THESIS

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THE EVOLUTION OF THE CADASTRAL SURVEYOR

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This thesis considers the role of the cadastral surveyor and how the profession may to respond to changes in society.

The basis for this thesis arose during my civil servant exchange period at the Netherlands Cadastre and Mapping Agency *Kadaster* in the autumn of 2011. During this placement I became familiar with the establishment and developing of cadastres and had very inspiring conversations regarding its future. Christiaan Lemmen proposed this topic as the possible subject of my thesis and was instrumental in its final selection.

Society has changed greatly over time and the velocity of this change has escalated in recent decades. Such changes have been closely linked to the rapid advances in technological development. The next step of society evolution may be a ubiquitous society, in which technology will be globally pervasive. A ubiquitous society will also be likely to be more transparent. Technology will become easier to use and in the context of cadastre compilation, there may be no further need for a professional to be tasked in making accurate field surveys – in the future, the customers could make these by themselves. It is therefore foreseeable that cadastre changes may take the form of an open source database, where customers input and save the data of their own real estate.

In Finland, the work of a cadastral surveyor may thus change to maintaining databases and refereeing serious cadastral problems. Also the land development tasks will be a great part of land surveyor's work in the future.

Keywords: cadastral surveyor, futurology, scenarios.

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Tämä opinnäytetyö käsittelee toimitus- ja kiinteistöinsinöörin työtä ja sen muuttumista tulevaisuudessa; miten ammattilaisen on muututtava vastatakseen tulevaisuuden tuomiin muutoksiin.

Idean ja aiheen tähän opinnäytetyöhön sain ollessani virkamiesvaihdossa Alankomaiden maanmittauslaitoksella, Kadasterilla, kolme kuukautta vuonna 2011. Siellä tutustuin kiinteistöjärjestelmien perustamis- ja kehittämishankkeisiin ja kävin hyvin inspiroivia keskusteluja tulevaisuudesta. Christiaan Lemmenin ehdotus tulevaisuuden tutkimisesta lopputyössäni antoi lopullisen niitin aiheen valintaan. Tulevaisuuden tutkimus on kiitollinen aihe, kukaan ei loppujen lopuksi tiedä tarkalleen mitä tulee tapahtumaan.

Yhteiskunta on muuttunut aikojen saatossa ja tulee yhä muuttumaan. Muutoksen nopeus on ollut kiihtyvää ja se on ollut viime vuosisatoina kytkeytynyt teknologiseen kehitykseen. Seuraava askel tietoyhteiskunnasta tullee olemaan ubiikkiyhteiskunta, jossa teknologia on läsnä lähes kaikkialla, ja samalla yhteiskunta tulee yhä läpinäkyvämmäksi.

Teknologia kehittyy ja tulee yhä helppokäyttöisemmäksi. Esimerkiksi ammattilaista ei enää tarvita tarkkojen mittauksien tekoon maastossa, vaan asiakkaat voivat tehdä itse. On mahdollista, että koko kiinteistöjärjestelmä on avoin ohjelma, jossa tallennetaan asiakkaiden itsensä hankkimia ja tallennettuja tietoja.

Näin ollen toimitusinsinöörin rooli tulee muuttumaan Suomessa järjestelmien ylläpitäjäksi ja vakavien ongelmien ratkojaksi, jopa osittain lainopilliseksi asiantuntijaksi. Lisäksi maan kehittämiseen liittyvät tehtävät voisivat tulla isoksi osaksi maanmittareiden työtä.

Asiasanat: toimitusinsinööri, tulevaisuuden tutkimus, skenaariot.

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List of Abbreviations

FIG	Fédération Internationale des Géométres, International Federation of Surveyors
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
LAS	Land Administration System
Lidar	Light Detection and Ranging
MML	Maanmittauslaitos
NLS	National Land Survey of Finland
STDM	Social Tenure Domain Model
UAV	Unmanned Aerial Vehicle
VGI	Volunteered Geographic Information

1. INTRODUCTION

"*Prediction is very difficult, especially if it's about the future*"

Niels Bohr

Cadastre is the most important part of the Land Administration System (LAS). Development and changes in the LAS will also cause changes to the cadastral system. An LAS is an integral part of modern stable society and any changes in society are thus liable to affect both LAS cadastral systems and also the role of the cadastral surveyor.

We have progressed significantly from our origins as an agricultural society by way of an industrial society, to becoming an information-based society. Our next step therefore could be seen as a ubiquitous society in which artificial intelligence is an everyday part of our daily existence. Computers are already communicating between themselves and reduce the need for human input. For example, a fridge will check whether there any milk left and send an order to a shop's computer to send more milk without your involvement. So, if modern society will develop to become a ubiquitous society, how will this affect the LAS and the cadastral surveyor?

The study of the future (futurology) presents an ideal target for this thesis as there is no unambiguous answer to the question of what the world will look like after 30 years. Predicting and making a detailed picture of coming events is impossible, but we are able to forward a "best guess" by using different theories and methods, and a creative mind. The basic presumption is that technology will develop a lot, but human nature is still much the same as during the Stone Age. Human needs are basically the same as 40 000 years ago and those perpetual needs will affect society, politics and legislation, regardless of technical developments.

The Land Administration System will be based on a multipurpose cadastre and will still need to include all the information of land, from the land owners

to land development actions. As such, land surveyors play a considerable role in the development of an LAS.

Cadastre is the most important part of an LAS, but is there a need for an author to administrate the cadastre? It may be possible for the public to do the administration by themselves using technologies such as OpenStreetMap. Therefore, is there a need for professional land surveyors to maintain cadastral databases or undertake cadastral proceedings? As an example of these future trends: the National Land Survey of Finland launched a web based service, where it is possible to make real estate purchases without the involvement of a public purchase witness. Would the next step be a parcelling of land, made without the need for a cadastral surveyor?

A major and expensive part of cadastral proceedings is the field work that links the cadastral system and borders to the terrain. There may therefore be other solutions to accomplishing such linkage, rather than sending a professional surveyor into the field to make such measurements. These examples give rise to a lot of open questions, none of which are easy to answer.

Within this thesis, Chapter 2 looks at the principles of Land Administration System and the central role of cadastre formation. Chapter 3 considers the methods involved in futurology and how society may be predicted after 30 years. Chapter 4 introduces the different possible scenarios which may arise in the cadastre context and Chapter 5 deals with organic cadastre and the testing of its possibilities and accuracy.

2. LAND ADMINISTRATION SYSTEM

2.1 The principles of the Land Administration System

LAS is a very important tool by which to provide land-related policies and land management strategies to society. In LAS, the term 'Land' includes the infrastructure, natural resources, and everything which is on, attached to, or under the surface (Williamson, Enemark, Wallace & Rajabifard, 2009, 5). Figure 1 shows the different elements of LAS.

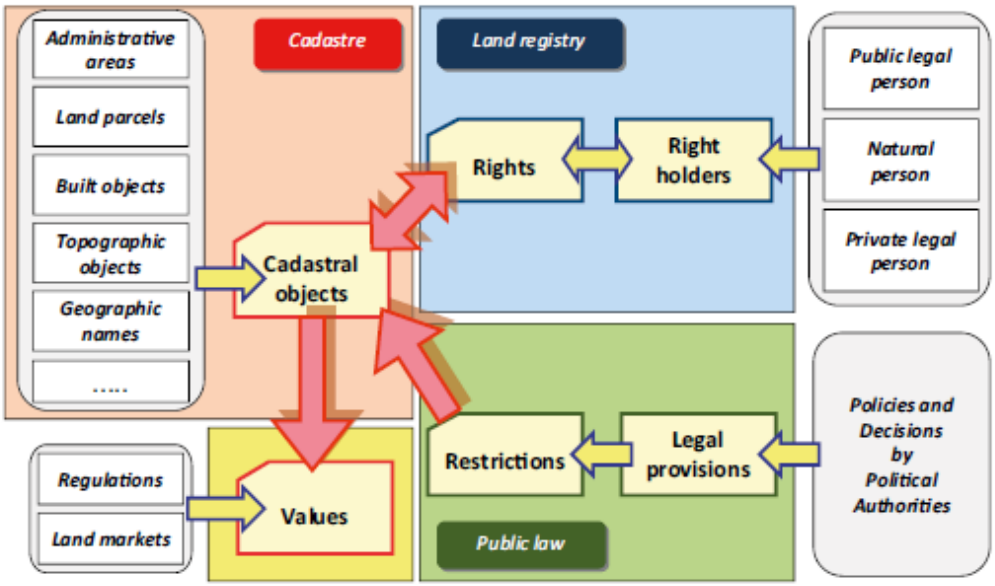


Figure 1 Elements of LAS (Steudler & Rahabifard 2012, 14)

Every country has their own land administration system which reflects their own differences, however each system tends to follow common processes which fulfil the four main functions of LAS:

- land tenure
- land value
- land use
- land development

FIG Commission 7 Statement of Cadastres working group Hennsen, Hawerk, Kaufmann, Nichol, Sheg, Williamson & Österberg (2013) defines cadastres as follows:

> "A cadastre is normally a parcel based and up-to-date land information system containing a record of interests in 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." (Hennsen et al., 2013)

Cadastre is one fundamental tool of LAS, especially the cadastral map. Land parcel maps show people's relation to specific land and land property. In the western world, cadastres are based on three different categories: the German approach, the Torrens approach and the French/Latin approach (Williamson et al., 2009, 9).

Aune Rummukainen divides cadastral systems into four categories according Gerhard Larsson (1991 cited Rummukainen, 2010, 51) and additionally includes the English system. These systems have been created in the western world, however these or their variables have been adopted in different countries around the world. Some countries also utilize mixed systems.

German approach connects the land register and cadastre firmly together. The foundation of land ownership is the title which is granted by author. A deed is not enough to prove the ownership. The land register also documents other tenures and mortgages. Changes to the cadastre need legal surveys and agreements made by the land owners are not registered without a legal survey (Williamson et al., 2009, 122). The German approach is used in e.g. Turkey, Austria and variations are also used in the Nordic countries (Rummukainen, 2010, 50).

The Torrens approach follows the same principles as the German approach, but the history of the Torrens system is much shorter. The Torrens system

was created to support the land market and the original focus was to create a system without the dual function of supporting deeds, titles and tenure (Williamson et al., 2009, 123). The Torrens system is used for example in Australia, South-Africa, Canada and Syria (Rummukainen, 2010, 51).

In the French/Latin approach, the connection of the cadastre and deeds register is loose and they are completely separate elements. Land ownership is based on deeds and there are no titles, which causes problems in creating an effective LAS (Williamson et al., 2009, 122). The French/Latin approach is used e.g. in The Netherlands, Belgium, and France (Rummukainen, 2010, 51).

The German and Torrens system based countries are more easily focused towards land management than those countries using the French/Latin based system. The cadastre itself could be an engine of the overall land administration system and a large scale cadastre map is great tool for the representation of how people are connected to the land. It identifies legal rights, together with the units which form commodities and properties (Williamson et al., 2009, 127-128).

Therefore, cadastre is at the heart of a properly functioning LAS. All the layers of LAS are based on the cadastre and a properly functioning LAS provides a vital tool in assisting in the process of sustainable development (Figure 2).

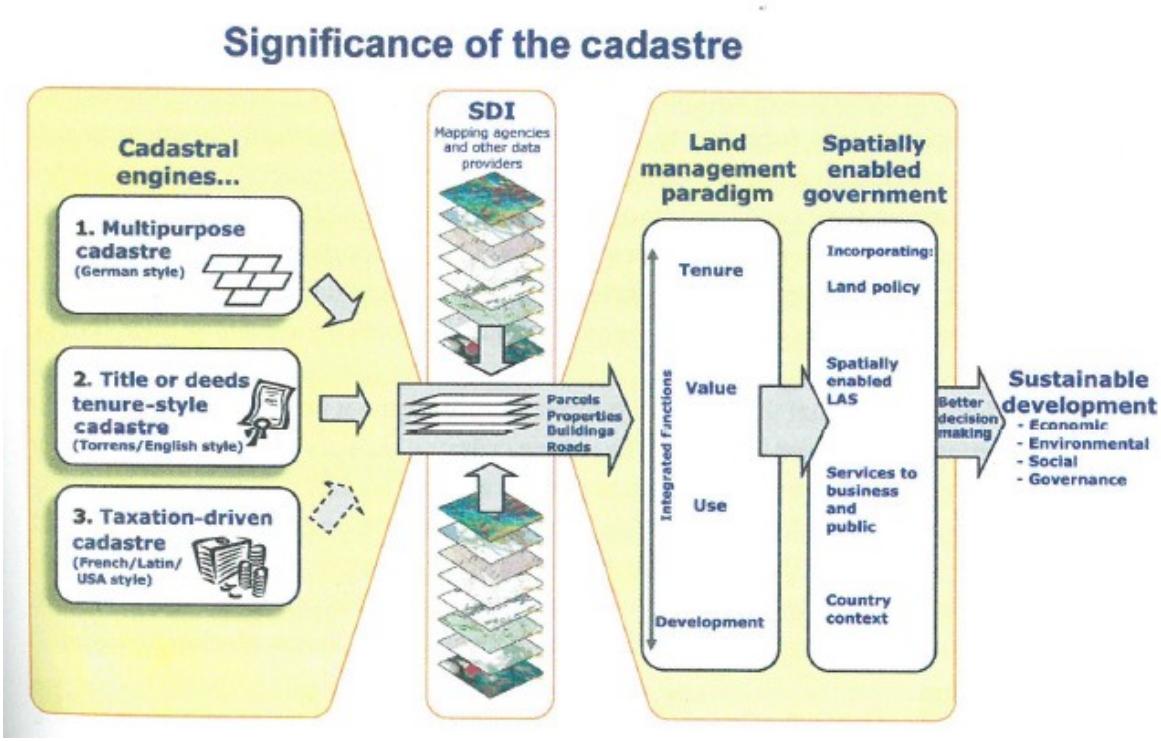


Figure 2. Cadastre as the engine of LAS (Williamson et al., 2009, 127)

Cadastral information cannot be replaced by other layers derived from geographical information system (GIS) because the core cadastral information eventually forms the core of the spatial data infrastructure. Nowadays however, new opportunities in addressing such information also pose new challenges to design land administration systems. The success of a cadastral system depends upon how it can utilize these new opportunities whilst still achieving economic, social and environmental objectives. Therefore, it has to combine wider forms of spatial data. Today the amount of available spatial data is increasing all the time, including the spatial enabled data of boundaries, demographic and topographic information and natural resources. All these elements should be encompassed when designing a new LAS (Williamson et al., 2009, 128-130)

How does society see a properly functioning LAS and cadastre? It is shown (Figure 3), that the most visible part of an LAS is the individual land parcel owned by a juridical person or entity (e.g. a natural person, company, association etc.).

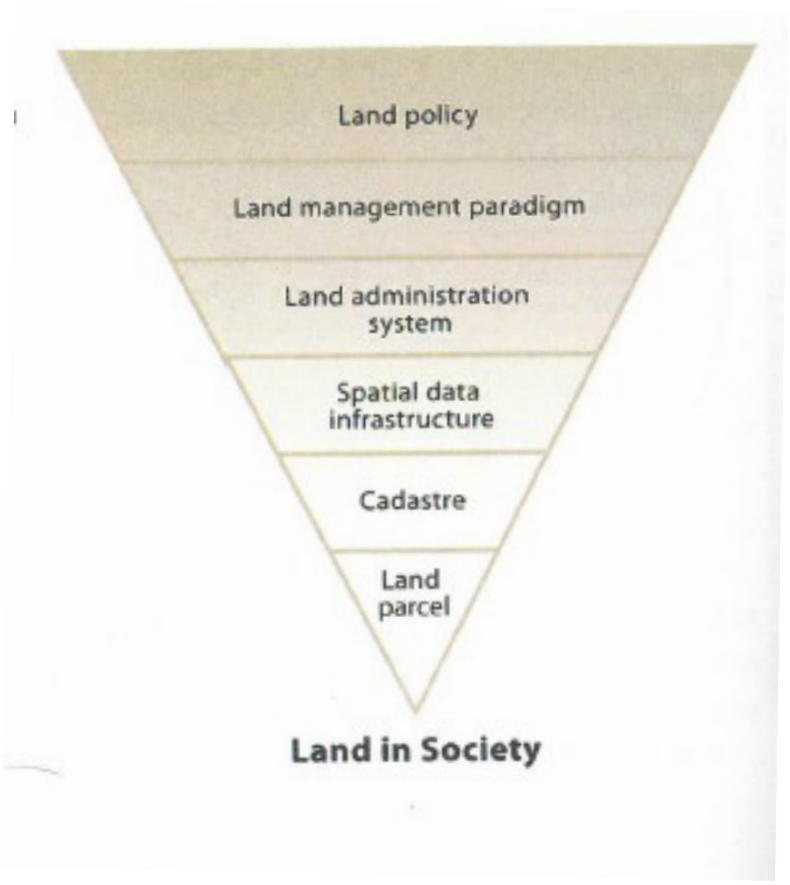


Figure 3. The hierarchy of land issues (Williamson et al., 2009, 132)

Any new form of land administration system should also include all possible spatial data derived from the surface of terrain and beneath it. The core and heart of a new LAS is therefore the cadastre and cadastral map, and without knowing the owners of a certain area of land, any planning or determining of the terrain's resources is of little value.

