should be synthesized to unify the accuracy requirement and update the adjudication procedure and the technical tools which meet the contemporary economic and technical development.

5.4. Conclusion

According to the model in this chapter, the suitability of the newly-designed procedure is assessed by four indicators - data quality (accuracy), efficiency/time, cost and law compliance.

Table 5-9, Result of Four Factors

Indicator	*Result*	*Suitability*
Data quality (Accuracy)	*21 cm*	*No (but promising)*
Efficiency/Time	*4.5% of the current procedure time*	*Yes*
Cost	*20 % of the current one*	*Yes*
Law compliance	*Non-compliance with the specific rules and specifications*	*No (Because the law is outdated)*

Accuracy:

The result (21 cm) is promising. For rural area in China, large areas have not yet been registered and the accuracy requirement is not high. The procedure is applicable in theory. For some African and south American areas with large areas to be adjudicated, the procedure is also suitable to achieve pro-poor adjudication. In future, with the development of LARSI, the resolution will be higher and the cost will be reduced. So, the procedure integrated the technology tends to be more accurate.

Time: The new procedure takes up 4.5% time of the current procedure, which greatly enhances efficiency.

Cost: The new procedure saved 97.5% of the current procedure due to time and labor reduction. With the development of remote sensing technology, and the data accuracy is supposing to be higher and the imagery tends to be much cheaper. The availability of supporting software and data analysis techniques with the system will further reduce the operating cost (Kishore C.Swain, H.P.W. Jayasuriya, & Salokhe, 2007).

Law compliance: For the national fundamental and basic law, the current procedure and the test procedure satisfy the law purpose. But both of them do not comply with the specific rules and specifications. Because the rules and standards are outdated for technical tools of adjudication and the content is contradictory in accuracy requirement, so the law system should be re-organized and synthesized to be unified and up-to-date.

6. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The thesis aims to assess the suitability of participatory urban adjudication procedure integrated Low Altitude Remote Sensing Imagery (LARSI). The main structure of the thesis is literature review, the design and test procedure, the assessment modeling and the assessment.

This chapter will discuss the following issues, come to the conclusion and make recommendations for the future related research.

6.1. Discussion

There are 10 research questions in the thesis. This section will discuss them and the results:

- **Research question 1**: What is the current adjudication procedure in Luochuan County?

  As introduced in chapter three, five steps compose the current adjudication procedure - preparation, land right investigation, cadastral surveying, data compilation and verification. The thesis focuses on the land right investigation and cadastral surveying parts. For both parts, land investigators and land obligees identify the boundary and points, fill the cadastral forms and draw the sketch, then surveying team surveys the points on the site parcel by parcel. The technical tools are GPS RTK and total station.

- **Research question 2**: What are advantages and disadvantages of the procedure?

  The advantage of this procedure is producing cadastral output with qualified accuracy - boundary points and cadastral map. The disadvantage is that the process is time, labor and cost consuming.

- **Research question 3**: What are the features of LARSI?
  - Low cost
  - High resolution
  - Current
  - Flexible to take off (<=20 km2)
  - Free from weather for land adjudication.
  - Suitable for mapping in large scale

- **Research question 4**: What is the new adjudication procedure?
  As explained in chapter four, the new adjudication procedure is gathering land obligees and land staff together in one workshop and implement land right investigation and cadastral surveying based on the 5cm LARSI in order to improve efficiency, reduce cost and save labor.

- **Research question 5**: Where are the pilot areas?
  One area with 17 parcels in Luochuan County is the pilot area, where 5 cm resolution imagery is available. The latest adjudication in Luochuan County was finished in 2009, so the reference dataset of cadastral maps and forms are available as well.

- **Research question 6**: What are the features of the pilot areas?

The area is flat so that the image quality is high without too much error caused by relief. And there are no eaves, which can enhance interpretation.

