Chapter 9
Land Parcel Identification

Li Lin and Chen Zhang

Abstract Land parcel is the finest unit to describe the location, boundary, and ownership in land management. Land survey is the most popular way to identify land parcel in the history of land management. However, land parcel survey come with huge financial cost while the accuracy of the survey is not acceptable for many applications such as agricultural management. The development of Remote Sensing and Geographic Information System (GIS) introduced a novel way of collecting, storing, and analyzing agricultural land parcel information. This study discusses agricultural land parcel identification and management approaches from local to global level. In most countries, local authorities are responsible for the collection and storage of land parcel information. For this reason, the aggregation of land parcel information from various authorities' datasets becomes critical in large-scale agricultural management activities. However, agencies and nations develop land parcel databases differently, and these databases are often not interoperable. This study also summarizes the state-of-art approaches to reduce friction in land parcel database integration across the globe. The study concludes that international standards and corporations between organizations are essential to the management of land parcel information in agro-geoinformation systems.

Keywords Land parcel · Agricultural management · Agro-geoinformation systems · Remote sensing · GIS · Interoperability · Web-services

9.1 Introduction

Land plays one of the most significant roles in the history of human beings. It is the fundamental of many other developments such as agricultural production and urbanization (United Nations 1976). Within the science of location, land

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identification is one of the basic and key components (Rindfuss et al. 2004). The earliest recorded land identification was conducted by the Egyptians while they measured land for taxation (Cuno 1980). Starting with the Industrial Revolution, accurate land identification was required for various infrastructure development (Kain and Baigent 1992; Williamson and Ting 2001).

Land parcel could contain information for various purposes. For example, urban planners who study residential land use change has their own model to map land (Irwin et al. 2003). Agricultural experts need land parcel data with information about crop types and conditions. It is not wise and possible to include all attributes when identifying land parcels since including irrelevant information waste data storage and processing capacity.

In the United States, both public and private sectors worked on identifying land parcel for agricultural purpose. Both have done great job on local land parcel identification using traditional approaches. However, land parcel identification and management became problematic for large-scale (even global-scale) agriculture. Large-scale agricultural studies were emerged to study the impact on cropland from global change (Deng et al. 2012; Han et al. 2012). The challenger required the development of new approaches of land parcel identification. New land parcel identification benefited from the development of new techniques such as remote sensing and geographic information systems. Moreover, the national and international standards in geoinformation also helped in better management of land parcel in large-scale agro-geoinformation systems.

This chapter discusses land parcel identification and management in agriculture for different scales: from the local to the global level. Land parcel management becomes harder when dealing with larger area. Good land parcel management requires a corporation between agencies, states, and countries. This chapter also discusses about the current challenges and problems in the agricultural land parcel identification.

9.2 Land Parcel and Agricultural Land Parcel

9.2.1 What Is Land Parcel?

Land parcel is the basic land unit, which is described by its location, boundary, and ownerships. Land parcel is defined as the finest unit when identifying land. It means that one parcel will not be able to be separated into multiple finer units. For example, it is not possible to sell one land parcel to two individuals separately; however, it is possible for one individual to own multiple land parcels.

Although land parcel represents the basic land unit, land parcels are not identical since they are defined with actual geomorphic conditions. In the real world, no identical land parcels exist. In addition to the uniqueness of land parcel, the boundary of land parcel may change over time due to change in the development of construction, regional structure, and variation in ownership (Worboys 1994). For

example, human development may influence the shape of the parcels (Worboys 1994; Irwin et al. 2003). In addition, land parcel could be influenced by administrative boundary shift such as state boundary expansion/shrinkage after conflicts. Land parcel may be changed by nature as well. For example, common natural disasters such as flood and drought could introduce notable change in landscape which will cause changes in land parcel later (Lin et al. 2019).