How do public organizations currently consider the future of land management and is the complete LAS included in such visions? The projected views of the National Land Survey of Finland and the Netherlands Cadastre and Mapping Agency (Kadaster) provide good examples because the two organizations are quite similar in their base tasks.

To quote the National Land Survey of Finland: "*Maanmittauslaitos luotettavasti verkossa ja lähelläsi*" - 'The National Land Survey of Finland, reliably on the web and near you'.

Kadaster provides the following vision:

- One shop for both property and geographical information
- Internationally innovative and trendsetting
- Resilient for its clients:
  - Streamlined processes
  - Slender management structure
  - Central management structure
  - Less offices
  - Low costs, high quality"

(Fennerman-Koch, 2009)

One function of a proper LAS is land development. These activities are performed in Finland by municipalities, regional councils and at a governmental level by the environmental administration. The municipalities have a monopoly over land use planning, whilst the National Land Survey of Finland executes land development tasks in land consolidations. These activities normally take place in rural areas such as agricultural and forest areas, however land consolidations are dependent on the willingness of the land owners and on the financial support of the government.

In The Netherlands, land development tasks at a regional level are executed by Kadaster. The activities include rural area land exchange and consolidation, but such activities are increasingly being seen in urban areas. The themes of development are: Nature and landscape, Residential and Business, Environment and Climate, Public Order and Safety, Water Management, and Infrastructure (Fennerman-Koch, 2009).

2.2. Present Cadastral Systems and Procedures

2.2.1 German approach; Finland

The Finnish cadastre is based on the principles of the German approach. The Finnish cadastre has a history spanning from its control by Sweden in the 17th century, the Russian Empire in the 18th and 19th centuries, to its continued adoption following independence in the 20th century.

The Finnish cadastral system and proceedings are maintained by the *Maanmittauslaitos* (the National Land Survey of Finland). This is a governmental agency and employees working with cadastral issues are civil servants. Some municipalities (e.g. Helsinki, Espoo, Turku, Tampere and Oulu) administer their cadastral system on a binding plot division areas. This results from historic reasons, where there was a land book to show the land owning on rural land and an urban cadastre available in towns to guide the construction of the urban environment (Rummukainen 2010, 63). This is also enacted in Real Estate Registration Act 5§ (Kiinteistörekisterilaki 5 §):

> ”Kiinteistörekisteriä pitää Maanmittauslaitos sen mukaan kuin Maanmittauslaitoksen keskushallinto määrää. Asemakaava-alueella, lukuun ottamatta maankäyttö- ja rakennuslain (132/1999) 10 luvussa tarkoitettua ranta-asemakaava-aluetta, kiinteistörekisteriä pitää kuitenkin kunnan kiinteistöinsinööri, jos kunta päättää ottaa huolehtiakseen kiinteistörekisterin pidosta.”

Private sector involvement in cadastral proceedings is minor. Private companies are able to conduct field work and take measurements, but the official documents and cadastral surveys are to be made and registered by the National Land Survey of Finland or a city’s municipal government.

Cadastral proceedings are mainly based on the Real Estate Formation Act however legislation such as the Private Road Act and Expropriation Act are widely used in different proceedings. The cadastral proceedings of the Finnish system during 2012 comprised: parcelling (68,6 % of all registered proceedings), border reconstruction (4,4%), private road surveying (7,7%), expropriation proceedings (3,6%), partitioning (1,0 %), land consolidation

(0,2%), confirmation of joint property unit shareholders (7,4%), and other activities including e.g. land-for-land exchanges and property definitions (7,1%). The total amount of registered proceedings during 2012 was 21 637 proceedings (Maanmittauslaitos vuositilastot, 2012).

A cadastral map includes parcel borders, the parcel register number, the coordinates of border marks, easements, and the location of planned areas and nature protection areas. The details of these areas however are not included in the cadastre. In the register part of the cadastre is the register number of the registered unit, registered area and the total number of parcels, archive numbers, legal surveys, and information pertaining to joint property units and easement (Kiinteistörekisteriasetus 6-10§). Through the cadastral database it is also possible to seek documents from the digital archive although the number of digitalized documents is currently low.

The cadastre has a connection to the Land Registry where the titles, mortgages and tenures of the register units are registered. In 2010, the Land Registry was placed under the auspices of the Maanmittauslaitos by way of local courts and the integration of the cadastre and land registry is currently under construction. In future, both the cadastre and the land registry will be under the same register.

In November 2013, the Maanmittauslaitos launched a web service which made it possible to undertake online real estate purchases without the involvement of a public purchase witness. The system verifies the competence of parties after they have logged in by using e.g. an online bank service username and password. After the purchase is confirmed, the land title starts automatically.

Cadastral proceedings are comparable to a District Court hearing and the role of the cadastral surveyor is comparable to that of a judge in cadastral issues. The cadastral surveyor does not have to follow the opinions of customers and can make their own decisions according to the law. Customers are able to complain to the Court of Appeal, which provides

expertise in the case of cadastral issues. After the judgment of the Appeal Court, customers are further able to complain to the Supreme Court (Kiinteistönmuodostamislaki 1995, chapters 19 -21).

The cadastral survey process includes both judicial and technical elements. In the judicial part, the rights of a registered unit are processed, together with other issues pertaining to the registered unit. Easements are also established and handled during the cadastral meeting.

In the technical component the fieldwork is undertaken, including marking the border to the field and the surveying of border marks and other objects. As a result of the cadastral survey the minutiae of the cadastral meeting and the cadastral map is produced.

The Finnish cadastre is a field cadastre in which there is a link from the database to the field, however border marks found on the field are more ruling than cadastral maps or coordinates in most cases. In shores and other natural features borders are fixed. This is shown in Figure 4 where the straight borders leading to other borders and the border adjoining the riverbank are fixed.

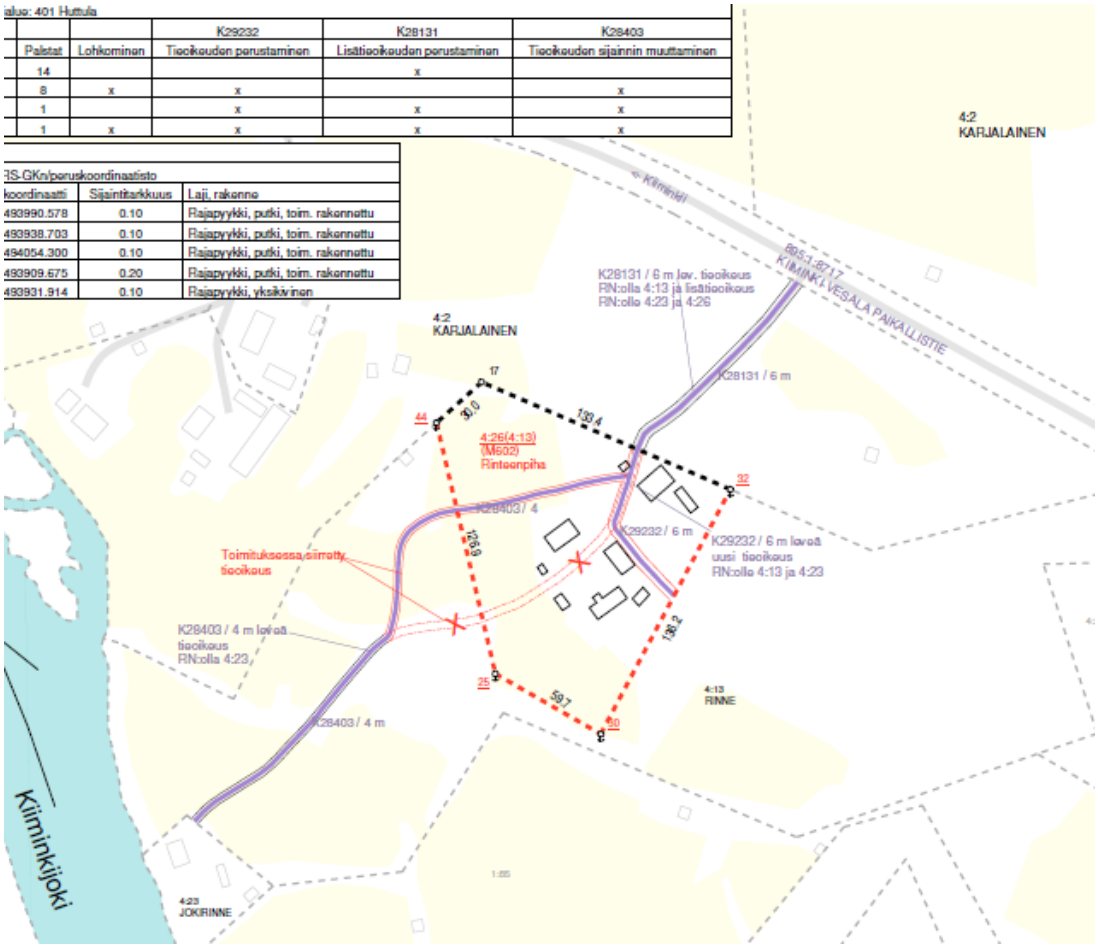


Figure 4. An example of cadastral proceeding map in Finland

2.2.2 Roman/Latin approach: the Netherlands

The cadastral system of the Netherlands is based on the principles of the French/Latin approach. The basis of the modern cadastre was established in 1832 (Van der Molen, 2010).

The cadastre and cadastral proceedings are maintained by Kadaster, the Netherland's Cadastre and Mapping Agency, which also has a monopoly on cadastral proceedings. Cities are not involved in the maintenance of the cadastral system. Employees working with cadastral issues are classed as civil servants. The private sector is due to become involved in cadastral proceedings, undertaking fieldwork and measurements, but the final registration will still be made by Kadaster (Van der Molen, 2010).

The legal base of cadastral proceedings is the *Burgerlijk Wetboek* (Civil Code). Cadastral proceedings include parcelling and land border reconstruction. Land consolidation is processed under a different department, but this may also be counted as a cadastral proceeding. The basis of land ownership is the land deed. Kadaster registers the deed submitted by the notary and does not investigate the competence of parties. This investigation of competence is made by the notary, which is a private undertaking.

The Dutch cadastral map includes the parcel boundaries, parcel numbers, house numbers and street names. You are not able to use the coordinates given on a cadastral map to locate the border in the field setting and in such cases you have to investigate the sketches made of earlier proceedings (Van der Molen, 2010).

Easements are registered on the deeds register and are not visible on the cadastral map. In the Netherlands, the different types of easement are not restricted by legislation and parties are free to reach mutual agreements.

In parcelling, the role of the cadastral surveyor is more that of a technical assistant. In these proceedings the surveyor will confirm the location of a new border according to the agreement of parties. The surveyor has to follow the agreement reached by the parties and if these parties encounter disagreement, they have to bring the disagreement to a local court where a judge will make the final decision. After judgement is passed, the surveyor will undertake the cadastral proceeding following its auspices.

In border reconstructions, the surveyor has to relocate the old borders. This task is very challenging, because there is often a different sketch for each old border and the surveyor has to locate the borders using these sketches. They are not able to use the coordinates drawn from the cadastral map. If parties are unsatisfied with the result of boundary reconstruction, they can request for a second opinion from Kadaster. If parties are still unhappy with the result, they can take the proceeding to the local court.

Land consolidation is not as much a cadastral proceeding as are parcelling or border reconstruction. Expropriations are executed by province and Kadaster supports provinces by making maps etc. (Jellema, 2011).

From the process of parcelling, the cadastral minutes, sketch and cadastral map are produced. Figure 5 shows an example of a field sketch which shows the location of new borders and how those are determined.

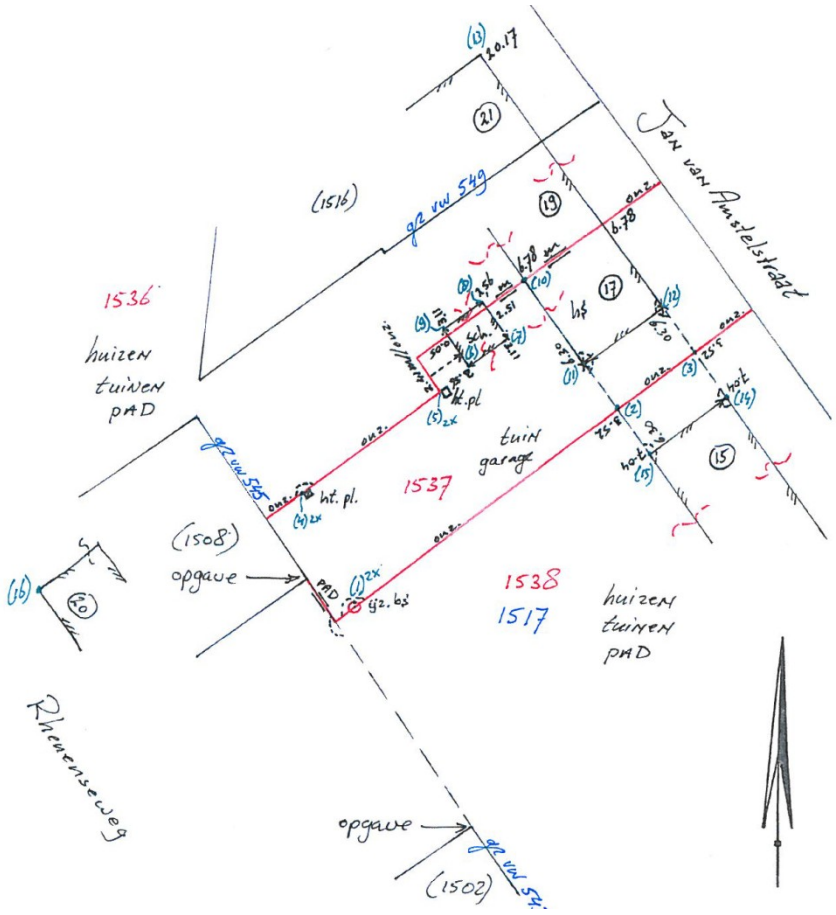


Figure 5. An example of a field sketch in the Netherlands

2.2.3 Torrens system; Australia

> “The cadastral systems in Australia were historically designed for the transfer of land ownership a legal land market. Secondly the cadastral system supports the legal ownership of land, and defining, identifying, demarcating, measuring and mapping legal parcel boundaries.”
> (Mitchell, 2010)

Australia utilizes a Torrens cadastral system. Originally, an English system of deeds registration for land transfers was employed during the period of colonization since 1788. In 1850 Robert Torrens introduced a more effective system to support land exchange. All states of Australia had adopted the Torrens System by 1874, however this has since become both expensive and complicated.

Australia has two governmental organizations that administer the cadastre. The Crown Lands Administration takes care of public lands and the Land Registry takes care of private lands. These two organizations are going to integrate into one agency, which will be responsible for the up-to-date maintenance of the cadastral map. The Land Registry maintains the title registry, however, because every state has their own authors to maintain the cadastral system, there are eight different cadastres maintained in Australia. Although these are all based on the Torrens system, the means of titling and registration differ in each case (Mitchell, 2010).

The cadastre includes the information which pertains to land parcels. They are divided into two components: a textual component identifies the information held by the Land Registry, such as an owner’s rights, restrictions and responsibilities, easements and mortgages. A spatial component (the cadastral map) shows the dimensions of a parcel corresponding to a registered title and unique identifiers. Cadastral maps account for 90 % of fixed and 10 % of general boundaries (which are based on natural or man-made features). Additional information such as legal information, valuations and other related activities which are involved in the land administration process are also retained in the cadastre.