- Research question 7: What is the test procedure?
  The test procedure is to print out the imagery of the pilot area in the size of 90*90 cm, inform people of taking three certifications and gather land obligees and land administrators together in one workshop to identify boundary points on the map and fill the cadastral forms.
- **Research question 8**: What is the output of the pilot practice?
  The output of the pilot practice is the delineated ortho-image, cadastral forms with signatures and the digitalized cadastral map. The whole practice lasted three hours for the pilot area.
- **Research question 9**: What are the indicators to assess the new procedure?
  The indicators are data quality, efficiency, cost and law compliance.
- **Research question 10**: To what degree does the new procedure enhance the current one?
  The new procedure has made great progress in cost and efficiency. Even though the accuracy is 21 cm which fails to satisfy the urban requirement in China, but the result is still promising - the development of the LARSI and data processing technology makes that accuracy tend to be higher.

6.2. Conclusion

The objective of the thesis is to assess the suitability of LARSI-integrated Participation Procedure for Urban Adjudication in China. In this thesis, after preparation, the design and test procedure, assessment modeling and the assessment, the conclusion is made: The accuracy of digitized ortho-image is 21 cm and it spent 4.5 % time and 2.5% cost of the conventional procedure. The new procedure complies with the national fundamental law and basic law in land administration but not with the specific laws.

It shows that the new procedure greatly contributes to improving efficiency, saving labor and reducing cost of land adjudication. Even the accuracy 21 cm fails to satisfy the urban adjudication accuracy standards in China, it still benefits China's rural area and larger area where first adjudication is necessary like South American and African.

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

The new way is promising but it cannot replace fieldwork completely, because of control points acquisition and those points hidden by barriers acquisition (e.g. trees) in cadastral surveying.

Figure 6-1, One Cadastral Parcel Point Hidden by Tree

6.3. Limitation of the Research and Recommendations

This research has the limitation because of non-availability of the 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 thesis.

Even with the limitation, there are still relevant recommendations presented as follows:

1. The suitability of the new procedure for other countries can be researched. Because land adjudication is not only a technical or administrative issue. It is more than a social and political issue. So land adjudication of different countries varies due to different social regime and technical situation. For the time being, the newly-designed procedure is suitable for Germany and Areas where large terrains remaining to be adjudicated.

2. How to improve the assessment model of the adjudication procedure is one topic for further research. There is no unified assessment model for land adjudication internationally accepted, so that there is a gap between the reality and the necessity.

3. What is the new procedure development in future is another topic that can be researched. Because of the following elements, the development of adjudication procedure tends to achieve one-stop service, more accurate, efficient, participatory, economic and intelligent.

   -- LARSI can achieve higher accuracy
   --Tablet PC development , touch technology and fingerprint authentication
   --One Bigger Tablet PC showing the LARSI and achieve one-stop adjudication procedure.

4. How to apply the newly-designed adjudication procedure to build a dynamic cadastral system with time series can also be a direction for investigation. According to Cadastre 2014, it should be 3D converted from 2D and modeling will replace the map, and dynamic management can be achievable with images available of time series.

5. Other utilities to promote LARSI method are promising and beneficial for scientific research as well, because of LARS characteristics (e.g. be able to reach places where human being cannot).

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Appendix A: A1. Introductions of Interviewees

Group	Method	Name	Number	Information
SNLSP in Luochuan Segment	(Before fieldwork) Semi-structured Interview: a. Face-to-face b. Telephone	Luan Weidong - Project Manager Lian Heng - Cartographer Leader Zhao Bohui - Surveyor Leader	Three Persons	a. The current procedure b. Efficiency c. Cost
Bureau of Land and Resources of Shaanxi Province		Lu Fan - Director in the Bureau Cao Jia - Division Director for Data Verification	Two Persons	a. The current procedure b. The efficiency and cost c. Opinion on the new way
Bureau of Surveying and Mapping of Shaanxi Province		Zhao Libin - Director in the Bureau Tian Chao - Division Director for Data Management	Two Persons	a. The current procedure b. The efficiency and cost c. Opinion on the new way
Land Obligee	(After fieldwork) Questionnaire	Gao Sheng etc. - One Land Obligee	Seventeen Persons	a. Interpretation b. Cooperation

Appendix A

A2.Interview for Director of Land Administrative Department

1. Could you please introduce the land tenure system and the Second National Land Survey in China? What is the background and purpose of carrying on the national project? And what role does urban adjudication play in the whole project?