9.2.2 Land Parcel in Agriculture

The requirements of containing information are different between the diverse types of land parcel systems. For example, parcels were grouped into undeveloped and developed to study residential land use change (Irwin et al. 2003). Data in the residential research contains more economic variable while not distinguishing land parcel by agricultural types (Irwin et al. 2003). It is totally fine since the parcel model were built for studies in residential change which would be unnecessary to including information about agricultural type for the land parcels.

Land parcel in agriculture mainly focuses on agriculture-related information while discarding other types of parcels. In general, land parcels, which are not related to agricultural activities, in agro-geoinformation systems are categorized as non-cropland or developed area. In some agricultural land parcel identification systems, non-cropland parcels were even totally discarded to save storage and increase access and process speed.

The attributes of agricultural land parcel not only clearly describe the location, boundary, and ownerships but also contain agricultural statistics such as crop type and soil type. For example, crop rotation is a common way to increase productivity that could harm soil health (Moudon 2000). Monitoring cropland at the parcel level is necessary to evaluate the health condition of the land (Moudon 2000). Such kind of information do not exist for other types of parcel but only belong to agricultural land parcels (Fig. 9.1).

9.2.3 Techniques to Identify Land Parcel

Accurate land information is significant to both private owners and public society (National Research Council 2007). As a result, land parcel information need to be accurate and reliable both spatially and temporally (Library of Congress 2011). However, significant effort is needed to continuously provide such land parcel data. In addition, accurate land parcel data is not only expensive but also hard to access. The techniques of land parcel identification, which have benefited from the development of science and technologies, improved significantly in the last decades.

Land survey is one of the earliest but most reliable way of identifying land parcel for thousands of years. Prior to the Industrial Revolution, accuracy was important

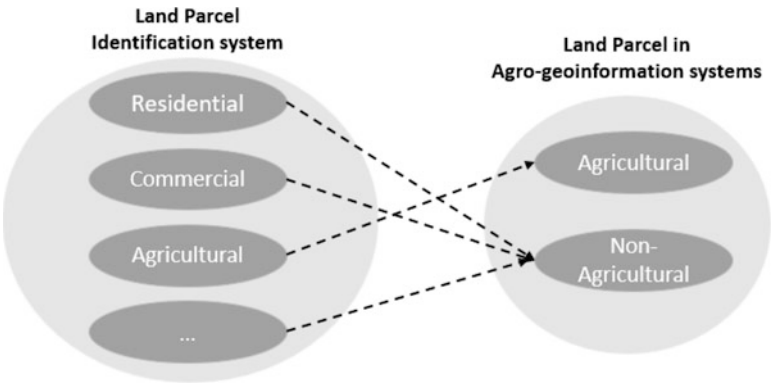

Fig. 9.1 Land parcel system management in agro-geoinformation systems

but not listed as one of the top priorities, and a rough information of ownership was enough. Starting with the Industrial Revolution, land parcel information is required to be accurately measured due to the development of road, railroad, and constructions (Kain and Baigent 1992; Williamson and Ting 2001). Benefiting from the popularity of desktop computers, many land parcel data were transferred to digital. The National Research Council (2007) pointed out that one-third counties in the United States have digital land parcel data available, and many private companies have built their own electronic land parcel databases. Although these data were stored digitally, it was not convenient to use digitalized land parcel data since they were just digitalized images.

The development of remote sensing and geographic information system (GIS) delivered an alternative way to collect, store, and analyze land parcel data. Remote sensing as one of latest Earth observation techniques has been deployed into many land parcel identification studies (Bocco et al. 2001; Oesterle and Hahn 2004). Remote sensing not only provides an unbiased data source for land parcel identification at low cost, but satellites also provide the ability of continuous monitoring. GIS was utilized as a key tool in managing land parcel data in research (Kiehle et al. 2007; Moudon 2000).

