„A GEOCODED CADASTRAL FABRIC AS PRECONDITION FOR A SUSTAINABLE LAND MANAGEMENT SYSTEM“

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INTRODUCTION

The Peruvian Economist Hernando de Soto has stated in 2000, that land remains “dead capital”, if it is not officially registered defining its geo-location and the rights individuals hold on these land objects.

The International Federation of Surveyors FIG has expressed the fact, that only 25% of the countries in the world have an operational cadastral system, and another 25% are in the process of establishing one.

The World Bank has recently funded such projects with sums of over 1.5 billion $.

Land Management cannot be properly carried out without cadastral registration systems.

Land Management activities within FIG have identified 3 major types of cadastral land registration systems across the world, which all rely on 1) geometric definitions of the land object in form of a geocoded digital map 2) the description of the rights to the land in form of a relational data base.:

- The French-Latin American Deed system, oriented heavily on the legal aspects
- The German Land Book Cadastral Registration System with title status and accurate mapping
- The Torrens Cadastral Title Registration which is the Commonwealth approach

If these systems are introduced with digital technology tools, they can all be used as an effective mechanism for Land Administration, Land Use Planning and Good Governance Decision Making.

Between the choice of a cadastral land registration type and its use for land administration, mortgaging and decision making lies a rather weakly defined technical toolbox. This toolbox determines the main cost of establishing the system, defining the accuracy and its maintainability.

It can make use of the vast technical innovations, such as

- GPS-GNSS survey technology
- digital aerial mapping
- high resolution satellite imaging
- GIS tools for storing, administering and disseminating the information via networks and the web

These tools are at the heart of the surveying and geoinformatics profession.

Due to the different approaches in the different regions of the world in the past and at present, these tools need to be adapted with respect to the quality of data already in existence, or the information still lacking:

- In Continental Europe
- In the U.K.
- In the USA
- In Canada and Australia
- In the Middle East
- In the Transformation Countries
- In Africa

The aim must be to design a “cadastral engine”, which is affordable, reliable, updatable and quickly installed to make sustainable development of land possible.

Land Management needs for its implementation a “cadastral engine”. Most authors have concentrated on its availability and its further uses, but little has been said about its implementation. The paper analyzes the possibilities to make cadastral boundary management possible in form of a “cadastral fabric”. GPS-GNSS, aerial and satellite imaging have now become effective tools for its realization. In different parts of the world there exist different scenarios for its implementation.

All those concerned with Land Management have identified the preconditions for managing land. There are (see Fig 1) the ‘cadastral engines” composed either of tax driven cadastres, title or deed tenure style cadastres or multipurpose cadastres and the SDI solution collects data on parcels, properties, buildings or roads. If these components are available, then land management depending on development aims, tenure, value and use conditions can serve a spatially enabled government for decisions or sustainable development in economic, environmental, social and governance terms.