One property can have multiple parcels in the Australian system. It usually has a single address and one house, however other parcels can be located elsewhere. This is common in rural areas and around 90 % of parcels consist of a single area. Australian cadastres include approximately 10.2 million parcels and include freehold and state owned land, strata titles (the form of ownership for e.g. multilevel apartment blocks), and Native Title parcels. All cadastral maps and land registers are computerized and updated daily. Most cadastral surveying is carried out by private, licensed surveyors, and they and governmental organizations input data into the cadastre on a continuous basis (Mitchell, 2010).

The process of subdividing land is generally as follows:
Person A owns a rather big parcel and is willing to sell the extra part of parcel for construction purposes.

1) First he has to contact to the local council and check out the zoning and the minimum size of the lot.
2) He has to clarify the connections of the subdivision to road, electricity, sewer systems and other utilities.
3) He contacts the licensed surveyor to perform a legal survey of the subdivision.
4) The licensed surveyor marks the borders on the ground. He then makes a subdivision plan and sends it to the Land Titles Office for registration.
(Process to subdivide the land)

From this survey, a plan is produced that shows the new borders, border marks, distances and bearings. The survey plan may not be larger than an A4 sheet. Figure 6 shows a model of a survey plan (Department of Natural Resources and Mines, 2010).

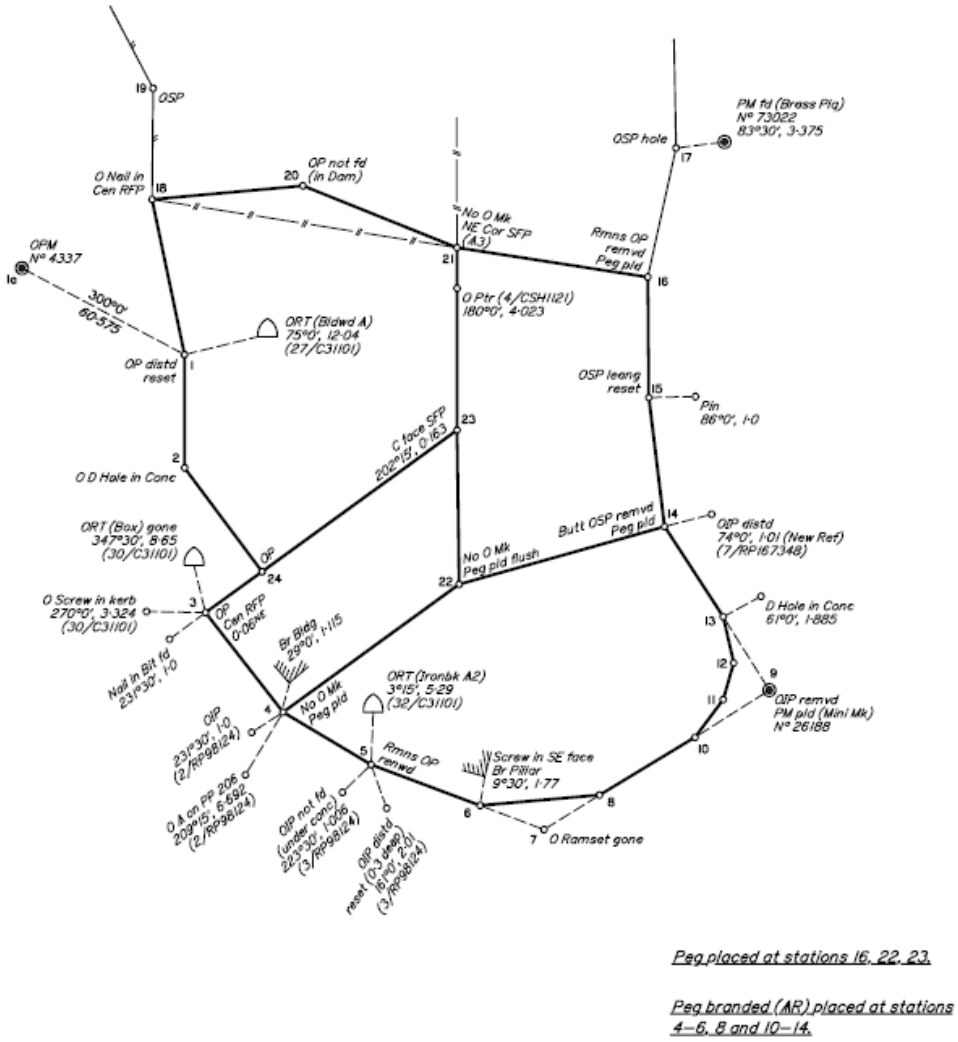


Figure 6. An example of a survey plan in Australia (Department of Natural Resources and Mines, 2010)

Different survey types are used to define new boundaries (parceling), redefinition of lost boundary marks (border reconstruction), and easement surveying. For example, in Queensland territory all surveys are standardized and guided by formal cadastral survey requirements (Department of Natural Resources and Mines, 2010)

2.2.4 English system; England

In England there is no single general cadastre record and no cadastral surveys are made. At the FIG Commission's 7th annual meeting in 2008, Richard Grover (2008) asked how England is able to have a welfare society without the use of a cadastre.

Land Administration in England is based on different principles than those seen in the German or French/Latin approaches and is built around the notion of proprietary rather than physical land. An estate is described more in terms of the relation between the landowner and the land. Land owners own rights to the land and same piece of ground may have multiple right holders.

> " … the right to graze woodland or hunt over it can belong to a different estate to that of the proprietor who has the right to cut the timber. The fishing rights over a river bank may be owned by a different person from the one whose cattle can graze the land and drink from the river." (Grover, 2008)

Sometimes rights are dependent upon a certain time and therefore this system needs a multidimensional means by which to be able to record such details. The English system however evolved a millennium before the land was able to be measured accurately (Grover, 2008). For historical reasons, it is not possible to record the data of rights and right holders by parcels. The only way to organize such real estate is so that it is possible for an individual to have many proprietary estates, and then to create a link to a certain area on the ground. Also taxation has a useful function in as a record of hereditament properties. Hereditament may be defined as:

> "a property that forms a single economic unit for real estate tax purposes with a single occupier comprising a single geographical unit, being capable of separate occupation and put to a single use. A hereditament could comprise several parcels. The hereditament rather than the parcel is a suitable building block for land information since, as an economic unit, it brings together the concept of an estate (the rights and interests) and the physical area over which they are exercised." (Grover, 2008)

Thus, there are still some ways to link a certain piece of land to the right holders in the English system, however there is no governmental record of

the legal boundaries of properties. The Ordnance Survey has been required to show boundaries in a terrain map since year 1841, however such borders are only general and do not determine the exact location of property borders (Grover, 2008).

In order to describe the exact location of a border line, individuals and authorities have to trace the construction of the border and how it was initially formed. In case of ditch and hedge boundaries you have to determine who has dug the ditch/planted the hedge. The border is then demarqued to the far side of the ditch. In modern walls and fences, the owner of the border is the person who holds the land in which the columns and supports are located. HM Land Registry offers a service to resolve any disagreement over a border and the courts resolve disputes enacted by common law (Grover, 2008).

In England, the idea of general borders does not cause a lot of disputes because the law contains a doctrine of adverse possession, which terminates claims after a certain time. For example someone can take some piece of land to his usage and if no-one claims it within a set number of years (usually 12), then the occupier becomes the new owner of the land (Grover, 2008).

Land registration varies between different parts of the UK and is governed by the Land Registration Act 2002. This act requires that all land will be covered by a Torrens-style system and that ownership is proved through the Land Registry, rather than by title deed. The act also enables electronic conveyancing and the searching of documents through the internet instead of visiting the Land Registry office. Torrens system is not widely adopted yet.

The Land Registry comprises of property, proprietorship and charges registers (Grover, 2008). The property register identifies the location and extent of the property, and also the rights that benefit the land. It is supported by a Title Plan, which shows the approximate location and borders or the property. The proprietorship register specifies the quality of title, the names and addresses of the legal owners and any restrictions to mortgage or sell the land. The charges register includes the details of any mortgages and

financial burdens linked to the property. It also notes other interests and rights to which the property is subject, for example leases and easements (Grover, 2008).

Strictly speaking, England has no general cadastre but rather maintains two different cadastres which include most of the land properties in England. These two cadastres have been created to fulfil specific functions. The Rural Land Register includes the agricultural land and records those persons who are permitted to make claim on the property. All of the agricultural areas are correctly identified and parcels have coordinates and areas. This system was initially created because of lack of such a system caused delays to the land-related payments due to farmers. Fiscal cadastres are structured to reflect taxation and include all the other land (other than agricultural land). There are however no fixed borders or coordinates used (Grover, 2008).

Whilst England has a certain cadastre, it is not in same spirit outlined in the FIG statement. It is therefore questionable as to whether a cadastre is useful at all, and is there a specific need for an author to confirm conveyances and land ownership? Usually, people know their property and their rights. The individuals, companies and institutes of England have become used to this English style cadastre over the centuries and trust the information given by the non-general cadastre as it is guaranteed and supervised by the state.

This also causes problems. For example when buying a property or real estate, you need a lawyer to examine the different restrictions of the property, the borders, and the planning and other rights you'll have when owning a certain real estate. This information is found from several locations, and there is no single database from which the data may be obtained, thus causing extra expense for both the real estate buyer and seller.

2.3 The Social Tenure Domain Model

The Land Administration System (as described in chapter 2.1) is not suitable in developing countries because creating and maintaining a fully functioned LAS is expensive. Other tenure types than formal rights should therefore be recognized more carefully in such countries and render the 'person–land' relationship to be more flexibly considered than is currently determined in western styles of LAS.

One solution to this problem is the Social Tenure Domain Model (STDM) and is introduced in the FIG Publication No 52 by Christiaan Lemmen (Lemmen, 2010).

The Land Administration System provides the infrastructure for the implementation of land policies and land management. This infrastructure includes e.g. a legal framework, processes, standards, land information, allocation, land markets, valuation and the control of use. Only 25-30 countries have such a national wide system. LAS are not designed to handle the registration of customary and informal tenures of land, and existing LAS require extensions to be made that include these tenures. In practice however, this would entail very radical institutional changes.

STDM is developed to cover this lack in existing LAS and allows all types of tenures which are observed in the field and for which the terms of tenures are agreed by the local community. The problem in developing countries is that there is no national cadastre and people are often settled informally in slums especially near big cities. To provide the security and stabilization of society, a cadastre is needed and the existing LAS in developing countries secure only the land ownership of title holders and not local communities (Lemmen, 2010).

The other problem in developing countries is that the land administration system falls under the jurisdiction of several organizations and this causes a higher risk of non-transparent administration; e.g. citizens often pay authors to forward their issues. As such, people do not recognise the land

administration as their own administration, but one simply formed for rich people (Lemmen, 2010).

The LAS as it is formed in western countries is not effective and flexible to close the gap caused by a lack of cadastre and informal settlement. Land rights are not just formal rights (e.g. ownership, apartment rights, usufruct, free hold, lease hold, state land), and should include issues such as social tenant rights, occupation, tenancy, indigenous rights and possession. Also, the STDM principle cadastre is not only parcel -based, but can include textual representation. The cadastral map can be surveyed by satellite image and the parcel borders marked, together with the owner's name. Alternatively, the cadastre can be only a point cadastre where no borders or areas are determined. This is shown in Figure 7, where the dot on the satellite image provides the name of the owner and other relevant information (Lemmen, 2010; Meijer, 2011).

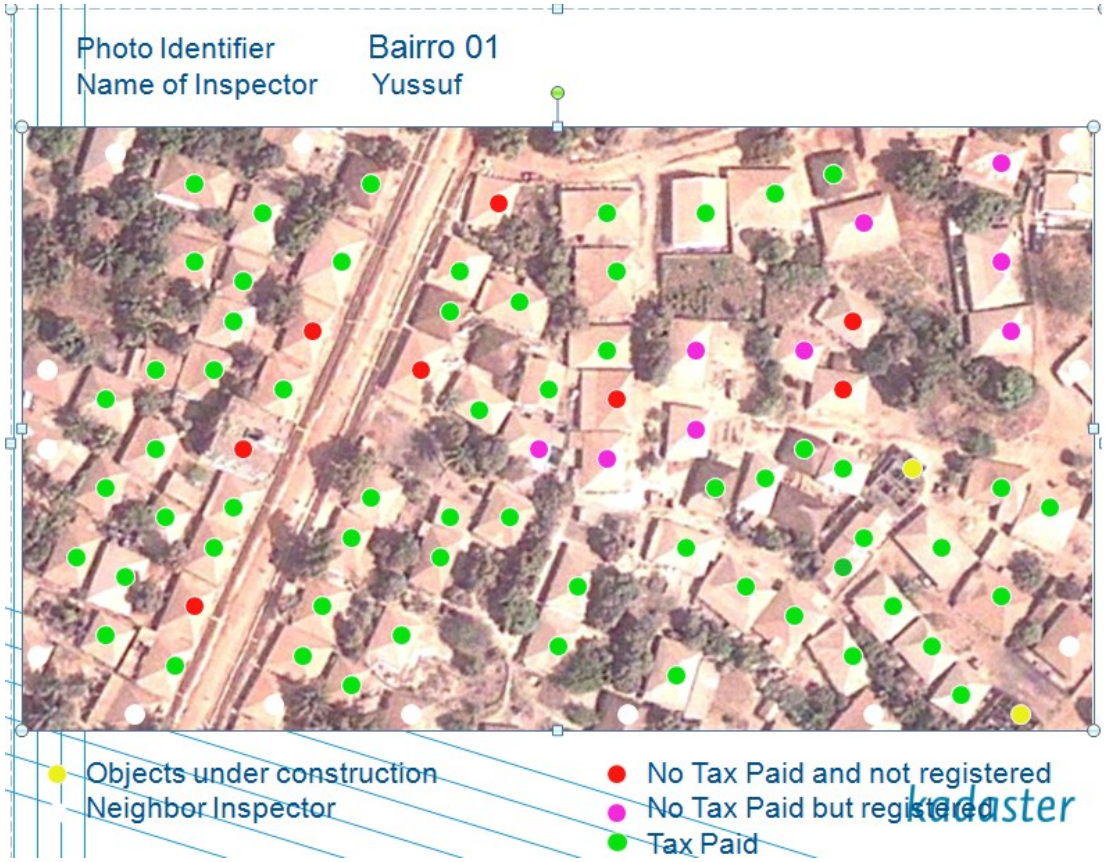


Figure 7. An example of point cadastre in Bissau (Meijer & Lemmen 2011)

The process of formalizing rights could be as follows: a land surveyor comes to a village with satellite images, places the image on the ground and steps back. People come to look at the image and recognize their land from the picture. After that, they can draw the borders of their parcel on the image and write their name on it. If there is an argument over borders, the people solve the problem by themselves. A land surveyor does not take part in this process. After all the borders of the village have been drawn on the satellite image, the land surveyor takes the images for digitizing. After digitizing the final cadastral maps come back to village and if there is no dispute, the informal land rights become formal. The original satellite images with the hand drawn annotations are archived (Lemmen, 2011).

In STDM, the role of the professional surveyor is minimal but there is still the requirement for professionals to create the system of an STDM-based LAS and to administer it. Thus expertise in land administration and ICT is still needed. At first the data gained from field is inaccurate but after a while the data becomes more reliable, for example in slums which are located near major cities and where land value is higher than in rural areas (Lemmen, 2010).

STDM principles are not suitable for developed countries as the existing cadastre coverage is 100%, and the cadastre and land registry are reliable. The occupation of another person’s land is illegal and it is not possible to legalize such occupation via the land administration system. However, some other STDM principles are possible to adapt to the modern LAS and cadastre, for example we could consider the cadastral map and question the necessity of its accuracy.

3 FUTURE STUDIES - FUTUROLOGY

"*If you don't think about the future, you cannot have one*"

-John Galsworthy-

Future studies (futurology) is a field of study which tries to predict the possible future using different methods. Futurology locates near social science and humanistic science. The history of futurology is quite short and the origins of future studies can be timed to the writings of Ossip K. Flechheim in late 1940's. At the same time, the USA studied the future in terms of military and world politics, and those methods spread to studies of the economy (Vapaavuori, 1993, 6-7).

Futurology combines different studies and it is not possible to tie it to a single domain of science. The purpose of futurology can be divided and characterized into five segments:

- The future is not pre-scripted and can be influenced by the actions of today.
- In futurology different possibilities, powers, operations and conditions are described on a general level.
- It creates a picture of possible passive developments.
- Technical development is estimated by needs.
- The purpose of future studies is to try to expand people's awareness.

(Vapaavuori, 1993, 9)

The methods used to explore the future are, for example, Utopia prediction, dystopia prediction, analogy prediction, system prediction, evolutionary prediction and scenario thinking (Vapaavuori, 1993, 9).