It is necessary to have land parcel information in agricultural management systems since all types of agricultural activities are conducted on land. For example, the input of land parcel data could describe land supply and capacity for agriculture (Moudon 2000). Land parcel information is required to evaluate and support agricultural sustainability and productivity (Oesterle and Hahn 2004; Zhang et al. 2019b). Better understanding of the condition of the land required reliable land parcel data as reference and input parameters.

There are few benefits for adding land parcel information in agro-geoinformation systems. Land parcel is a necessary input in agricultural studies. With the inclusion of land parcel information (especially for large-scale research), results from agricultural studies will be more reliable. Thus, the reliable result could benefit policy and decision-makers. However, land parcel identification and management in agro-

geoinformation systems is not an easy task. The following sections will discuss approaches to identify and manage land parcel information in agro-geoinformation system for different scales.

9.3 Managing Land Parcel Information in Agro-Geoinformation Systems for Local Governments, Agencies, and Companies

Unlike land parcel data collection, which is a labor- and time-intensive process, the challenges of land parcel management come from its data volume and complexity. Land parcel generated tremendous amount of digital data including footprint and other attached attributes. As a result, many land parcel information is organized at local governments, agencies, and companies (National Research Council 2007).

Many land parcel information was transferred from physical storage to digital archive with the development of desktop computer and GIS software. Most land parcel information are stored in vector data model, which is a superior data model, than raster to represent features with discrete boundaries. However, vector data may consume more storage space than other data model due to its complicated feature and precise boundary representation, especially for desktop computers.

There are few techniques widely used for managing land parcel information in agro-geoinformation systems. The size of parcel dataset could be reduced by simplifying polygon boundaries. For example, ESRI provides tools to allow user to smooth polygons by reducing/repositioning edge points (ESRI 2014). Firstly, the method, which reduces land parcel data size and increases performance by losing the detail of land parcel footprints, lowers spatial accuracy of land parcel too. Secondly, land parcels could be divided into two groups: agricultural and nonagricultural. Information about nonagricultural land parcels could be discarded in agro-geoinformation systems and only keep agricultural land parcels to save space and processing power. For example, a mask layer could be produced to define an area with agricultural activities (Boryan and Yang 2012). To add an agricultural mask layer is a simple but efficient way to reduce land parcel data size in agro-geoinformation data management.

In addition to reducing the size of land parcel dataset, land parcel for agriculture could be tagged in land administration systems; thus these tagged land parcels could be linked with agro-geoinformation systems. The first approach requires the integration of land parcel dataset and agro-geoinformation systems. However, it is hard to integrate two datasets since land parcel information is dynamically changing. The second approach was introduced to minimize the effort from data modification by using standardized structure (Inan et al. 2010). This approach is more flexible during the collaboration between multiple agencies such as the states within the European Union. However, it requires a large effort from local agencies that are collecting and building land parcel systems. Local government, agencies, and companies may not

be motivated to do the enhancement since they may not see the benefit (Library of Congress 2011).

As desktop computer became one of the most common and cost-efficient ways to process and store data, many local governments, agencies, and companies used it to store and analyze land parcel data for agricultural studies. Multiple approaches were used in managing land parcel information in agro-geoinformation applications including simplifying data complexities, discarding land parcels which are unrelated with agriculture, and linking land parcel dataset with agro-geoinformation systems by tagging agricultural land parcels. The methods discussed above are widely used in desktop applications. However, they do have limitations, which are commonly existing in desktop computers, such as the balance of reduction in spatial and temporal accuracy. The following chapters will be discussing ways to facilitate these problems for the larger regions.

9.4 Managing Land Parcel Information in Agro-Geoinformation Systems at State and National Levels

Spatial information plays important roles when conducting research. For a long time, scientists found that location is the key to some aggregated phenomena. Regional geographers conduct research by finding similar patterns within a region of study (Hartshorne 1939). However, one single county is too small for scientists to find meaningful patterns. Scientists, especially agricultural experts, work on regional scales: one state or several states. It requires the aggregation of local land parcel information which is not easy for few reasons: (1) inconsistent data collection leads to result incomparable; (2) nonstandardized data storage brings difficulty in the collaboration between land parcel datasets.

