KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATICS ENGINEERING

DHULIKHEL, KAVRE

A PROJECT REPORT ON

A Brief History, Process and Challenges of Cadastral Surveying: A Case Study of Denmark

Submitted by:

Aashish Kumar Karki (029006-21)

Bipul Chaudhary (028998-21)

Dikshya Khadka (029008-21)

Pratiksha Dahal (029001-21)

Rupa Bajgain (028994-21)

Submitted to:

Mr. Ram Kumar Sapkota

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ABSTRACT

Cadastral surveying is fundamental to land management and governance, providing the framework for property boundary definition, land ownership documentation, and spatial planning. In Denmark, cadastral surveying has evolved over centuries, influenced by historical, legal, and cultural factors, culminating in a system recognized globally for its efficiency and technological integration. This report investigates the historical development, current methodologies, and challenges associated with Denmark's cadastral system, offering insights into its transformation from traditional practices to a digital and technology-driven framework. The study highlights key milestones, such as the 17th-century Danish Cadastre and subsequent modernization efforts, including the adoption of Geographic Information Systems (GIS), digital mapping, and blockchain technology. The report also examines the role of cadastral surveys in supporting sustainable development, urban planning, and climate adaptation initiatives. Despite its successes, the Danish system faces challenges, including boundary disputes, data integration issues, and the demands of rapid urbanization and climate change. By comparing Denmark's cadastral system with that of Nepal, the report underscores the importance of leveraging technology, fostering public-private collaboration, and maintaining transparency to achieve effective land administration. Denmark's experience serves as a model for countries seeking to modernize their cadastral systems, offering lessons in resilience, innovation, and adaptability to address present and future land management challenges.

Keywords: Denmark, Cadastre, Process, History, Challenges

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Chapter 1 : INTRODUCTION

1.1 Background

Cadastral surveying, which involves the definition, documentation, and mapping of property boundaries, is essential for effective land management and governance. In Denmark, this practice has developed over centuries, influenced by the nation's distinct historical, legal, and cultural circumstances. Originating from medieval land division systems, cadastral surveying has become a vital component of Denmark's framework for land ownership, taxation, and urban planning. The importance of cadastral surveys goes beyond simply marking property lines; they support various societal functions, including property registration, conflict resolution, infrastructure development, and environmental planning. The Danish cadastral system, noted for its efficiency and accuracy, serves as a benchmark for numerous countries aiming to enhance their land administration practices.(Enemark & Dahl Højgaard, n.d.)

Nevertheless, the cadastral surveying process encounters several challenges. As Denmark progresses towards urbanization and responds to global issues such as climate change, technological innovations, and shifting land-use priorities, the cadastral system must strive to maintain its accuracy, accessibility, and adaptability.

This report examines the history, processes, and challenges associated with cadastral surveying in Denmark. It begins with a historical overview that traces the development of land surveying practices and their socio-economic impacts. Subsequently, it explores the contemporary processes involved in cadastral surveying, emphasizing the technologies and methodologies utilized. Finally, the report discusses the challenges faced by the Danish cadastral system, highlighting the necessity for innovation and resilience to meet current and future demands.

1.2 Problem Statement

The Danish cadastral system, although historically strong, encounters difficulties in adjusting to contemporary requirements influenced by urbanization, climate change, and technological progress. These challenges underscore the necessity to address problems such as discrepancies in boundary information, fair access to data, and the incorporation of new technologies to maintain the system's accuracy, efficiency, and preparedness for the future.

1.3 Objectives

1.3.1 Primary Objectives

The primary objective of the project was to assess the process of Cadastral Surveying in Denmark while also learning about the historical transformation and challenges.

1.3.2 Secondary Objectives

The secondary objectives of the project included:

- Assess the role of technological advancements in modernizing Cadastral Survey in Denmark,
- Compare the cadastral system of Denmark with other nations,
- Explore the rules and policies that governs cadastral system in Denmark.

