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Table of Contents

Editorial

NJSR Issue 14:1 comprises three excellent original research papers from the Nordics. The studies represent the fields of Land Management, Real Estate Economics and Law, in line with our journal's wide and varied scope.

The first contribution by Anna Granath Hansson addresses affordable, or *inclusionary housing* through case studies in Sweden and Germany. The paper concludes that, although the two countries in general have similar objectives and structures, there are significant differences in the underlying institutions, as well as the level of public land ownership.

The second contribution is an interesting cross-disciplinary undertaking on what automatization in the public sector will mean for legal decision-making. Magnus Hjelmblom et al. describe and analyze a fictitious property subdivision case from Sweden, focusing on the legal relations between different entities and parties.

The third and final contribution in 2019 examines the various effects of land consolidation in a Norwegian context, focusing on rural areas. Helén Elisabeth Elvestad and Per Kåre Sky find that, the effects of land consolidation are difficult to estimate or to calculate, but may be divided into economic, spatial, legal, environmental and social effects.

The Nordic Journal of Surveying and Real Estate Research wishes to thank all authors and reviewers for their valuable input in 2019.

Looking forward to a new decade of built environment research!

Riikka Kyrö
Editor-in-Chief

Inclusionary Housing Policies in Gothenburg, Sweden, and Stuttgart, Germany:
The importance of Norms and Institutions

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Abstract. *Concerns about affordable housing shortage and social and income segregation have contributed to the introduction of inclusionary housing (IH) policies in a number of Western countries. IH is a term that summarizes municipal ambitions to spur the inclusion of affordable housing in otherwise market-rate projects through development restrictions. The aim of this article is to describe and compare IH policy objectives and incentives in the German city of Stuttgart and the Swedish city of Gothenburg, and to tentatively explain why policy is applied differently in the two cities. The comparative case study builds on the international literature on IH, housing policy documents of the two cities, seminars, and expert interviews. The main findings relate to the decisive impact on policy implementation of underlying slow-moving institutions on housing allocation and the extent of public land ownership. Although IH policies in the two countries generally have very similar objectives and incentive structures, underlying slow-moving institutions decide fundamental traits of the fast-moving institution of IH. In the Swedish case, allocation methods of low-rent apartments under the unitary housing system might prevent targeted polices, such as IH, from functioning as intended. In the German case, IH is integrated into the existing social and affordable housing system. Therefore its social objectives are not contested, although the limitation of private property rights and the incentive structures of developers are bound to be discussed. The extent of public land ownership might also be a decisive factor in whether to implement IH policies or not. Stuttgart has limited public land ownership, and finding inexpensive land for public production is a challenge. Therefore, IH policies might be an effective way to produce affordable housing. Gothenburg municipality owns most of the land available for housing development, has a planning monopoly, and public housing companies with good financial standing. As a result, other, quicker and possibly less costly, alternatives to develop affordable housing could be discussed for Gothenburg. This is especially the case for implementation through public investors. As research on IH policy is scarce in the Nordic context, this paper contributes to the limited literature with the hope of inspiring more research. Future research might focus on how the relatively new housing policy instrument of IH might be applied (or not) in a Nordic city development context.*

Keywords: affordable housing, housing policy, housing systems, inclusionary housing (IH), municipal land

1   Introduction

In the last decade, affordable housing shortage and concerns regarding social and income segregation have become focal points of housing policy debate in many Western countries. In order to increase affordable housing supply, several governments have reformed urban development processes and/or increased the scope of targeted affordable housing policies (Granath Hansson, 2017b). A general shift away from traditional ways of providing affordable housing, involving mainly public actors and including supply-oriented support, toward market solutions including private financing and demand-oriented support has taken place (Gibb, 2011; Marom and Carmon, 2015). The shift has inspired a search for new institutions that fit the new institutional setting.

Inclusionary housing (IH) policies aim to create affordable housing in otherwise market-rate housing projects through development restrictions. These IH policies have emerged as a key housing policy tool in a wide range of countries, including the US, the UK and France. The main aims of such policies are the extension of affordable housing supply and mixed-income housing areas (Calavita et al. 1997). As affordable housing has advanced on the housing policy agendas in Germany and Sweden, IH has caught the attention of cities (Göteborg, 2014; Stuttgart, 2013b). Several German cities apply land policy strategies, of which IH is a part. In Sweden, IH is not applied as of yet, but a pilot project is now being negotiated in Gothenburg. One further project is planned in Örebro.

This study compares the institutional set-up of IH policies in Stuttgart, Germany, and Gothenburg, Sweden, with the aim to tentatively explain why IH is applied differently in the two cities. The research questions have been formulated as follows: What are the policy objectives behind the introduction of IH and how are they shaped by the wider institutional prerequisites? How do agents' incentives shape the design of IH policies? Compared to other north-western European countries such as Great Britain and the Netherlands, there is only limited research on German IH models, and almost none on Swedish IH models. It would be of interest to better understand how the relatively new housing policy instrument of IH fits into the German and Swedish housing systems, and what drives the development of the models in the two countries. This article is meant to close part of the present research gap.

The article is structured as follows: After this introduction, the literature review and the methodology section are presented. Thereafter, the results section describe the development of IH policies in Germany and Sweden to date, national rent-setting principles and the two case studies with regard to policy objectives, policy design and developer incentives. Then, the cases are analysed and discussed in relation to the literature. Last, conclusions are drawn.