Utopia prediction starts by investigating the positive aspects of today and thinks how these are possible to further develop. The next step is to think what kinds of actions are needed today, in order to achieve the utopia of better things. Dystopia prediction is the opposite of Utopia prediction. It

investigates the major problems of today and tries to envisage what the world would be like if the mechanism which causes the problems becomes more powerful. In analogy prediction, the unknown predicted thing is compared to a well-known thing which holds similarities. This gives the potential for speculative comparison.

System prediction starts from the presumption that all the information surrounding a certain issue or topic is the information of some system. This method builds its own very strictly limited reality and tries to predict the future within this little reality. It then examines how such a future affects the world outside the envisaged reality and draws conclusions. Evolutionary prediction is similar to system prediction and includes some hermeneutics studies of established literature that may indicate a future path.

Scenario thinking takes a story or situation from today and transposes it to the future in order to see how the future ends up. In this method there is not just one scenario, but it often includes other different scenarios which end in different results. In scenario thinking, we have to think that every moment has other alternative moments and that the present scenario is only one possible alternative futures of transposing past events and possibilities. If things would be somehow different in the past, then the present would be different to how it appears now (Vapaavuori, 1993, 11-12).

In this thesis, the best method to predict the future is to create scenarios which end up with different results. Before we are able to create these scenarios however, we have to predict how society will change during the next 30 years. A cadastre reflects the changes of society and these changes stem from the societies metamorphosis.

In terms of a society: this thesis considers the developed countries and especially Finland. In developing countries the future could be different as those countries have problems that are opposite to those seen in developed countries and solving such problems leads to different future results. Also, the cadastral structure is differs from those in developed countries. In most

cases the cadastre of developing countries has a short history and the cadastres have been established in recent times. In developed countries however, the cadastre has a long history and changing it is a long and very laborious undertaking. The cadastre is also linked to many other systems and databases, so all effects on other systems would be difficult to predict. Additionally, the political willingness to affect change could cause difficulties: why change methods and systems if everything is working properly?

3.1 Finland in 2040: according to statistics

Statistics Finland is an agency which produces most of the official statistics in Finland, and their website (www.stat.fi) provides statistics covering a wide variety of topics.

According to statistics: in the year 2040, Finland is predicted to have about 6 million inhabitants. 16 % of total inhabitants are envisaged to be under 15 years old and 26 % are seen to be over 65 years old. In 2030, mortality is higher than births but net immigration maintains the growth of population. In 2040, 57% of the population are of working age and the demographic dependency ratio is approximately 78 / 100 working age people. The ratio of over 85 years is rising and accounts for approximately 6 % of the total population (Figure 8) (Population projection 2007-2040).

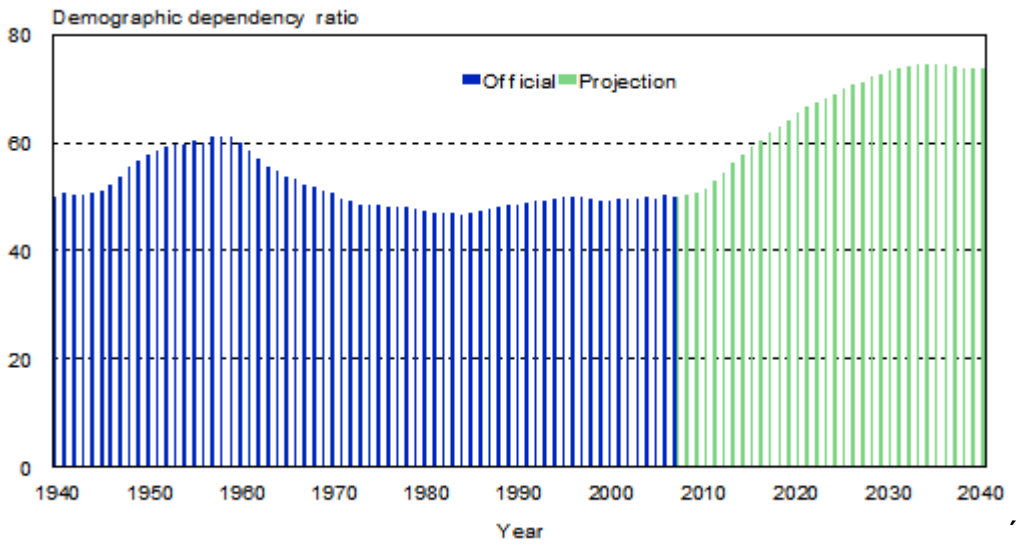


Figure 8. Demographic dependency ratio in Finland (Tilastokeskus, 2007)

According these statistics and predictions it is obvious that an increase in workforce is needed more and more in the area of social and health care services. The demographic dependency ratio shows that there are less people in the workforce to run the society and this means that in the future, the current administrational structures have to be modified to operate with a reduced workforce. This would free the available workforce to run social services and healthcare, especially the supply of geriatric nursing. The costs of administration have to decrease significantly to reflect a possible decrease in government income. Raising the retirement age provides some relief, but still the ratio of very old people is higher than we see today.

This also means changes to the cadastre administration. When the total number of inhabitants rises, the number of parcels and land owners is also increasing. At the same time, there are less people involved in cadastral issues. In short – in 2040 there is more work to do with less people to it.

3.2 Society in 2040

During the last 200 years, the societies of developed countries have progressed from an agrarian society, via an industrial society, to become a modern information society. These development steps have been connected firmly to the development of technology. The industrial revolution, using coal as energy and steam engines to facilitate production, started the industrial society. The development of information technology (especially the internet), made it possible for people to have global networks and all the subsequent influence influences on society are based on information.

What would be the next step? Of course there are many possible scenarios ranging from the collapse of the Western World to world peace, but the best guess would be a ubiquitous society. This is based on the prediction that society stability and technological development are in comparatively the same state as in the present day. In terms of rational prediction however, we have to eliminate possible crisis, natural disasters and unexpected incidents.

3.3 Ubiquitous society

Ubiquitous society can be described as a new period of the information society, where technological development is still powerful. The most interesting thing for society however, is the where the technology will be used (Mannermaa 2009, 25).

The main point of view of this ubiquitous society is that technology and intelligence are pervasive in everyday life. Technology is hidden in almost everything; it surrounds us, and works undetected and without human influence. Small computers will become as commonplace as oxygen and will be found wherever there are human beings (Mannermaa 2009, 29-30). These small computers need very fast and wide broadband connections to handle the massive amount of increased communication, and it is possible to divide such communication into three categories:

- Person to person (P2P)
- Person to object (P2O)
- Object to object (O2O, Internet of Things)

In the future, computers can communicate between themselves and there is no human input required. For example, the broken device can call the repairman and can order the right parts independently (Mannermaa 2009, 33).

A ubiquitous society needs a very fast broadband infrastructure to handle the huge amount of information. In wealthy countries the broadband infrastructure is spreading to be made available to every citizen, and so provides citizens and objects with a means to communicate with each other (Mannermaa 2009, 34). As an example, the Finnish parliament has enacted legislation in year 2009 where the government supports the construction of broadband connections in rural areas (Laki laajakaistan rakentamisesta haja-asutusalueilla).

A ubiquitous society would handle a lot of information, with everybody both using and producing it. As a result, the ‘invisible operator’ knows and supervises everything, and never forgets anything. This operator is not the “Big Brother” of Orwell’s book 1984, but includes all the individuals of society. This is comparable to the Adam Smith’s “invisible hand” but the operator does not influence the markets, it influences the whole society. We could term this operator as ‘Some Brother’ (Mannermaa 2009, 34-35).

Some Brother is not a lone operator; it includes all the public operators as authors and political decision-makers, both companies, and individuals. Through activism, the individual, different organizations and other communities are part of this Some Brother. In an ideal scenario, Some Brother is transparent and the society heads towards becoming a ‘gentle supervising, knowing and Never-Forget-Society’.

In less ideal cases, some part of Some Brother gains too much power and the transparency gets weaker. Ideally, transparency works not only from power keepers to the citizens but also in the other direction. In a future society, all individuals are supervisors and under the supervision of others. Spreading intelligence makes this easier and in many cases the system or information network is supervising the life of individuals and organizations. Our every action is recorded in databases and as a matter of permanent record (Mannermaa 2009, 35-37).

Transparency or the so called ‘aquarium life’ is not the product of a modern world or technical development. For example in agrarian society, people lived in small villages and all of the actions of an individual were visible to others; the neighbours supervised each other. Ubiquitous society will also render transparency to the people in power if the citizens make sure it will happen. Wisely used, the concept of a ubiquitous society increases the establishment of democracy (Mannermaa 2009, 38).

The problematic of a more open and transparency society is very complex. We are living in a world where the concept of privacy is stronger than ever

and yet we are giving our very private information voluntary to the web. In future, to achieve a more transparent society more information regarding our privacy is needed. The problem is how to meet these opposite demands. Even the demand of being available is quite strict nowadays - if you are not available or you are not using the devices you have, you often have to give explanations to other people (Mannermaa 2009, 40).

Ubiquitous society is one possible and likely future scenario. However, the requirement for this scenario to become a reality is that technical development continues and people adapt to the new technology. The influence of ubiquitous society to LAS and cadastre is dependent on technical innovations and the next generations of modern technologies and applications will influence the supported services. For example, smart devices such as Google Glass may have applications where it is possible to visualize the information gained from the cadastre, e.g. borders, owner etc.

4 FUTURE CADASTRE SCENARIOS

4.1 OpenCadastreMap

The idea of OpenCadastreMap would be same as that employed on the website openstreetmap.org (OpenStreetMap, 2013). On this website, people are able to make their own world map and do so voluntary. Most of the people are not professional land surveyors but are enthusiastically taking part in the mapping of their own environment, recording GIS-data and sharing it free with other users in an open system. OpenCadasterMap could be based on the same idea, because mapping a border and sending it to an open system is similar to mapping a road.

An open system can be described as: "*a system with input, an entity that changes its behaviour in response to conditions outside its boundaries*" (Principia Cybernetica Web). This means the system can be changed and responds to the user's needs and input. The system is not closed and everybody can make changes. They share the changes without charge and sometimes even the source code of a certain system can be edited by users.

Open systems are common in computers and programming but there are also applications oriented to volunteered geographic information (VGI). Examples include Wikimapia, OpenStreetMap and Google Mapmaker. On these websites, users are able to send GIS-data, edit it and trace the changes. Editing and updating is free and users are able to use the database without charge. For example the OpenStreetMap is operated by the OpenStreetMap foundation and everyone who is interested can join it as a member. The fee for joining is 15 £ per year and covers the foundation's funding needs to operate the servers. Joining as a member is not compulsory (OpenStreetMap Foundation).

Voluntary Geographic Information (VGI) user numbers have risen since 2007 when it was at first described. To participate you only need an interest to do so and a device such as a smart phone or GNSS device (Laarakker & De Vries, 2011).

Peter Laarakker and Walter de Vries conducted research into the potential of Opencadastre by posting an issue in different discussion groups in 2010. They wanted comments from professionals about Opencadastre. The members of discussion groups could give their own opinion, and the results of the discussion and comments were able to be divided into two main concerns: socio-organizational concerns and technical concerns
(Laarakker & De Vries, 2011).

These main concerns are able to be further subdivided into special concerns:

Socio-organizational concerns:

- Necessity
- Legality / role of government
- Legitimacy control
- Economic effects

Technical concerns:

- Quality control in OpenMapping
- Quality control on OpenCadastreMap
- Required technology

(Laarakker & De Vries, 2011)

Discussion participants determined that OpenCadastreMap could be necessary in developing lands where land reforms progress slowly and especially, this is necessary for slum dwellers. Also, the need for data following natural disasters is important. The government role for OpenCadastreMap is however practically non-existent because governments are not taking a lead role in the OpenCadastreMap which leads to a result that without governmental support, OpenCadastreMap will always remain a limited project (Laarakker & De Vries, 2011).

Quality control in OpenMapping and OpenCadastreMap is a huge challenge. In OpenStreetMap the quality control is undertaken by users, so it is closely

related to the openness of system. This has caused some problems, because users are able to change other users corrections and this leads to ‘edit wars’. In OpenCadastreMap, the quality control needs to be on a much higher level. One solution would be a ‘social quality filter’ where the system decides which users comment or editing is more reliable. A condition for this could be the expertise of the user. In OpenCadastreMap, quality control is not only related to the quality of accuracy but also to the quality of legitimacy. Controlling legitimacy without governmental support is virtually impossible but discussers in the original inquiry brought up the aspect of trust: “If everyone believes that someone is the owner of parcel, that can be assumed to be a fact” The technology to launch an OpenCadasterMap however, currently exists (Laarakker & De Vries, 2011).

As a conclusion, Laarakker and de Vries view that: “the land administration paradigm places the government in the centre of land registration processes” (Laarakker, P. De Vries, W.2011.) OpenCadasterMap could be quite a useful tool but would only work if the government assumed a lead role and gave security and legitimacy to the system. Without governmental support and participation, the OpenCadastreMap is only a limited project. If OpenCadastreMap were to be adopted as a cadastral system by a particular country, it would need a lot of support from citizens, politicians and other parties of society. It would also require a strong will to change existing structures.

Scenario: The government decided to save costs in general administration because there are fewer workers and income has become significantly decreased. Costs have to be cut and one part of the saving program is giving up the cadastre administration.

The political willingness was subdued in the first years, but after huge cuts in costs, the political will became positive to adapt the cadastre to an ‘OpenCadastre’.

In the next few years, the government and experts build up a system which will be open but supervised by the government to ensure the legitimacy and quality of the data people submit to the cadastre. The government still grants titles and mortgages, but the technical part of the cadastre is conducted by the customers themselves. The role of the cadastral surveyor is only to maintain the system and supervise. In cases of disagreement, the surveyor needs to solve the problem by tracing the changes and determine who has made them.

The system would work like follows: Person A is selling the piece of land to person B. They agree the terms and sign the deed electronically. After the cadastral system is sure of both parties competencies, the title for the conveyance is granted and customers are able to draw the new border on the cadastral map and register the new parcel/register unit. The following day, the system asks for confirmation of the conveyance by sending an email or other message to the parties. They confirm the changes by identifying themselves to the system by bio-marker, e.g. iris scan. Every change made to registered units made by other users should be confirmed by the land owner. In case of disagreement, the cadastral surveyor or local court makes the decision.

If a system is built solely on the principles of open systems however, the society and economy would lose confidence if anyone should just have access to make changes to the cadastral register. OpenCadastreMap would therefore work best if there was an author to ensure the reliability of data gained from the cadastre.

4.2 Crowd sourcing

> “The practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers” (Merriam-Webster, 2013).

Crowd sourcing is used by companies to obtain new ideas and innovations from a group of volunteers who receive little or no pay for the work. In past

years, crowd sourcing has become part of land surveying, especially in recording GIS-data. One good example is Kadaster's project to verify the border markers on the border of The Netherland's and Germany. Sending a professional land surveyor to check all of the border markers (ca. 600) would be very expensive, so Kadaster launched a crowd sourcing project to reduce costs. Kadaster offered free smart phone applications and the exact coordinates of border markers to users. Volunteer users (e.g. hikers, border marker "collectors" and geocachers) locate the border marker and make the needed observations. After this, they send the data to Kadaster's database where a professional can estimate the need for renewal or replacement of the border marker (Kadaster Grenspale Project). Picture 1 shows a crowd sourced border marker.

Picture 1. Crowd sourced border mark on the border of The Netherlands and Germany.

Crowd sourcing has been used successfully in some cadastral proceedings. For example, crowd sourcing has been used to establish completely new cadastres in Ethiopia, Lesotho, Rwanda and Namibia. In these projects, the landowners participated in data acquisition by drawing their own parcel on

the satellite image or ortho photo. The maps were then digitized and a cadastre established. The method was found to be very efficient: in Rwanda, 10 million parcels were registered in two years and the total cost per parcel was under 1 US$ (Meijer & Lemmen, 2011).

In cadastre administration, crowd sourcing in not so widely used. But for example, the National Land Survey of Finland is thinking of adopting crowd sourcing as one part of the cadastral proceedings (Kokkonen, 2012). The difficulties of crowd sourcing are the same than those mentioned in the OpenCadastreMap project. The biggest question that remains is how reliable is the data people have sent to the database and how the legitimacy and reliability of such data is secured. Also, motivating volunteers to acquire and send data to the database without payment is challenging.

In some crowd sourcing projects, data liability is secured by random testing of the received data and a professional or independent controller makes this control from a certain location. Kadaster used this method in their border mark crowd sourcing project and the benefits of this were economically clear: Kadaster had no need to send professionals to make an inspection of the border marks, therefore the saving in costs was huge (Witteveem, 2011).