1.4 Scope of the Project

The project intended to investigate the Danish cadastral survey system's historical development, present procedures, and difficulties. It worked on examining how stakeholder involvement, technological developments, and legal frameworks have shaped the system. The socioeconomic effects of cadastral surveys, including their role in sustainable development, urban planning, and land administration, were also be assessed in the study.

Chapter 2 LITERATURE REVIEW

Cadastral surveys are essential for land administration, documenting land ownership, boundaries, and rights to support taxation, urban planning, and infrastructure. The roots of Denmark's cadastral system can be traced back to the 17th century, specifically to King Christian V's "Danish Cadastre" of 1688, which aimed to standardize land taxation based on property size and productivity (Enemark, 2005). This early initiative laid the foundation for a centralized and transparent land administration system. Over the years, significant land reforms in the 18th and 19th centuries further refined the cadastre, transitioning it from a taxation tool to a broader framework for land management and ownership documentation (Williamson et al., 2010).

In the 20th century, Denmark's cadastre underwent a transformative modernization process. The introduction of photogrammetry and aerial mapping techniques in the mid-1900s marked a significant technological leap (Kaufmann & Steudler, 1998). By the late 20th century, Denmark became a pioneer in adopting digital technologies, integrating Geographic Information Systems (GIS) and computerized land registries into its cadastral operations (Enemark & Sevatdal, 1999). This digital transformation not only enhanced efficiency but also improved accessibility and accuracy in land-related data.

On 1 January 2013, the agency changed its name to Danish Geodata Agency. In 2014, the Danish government launched a full 1:1 recreation of the country of Denmark in Minecraft. The game map was based on real, official measurements made public by the Danish Geodata Agency. The reason was to "use the appeal of gaming to draw the public's attention to geographical data" and an "invitation to teachers and schools to use the data in geography, math, science and history lessons". This, of course, drew attention of cyber vandals who attacked the server by blowing up areas of the map, destroying buildings and planting American flags (siliconANGLE, 2014)

Today, Denmark's cadastral system is characterized by its seamless integration of digital tools, including the use of cloud-based platforms for land registration and real-time updates to property records. The system operates under a unified framework regulated by the Danish Geodata Agency (Geodatastyrelsen), ensuring consistency and reliability across various land administration activities (Geodatastyrelsen, 2021). Furthermore, UN-GGIM (2020) states that Denmark's cadastre supports sustainable development goals by promoting equitable land use and climate adaptation measures, such as flood risk mapping and urban green space planning.

Chapter 3 METHODOLOGY

3.1 Study Area

Denmark is located in Northern Europe, primarily on the Jutland Peninsula and around 406 islands, with the largest being Zealand. The geographical coordinates of Denmark are approximately 56.0000° N latitude and 10.0000° E longitude. This positioning places Denmark at a strategic point between mainland Europe and Scandinavia, bordered by Germany to the south and surrounded by the North and Baltic Seas, contributing to its rich maritime history and culture.

Figure 1: Study Area Map

3.2 Data Sources Used

Since the research was based on Desk Study, the data sources were mainly **Secondary Sources, Google Scholar** was referred to for thorough review of previous academic publications, reports, and policy documents that offer information about Denmark's Cadastral system throughout history, processes involved and withstanding challenges in the current scenario. The **Danish Geodata Agency** website also provided with significant insights.

3.3 Method

The development, process and difficulties of Cadastral Survey in Denmark were examined in this study using a literature review methodology. The approach was based on a thorough review of

previous academic publications, reports, and policy documents that offer information about Denmark's Cadastral system throughout history, processes involved and withstanding challenges in the current scenario. The literature referred to, are mentioned in the 'References' Section.