Land parcel data is collected by various agencies including private companies, and the methods of data collection were not standardized among different counties. For example, surveys on farmers could be used to evaluate agricultural condition for land parcels, but the result may lead to uncertainties if the survey was conducted independently across counties. Moreover, counties may have various methods to collect land parcel data. Many land parcel data were collected at various nonstandardized methods due to the nature of using desktop computer and the lack of the requirement of collaboration between other counties or states. All these inconsistent land parcel identification approaches bring difficulties in managing land parcel data in agro-geoinformation systems.

Land parcel identification in EU was one of many successful cases. The Common Agricultural Policy (CAP) from the EU needed aggregated land parcel data for distributing aids to farmers. Scientists developed a standardized land parcel identification system to collect and manage land parcel. It is a standardized system which manages land parcel information and is widely used in the European Union (EU) to

deal with the inconsistency in land parcel data (Inan et al. 2010; Leteinturier et al. 2006). Agricultural research became easier to be conducted based on the good land parcel management system (Leteinturier et al. 2006; Lin et al. 2016). The availability of land parcel information benefited scientists to have better understanding on crop growth and rotation (Leteinturier et al. 2006). Agro-geoinformation systems also monitor the damages from natural disaster, and land parcel serves as a critical information when evaluating the impacts of natural disasters on agricultural fields such as acreage affected and yield loss (Han et al. 2012; Lin et al. 2016).

Both scientific and industrial communities developed land parcel information systems for agricultural purpose. Scientists have noticed the importance of having land parcel information for the entire United States since the last century (Okpala 1992). Many researches focused on the development of national land parcel database (a part of the National Spatial Data Infrastructure) (Library of Congress 2011; National Research Council 2007). Most land parcel databases were developed at state level and funded by the Federal fund. After that, a national land parcel database was developed by the Federal Geographic Data Committee (FGDC) using the standards (Library of Congress 2011; National Research Council 2007). Most scientific land parcel identification systems mainly focus on collecting public land due to the limited access and releasing of private-owned land. The successful development of land parcel database for large-scale relies on techniques such as remote sensing and GIS. Traditional land parcel identification and information validation were heavily relying on the manual correction and field trip (Tasdemir and Wirnhardt 2012). Remote sensing is able to release the pressure on manual intervention and provide reliable source for land parcel identification systems (Tasdemir and Wirnhardt 2012). Remote sensing-based automatic land parcel identification required high-spatial-resolution aerial or satellite images which means the temporal resolution will be relative low. The moderate or coarse temporal resolution will have limited influence on automated generated land parcel identification system since the change of land parcel is not frequent.

Unlike the free distribution of government data, private companies from different sectors managed several types of land parcel database. For example, Zillow is one of the leading online search tools for real estate managing land parcel data on residential (PR Newswire 2012). AcreValue is another company selling information on farmland parcels. Both companies provide land parcel information, but their audiences are different. As a result, the attribute for one land parcel is different from two companies. For example, land parcel data on AcreValue are prepared for agricultural activities, so there are some agricultural land parcels existing in AcreValue's database while not showing on Zillow's website since Zillow focuses on real estate (Fig. 9.2).

Both national land parcel database and land parcel data from private companies have few limitations. First, a continues update of parcel database is needed (Rindfuss et al. 2004). Although attributes or boundaries for single land parcel do not change frequently, many data need to be updated since the database covers a large geographic area. Secondly, it is hard for a national database to manage all detailed information for each state (Rindfuss et al. 2004). For instance, a state may have