Scenario: The government is reducing its expenditure budget. The public sector is getting thinner and the workforce should be prioritized to other sectors. This scenario also impacts upon the cadastral system and the professional responsible for its administration.

When thinking of cadastral proceedings, the technical part of the proceedings is more suitable to maintain via crowd sourcing, especially when there is no longer any fieldwork to do. Professionals are too expensive to send to conduct fieldwork, and travelling and work time spent in the field causes extra cost.

The system could be built as follows: Person A is selling a piece of land to person B. They agree the terms and sign the deed electronically. After the

cadastral system is sure of the competency of both parties, the title for the conveyance is granted. Parties are now able to determine the new border on the cadastral map and/or the field location. They send coordinates measured by themselves to the cadastral surveyor who registers the new border on the system after asking for confirmation from each party. If parties disagree, the proceeding is not registered until the dispute is solved by the cadastral surveyor.

Crowd sourcing would be possible to use in proceedings based on the agreement of parties, e.g. parcelling, land-for-land exchanges etc. When talking about the valuation of land and cases of dispute however, crowd sourcing would cause a lack of trust.
In crowd sourcing, the role of the cadastral surveyor remains that of a judge in cadastral issues. There is some argument to support the conservation of this role:

- Cadastral surveyors are more aware of the legislation and legal praxis in cadastral issues than lawyers.

- Subordinating the disputes of cadastral issues to local courts instead of the cadastral surveyor would cause a backlog of work for the courts. This would overly diminish their capability to process other, more serious cases/crimes.

- After a long history, the public have placed their trust in cadastral surveyors as professionals who are both independent and legitimate.

4.3 No Maintenance

In this option, the cadastre is recorded and re-established e.g. at a ten year frequency. Between these two points, no changes to the cadastre are registered. When there is a good base of reliable registers and a cadastre, any changes since the last renewal are easy to trace.

This method has been used in Rwanda to establish a totally new cadastre. The result of the project was ca. 10 million new parcels, registered in 2 years. In this method, because there is no reliable base for the cadastre, the time used in fieldwork and interviewing people forms a huge part of the work (Meijer, 2011). When estimating the time to undertake a complete renewal in Finland on a 10 year frequency, a good guess would be approximately 1 year.

Scenario: In reducing costs, the government decide to give up the constant maintenance of a cadastre. The abolition of the cadastral system is not proposed but the situation is frozen until the next renewal.

The benefits of this option would be the reduced costs of maintenance and a reduced need of work force between the establishment periods. There is little or no requirement for permanent workers between renewal and the next renewal would be executed after a bidding process.

The negative influences of this scenario would be that the cadastre would only be up-to-date immediately after the updating of cadastre. Between the renewal periods, the data gained from the cadastre is not current and you can not trust the information provided by the system. Between the renewal periods there is a risk that an informal system would appear, that assumed dominance over the formal system.

4.4 Option Zero

Option Zero would mean there are no changes to the way we are currently dealing with cadastral issues. All of the procedures, workforce requirements, legislation and principles remain the same.

In 2012, the maintenance of the cadastre in Finland cost approximately 4.30 € per property unit. In Finland there are about 2.3 million registered units and the total cost of the cadastre is in the region of 10 million €. This is the cost of maintenance and betterment per annum and is granted from the budget of

the Finnish government. The real costs are higher because the National Land Survey of Finland is a net-budget-agency, and some of its expenses are covered via fees charged from e.g. cadastral proceedings or title and mortgage grants (Kokkonen, 2013).

Table 1 shows the price index of public expenditure 2013 (3rd quarter) produced by Statistics Finland. It is possible to see that expenses have risen since 2005 in the Ministry of Agriculture and Forestry, by approximately 20 points (marked in yellow).

Table 1. Price index of public expenditure - 2013 (Tilastokeskus, 2013)

Vuosineljännes, pisteluku	2012					2013 1)		
	2012	I	II	III	IV	I	II	III
01 Yleinen hallinto	124,1	122,5	124,2	124,6	125,1	125,0	126,6	126,7
02 Ulkoasiainministeriö	117,3	116,8	117,4	117,5	117,7	119,7	120,3	120,3
03 Sisäasiainministeriö	124,6	123,2	124,9	125,0	125,3	125,0	127,0	127,1
031 Poliisi	124,4	123,1	124,7	124,8	124,9	124,9	126,9	127,1
032 Rajavartiolaitos	122,8	121,5	123,2	123,2	123,3	122,4	124,5	124,6
033 Sisäasiainministeriö - muut	127,2	125,5	127,3	127,8	128,4	128,2	129,9	130,1
04 Puolustusministeriö	118,1	116,9	118,2	118,5	118,8	118,9	120,0	120,1
05 Valtiovarainministeriö	121,6	121,4	121,6	121,6	121,8	123,6	124,1	124,2
06 Opetusministeriö	122,1	121,6	122,2	122,3	122,5	123,2	124,1	124,2
061 Yliopistot, korkeakoulut	122,3	121,7	122,3	122,4	122,6	123,2	124,2	124,3
062 Opetusministeriö - muut	122,1	121,6	122,1	122,2	122,4	123,2	124,0	124,1
07 Maa- ja metsätalousministeriö	118,3	117,4	118,3	118,5	118,9	119,4	120,2	120,2
08 Liikenne- ja viestintäministeriö	131,7	131,1	131,7	131,7	132,2	133,1	133,1	133,4
09 Työ- ja elinkeinoministeriö	118,7	118,1	118,9	118,9	119,0	119,3	120,3	120,4
10 Sosiaali- ja terveysministeriö	115,0	114,7	115,0	115,1	115,2	116,9	117,1	117,1
11 Ympäristöministeriö	129,7	127,9	129,9	130,3	130,9	130,6	132,7	132,9
SSS YHTEENSÄ	120,9	120,4	121,0	121,1	121,3	122,4	123,1	123,2

1) Ennakollinen

Lähde: Julkisten menojen hintaindeksi 2005=100. Tilastokeskus

According this statistic, expenses have risen, even though the amount of employees has decreased and operations have been optimized. If this trend

continues and no major changes made to the structures and system, expenses will continue to rise in the future.

The Option Zero model is easy to adopt because we are living it already. There are no changes to the present system and proceedings, and the workforce requirement is the same as today. The positive influences would be that processes are working properly and effectively at present, so people would be less afraid of change and so the model creates the feeling of security. Negative influences however, is the economic burden imposed on society and the continued need for a workforce that may be utilized more effectively in other branches than in maintaining the cadastre.

4.5 No cadastre

Is cadastre necessary in the modern or future society, and would there be a possibility in the future that no cadastre is required? If so, would the society be able to develop and maintain its welfare?

When speaking of the situation in countries where there is no formal cadastre, it does not mean that nobody owns the land or there is no land market. The system is informal and there is no official register showing land ownership or guarantee. In some cases there is an author who registers deeds, but the informal system mostly provides the rights of occupancy and does not have legal security.

This means that proving the provenance an owner of a certain piece of land is insecure, and is based on the heritage and old deeds which a land owner has to archive. The local community often knows the owner of a certain piece of land, but even if you have all these factors to prove land ownership, someone can still occupy your area and claim he is the owner of land.

At the moment there are somewhere in the region of 6 billion parcels in the world. However 70–75 percent of these are not registered and most of these are located in developing countries. In these countries, only 20 percent of

parcels are in formal registers and rest are held informally. Cadastres cover nearly 100 % of all land in Western countries and the cadastres in developed countries are transforming into multipurpose cadastres. In developing countries the only function of a cadastre is to show and secure land ownership (Rekha, 2013).

Are cadastres vital to society? Ian Williamson (1997) answers this question in his paper “The Justification of Cadastral Systems in Developing Countries” with the following list:

- After 1980 the major organizations such as World Bank and United Nations recognized the land tenure was restricting a lot of the projects organizations were running.
- Powerful publications have promoted the importance of land rights regularization to support of poverty alleviation, sustainable development, environmental management and financial systems.
- The Urban Management Program (UMP), a joint initiative of the United Nations Development Programme (UNDP), the United Nations Centre for Human Settlements (UNCHS - Habitat) and the World Bank (IBRD) has paid a attention to cadastral and land administration issues.
- United Nations Conference on Environment and Development (UNCED) or "Earth Summit" recognized the importance of cadastral, land and geographic information systems to environmental management and sustainable development.
- Cadastral systems are accepted as basic infrastructure required for sustainable economic development and environmental management
- Over the last two decades the economic and social benefits of cadastral and land information systems and land titling projects have been increasingly quantified.
- The growth in information technologies e.g. automation the cadastral recording has given a higher profile to land tenure issues.
- Technological development has increased the speed and efficiency of establishing and maintaining the cadastral systems. In same time the costs have reduced.

- The changes in Eastern Europe in 1990's and the demands of cadastral systems to support efficient land markets have raised the awareness of the importance of cadastral and land information systems worldwide.
- The importance of cadastral systems to economic growth, environmental management and social and political stability has been equally recognized. (Williamson, 1997)

This listing is still current although it is written in 1997. A properly functioning cadastre is vital to economic growth, welfare and reducing poverty. For example, in African countries land is a key to economic development; it is a basis of independence and the economy is dependent on agriculture and its products. For that reason, land reform and the creation of a functional cadastre is very high on the agendas of many African countries (Arora, 2013).

The FIG Commission 7 Statement on the Cadastre lists the benefits of cadastral reforms, which also mention the benefits of a cadastral system:

- more security of land tenure
- better access to long-term credit
- increased productivity of land
- lower transaction costs on the real property market
- cheaper information for land administration
- more equitable and cost-effective collection of land taxes
- improved opportunities to implement land policies
- improved opportunities to plan for sustainable development of land and other natural resources

(Hennsen et al., 2013)

Would land administration work without a cadastre? The simple answer to this question is no. There are a lot of examples in the world of what can happen if there is no proper cadastre in place. The situations that people deal with in developing countries with informal cadastres are totally different to

those in developed countries. In the Third World, there is no author to guarantee land ownership or mortgaging. Conveyances are made by individuals and there is seldom any documentation to prove the transaction. It causes the unsatisfactory situation where someone can take your land at will because you cannot prove you are the owner of that land. The lack of state supervision also causes a lack of confidence in mortgages and the possibility of extremely high interest rates.

5 ORGANIC CADASTRE - FUZZY BORDERS

One very interesting scenario would be the ‘fuzzy borders’ (aka green) cadastre. This subject is handled in its own chapter, because the accuracy and usability of the system are possible to estimate by testing, and therefore possible to adopt as part of a current system. This chapter includes the results of such testing.

Bennet and van der Molen (2012) published an article about natural and sc. fuzzy borders in GIM Magazine. An organic cadastre is defined as a cadastre where the borders follow natural phenomena which are generally impossible to determine accurately. Those borders may also be changeable. These principles are shown in Figure 8.

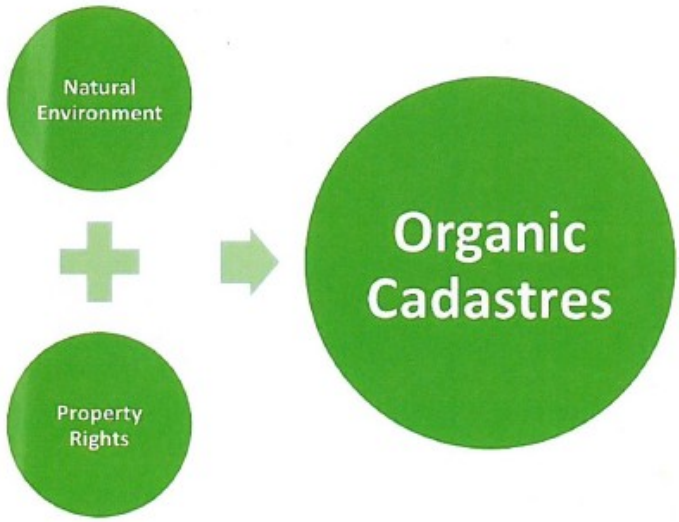


Figure 9. The principles of green cadastre (Bennet & Van der Molen, 2012)

Borders would not be straight lines on the map and on the ground; they would follow natural shapes and this approach would lend to more efficient land use (Bennet and Van der Molen, 2012).

Natural boundaries already exist in some cadastral systems. For example, in Finland a border is possible to determine by following the natural shape of e.g. a shoreline, ditch, or even the borders of different vegetation zones.

Borders however will not follow the changes of natural shapes. This is shown in Picture 2, where the red lines are the present borders and the longest east-west border is determined by the 1931 shoreline. The shoreline has however since receded because of upthrust (at a rate of approximately 1 cm / annum) and the determined border and shoreline are no longer in same locations.

Picture 2. The results of upthrust in Hailuoto

Australian states use a similar approach to Finland, but the border follows the changes. For example, if the border is determined to the waterway but because of erosion the location of waterway changes, the border then follows the true location of the waterway (Bennet & Van der Molen, 2012). If the natural borders follow the phenomena of nature; although it changes, the cadastre and related data are not necessarily up-dated. In such cases, the land surveyor needs to input the new location of border to the cadastre.

Fuzzy borders are possible to determine in many ways, and this thesis introduces the most common methods: field surveys, ortho / satellite photos and the usage of images produced from Lidar data.

5.1 Ortho photos

An ortho photo is produced from aerial photos by correcting the errors caused by inclination and scale. The ortho image is an aerial photo map and you can correctly measure distances and areas from the ortho photo (Maanmittauslaitos 2013a). The most common way to perform aerial photography is to install a digital aerial photo camera in an aeroplane. From one flight, it is possible to produce black and white, colour and infrared images. The frequency of these flights is 3–10 years (Maanmittauslaitos 2013b). The National Land Survey of Finland is using digital aerial photos to map and produce a height model. From the ortho photo it is also possible to orientate the image to form the background of a cadastral map, with the resolution of the image being approximately 0.5 m per pixel (Maanmittauslaitos 2013a).

5.2 Light Detection and Ranging (Lidar)

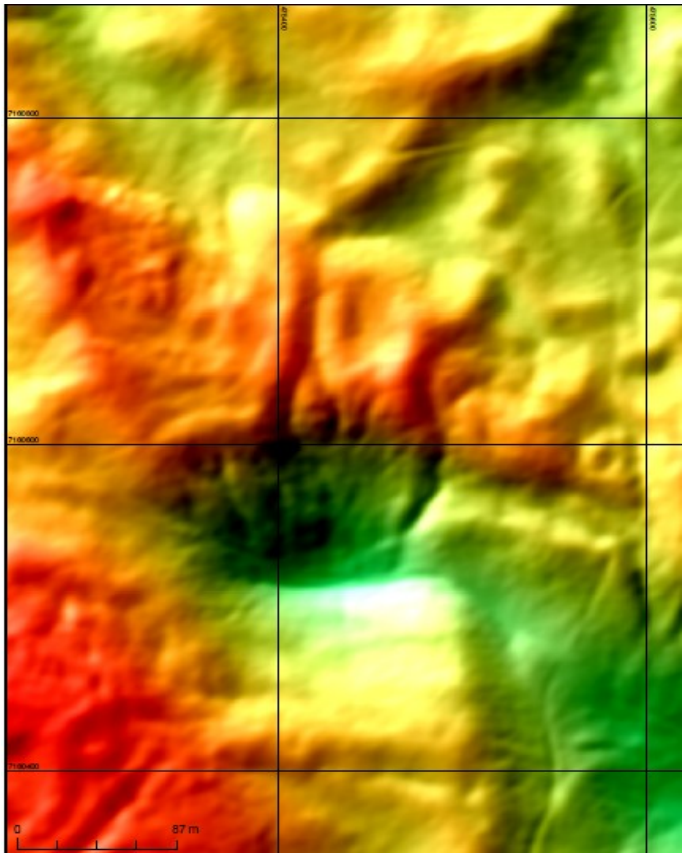
Lidar is a remote sensing method which uses pulsed laser to measure distances between the target and sensor. The sensor sends a laser beam to the surface and when it reflects back it is possible to measure the range between the sensor and the surface. From the results it is possible to generate a 3D-model of the surface and everything above it (NOOA, 2013).

Common platforms for a Lidar instrument are aeroplanes and helicopters and it is possible to cover broad areas in a short time. The Lidar instrument includes a laser, scanner and GNSS receiver to locate the exact location of Lidar instrument (NOOA, 2013).