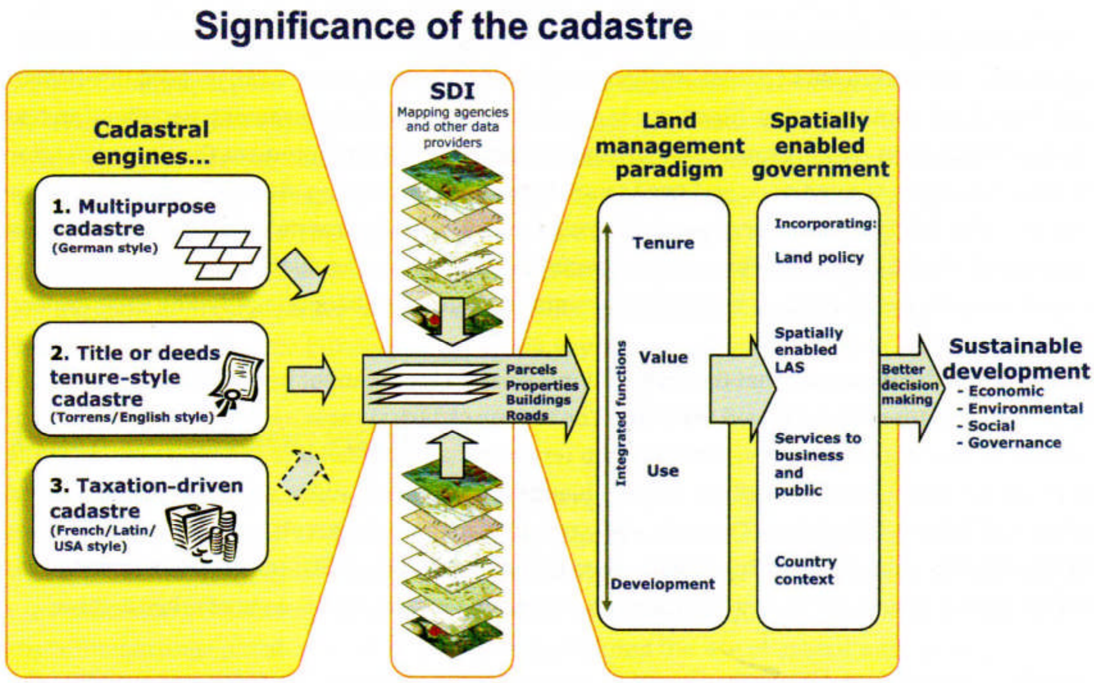


Fig 1 – Significance of the Cadastre – from Williamson, Enemark, Wallace, Rajabifard – “Land Administration for Sustainable Development”, ESRI Press Academic, 2010, ISBN 978-1-68948-041-4

While the cadastral engines, the land management tools, the services of a spatially enabled government and the sustainable development goals have been expressed rather well, there is a void in describing the SDI options available. This is particularly difficult in a rapidly changing situation of technological development, in which one technical solution may easily be exchanged for another, which is more costly, more time consuming or more complex. The GPS-GNSS is such an example.

The purpose of this paper is to shed light on this issue for a better understanding of the situation. (Fig.2).

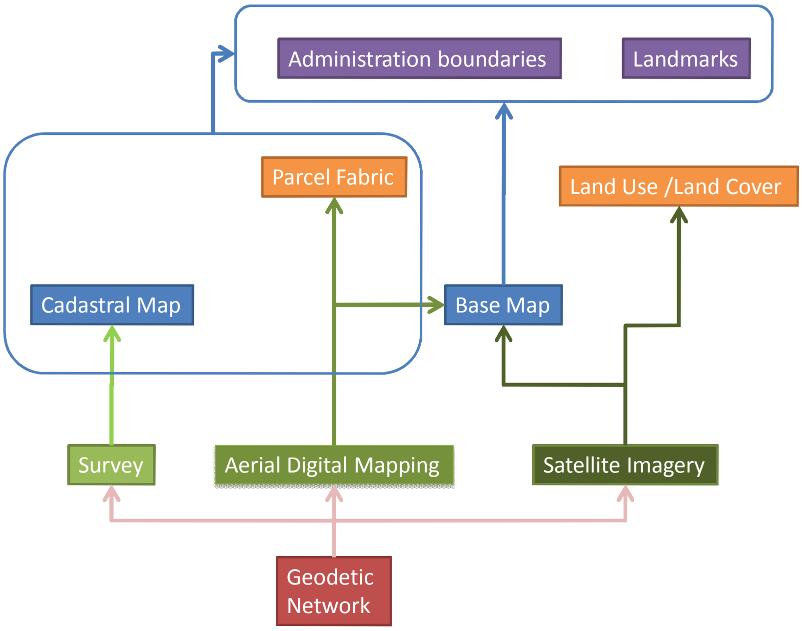


Fig 2 – The SDI Options

1. HISTORICAL CADASTRAL BOUNDARY MANAGEMENT

When the first property cadastres were established in the early 19th century in Europe, the survey of cadastral boundaries was made by plane table. In North America the stakeout of land parcels granted by the Crown or the State was made by metes and bounds using a magnetic compass and a chain. The parcel fabric of a country established at that time may have been relatively consistent, but it lacked absolute accuracy because these surveys were not referenced to a geodetic survey control system. Nevertheless, the design of a tax cadastre became possible by these methods. An ownership-oriented cadastre became possible around 1900 in countries where legal measures for geo-referencing to a geodetic control system were introduced, and where transactional updating procedures were regulated. If survey accuracies were tightly maintained to the decimeter level, even a multi-purpose cadastre could be established.