2. How many parties are involved in the whole adjudication procedure? What are the responsibilities (duties) of the Land Administration Bureau/Local government at national, provincial and municipal level?

3. What is the present status of urban adjudication? What is the present percentage of urban adjudication? Is there history data available for this area or not? If so, how is the data quality (completeness, currency, accuracy)?

4. What are the main standards guiding the project? (Laws, regulations, standards and regulations)

5. What is the final output required by the authorities? And what is the next step after adjudication of the SNLS project?

6. Is there fixed adjudication procedure for urban adjudication nationally? And what is the duration of adjudication required by the authorities?

7. Where is the fund from, from the central government? And what is the standards to disseminate the fund to different branch or outsourced companies?

8. Are there problems existing in the current procedure? And what are the aspects are expected to enhance?

9. Have remote sensing images ever been used in adjudication? Do you know that Low Attitude Remote Sensing Images (LARSI)? And what do you think of integrating this kind of imagery into urban adjudication?

A3. Interview for Project Manager of Luochuan County

Could you please introduce the adjudication procedure in Luochuan County? And what aspects do you feel necessary to enhance in the present adjudication?

Could you introduce the geographic characteristics of the segment? (Area, landform demography, climate, etc.)

How to disseminate the land survey task in detail for every group or team? (eg. what kind of teams take responsibility for different tasks?

How much labor is there for every team? What about the salary per labor and duration for every task?)

How long does it take to finish the adjudication procedure of each stage? And what preparations have you done before the real fieldwork? (Equipment, software, and other stuff)

How do you think of the LARSI to enhance the procedure? What are the feathers of this kind of images?

In what aspect do you realize that this kind of images could bring benefit?

What kind of platforms exists? And what about the image data quality? What about the accessibility of this kind of data?

If available, which areas could be better chosen as the pilots for urban adjudication?

A4 Interview for land staff

(Adjudicator, surveyor and cartographer)

1. What is your function/department in the adjudication procedure? How many colleagues are there in the department in total?

2. Could you explain what have you done in detail? And what problems have you met with? What aspects are you expected to enhance?

3. Take one block for example, how long have you finished your job? What is your salary?

4. How do u you contact with other staff in different departments?

5. What is your salary? And what is the price of the equipments and stuff involved in your task?

6. Have you heard Low Altitude Remote Sensing Images (LARSI)? And what do you think of this kind of images? What benefits or problems could it bring about?

A.5.Questionnaires for Land Obligees

Department: Twente University & Chang'an University
Email:Jing24741@itc.nl
Phone:13679277277

Dear Sir/Madam,

I am Ying Jing, a postgraduate in Chang'an University and in pursuit of an M.sc. degree in Twente University in the Netherlands. My major is Land Administration (LA) and my research topic is "Assessing the LARSI-integrated Participation Adjudication Procedure in Urban Adjudication in China: Case study in Luochuan County".

Adjudication is a very important activity for land administration and concerns the direct interest of every land obligee. However, the efficiency is not satisfied because of the limitation of technical tools and complicated procedure. This block has been chosen as a proper pilot. The purpose of testing is to judge whether the LARSI-integrated participation method can be effective and efficient enough or not in adjudication.

Now I show my sincerest gratitude to all of you for what you have cooperated in the newly-designed adjudication procedure. And please also fill in the questionnaire as a feedback. I will appreciate you again.

If you have any questions, please contact me without hesitation.