Lidar generates a digital 3D point cloud model from the measurement and the post-processing programmes can separate different structures of the surface, e.g. the terrain, vegetation, buildings etc. The National Land Survey

of Finland has produced Lidar data since 2008 and it is mainly used to generate a height model. The accuracy of the data is approximately 0.3 metres in vertical and 0.6 metres in horizontal accuracy. In Finland, Lidar data is classed as open data, which you can download without charge. (Maanmittauslaitos 2013c).

From the point cloud model, you can generate a picture of the terrain with a diagonal hatch to show the differences in height. These images are also possible to orientate to the background of a cadastral map, in the same way as ortho photos. One application of Lidar images in cadastral surveys is to locate the position of roadways and possible easement. It is also used when a new right of way is established to an existing roadway and there are no field surveys conducted. Picture 3 shows the image produced from Lidar data and the heights of terrain are indicated with different colours.



Picture 3. Lidar image from Rokua National Park

5.3 Testing

To test the usability of fuzzy borders and their determination, a series of test ranges were established and measured using different methods. These results were then compared to the Finnish system.

In the present system, the borders are shown in the databases but there is still a link to the field. Using the coordinates downloaded from the database you can locate the border located in the field which is marked by markers on the ground level. Such coordinates however are not the primary demarcation when determining the location of former border, and physical markers in the field hold more precedence, likewise old cadastral maps of the area. In the Finnish system, the root of the cadastre is in the Base Land Consolidation, which took place from the late18th century to the 1960s. Coordinates have only been measured since the late 1980s.

In the Finnish cadastral map, almost every border mark has a coordinate, but the location accuracy of these border marks is inadequate. Also, due to the historical aspect there is still a lot of error in the demarcation of borders and parcels.

What if coordinates were held as the primary clause instead of the markers found on the field? In this scenario, the information contained on the cadastral map and database has to be accurate and all borders should be fixed. Vesa-Matti Mikkonen researched this possibility in his thesis in 2013 and determined that surveying all the inaccurate border marks to provide an accurate representation would take around 19,700 working days in the area of North-Ostrobothnia District Survey Office alone (Mikkonen 2013, 43). This amount of labour is not possible to apply directly to other parts of Finland, because due to a historical lack of homogeny in the construction of cadastre. The Base Land Consolidation took place firstly in the western part of the country and the resulting cadastre is older than that found in eastern or northern parts of Finland. For that reason, more border marks have vanished here than in other parts of the country. However, the number gives a good

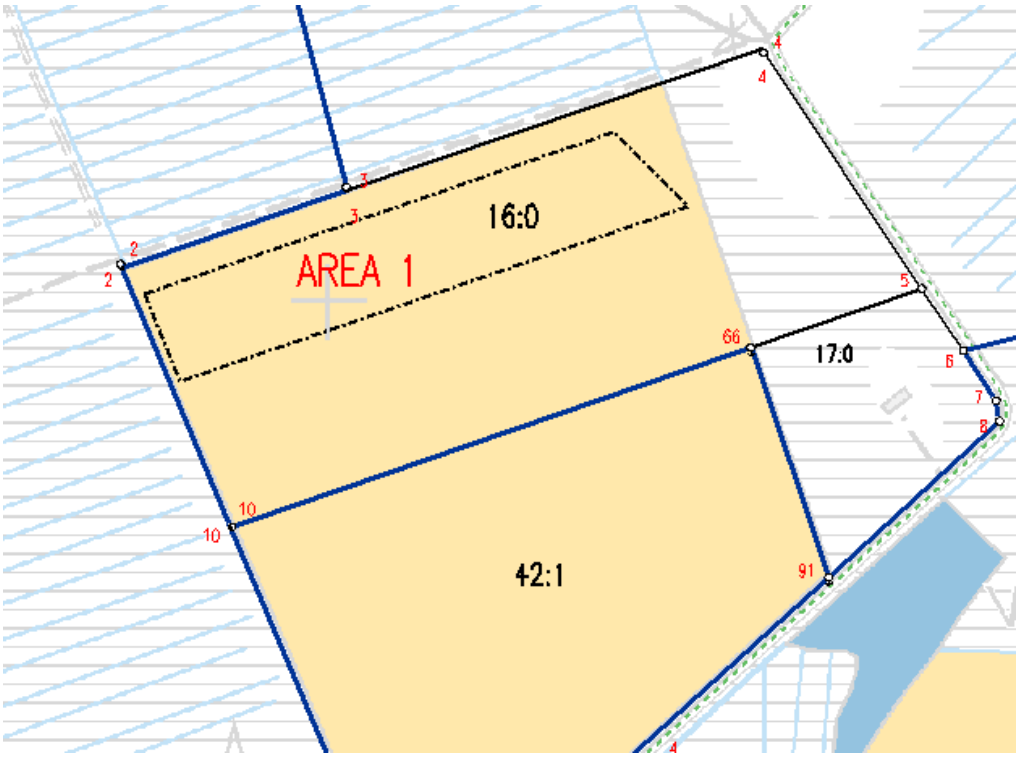
indication of the amount of working days and expense where the system to be applied on the scale of the nationwide Finnish cadastral system.

Using natural shapes such as ditches, shorelines, roads, fences etc., could be a useful way to conduct cadastral proceedings without the need for field work. Many of the shapes are visible and possible to locate from ortho photos, but in covered areas such as forests, the ortho photo is not accurate enough to locate these shapes. One solution to this problem could be the images produced from laser scanned terrain data. In these images, even the smaller shapes of terrain become significantly more visible.

In order to test the accuracy and efficiency of the natural borders, I made four test ranges. For each range I measured the points/borders using ortho photos, laser scanned images and field surveys.

5.3.1 Test Area 1

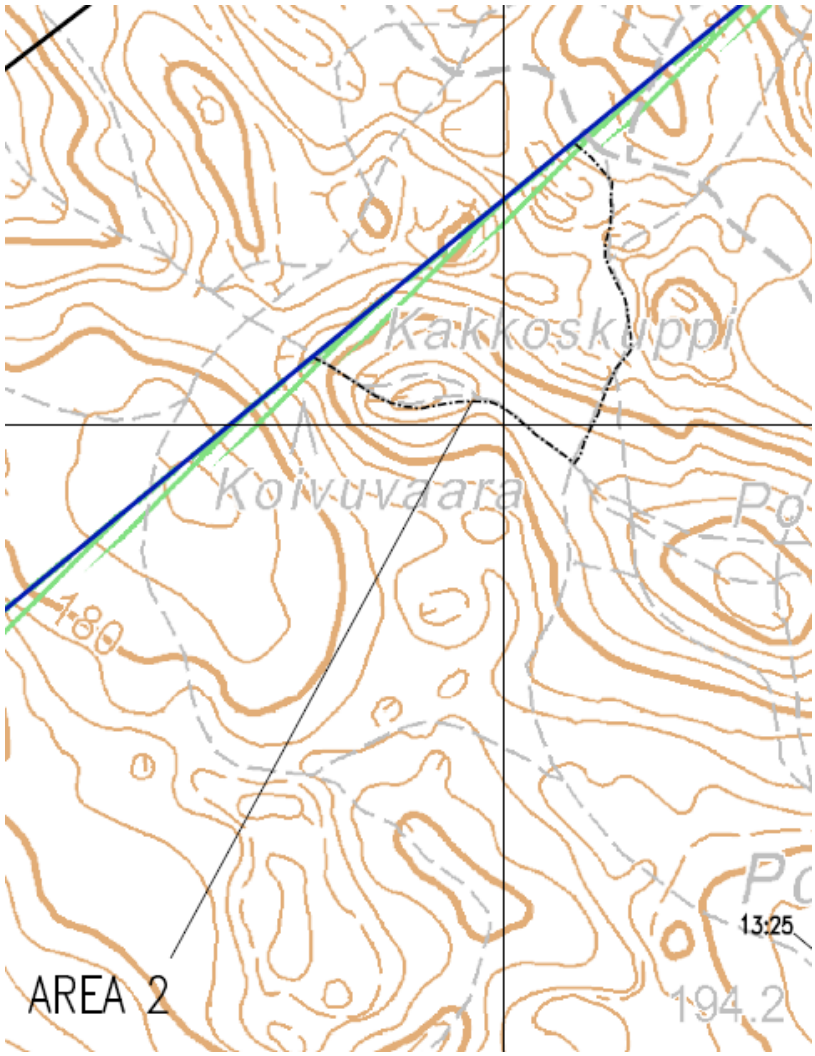
Test Area 1 is located in the village of Veneheitto in Vaala. The environment is open field and there are no obstacles. The goal was to measure a certain area bounded by ditches. The location of the test area is shown on Map 1.



Map 1. Test Area 1

5.3.2 Test Area 2

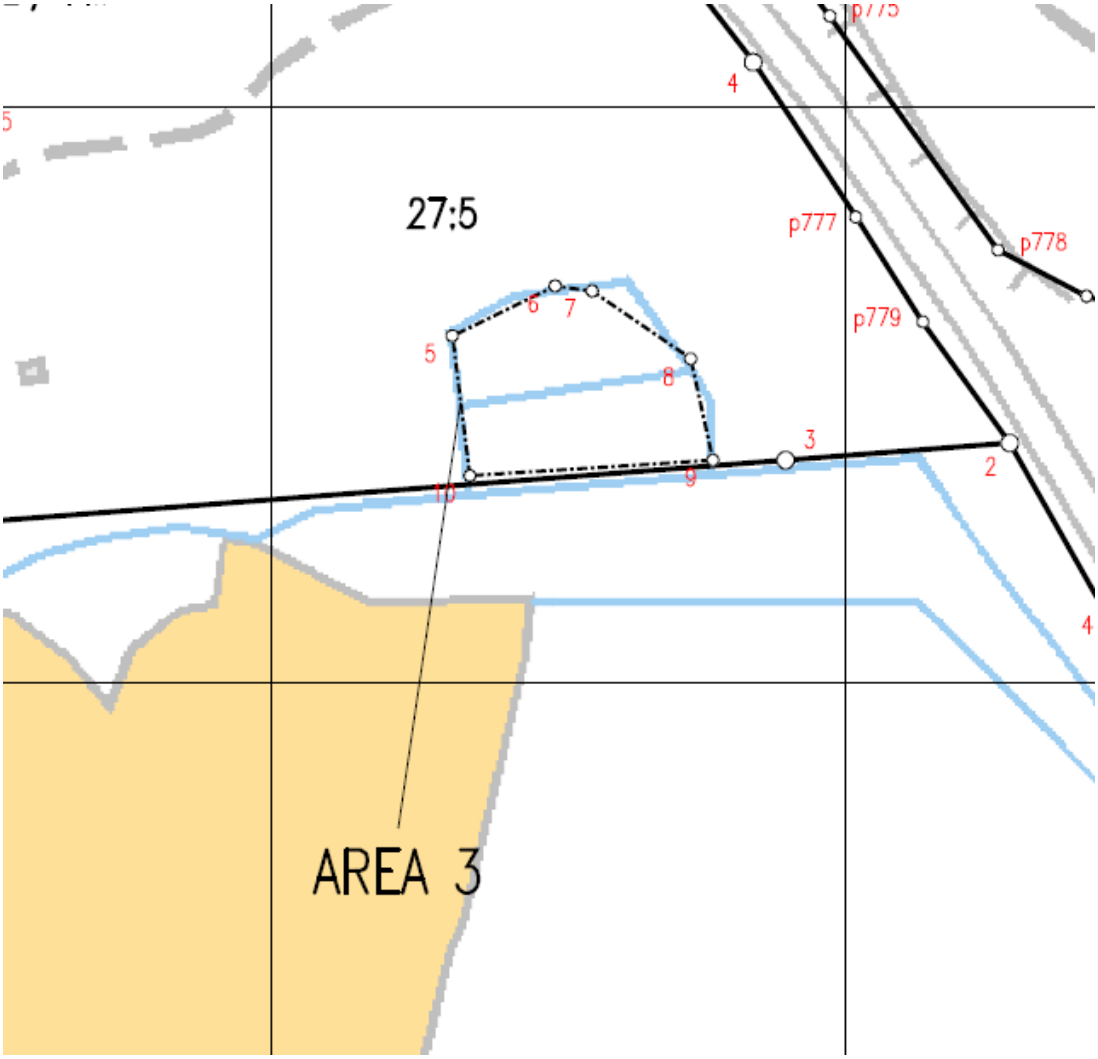
Test Area 2 is located in Rokua National Park and is bounded by roadways. The terrain is covered by pine trees, but the roadways are possible to locate from ortho photos and laser scanned images. Map 2 shows the location and terrain of the test area.



Map 2. Test area 2

5.3.3 Test Area 3

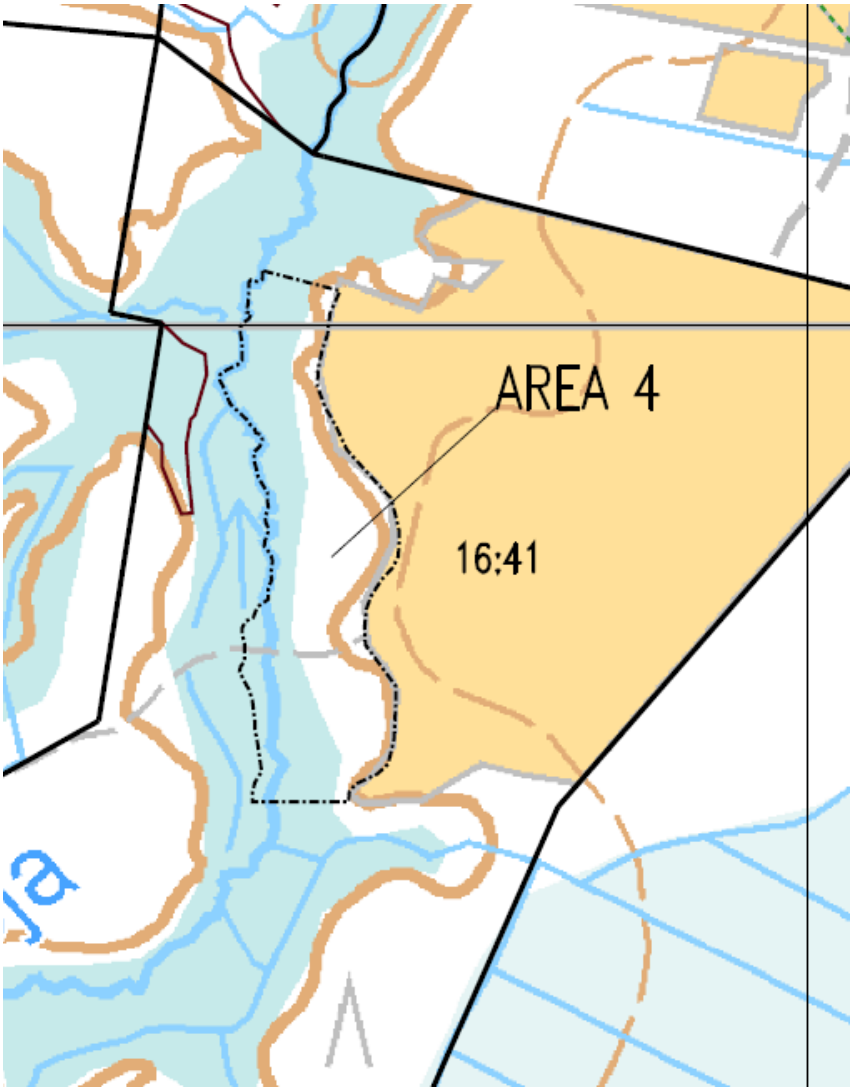
Test Area 3 is located in Utajärvi near the river Oulu. It is bounded from every side by ditches and the terrain is covered by tall pine trees. The goal of this test area was to measure the ditches marked on the terrain map. Map 3 shows the location and terrain of the test area.



Map 3. Test Area 3

5.3.4 Test Area 4

Test Area 4 is located in Vaala near the river Oulu. It is bounded on the eastern side to the edges of field and forest and on the western side it is bounded to the Lohioja brook. The terrain is covered by trees and bushes. Map 4 shows the location and terrain of the test area.



Map 4. Test Area 4

5.4 Field Surveys

Field Surveys on Test Areas 2 and 4 were conducted on the 13th July 2013. All specified structures were surveyed using a Trimble R8 RTK-device. Test Area 2 was measured by using a Continuous Survey method to survey the midline of the roadways, and in Test Area 4 the middle point of the brook was mapped in normal mode. The Test Area 3 field surveys took place on August 15th and 16th 2013. Structures were surveyed using a Trimble R10 RTK-device.