Chapter 4 RESULTS AND DISCUSSIONS

4.1 Historical Development

In the mid-18th century, Denmark operated under an absolute monarchy, where all land was theoretically owned by the king. He allocated various manor estates to members of the aristocracy, who in turn leased smaller agricultural plots in the villages to peasants. These peasants were required to contribute labor to the manor estate as part of their tenancy obligations. Tenant rights were typically inherited, restricting most tenants from relocating or pursuing different occupations. The management of the estate, along with the administration of justice over the peasantry, was the responsibility of the manor lord, his officials, and a manorial court.(Enemark & Dahl Højgaard, n.d.)

Additionally, peasants were obligated to pay taxes in the form of natural goods, while the manor estate remitted monetary taxes to the king. The tax obligations were established by the first cadastre in Denmark, which was initiated in 1681 and implemented in 1688. This cadastre involved a basic survey measuring the dimensions of individual fields and assessing soil quality across four to six categories. Taxes were calculated based on a unit known as "hartkorn," which was approximately equivalent to 0.55 hectares of the most fertile land. Notably, the cadastre did not include any mapping, nor were there provisions for its upkeep.(Enemark & Dahl Højgaard, n.d.)

The villagers engaged in collective agriculture by partitioning the surrounding area into three expansive fields designated for a rotational system of grass, barley, and rye cultivation. Each of these large fields was further subdivided into smaller plots of comparable soil quality, which were then divided into numerous narrow strips managed by individual farmers. Although the land was fundamentally farmed collectively, the arrangement permitted each farm to receive a share of the harvest proportional to its size as outlined in the tenancy agreement.

However, the cadastre of today is younger. It derives from the results of the enclosure movement in the end of the 17th century and was established in 1844. The Danish cadastre, which derived from the results and the enclosure movement, was established within the year 1844. The cadastre consisted of two parts: the cadastral register and the cadastral maps. Both of these components have been updated since. As a result of the enclosure movement, the previous feudalistic society was changed into a society based on private ownership of land. The necessary maps were surveyed by the plane table at a scale of 1:4000. The resulting property framework from the enclosure

movement formed the basis for the new cadastral maps. Each map normally includes a village and the 2 associated cultivated areas. As a result, the maps are "island maps" covering different areas and not based on any local or national control network. The boundaries of the urban parcels in the villages were shown very approximately on the cadastral maps since these urban properties were not important for land valuation purposes. The provincial towns were surveyed separately based on a provision from 1863. The maps are established by traversed surveys, most of them on the scale of 1:800.(Skrubbeltrang, n.d.)