Best regards,

Ying Jing

Please fill this form first (Basic information):

Interviewee	Gender	Address	Educational Level	Parcel No.	Parcel Size

1. Could you interpret different land types on the imagery easily?

☐ Easily ☐ Not so easily ☐Difficultly ☐ Not a bit

2. Could you identify the location of your parcel easily or not?

☐ Easily ☐Not so easily ☐Difficultly ☐ Not a bit

3. Could you identify the parcel point and line of your parcel?

☐ Easily ☐Not so easy ☐Difficult ☐ Not a bit

4. Are you satisfied with the present adjudication procedure?

☐ Yes ☐ No

If it is 'No', please give your reasons_____

_____

5. What kind of the transportation do you take? How long does the distance from the office to your house?

6. Do you think it is an efficient way to do adjudication or not, compared with the current procedure?

☐ Yes ☐ No

Please specify your
reasons_____
_____

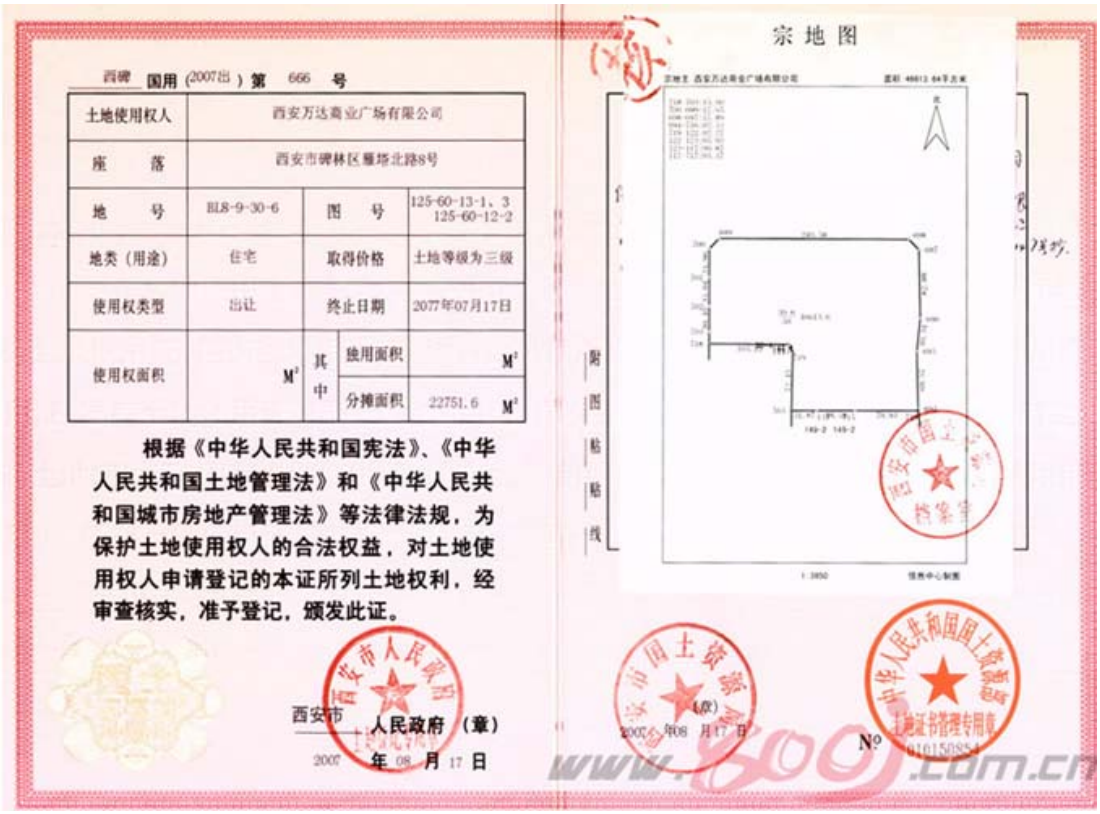
7. Do you believe the way to survey the point?