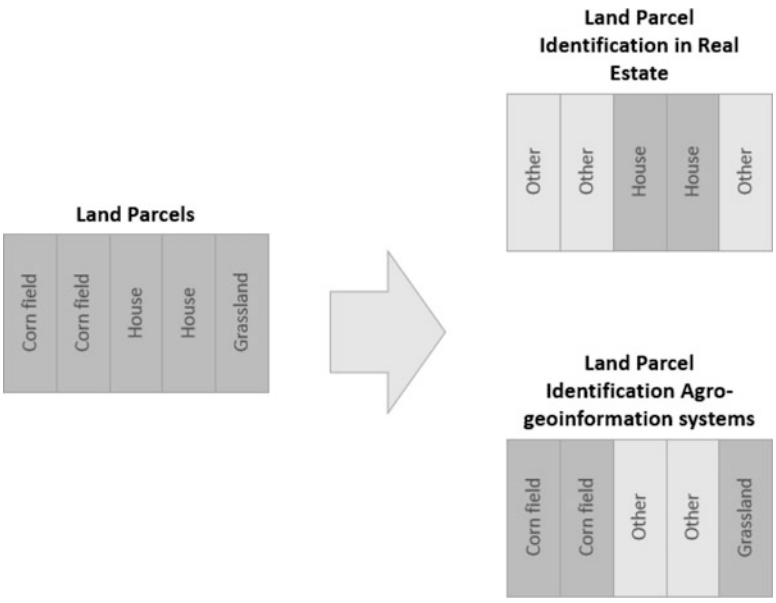

Fig. 9.2 Land parcel management in real estate and agro-geoinformation systems

different regulation on land use than the other. Both problems are possible to be resolved by the integration between the data sources. As national land parcel database is not only counted on its own data, it also relies on land parcel database from different states (National Research Council 2007). Lastly, all data have some sensitive personal information when stored in a local or state level. The improper management of data security could be harmful when the details of the data are leaked. The removal of personal and sensitive information is needed when managing land parcel data in agro-geoinformation systems.

9.5 Approaches to Manage Land Parcel Information in Globe Agro-Geoinformation Systems – International Standards

Global agricultural study requires data sharing between countries. As one of the key features in agricultural research, land parcel data is needed to be shared between countries as well. The Federal Geographic Data Committee (FGDC) and American National Standards Institute (ANSI) are two major standard institutes in the United States. Both agencies focus on standards inside the United States, such as the National Spatial Data Infrastructure (NSDI) (National Research Council 2007). However, mainly the foci of standards in NSDI serve for data accessing and sharing

between agencies in the United States, while it lacks the ability of providing support globally. On the other hand, land parcel identification methods are very different between countries, especially in developing countries. For example, many developing and undeveloped nations may experience difficulty in mapping land parcel due to either economic pressure or technology lag. Like the idea of NSDI, standard-based Spatial Data Infrastructure (SDI) is able to serve as the bridge to share data between countries (Nebert 2004).

Few international organizations focus on developing standards to support interoperability between countries. The Open Geospatial Consortium (OGC), which is one of the leading international standard organizations, is specialized in geospatial standards. There are many agro-geoinformation systems adopted to OGC standards (Deng et al. 2013; Han et al. 2012; Lin et al. 2017; Sun et al. 2016a, b; Zhang et al. 2016). Land parcel identification using web services has been widely accepted in the first generation of SDI (Kiehle et al. 2007). Standards made the visualization of global land parcel data possible. It is valuable since global agro-geoinformation systems could be directly overlaid with land parcel data. The result is very useful for visual comparison and studies. Furthermore, studies were conducted for more operations with land parcel data. Land parcel could interact with the second generation of web services, such as Web Processing Service (WPS) and Catalog Service for the Web (CSW) (Kiehle et al. 2007; Zhang et al. 2019a). The movement from displaying to processing land parcel information provided more powerful functions for global agro-geoinformation systems (Fig. 9.3).