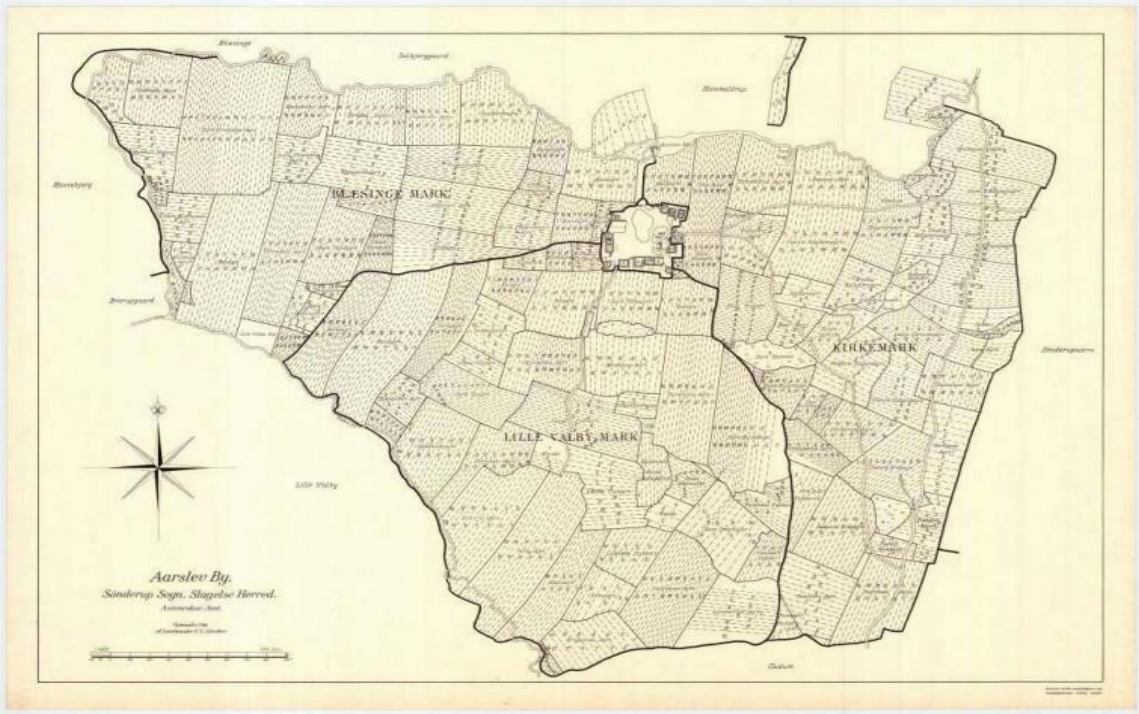

Figure 2:Illustration of the farming system used in the village of Aarslev second half of 1700 (Danish Geodata Agency)

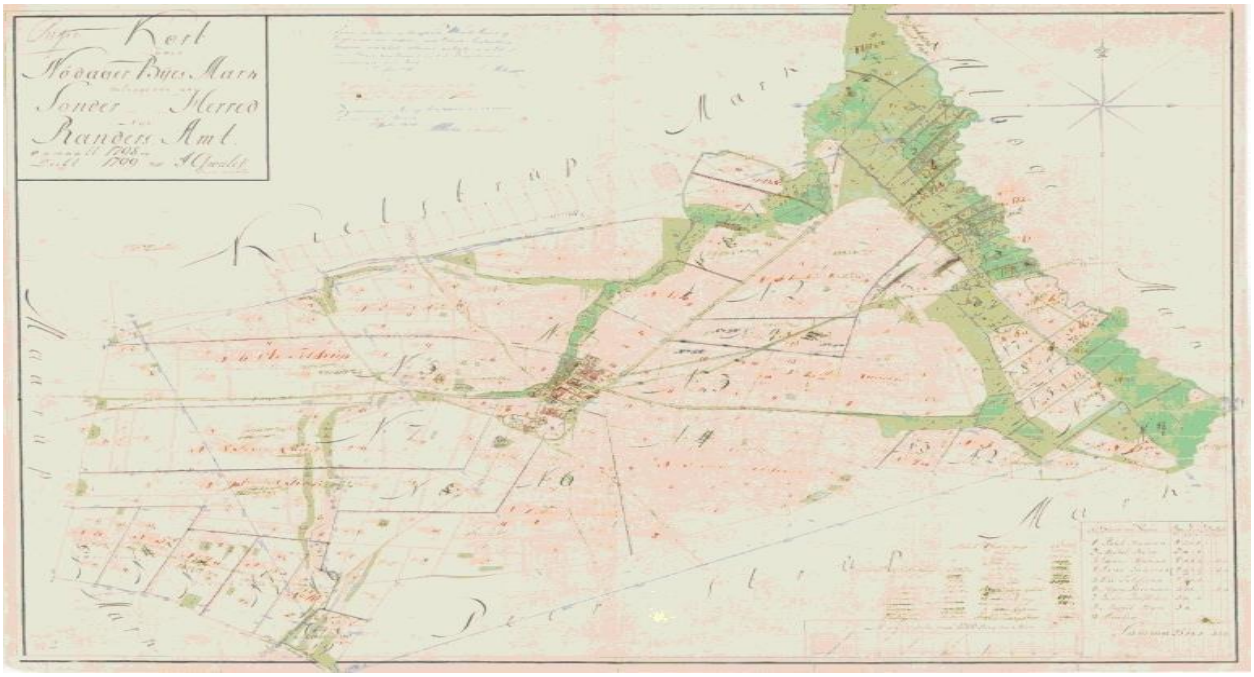

Figure 3: Cadastral map from 1799 (Nødager By, Nødager 1:4000)