However, only a few countries, maybe 30 out of a total of 200 have been able to establish multi-purpose cadastral systems. The other countries were not able to introduce them because of the cost and the lack of infrastructure involved.

This means that 170 out of 200 countries lacked cadastral systems, in which the boundaries of parcels were properly described.

This situation changed dramatically, however, in the 20th century when electronic distance measurement using total stations was first introduced in the 1960's. And this improvement of the situation went even farther with the practical uses of GPS-GNSS technology in the 1990's.

2. MODERN POSSIBILITIES TO ESTABLISH A PARCEL FABRIC: GPS-GNSS

To establish accurate cadastral boundaries, survey documents are required, which certify the location and the dimensions of the particular land parcels. These can be contained in documents attached to the deeds or titles, or they are described in subdivision plans.

In case of missing or doubtful documentation, records can be taken from existing boundary monumentation or from established building footprints related to the parcel boundaries.

If this again is not possible, an adjudication process is required. In this process the adjacent parcel owners agree on the monumented or coordinate surveyed boundary point locations and attest to it by the signature of the survey protocol. This process can also be witnessed by a lawyer, judge or notary public to give it official legal status.

In this process the accuracy with which boundary parcel coordinates can be established by GPS-GNSS phase receivers tied to a dense CORS network is at the centimeter level, which will satisfy all cadastral demands. However, the process involves the cooperation of land owners and a strong governmental interest to clarify land ownership boundaries. This process is of course also costly and time consuming, so that the question whether this process is necessary is valid.

The establishment of a cadastral system with the cadastral parcel boundaries surveyed in this manner has been demonstrated in the state of Georgia, where a cadastral registration system with accurate boundaries has been established in a 5 year period at a final survey cost of about $2 – 3 per parcel for the entire accessible area of the state.

If such an approach is deemed too costly, then the accurate survey and / or adjudication approach is also possible on a transaction basis, whenever parcel boundaries are changed. This sporadic approach leads to a gradual improvement of the geometric accuracy of the geodatabase, which needs to be properly structured with links between parcel coordinates, parcel number, boundary lines and parcels. In this database, the topology of the parcel fabric is maintained, however, the exiting coordinates are replaced with more accurate ones based on the more accurate surveys conducted as part of the sporadic process.

3. IMAGE ADJUDICATION

As the primary interest in the establishment of a cadastral system is to link a uniquely defined parcel with a particular right (ownership, encumbrance, lease, etc.) and with a particular holder of the right, it is secondary how the parcel is geometrically defined, as long as it is uniquely identifiable and the parcel fabric covers the entire area of the cadastral system (city, state, region, globe) without gaps and overlaps.

This means that areas, which could be covered by a cadastral system quickly and at high cost, can also be defined by a less accurate cadastral parcel fabric that has been generated by the interpretation of aerial or satellite imagery at a certain resolution or ground sample distance.

Again, the boundaries need to be interpreted from the imagery, and verified by available documents and plans, or locally adjudicated.

For areas that lack imagery coverage collected for topographic mapping purposes, satellite imagery, such as Google Earth or Bing images may even be used for that purpose. This is propagated, for example in Africa, if a geocoding of the data with augmented accuracy GPS-GNSS code receivers (e.g., EGNOS or Omni-Star) is carried out.

This procedure permits to establish the parcel fabric for the establishment of cadastral registration systems quickly and at low cost, until a higher accuracy survey becomes possible and affordable.

It is even possible that a low accuracy parcel fabric definition may coexist with high accuracy cadastral survey areas within urban environments where there is a need for the higher accuracy.