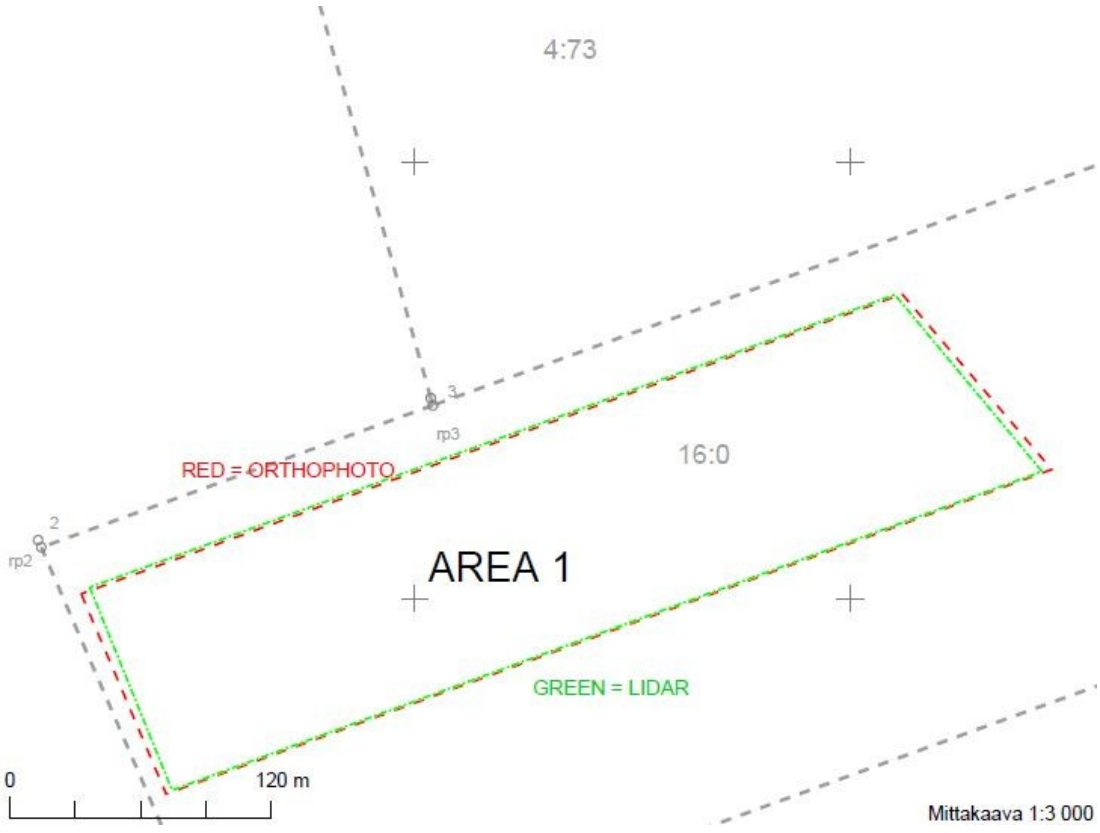
The results of the field surveys were compared to earlier measured data in the office. On Test Area 1 there was no requirement to execute field surveys,

as the results provided by ortho photos and Lidar images depends only the accuracy of the photo orientation.

5.5. Analyzes of results

5.5.1 Test Area 1

In this test area, field surveys were not conducted because the environment of the area was open field and the accuracy of ortho photo and Lidar images depends only on the orientation of images. As Map 5 shows, the results did not differ remarkably.



Map 5. Results of Test Area 1

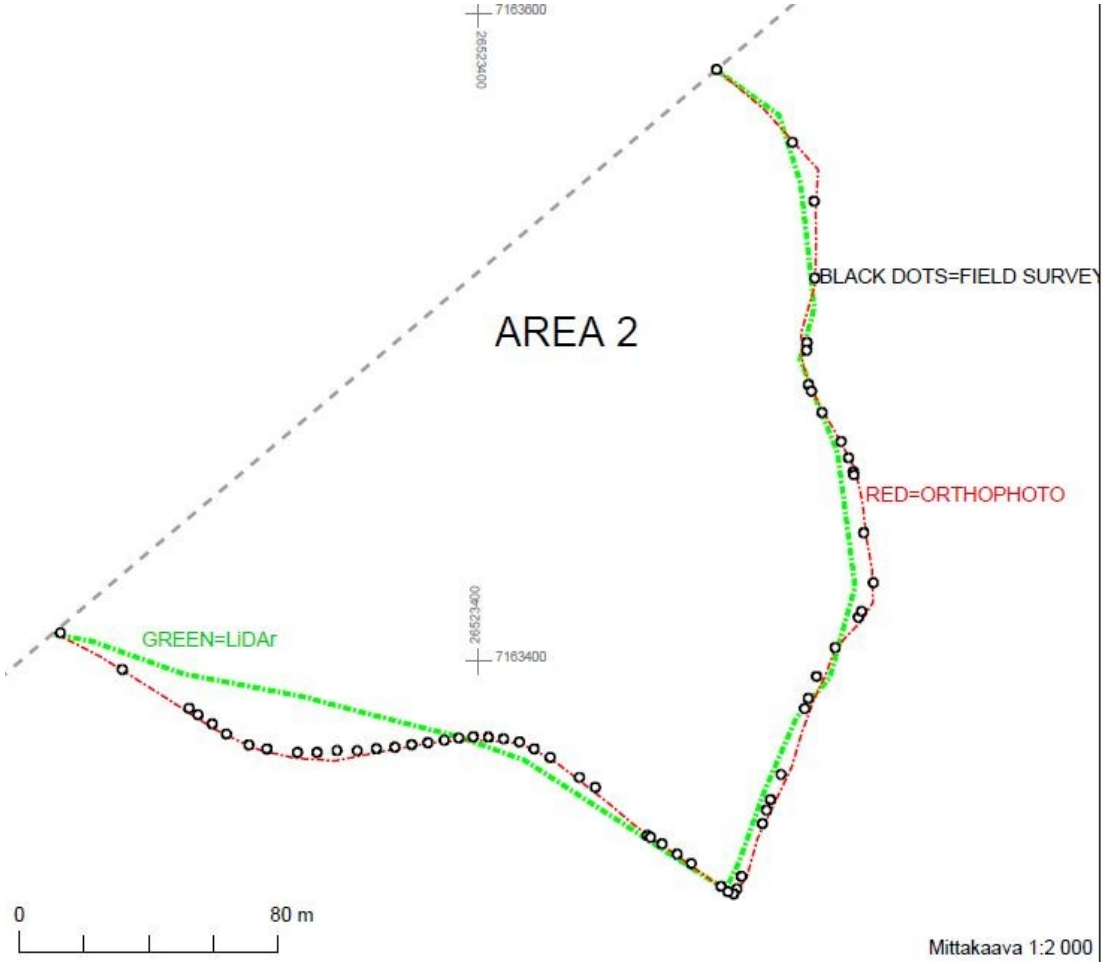
5.5.2 Test Area 2

The results given by the mapping from ortho photos and field surveys did not differ remarkably. The roads from the Lidar image were possible to locate

where the height differences were minor. However, when the roadway fell to the kettle hole, the accurate location was impossible to determine. Picture 8 shows the roadway falling to the kettle.

Picture 4. Surveying in Rokua national park

Field surveys took approximately 1 hour to conduct, and half an hour was needed to process the data. The ortho photos and Lidar images took approximately half an hour to process.

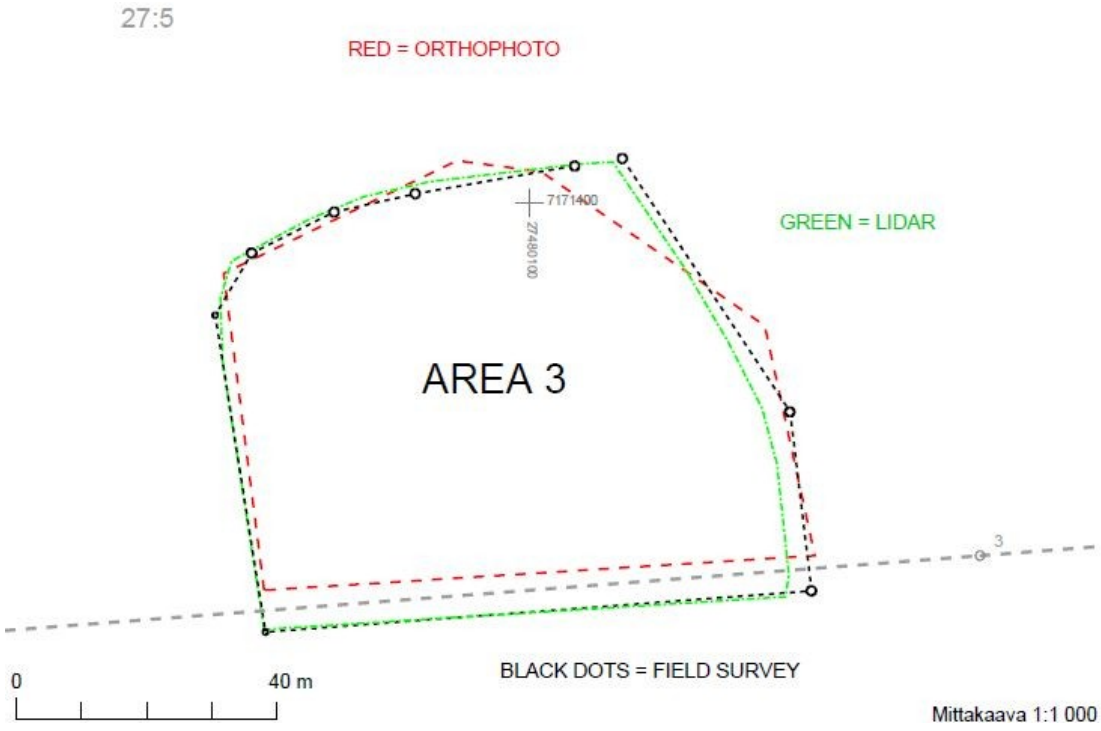


Map 6. Results of Test Area 2

5.5.3 Test Area 3

Differences between the results gained via the ortho photos and field surveys were significant. The ditch which was meant to form a new border was not visible from the ortho photos, and the location of some corners was approximately 5 metres different when measured from ortho photo and field surveys. Using Lidar images, the ditch was possible to accurately locate except in the eastern side of the test area. The maximum difference between field surveys and Lidar images was approximately 4 metres.

The field surveys took approximately 1.2 hours and a further half an hour was required to process the data. The ortho photos and Lidar images took approximately half an hour to process.



Map 7. Results of Test Area 3

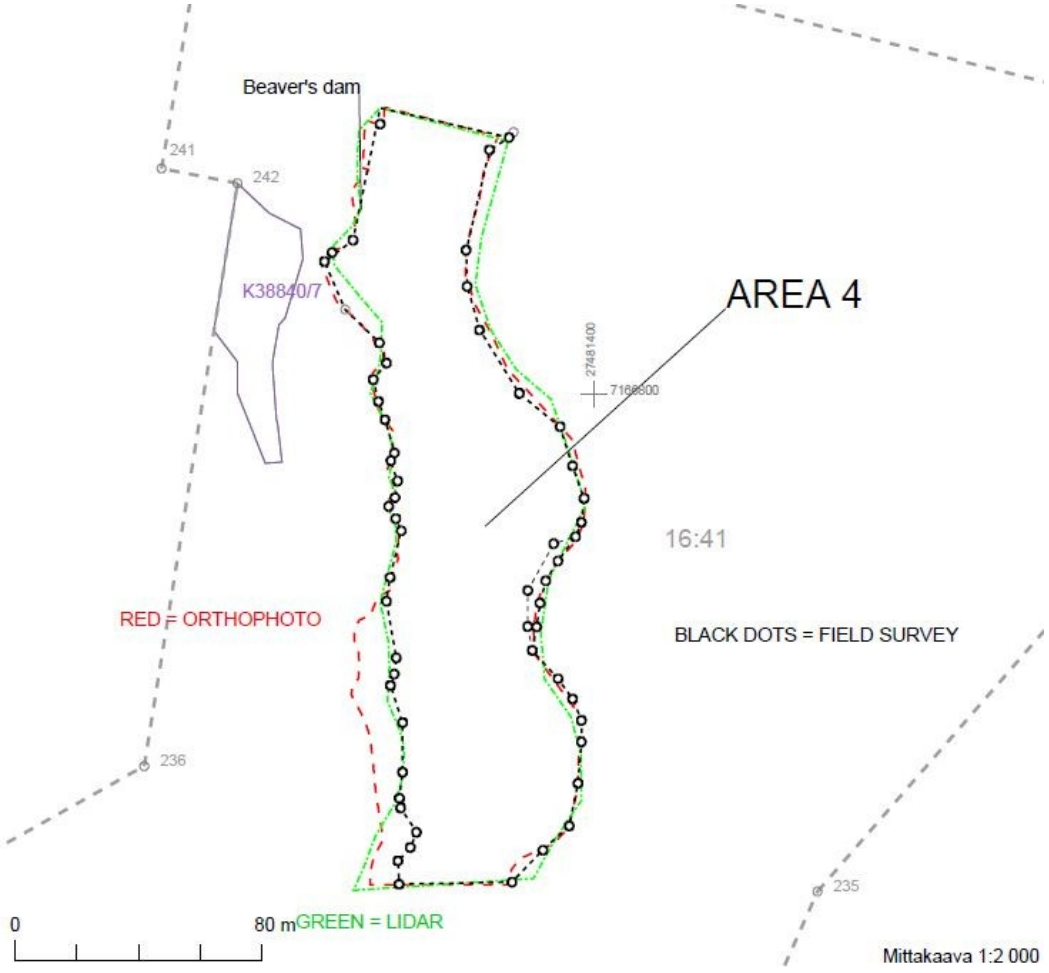
5.5.4 Test Area 4

The difference between field surveys and ortho photos (especially in the location of the brook) was considerable. Starting from the south and moving towards the north, the first 100 metres of brook mapped by ortho photos was mislocated approximately 9 to 12 metres from the real location. The cause of this error is the fact the brook was invisible (to the camera) in this area. When using Lidar pictures the brook was possible to locate quite accurately in most cases, but where the brook was covered by thick bushes, the picture was inaccurate. The brook was impossible to locate from pictures, because there was not enough measured data as not enough points were reflected back from the surface. Also, locating the edges of vegetation such as field was impossible because the vegetation was filtered out and there was only ground visible. These problems can be seen in Pictures 9 and 10.

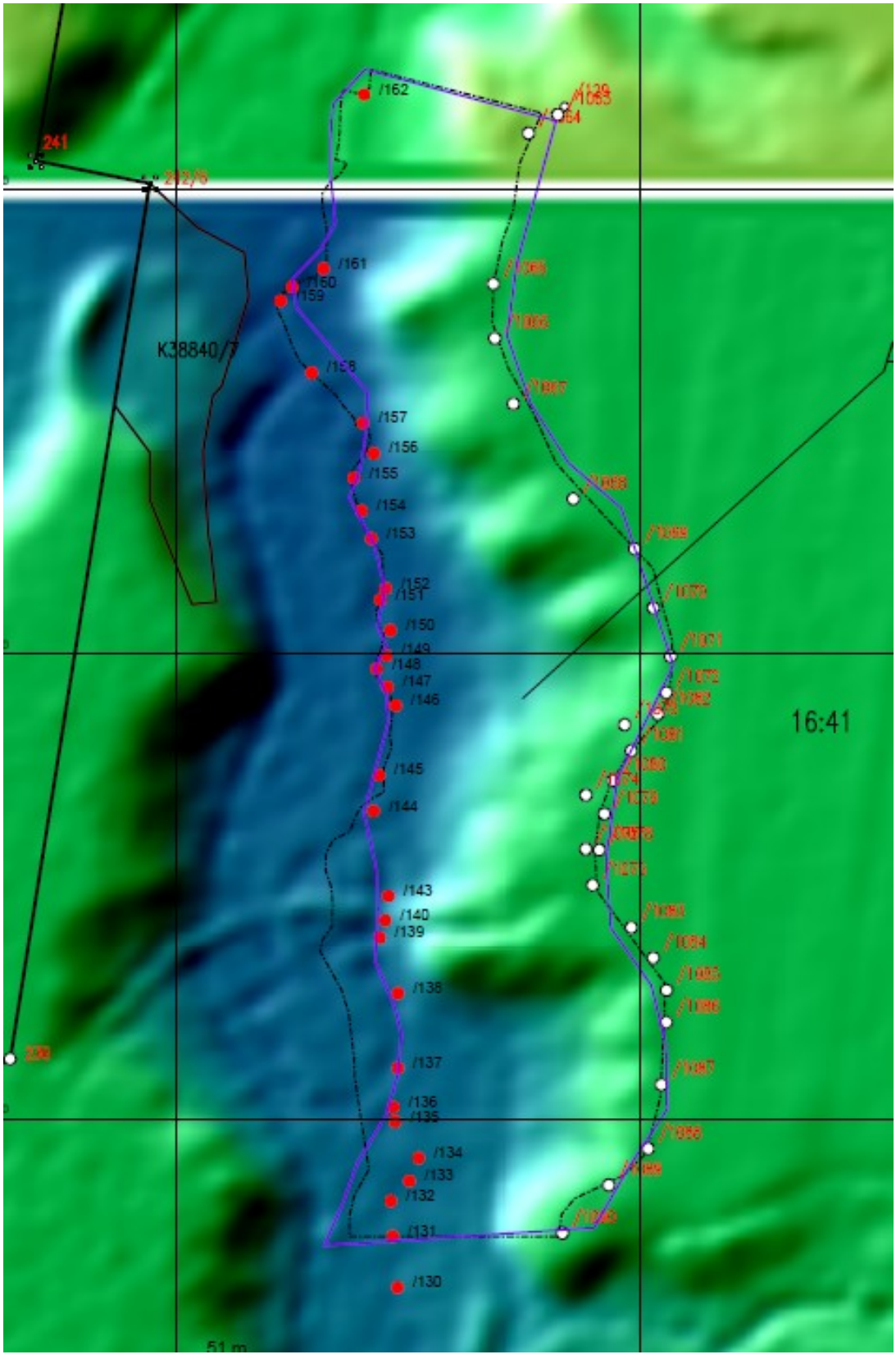
Picture 5. Where is the true location of field edge?