Therefore, the parcels were numbered and recorded in the cadastral register showing parcel areas, parcel numbers, and the valuation of each property (being an aggregation of several parcels in the property) with the cadastral maps showing the location of the cadastral parcels (Enemark, p. 3, 1999). The parcel identification was also used to support the land ownership and land transfer system. In 1845 the Land Registry System was established at the local district courts for recording and protecting legal rights of ownership, mortgages, easements, and leases for land. In addition, in the 1920s, a new land book system was established introducing title registration based on cadastral identification. The second half of the 1980s also saw the need for a digital reform converting the old analogue island maps into a digital format linked to the national grid. The aim was to establish a cadastral information infrastructure accessible for all kinds of users and tailored for efficient interaction with other land data systems. The cadastral register was computerized by1986and a pilot project for computerizing the cadastral maps was carried through over the years 1985- 89, and the full digitization of about 15.000 analogue cadastral maps, comprising about 2.5 million land parcels, was completed by 1997.

4.2 Institutional Framework

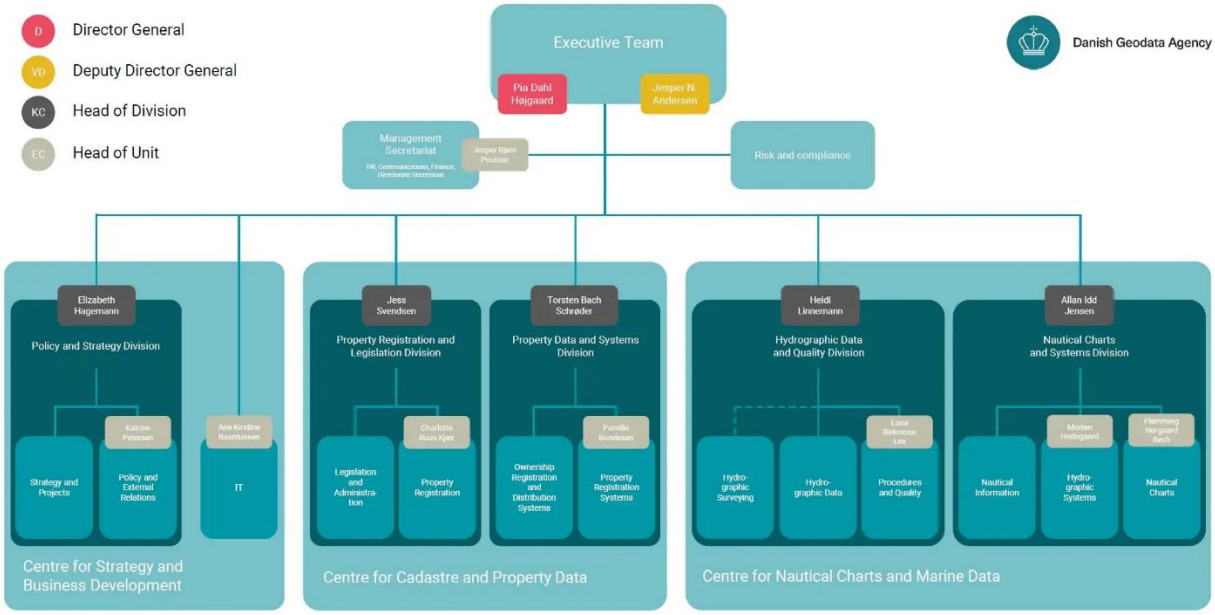

Figure 4: Organizational Framework (Danish Geodata Agency)