☐ Yes ☐ No

Please specify: _____

Appendix B

Proof Materials in Adjudication



西碑 国用（2007出）第 666 号

土地使用权人	西安万达商业广场有限公司		
座　落	西安市碑林区雁塔北路8号		
地　号	BL8-9-30-6	图　号	125-60-13-1、3 125-60-12-2
地类（用途）	住宅	取得价格	土地等级为三级
使用权类型	出让	终止日期	2077年07月17日
使用权面积	M²	其中 独用面积	M²
		其中 分摊面积	22751.6 M²

根据《中华人民共和国宪法》、《中华人民共和国土地管理法》和《中华人民共和国城市房地产管理法》等法律法规，为保护土地使用权人的合法权益，对土地使用权人申请登记的本证所列土地权利，经审查核实，准予登记，颁发此证。

西安市 人民政府（章）

2007 年 08 月 17 日

宗地图

附图贴贴线

（章）

2007年08月17日

№

B 1, Building Property Certification

镇国用（2005）第1155738号

土地使用权人	[redacted]		
座落	[redacted]		
地号	1443124	图号	62.75-9 -5
地类（用途）	城镇混合住宅用地	取得价格	
使用权类型	出让	终止日期	至2075. 9. 19
使用权面积	91244.6㎡	其中	宗地面积 91244.6 ㎡
			分摊面积 ㎡

根据《中华人民共和国宪法》、《中华人民共和国土地管理法》和《中华人民共和国城市房地产管理法》等法律法规，为保护土地使用权人的合法权益，对土地使用权人申请登记的本证所列土地权利，经审查核实，准予登记，颁发此证。

[redacted]人民政府（章）
2005年10月18日

记事

商业40年，至2045年09月19日；
住宅70年，至2075月09月19日。
该宗地土地出让金已全部缴清。
权利人应在项目竣工验收后30日内，持本证至发证机关申请分割变更登记，逾期本证自行作废。

登记机关　　证书监制机关

2005 10 18

中华人民共和国国土资源部 土地证书管理专用章

No [redacted]