4. DIFFERENT SCENARIOS

The following illustrations describe the relations and process schematically. Attached are also different scenarios for typical regions of the globe as examples: Europe, North America, transformation countries, the Middle East, and Africa.

Fig 3 illustrates the possible options of the geodetic network for the generation of a cadastral system. Those options depend on the existence of historical or established documentation and on the resources available in a particular region or country.

Figure 3 – Cadastral Survey Options

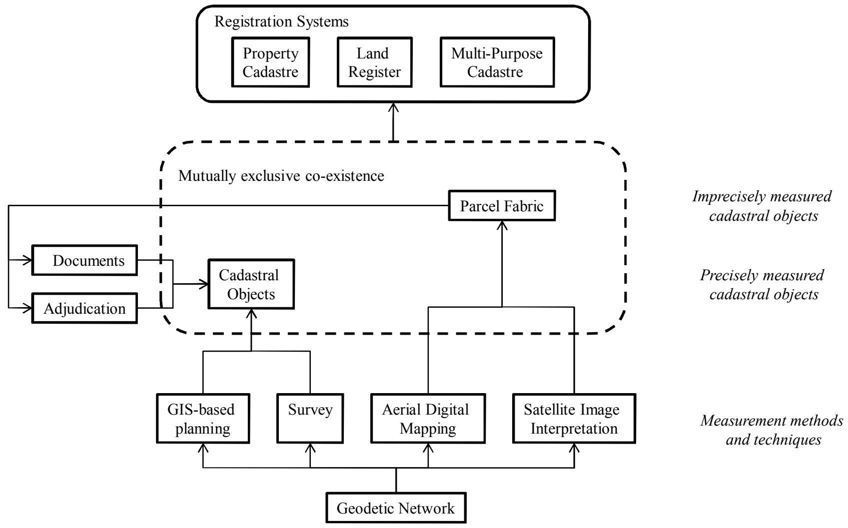


Fig 4 shows the continental European structure, where an accurate geodetic network exists, and where the generation of cadastral objects has been based on accurate ground surveys for the cadastre. The updating is done on a transaction basis with accurate surveys using modern technology.

Figure 4 - Continental Europe

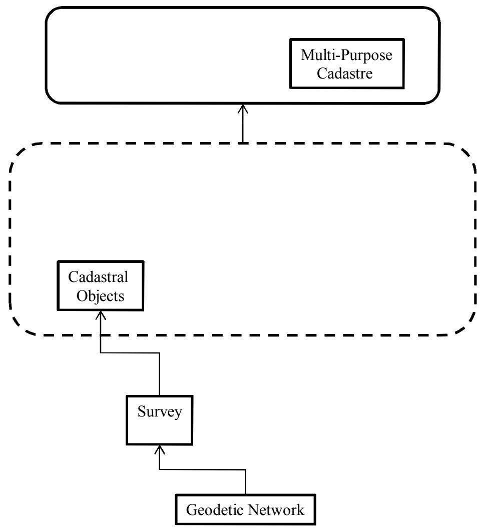
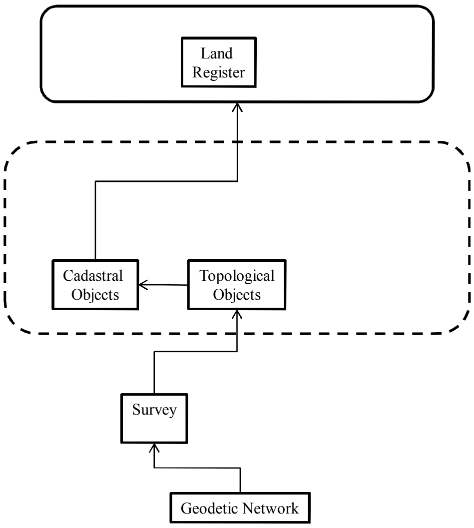


Fig 5 shows the situation in the UK, where the survey of topographic objects is accurately based on the geodetic network. The topography is maintained within a period of 6 months by update surveys based on on-site observations and construction reports.