The institutions involved are (Sapkota , Gyawali , Baral , & Adhikari , 2021):

Governmental Organization: The Danish Geodata Agency (formerly the National Survey and Cadastre of Denmark) is a state-run agency under the Ministry of Climate, Energy, and Utilities. It handles land surveying, mapping, and real estate registration across Denmark. The agency provides access to cadastral data for free, covering around 2.4 million land parcels and 45 million features. Legal land ownership, mortgages, and other rights are recorded in a central electronic Land Book managed by the Ministry of Justice. **Geodata Agency (Geodatastyrelsen)**, formerly known as the **National Survey and Cadastre of Denmark (Kort & Matrikelstyrelsen, KMS)**, is Denmark's central government agency responsible for surveying, mapping, and land registration across Denmark, Greenland, the Faroe Islands, and their associated waters. Operating under the **Danish Ministry of the Environment**, its primary mission is to provide reliable and accurate maps and geospatial information to Danish society.

Established on **1 January 1989**, the agency was formed by merging three entities: **Geodætisk Institut**, **Søkortarkivet**, and **Matrikeldirektoratet**, to strengthen Denmark's mapping capabilities. Initially under the **Ministry of Housing**, it was transferred to the **Ministry of the**

Environment in 2001. Over time, some of its responsibilities, such as seismology and geodesy, were transferred to other institutions like the **Geological Survey of Denmark and Greenland (GEUS)** and the **Danish National Space Center**.

The agency's role and responsibilities are defined by **Law #749 of 7 December 1988**, and its creation was formalized through a **Royal resolution on 10 September 1987**. Today, Geodatastyrelsen plays a vital role in ensuring access to accurate geodata for the entire Danish Realm.

Private Sector and Decentralization: Cadastral work in Denmark is a collaborative effort between private land surveyors and the National Survey and Cadastre. In most municipalities, private surveyors carry out tasks like land demarcation and preparing documents for registering land changes. In Copenhagen and Frederiksberg, municipal authorities handle cadastral work. Surveyors must follow the Subdivision Act, and private surveying firms also offer services in engineering surveys, mapping, and land use consultancy. About 40% of their time is spent on cadastral work, with the remainder divided among mapping, engineering surveys, and consultancy.

Professional Organization: The Danish Geodata Agency oversees the surveying profession in Denmark, ensuring surveyors adhere to the rules. The Danish Association of Chartered Surveyors (DdL) organizes surveying professionals. Surveyors in Denmark have a diverse skill set, combining technical, legal, and design expertise. Most surveyors work in private firms (40%) or public institutions (45%).

Licensing: To become a licensed land surveyor in Denmark, individuals must complete a 5-year course, 3 years in Bachelors and 5 years in Master's degree in Surveying, Planning, and Land Management Field, followed by three years of practical experience in a private firm. After completing these requirements, they can be licensed by the Minister of the Environment. There are exceptions based on international agreements.

Land Registry: The Land Registry plays a crucial role in property formation in Denmark. It helps verify ownership, easements, and other legal rights when land changes occur. Documents from the Land Registry are required for property transfers, especially when the value of the property exceeds certain thresholds (DKK 40,000 or DKK 8,000 for public roads and railways). The Land

Registry is updated after cadastral registrations and is also involved in the registration of condominiums, although these are not listed in the cadastre.

Denmark has emerged as a global leader in cadastral technology, leveraging cutting-edge innovations to maintain an efficient, transparent, and accessible land registry system. The nation has developed a strong and incredibly effective land management framework that incorporates state-of-the-art Geographic Information Systems (GIS), high-resolution satellite photography, and other sophisticated geospatial technologies. Digital cadastral mapping has been implemented by Danish authorities, guaranteeing accurate and current land parcel data. Because these digital maps are connected to land ownership information, they can be updated in real time and easily integrated with different government systems. This integration has improved the accuracy and dependability of cadastral data while significantly cutting down on the time and expenses related to land registration and management.