9.6 Conclusion and Discussion

Land parcel identification was introduced with the challenges for location change science (Rindfuss et al. 2004). The identification and management of land parcel information is essential in agro-geoinformation systems. Land parcel information provides precisely geospatial information in agricultural studies to help generate more reliable research outcomes. Unlike other land parcel identification systems, agriculture land parcel should contain the following features: (1) land parcel administrative data and (2) agriculture-related information.

Land parcel information is mapped by both private and public sectors. It requires the aggregation of land parcel information from local agencies to study large-scale agricultural change. When it comes to data management for a large area, such as states or even entire countries, data size and performance usually stand opposite each other. Both the EU and the United States spend a lot of effort to establish a large-scale land parcel database (National Research Council 2007). With the adoption of standards, the EU developed the land parcel identification system for agricultural policy studies, and the national land parcel database was built in the United States.

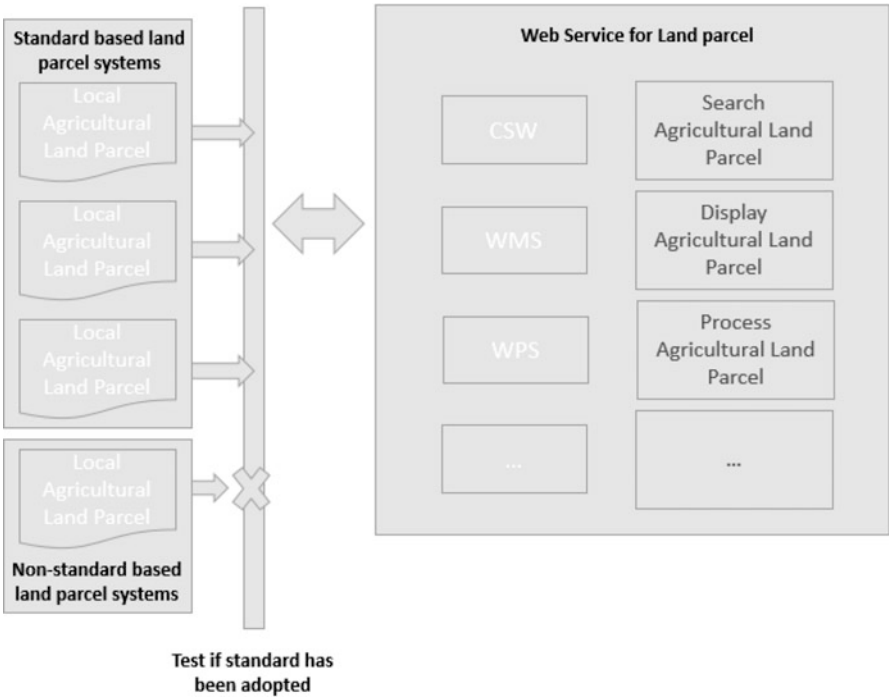

Fig. 9.3 Interaction between standard and non-standard based land parcel web services and agro-geoinformation systems

The inconsistencies in land parcel collection and storing format lead to the loss of dataset integration. Different data collection methods may lead to results with different accuracy levels. It is true that the data inconsistency could be simply solved by enforcing all data collectors to use the same data collection method. However, not all countries have the same techniques to collect and manage land parcel data. Significant technology gap could be found between developed and developing countries. Adopting new techniques such as remote sensing and GIS brings an alternative for measuring land parcel for agro-geoinformation systems. In addition, land parcel identification is based on geomorphology while considering the administrative boundaries as well. This nature of land parcel identification, which is the finest unit in agro-geoinformation system, makes the research outcome comparable.

The sharing of land parcel information is extremely significant in the global agro-geoinformation systems; however, it also has some problems. One of the largest problems is reflected in the motivation of sharing such data. As the chapter discussed earlier that counties lack the motivation to contribute the national land parcel database, international land parcel management faces the same issue. Individual nations may not share their data due to either lack of motivation or worry about the national securities. Although there are several approaches to effectively identify and

manage land parcel information, there is still a long way to go for dealing with such information for large-scale Agro-geoinformation systems.

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