B 2, Land Right Certification

姓名 李竹林

性别 女　民族 汉

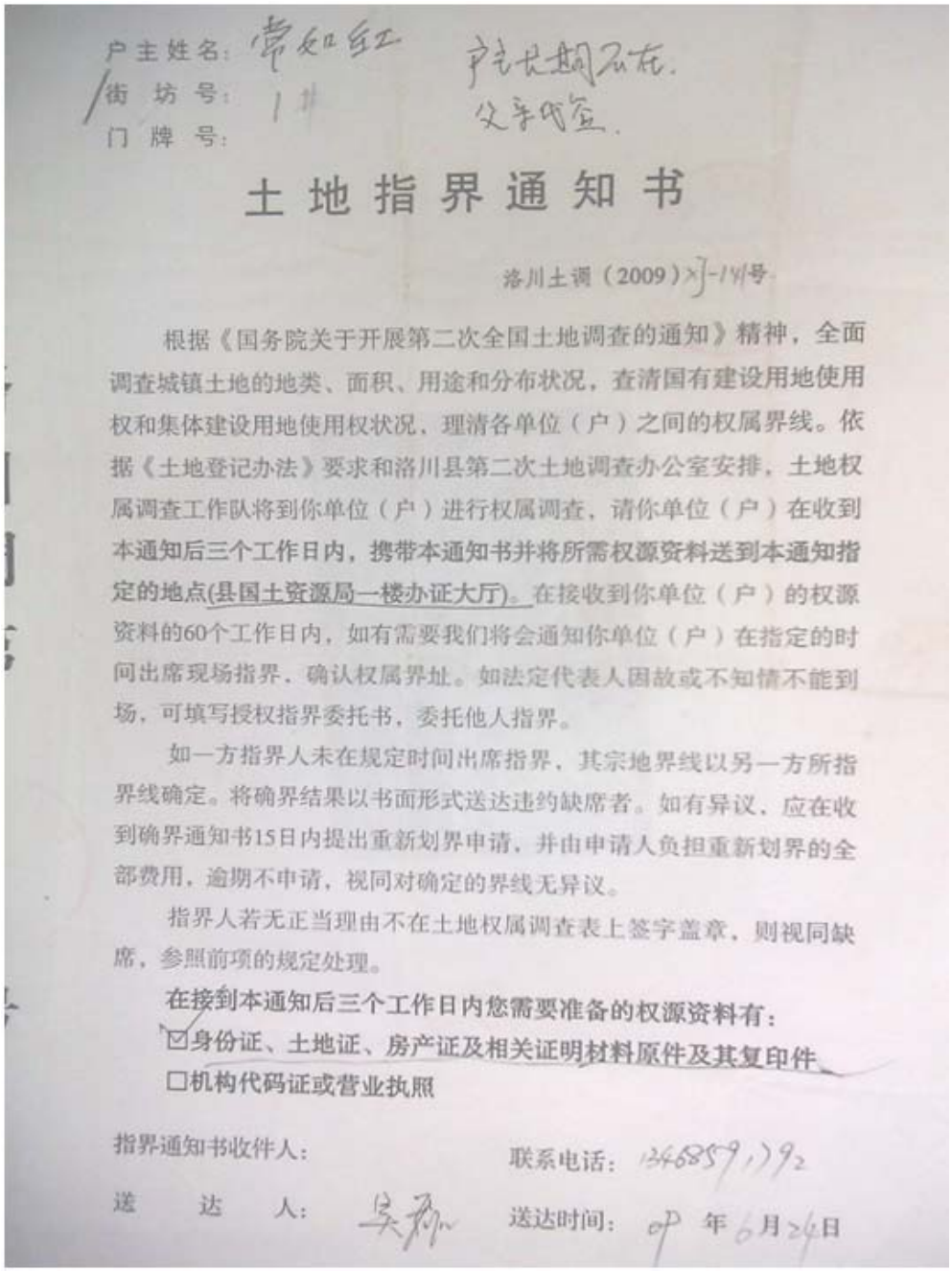
出生 1989 年 9 月 9 日

住址 [redacted]村河西尚庄三队295号

公民身份号码 320721198909094047

2010/04/02

B 3, Identification Card



户主姓名：常如红工　　户主共两个在，父子代签。
街 坊 号：1#
门 牌 号：

土地指界通知书

洛川土调（2009）XJ-19号

根据《国务院关于开展第二次全国土地调查的通知》精神，全面调查城镇土地的地类、面积、用途和分布状况，查清国有建设用地使用权和集体建设用地使用权状况，理清各单位（户）之间的权属界线。依据《土地登记办法》要求和洛川县第二次土地调查办公室安排，土地权属调查工作队将到你单位（户）进行权属调查，请你单位（户）在收到本通知后三个工作日内，携带本通知书并将所需权源资料送到本通知指定的地点(县国土资源局一楼办证大厅)。在接收到你单位（户）的权源资料的60个工作日内，如有需要我们将会通知你单位（户）在指定的时间出席现场指界，确认权属界址。如法定代表人因故或不知情不能到场，可填写授权指界委托书，委托他人指界。

如一方指界人未在规定时间出席指界，其宗地界线以另一方所指界线确定。将确界结果以书面形式送达违约缺席者。如有异议，应在收到确界通知书15日内提出重新划界申请，并由申请人负担重新划界的全部费用，逾期不申请，视同对确定的界线无异议。

指界人若无正当理由不在土地权属调查表上签字盖章，则视同缺席，参照前项的规定处理。

在接到本通知后三个工作日内您需要准备的权源资料有：

☑身份证、土地证、房产证及相关证明材料原件及其复印件

☐机构代码证或营业执照

指界通知书收件人：　　联系电话：13468591392

送 达 人：吴勇　　送达时间：09 年 6 月 24 日

B ***4, Notice Letter in the Current Procedure***

B 5，Cadastral Form

Code：_____

编号:

地 籍 调 查 表

Cadastral Form

_____区(县) _____ 乡（镇） _____ 街区（村）_____街坊（小组）

_____Region (County)_____ Town _____ Street (Village) _____Block (Team)

年 月 日

Year Month Day

初始、变更 (Origin、Change)　　单位(Unit)：平方米 (m^2)