Denmark has been actively exploring the integration of blockchain technology into its cadastre system to improve the efficiency, transparency, and security of land registration and property transactions. The Danish Land Registry (Land Registration and Cadastre) has collaborated with blockchain technology providers, such as **ChromaWay**, to pilot projects that leverage blockchain for streamlining property transactions and reducing administrative burdens. These initiatives include the use of smart contracts to automate and secure the transfer of property rights, ensuring greater accuracy and trust in the system.

Denmark is also participating in broader European efforts, such as those led by the **European Land Registry Association (ELRA)**, to investigate the potential of blockchain for modernizing land registries across the continent. While blockchain is not yet fully operational in Denmark's cadastre system, the country is at the forefront of research and pilot programs, positioning itself as a leader in adopting this innovative technology for land management. (Agency, n.d.).

The contribution of Denmark's cadastre technology to sustainable development is one of its major accomplishments. Denmark guarantees effective land use while protecting environmental resources by utilizing precise geospatial data and combining it with urban planning technologies. Decision-making about infrastructure development and urban expansion is further supported by sophisticated data analytics and predictive modeling. Other countries looking to update their land administration systems can take inspiration from the nation's emphasis on interoperability, which

allows cadastral data to interface with other digital governance platforms with ease. The success of Denmark serves as a reminder of how technology has the power to transform cadastral systems and guarantee equity and efficiency in land governance.

4.3 Cadastral Survey in Denmark

Danish Geodata Agency is currently under Danish Ministry of Climate, Energy and Utilities. The Danish Geodata Agency is responsible for maintaining key registers related to real property in Denmark, including the Cadastre, Property Ownership Register, and Register of Property Locations. Their objectives focus on ensuring fast and accurate registration, efficient cadastral management, and compliance with modern digital systems. (Agency, n.d.).

Key Activities:

1. **Property Registration**: Handling cadastral changes, condominiums, ownerships, and property location addresses.
2. **Legal Compliance**: Ensuring that property registration rules meet societal needs and legal standards, including the Subdivision and Surveyor Acts.
3. **System Development & Management**: Developing and managing systems like MIA and ERPO for efficient property data processing, and maintaining interfaces for involved parties.
4. **Quality Control & Distribution**: Enhancing data quality, producing cadastral maps, and distributing property information via platforms like Datafordeler.dk.
5. **User Support**: Offering support for users of cadastral records and systems, including guidance on special cases.
6. **Land Surveyor Oversight**: Administering land surveyor licensing and ensuring compliance with the Surveyor Act.

These activities collectively ensure accurate property management and support public and private sector needs related to real estate registration.

The cadastral survey process in Denmark consists of multiple stages and is regulated by Danish laws and regulations to ensure precise property boundaries and land registration. The major steps followed are listed and briefed below (Geodatastyrelsen, 2021):

- **Application**

The process generally commences when a landowner or developer submits a request for a cadastral survey. This may involve subdividing land, consolidating parcels, or clarifying existing boundaries.

- **Preparation**

A certified cadastral surveyor (landinspektør) is appointed to conduct the survey. Relevant property data is gathered, including maps, title deeds, and current cadastral records.

- **Field Survey**

The cadastral surveyor conducts a site visit to measure and delineate boundaries using advanced surveying tools such as GPS and total stations. The surveyor ensures that the boundaries correspond with historical records and agreements among landowners.

- **Stakeholder Involvement**

In cases of boundary disputes, consultations with stakeholders, including neighboring landowners, are conducted. Agreements may need to be formalized to resolve any conflicts.

- **Drafting and Documentation**

A cadastral map is either created or revised to incorporate the new measurements or modifications. Documentation, which includes boundary coordinates and descriptions, is prepared in accordance with Danish cadastral standards.