Picture 6. The Lohioja brook

The field surveys took approximately 1.2 hours and a further half an hour was required to process the data. The ortho photos and Lidar images took approximately half an hour to process from commencing to the demarcation of the new borders.



Map 8. Results of Test Area 4



Picture 7. Lidar image + measurements from Test Area 4

5.6 Accuracy

Table 2 gives the combined test results.

Test Area 1

	Aerial Ph	Lidar	Field survey	dAP-Lid[ha]	dAP-Lid[%]		dLid-FS[%]
Area [ha]	4,1408	4,0783	X	0,0625	1,51	X	X

Test Area 2

	Aerial Ph	Lidar	Field survey	dAP-FS[ha]	dLid-FS[ha]	dAP-FS[%]	dLid-FS[%]
Area [ha]	3,2771	3,1176	3,2760	-0,0011	0,1584	-0,03	4,84

Test Area 3

	Aerial Ph	Lidar	Field survey	dAP-FS[ha]	dLid-FS[ha]	dAP-FS[%]	dLid-FS[%]
Area [ha]	0,4486	0,498	0,5072	0,0586	0,0092	11,55	1,81

Test Area 4

	Aerial Ph	Lidar	Field survey	dAP-FS[ha]	dLid-FS[ha]	dAP-FS[%]	dLid-FS[%]
Area [ha]	1,3076	1,2725	1,1855	-0,1221	-0,0870	-10,30	-7,34

Comments
At field survey the Lohioja -brook was not able to survey completely. Approximately 40 meters was unable to be surveyed because of flooding caused by a beaver's dam.

Table 2. Accuracy of conducted surveys

From these results, it may be concluded that in open areas, ortho photos may be used to determine new borders with a high level of precision. In covered areas, the pictures produced from Lidar data can be used to identify the shapes of terrain. The differences in total areas are minor in good conditions and the differences are possible to reduce when using the combination of the Lidar images and the orthophotos.

Is field marking of the border necessary and is it possible to use only coordinates and visible shapes to determine such borders? In most cases this is possible. You can demarcate the new border by using a combination of ortho / satellite photos to determine the edges caused by vegetation and the visible shapes of terrain, and also use the images produced from Lidar

data. When compared to reality, the errors are minor. After determination, the new border has coordinates and the border on the field is also visible.

Difficulties could appear when using non-current data and this raises the question of how to obtain/maintain fresh images of a certain area. One answer could be the use of satellite technology, as satellites can cover a huge area a short time. Technological development will produce more accurate cameras and Lidar sensors, therefore gaining the live images from satellites lies inside the limits of possibility.

You could also use an Unmanned Arial Vehicle (UAV) to produce a digital terrain model of a certain area with high degrees of accuracy even with today's current technology. This equipment will likely be more accurate and cheaper in the future and could provide one possible way to collect up-to-date data from the field. UAV's could possibly become fully automatic 'surveyors' which fly and model the ground constantly.

6 CONCLUSIONS

"*The future cannot be predicted, but futures can be invented*"

-Dennis Gabor-

The first conclusion is that Finland should have a multipurpose cadastre where it is possible to find all of the different layers of spatial data. This data should be under the auspices of one author to ensure that the operational coordination of the cadastre is easier to maintain and more effective. The cadastral map should be the core of the LAS. To achieve this goal, all of the functions concerning land and its use should be under one agency - for example the Maanmittauslaitos.

The present situation of the Maanmittauslaitos (MML) is that the agency is focused on the base functions of the cadastre and maintaining the base registers. These are very important tasks, but the contributory influence to the development of society is almost non-existent. It is proposed that the MML could have a more important and visible role in society as the developer and administrator of a fully functional LAS.

To reach this goal we need to adopt a new way of thinking and think out-of-the-box. We have to take a wider point of view whilst not forgetting the base tasks required to run a functional cadastre. Such changes are required now, and not after a decade when it is too late. It is important to respond to the changes in society, and over recent years, the innovations of the MML have been mainly technical. It is now time to take some innovative actions that may positively influence the development of society.

These changes start with small steps. For example, changing the vision of the MML from its present base-task oriented perspective to one that is more society influenced, may help show people how the MML plays a role in developing society because all the functions of society are related to the land. Also, the lobbing of decision-makers should start now and Finland could learn from the example of Kadaster when thinking of a more important role in societal development. Of course, the countries are different but some of

Kadaster's principles are possible to adopt in Finland by applying them in the local environment. Finland will take a step towards having a 'one shop land administration agency' when the Finnish Geodetic Institute (Geodeettinen laitos) and the Ministry of Agriculture and Forestry's Centre of Statistics (TIKE) will merge to form National Land Survey of Finland at the beginning of 2015.

When examining the different cadastral systems, some questions emerge: Is the Finnish cadastre developed to respond to the needs of the people, or to the needs of land surveyors? Also: Is the benefit of cadastral items (e.g. the cadastral map) the same nation-wide and does it make sense to accurately survey certain areas of land, if the costs of surveying are higher than the value of the land itself?

Finland could take influence from principles of the Social Tenure Data Model. The maintainer of the cadastre should ask the users of cadastre what is needed. Cadastral surveyors have to leave their comfort zone when thinking of accuracy, and determine when it is necessary and when not. It is irrelevant to the land owner to have accurate coordinates in middle of a valueless area and the more important issue to the land owner is that of secured land ownership. The situation is different in valuable areas where economic interests are higher, and higher degrees of survey accuracy are needed. The present 0.5 m tolerance set in rural areas is still unnecessarily accurate. Cadastral surveyors could play a very important role in developing land so their thinking should be more oriented towards the benefit of society, rather than just the technical operations of maintaining the cadastre and proceedings.

Reflecting the scenarios introduced earlier, the most improbable scenario is Option Zero. During a prospective time span of 30 years, society and the cadastral system will change considerably. The world as we see it today will be changed by the development of technology and attitudes towards the role of state could also be considerably different. Therefore the Option Zero where no evolution is needed is implausible.

In the OpenCadastreMap scenario, the public would undertake the cadastral proceedings by themselves, and there would be no further needs for a professional land surveyor to make changes to the registers. Land owners would be able to execute a conveyance electronically, which would be confirmed by the system. The parties would then draw the new borders on the cadastral map and register the new parcel in the database. Easements could also be marked on the cadastre map by the parties. They are able to physically mark the borders on the land in question, however this is not necessary because of the accurate positioning systems available e.g. on mobile phones or personal computers.

The transparency of the OpenCadastreMap scenario is very high. All changes are made by the public and with open approaches to supervision, nothing is hidden in the structures of bureaucracy. There would be no author required to supervise the correctness of registers, the cadastral database and the land registry.

What would society's attitude be in this option? This option is very vulnerable and security and reliability is based on computers and databases. Any person has the possibility to make changes to the cadastral registers and if all the people were honest, there would be no difficulties. Human nature however still follows the same motivations as in the Stone Age and there will always be dishonest people who look to use the system to their own benefit. As the system is technology based, computers and systems have their blind spots and there is somebody who discovers a way to manipulate the system.

Any vulnerability of the cadastre and land registry would cause a loss in reliability for the system. The public would not trust the cadastre and the formal cadastre would transform to an informal cadastre. In this case there is a need for an author to confirm the reliability of the basic registers. If the key register is owned by a private company, the potential for abuse would be greater - unfortunately the well-being of the company may take precedence over the well-being of society.

This option could however be possible in some scale, using an author guided system of cadastral proceedings like parcelling and easements, based on the agreement of parties. Because such proceedings are based on agreements, there is no need for an author to confirm the agreement. In other proceedings such as expropriations, the OpenCadastreMap would not be a reasonable option.

The maintenance of the OpenCadastreMap is a very low-cost operation. The structure of administration machinery would be extracted and the only direct cost would be the maintenance of the database. However, there would be other economic expenses incurred from issues such as abuse, prejudicial inquiry and court hearings. There is also the potential for human suffering or even the loss of life if the system is subject to abuse. The reliability of the key register is priceless; should it be lost, it would be almost impossible to regain.

What would be the role of the cadastral surveyor in this scenario? Virtually none. Some cadastral surveyor expertise would be needed during the building of the database, in its maintenance and also in court hearings, however, compared to previous levels of requirement the active role of the cadastral surveyor is negligible.

In the crowd sourcing scenario, the author would be the administrator of the cadastre and registers, but the public would undertake lower level duties such as fieldwork. The public would then convey the details of the fieldwork to the cadastral surveyor and the surveyor registers the result and gives confirmation to the customers. In expropriations and other proceedings where a valuation is needed, the fieldwork and measurements should be made under the supervision of the cadastral author.

Crowd sourcing has already been used successfully in different land surveying tasks such as mapping and collecting GIS-data from the field. Also in projects where a low-cost cadastre has to be established, the crowd sourcing has proven one good way to reduce the cost. Unfortunately there

are no experiences of maintaining a cadastre by crowd sourcing available. There is a move towards this however, and the future vision of the National Land Survey of Finland indicates that people are able to take a part to the process if they choose.

In the crowd sourcing option, the costs entailed in fieldwork and measurement are significantly reduced for both the agency/author and also the customer. Of course, the fieldwork and measuring still entails costs to the customer but these are still lower than if a professional would come and conduct a survey. The costs caused by travel are reduced when compared to those of Option Zero and in crowd sourcing, people who are already in the location may be able to undertake the survey and eliminate the need for travel.

Difficulties could occur when estimating the reliability and accuracy of the data customers submit to the database. One way to supervise data reliability is by making random tests of the received data. In regard to the key register it is necessary to have good and accurate data. Of course there are a lot of errors in the present cadastre and land registry in Finland, but these errors are not currently visible to the public. A flawless cadastre is however a utopian aim as there will always be some degree of error.

Crowd sourcing could be useful in the OpenCadastreMap option and proceedings based on agreement would be more reasonably executed by crowd sourcing than by a civil servant. In this scenario, the cadastral surveyor only supervises the legality of proceedings and the reliability of data.

In some other proceedings where valuation is needed, crowd sourcing is impractical: it would decrease the reliability of legal surveying if for example neighbours value each other’s properties or evaluate their own properties. Of course it is possible to use consultation services from a private company, but after multiple valuations, no individual is responsible for the average value of the land and other objects of compensation.

The evolution of the role of the cadastral surveyor is an inevitable fact in this scenario. The cadastral surveyor or assistants will not undertake fieldwork and the role of the cadastral surveyor will be that of an administrator of the cadastral database and registers. The cadastral surveyor will undertake some cadastral proceedings where valuation is needed or to decide on any disagreement between parties. This task is not practical to off-load to local courts, because they have more serious and important cases to decide.

In the no-maintenance scenario the cadastre administration is run down and the cadastre will be re-established on a ten year frequency. In this option the cost of administration is practically none and would come only from the re-establishment itself and tracing any changes made after the last re-establishment. All expenses will be incurred during a two year period, after which the work would be completed and further expenses are non-existent.

The positive influence of this option would be the saving in costs, the potential for releasing the workforce to other tasks, and increases in operational effectiveness. Negative influences may be that the cadastre is not up-to-date in the period following re-establishment. During this period, all conveyances and other changes in landownership will not be registered until the next re-establishment. This situation leads to a result where society has an informal cadastre and formal cadastre at the same time. Between the re-establishments, the use of an informal cadastre would become more prevalent. This situation would be dangerous to the stability of the society and governmental power. Some areas of the country would be practically under a state of anarchy, and the reliability of the key registers would decrease.

In this scenario the role of the cadastral surveyor is minor. As examples from Africa indicate, there is no professional needed to record data from the field and to establish the cadastre. Professional land surveyors were only needed to make some measurements and to make corrections to coordinates. If the work were undertaken by cadastral surveyors, they would be only needed for

a couple of consecutive years and between re-establishments, they could be re-allocated to other tasks.

The No Cadastre at all option is envisaged as meaning that no cadastral system would exist as we know it today. For some reason, the cadastres would have collapsed or been run down. This option is not realistic because working land markets and mortgages need the reliable data regarding land ownership, location and area of the parcel, whether there are buildings involved etc. Fiscal authors would not be able to enable the taxation of land effectively. Mortgage providers are envisaged as lending money only at a great rate of interest to minimize their lending risks. Adopting this option would paralyze the economy and render the whole information regarding land ownership as being only informal. Of course there are some examples showing there is no need to have a complete cadastral system to have a welfare society, but for example, in England this situation is a result of a very long practice and people are used to dealing with it. England also has specialised cadastres that cater to the established practice.

Which option would *provide the most possible scenario in 2040?*

The basic needs of society are likely to remain the same as today, and the biggest change would come from the development of technology. If there are no great catastrophes, natural disasters, wars or anything else that would stop this development, the ubiquitous society is the most probable scenario for the future society. That leads to the situation where technology is everywhere in our environment, computers communicate between themselves and are installed practically everywhere. Positioning (i.e. location) technology will be more accurate and everybody would have the skills to use it.

Using fuzzy borders in real estate formation is one practical way to address cost reduction. The accuracy is sufficient and there is still a link from the database to the field, although the natural shapes will change and vanish over time. One huge problem is whether a determined border should follow

the floating fuzzy border or not. Also the need of fixed boundaries should be reconsidered: do we really need an accurate cadastral map in valueless land? Changing this very important basis of modern and future society is risky and a cadastre should be changed to reflect changes in society. Changes in society are therefore reflected in the cadastre – perhaps not in the case of minor changes but certainly major changes.

The most plausible scenario in Finland could be the use of crowd sourcing, because of the current role of the land surveyor as a judge in cadastral issues. In the Netherlands and Australia the role of cadastral surveyor is strictly executional.

The work of cadastral surveyor according to the crowd sourcing scenario in Finland would be as follows: the professionals move from undertaking field work to maintaining the databases and resolving customer disputes or issues. The mass-production type tasks are eliminated and professionals deal with more difficult problems than they encounter today. Therefore their awareness of various legislation needs to increase to a new level and they also need to acquire new skills to assist them in the problem solving process. In response to the demands of the new role, cadastral surveyors need to develop their profession to one akin to lawyers. The cadastral surveyors have to adapt to this new role before society allocates these tasks to local courts, which as we have seen, have more pressing workloads. This therefore means changes to the education of land surveyors in which the study of jurisprudence should have a bigger role than present.

If the fully functional LAS is under one author, the role of the cadastral or land surveyors is oriented to land development rather than simply processing land consolidations. In Finland the monopoly of spatial planning held by the municipalities should be preserved because the municipalities represent the best source of knowledge regarding the local situation.

Forming a fully functional LAS also needs the political will to do so. According to the example of past decades we are able to see that politicians and

citizens are thinking quite conservative about society and its structures. Changes to cadastral proceedings will come and the public is well able to perform some tasks by themselves. Cadastral surveying is no longer a privilege of the land surveyors, however land surveyors could become more important in the overall process of developing land and its administration.

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