<table>
<tr><td rowspan="2">土地权利人
(Land Obligee)</td><td>名称（姓名）
Name</td><td colspan="6"></td></tr>
<tr><td>单位性质
Nature</td><td colspan="6"></td></tr>
<tr><td colspan="3">法定代表人或负责人 (Legal Person)</td><td colspan="4">联　系　人 (Contact Person)</td></tr>
<tr><td>姓 名
(Name)</td><td>身份证号码
(ID Code)</td><td>电 话
(Tele.)</td><td>姓　名
(Name)</td><td colspan="2">身份证号码
(ID Code)</td><td>电 话
(Tele.)</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">土地坐落(Location)</td><td colspan="5"></td></tr>
<tr><td colspan="3">土地权属性质
(Land Right Type)</td><td colspan="5"></td></tr>
<tr><td colspan="4">行　政　代　码 (Administrative Code)</td><td colspan="4">地　籍　号 (Cadastral Code)</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td colspan="3">图　　号 (Map ID)</td><td colspan="5"></td></tr>
<tr><td>宗地四至
(Parcel Neighbors)</td><td colspan="8">东至 (East)：
南至 (South)：
西至 (West)：
北至 (North)：</td></tr>
<tr><td>批准用途 (Approved Utility)</td><td colspan="3"></td><td colspan="2">实际用途
(Actural Utility)</td><td colspan="2"></td></tr>
<tr><td>使用期限
(Utility Period)</td><td colspan="3"></td><td colspan="2">终止日期
(Deadline)</td><td colspan="2"></td></tr>
<tr><td rowspan="2">宗地面积
(Parcel Area)</td><td rowspan="2"></td><td rowspan="2">使用权面积
(Use Right Area)</td><td rowspan="2"></td><td rowspan="2">其中</td><td>独用面积
(Exclusive Use)</td><td colspan="2"></td></tr>
<tr><td>分摊面积
(Shared Use)</td><td colspan="2"></td></tr>
<tr><td>建筑占地面积
(Construction Area)</td><td colspan="3"></td><td colspan="2">建筑面积
(Building Area)</td><td colspan="2"></td></tr>
<tr><td>建筑容积率(Building Floor Area Ratio)</td><td colspan="3"></td><td colspan="2">建筑密度
(Building</td><td colspan="2"></td></tr>
</table>

		Indensity)	
建筑限高 (Building Height Limit)		建筑物类型 (Building Type)	
共有使用权情况 (Land Common Use Right)			
说　明 (Introductions)			

界　址　标　示 (Parcel Points)																		
界址点号 (ID)	界标种类 (Type)						界址距离 (Line)（m）	界址线类别 (Lind Type)						界址线位置 (Location)			备注 (Note)
	钢钉	水泥桩	石	喷涂				围墙	墙壁					内	中	外	

界　址　线 (Parcel Line)		邻　宗　地 (Neighbored Parcel)		本　宗　地 (Parcel)	日期 (Date)
起点号 (Start Point)	终点号 (End Point)	地籍号 (Cadastral No.)	指界人 签字盖章 (Signature)	指界人 签字盖章 (Stamp)	