Figure 5 - United Kingdom



The cadastral fabric is merely a layer of the topographic database, which is generated as "unsharp boundaries" based on the identified and surveyed topographic objects.

Figure 6 describes generally the situation in the USA, where digital mapping on the basis of an accurate geodetic network is carried out. From the digital topographic map, the parcel fabric is generated and verified using existing documents, and if necessary, by adjudication. The process to generate a property cadastre is by no means completed, and the generation of the parcel fabric with a link to the register is still ongoing.

Figure 6 - USA

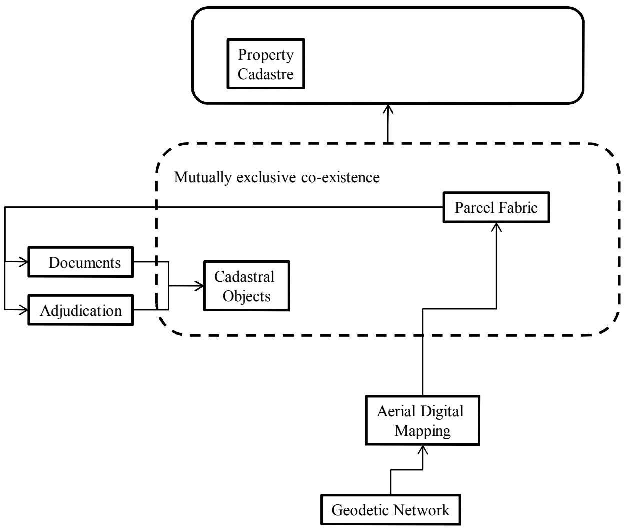


Figure 7 describes the more advanced situation in Canada where cadastral objects are generally surveyed and made available to the land register.

Figure 7 - Canada

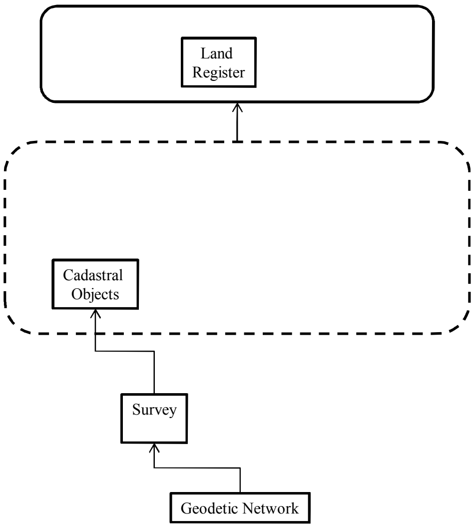


Figure 8 shows the situation in the Middle East, where the general intention exists to establish new cadastral boundaries by accurate surveys or by GIS based planning, which serve the stakeout of new cadastral objects for the land register. The previous records on parcel generation are, in general, based on old type of survey networks and there is a need to resurvey the boundaries to the new accurate cadastral network on an ad hoc sporadic basis when the need arises, or on a block by block basis.

Figure 8 - Middle East

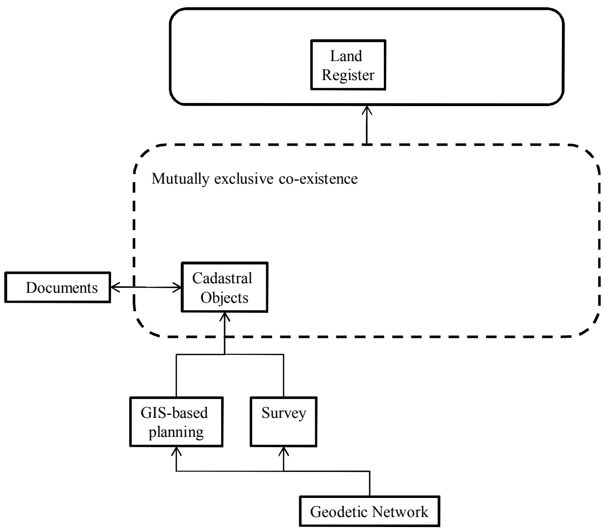


Figure 9. In the former socialist transformation countries, where privatization of land has recently become possible, the need arose to check new land parcels for distribution to owners on a planned basis. This was of course carried out quickly by new specifications and survey contracts. However, their quality control depends on verification by state wide orthophotos, since errors beyond tolerances have occurred in about 15% of the cases.