- **Submission to Authorities**

The surveyor submits the revised cadastral information to the Danish Geodata Agency (Geodatastyrelsen), which is responsible for land registration. If the submission entails changes such as subdivisions, approval from municipal authorities may also be necessary.

- **Registration**

Upon approval, the updated cadastral data is recorded in the national land register (Matriklen) and becomes legally enforceable. The revised information is linked to the land registry (Tinglysningssystemet), which documents property ownership and rights.

- **Completion**

The final cadastral documents are issued to the landowner and other pertinent parties. Any physical markers established during the survey serve as references for future boundary identification.

4.4 Comparison of the Nepalese and Danish Cadastre System

Table 1: Comparison

Aspect	Denmark	Nepal
System Maturity	Fully digitized, centralized, and advanced.	Partially digitized; transitioning from manual systems.
Registration System	**Torrens System**: Guarantees title ownership; highly efficient.	**Improved Deeds System**: Less efficient; prone to disputes and fraud.
Land Registration	Real-time updates; highly reliable and transparent.	Decentralized; inconsistent and prone to errors.
Technology Use	Uses GIS, blockchain, and smart contracts for automation.	Limited use of GIS; NeLIS in practice
Transparency	High transparency; public access to records online.	Limited transparency
Challenges	Cybersecurity and integrating advanced technologies.	Outdated records, land disputes, and lack of resources.
Accessibility	Publicly accessible online; user-friendly.	Limited access, especially in rural areas; reliance on manual processes.
Future Goals	Further integration of blockchain and AI for automation.	Full digitization and improved land governance with international aid.

4.5 Challenges of the Danish Cadastre System

The Danish Cadastre System still faces some challenges. These challenges are listed and explained below(Traeholt HVINGEL & Emil Vindfeld MØLLER, n.d.):

- **Data Quality and Integration**

Achieving consistency among interconnected systems, such as land registries and tax systems, is a complex task. Historical cadastral records may lack accuracy or not align with contemporary digital standards, complicating efforts to reconcile them with current cadastral maps.

- **Digital Transformation**

The shift from traditional paper-based systems to fully digital platforms present various challenges. Keeping digital systems secure, up-to-date, and reliable requires continuous investment, particularly to safeguard against cyber threats and ensure long-term functionality.

- **Boundary Disputes**

Even with a generally accurate system, disputes regarding property boundaries can occur due to vague or outdated definitions. Resolving these conflicts often necessitates legal action, which can be both time-consuming and expensive.

- **Adapting to Modern Needs**

The rapid pace of urban development increases the need for regular updates to cadastral maps. Additionally, climate change effects, such as rising sea levels, may influence coastal properties, requiring ongoing adjustments to cadastral records to account for changing environments.

- **Public Access and Privacy**

While transparency is crucial, protecting the privacy of landowners poses a significant challenge. Furthermore, enhancing the system's usability for non-experts demands improvements in design and functionality to make it more intuitive and accessible.

- **Technological Advancements**

Incorporating new technologies like AI, blockchain, and advanced geospatial tools into the cadastre necessitates careful planning and investment. It is also essential to ensure compatibility

with international standards and emerging systems to facilitate global collaboration and data sharing.

Chapter 5 CONCLUSION

Cadastral surveying plays a crucial role in Denmark's land management and governance, transitioning from traditional methods into a contemporary, technology-oriented system recognized for its precision and effectiveness. Utilizing instruments like GIS, digital mapping, and blockchain, it facilitates property registration, urban planning, and sustainable development.

In spite of its advantages, the system encounters obstacles from urban growth, climate change, and technological progress. Concerns including data quality, privacy, and regulatory compliance necessitate continual innovation and funding.

Denmark’s methodology provides significant insights for other countries, highlighting the value of integrating historical knowledge, technological advancement, and transparency. By tackling new challenges, the system can maintain resilience and adaptability, guaranteeing efficient land administration for future requirements.

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