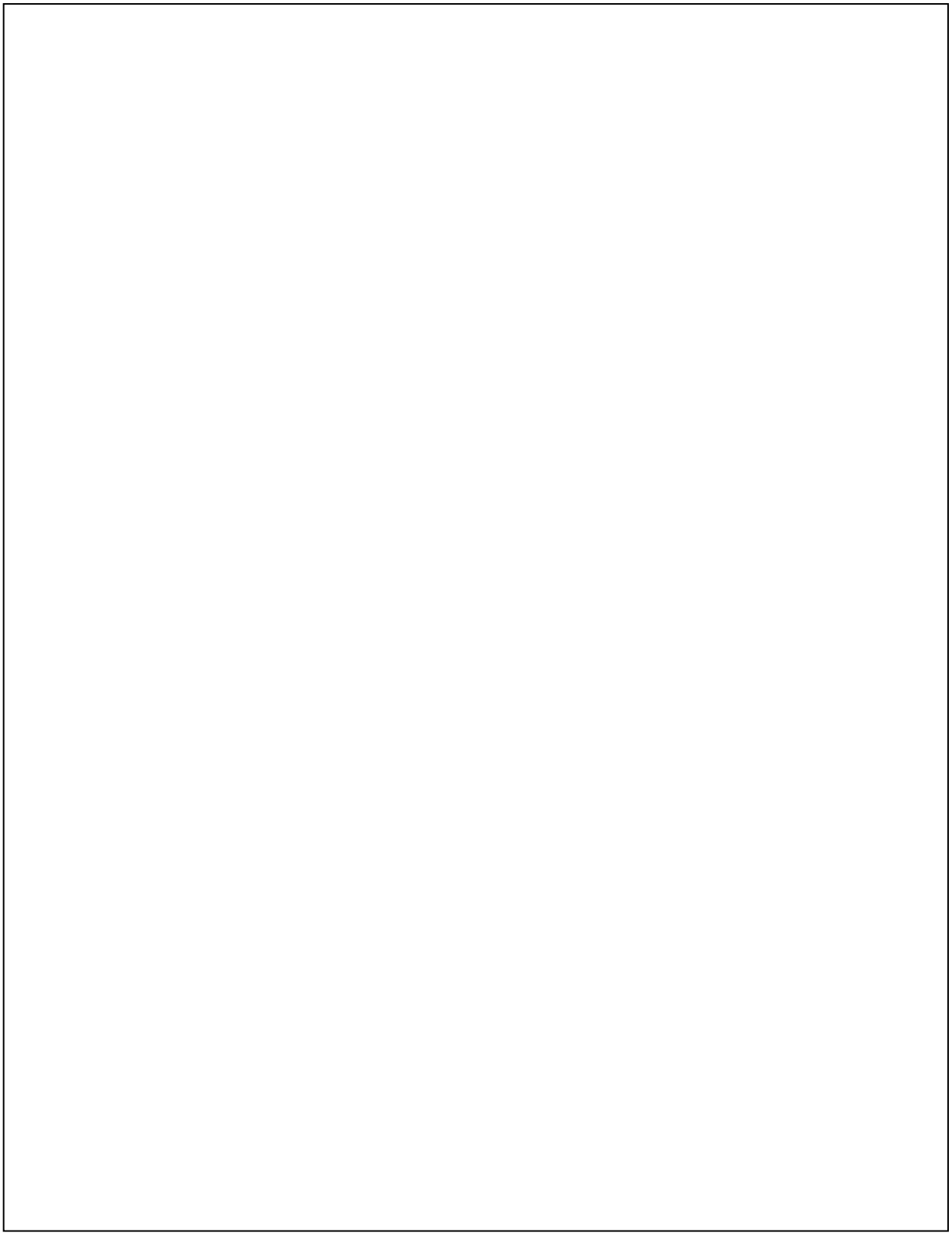
界 址 点 成 果 表 (Parcel Point Result Form)						
点　名 (Point Name)	标　志 (Mark)	纵坐标 X(米) (X Coordinate)	横坐标 Y(米) (Y Coordinate)	邻 接 点 Joint Point	方位角(° ′ ″) (Azimuth Angel)	边 长(米) (Side Length)
界址点总数 (Parcel Sum)		界线总长 (Total Boundary Length)				
宗地面积	平方米	使用权面积 (Use Right Area)				

注：坐标数值保留到小数点后 3 位，面积数值保留到小数点后 2 位

Note：Coordinate Values reserve three decimal places, and area values reserve two decimal places.

宗　地　图

(Parcel Map)



<table>
<tr><td rowspan="2">权属调查及地籍勘丈记事</td><td>权属调查
(Land Right Investigation)</td><td colspan="6"></td></tr>
<tr><td>地籍勘丈
(Cadastral Surveying)</td><td colspan="6"></td></tr>
<tr><td colspan="2" rowspan="3">调查勘丈员签字
(Surveyors Signature)</td><td></td><td rowspan="3">资格证书编号
(Certification No.)</td><td></td><td rowspan="3">资格证书代码
(Certification Code)</td><td></td><td>调查勘丈日期
(Date)</td></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

地籍调查结果审核意见(Verification opinion on cadastral surveying)	审核人 (Examiner)：　　审核单位 (Verification Unit)：（盖章） (Stamp) 土地登记代理机构资质证书号(Land Registration Agency Approved No.)： 年　　月　　日 Year　Month　Day