Figure 9 - Transformation Countries

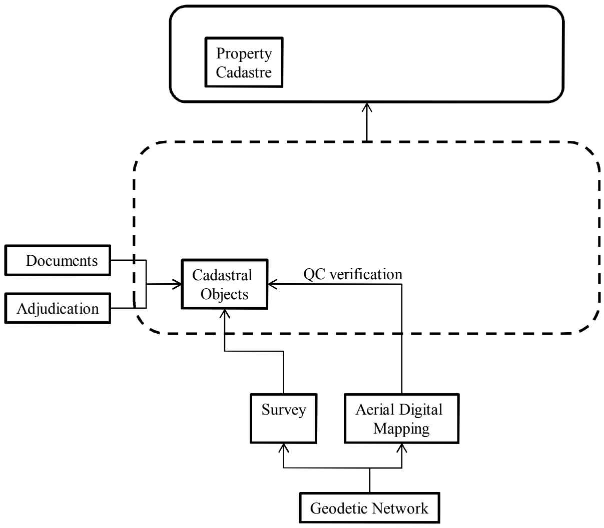
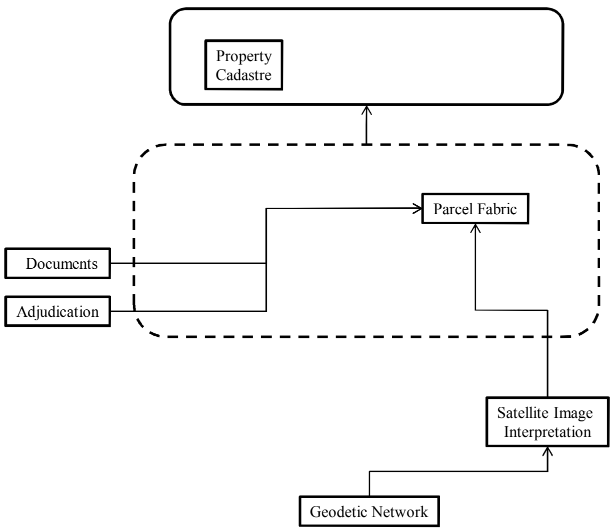


Figure 10. The situation is quite different in Africa, where an accurate control survey network generally does not exist. Even aerial images are often not available. However, Google Earth offers image material usable for the generation of a parcel fabric to be verified by documents or adjudication including determination of tribal rights. But the images can be orthorectified and georeferenced with local GPS surveys (e.g., Omni-Star) to serve for the generation of a parcel fabric.

Figure 10 - Africa - suggested



5. CONCLUSION

The paper has the intention to supplement the well documented land management literature with the technical component, which will help to quickly establish the needed parcel fabric for land registration systems. The three authors of this paper come from different regions of the world and from different professional backgrounds: those of a GIS strategic planner and business analyst with computer geographic background, those of a professional geomatics administrator, and those of a person concentrating on technical methodology. It is meant as a stimulant for further discussions within FIG. The integration of such backgrounds may leapfrog progress in land management systems.

A cadastral parcel fabric maintains the topology of adjacent parcels with good relative accuracy for the purposes of land management, land administration and land planning activities. The parcel fabric, which lacks absolute georeferencing, can be migrated to a relatively accurate cadastral map, , made possible by accurate control networks established via GPS-GNSS surveys. Engineering activities in general may benefit from it. With the availability of a properly structured geodatabase an improved overall accuracy can eventually be obtained by modern surveys on a transaction basis.

BIOGRAPHICAL NOTES

Gottfried Konecny is Emeritus Professor of the University of Hannover