2   Inclusionary housing and socially mixed neighbourhoods in the literature

Inclusionary housing (IH) policies summarize municipal ambitions to spur the inclusion of affordable housing in otherwise market-rate projects. The aim of IH policies is twofold: to increase affordable housing supply, and to create mixed-

income housing areas (Calavita et al., 1997). Programmes might address low-income or moderate-income households or both groups. IH programmes should be seen as an alternative to traditional public or social housing schemes. Such programmes have increased in popularity since the 1990s as housing policy in much of the Western world became a local rather than national policy issue. Simultaneously, there was a general trend toward more market-based solutions. IH policies have been seen as a tool for governments to take advantage of increased land values in strong housing markets (Schuetz et al., 2009).

IH policies have been applied in the US since the 1970s (Calavita and Mallach, 2010). Great Britain was the first country in Europe to adopt such policies, through the introduction of section 106 in the Town and Country Planning Act (Monk, 2010). The City of Munich in Germany followed suit in 1994, but it was only in 2009 and onwards that the practice spread in the country (Friesecke, 2015). Swedish municipalities have as yet not adopted such policies, with the exception of Gothenburg, where a pilot project is now being negotiated between the municipality and developers (Granath Hansson, 2017a). Örebro also intends to adopt an IH policy.

A general definition of IH that applies to most countries is: "Land use regulations that require developers of market-rate residential development to set aside a small portion of their units, usually between 10 and 20 percent, for households unable to afford housing in the open market. Alternatively, they can choose to pay a fee or donate land in lieu of providing units" (Calavita and Mallach, 2009, p. 15). IH can include municipal land provision at below-market price, land situated in locations that create social mix and the subsidy of projects out of development gains (de Kam et al., 2014). Developers participating in IH projects are compensated financially and/or receive regulatory relief. IH models vary between jurisdictions, but a number of ingredients are recurrent: density bonuses, in-lieu fees, construction in nearby locations, municipal land allocation, and financial subsidies.

In the UK, the country in Europe with the longest experience, such policies constitute the main tool for providing affordable housing (Gurran and Whitehead, 2011). However, it is noted that the system cannot deliver the needed amounts of affordable housing, especially during recessions (Mulliner and Maliene, 2013). Also, in the US, researchers argue that IH should be part of affordable housing strategy but that it cannot be the core of such strategy (Calavita et al., 1997). British and German researchers note that IH can be one tool to increase the supply of affordable housing, but not the only one, and that public subsidies are also necessary (Drixler et al,. 2014; Whitehead, 2007). It should also be noted that, policy design and extent of policy implementation vary over time, depending on, inter alia, antiregulatory pressures and economic trends (Calavita et al., 1997).

In the US, some states use IH policies as part of "fair share" politics under which all municipalities have to provide a certain share of affordable housing. In California and New Jersey, where such policies have "produced significant and measureable results" (Calavita et al., 1997), higher levels of government and the courts have been involved in policy enactment. Both states apply a cost-offset approach to lower the burden on developers. Calavita et al. (1997) argue that the

Californian model is likely to survive because of its adaptability when political and economic circumstances change. Compromises are made regarding affordability, cost-offsets and flexibility for developers. A preference for home-ownership over rental is also pointed out (Calavita et al., 1997).

De Kam et al. (2014) expect a strong relation between the wish to introduce IH, and housing systems. IH is claimed to be considered in locations where there is a shortage of affordable housing and where this shortage is considered to create important problems. Such problems might be functional, such as the undersupply of key workers, or social, such as segregation or the undersupply of services for certain types of households. The amount of housing expected under IH policies depends on the composition of current housing stock and on other policy measures. The choice of whether to implement IH or not will depend on the attractiveness, efficiency, cost, ease of implementation and acceptance of alternative policies. Further, de Kam et al. (2014) expect the wish to introduce IH to be stronger in dual housing systems than in unitary ones, since housing is more segregated and public budgets for social housing schemes are expected to be smaller. Also, IH policies are expected to be more popular in countries where public control in the urban planning process is less pronounced, which is supposed to result in market-driven housing production, which, in turn, might cause segregation. The size of the development surplus is expected to be a driver for municipalities to implement IH, as the use of such surplus could reduce the burden on public budgets. De Kam et al. (2014) also point out that IH "cannot be introduced without an appropriate definition of the types of housing and households that are eligible to benefit from it" and that an "important condition for acceptance and societal support of IH is usually the capacity of the housing system to retain the benefits of IH for eligible households exclusively, for a reasonable number of years" (De Kam et al., 2014, p. 397).

IH has been much criticized for the negative impact it might have on housing supply (partly contradicted by Mukhija et al., 2010), development cost (Kontokosta, 2014), and housing prices (partly contradicted by Hughen and Read, 2014). Hughen and Read (2014) also suggested that developers are likely to respond to policies by strategically altering production decisions. Here it must be pointed out that policy outcomes vary as much as do policy designs: no generalizations can be made; rather, each policy must be evaluated on its own merits (Schuetz et al., 2009). The effectiveness of such policies in terms of the amount and location of affordable housing is dependent on, for example, programme structure, political will to enforce policy, extent of supporting land-use policies, local housing market strength, and potential opposition to development (Kontokosta, 2014).

Socially mixed neighbourhoods are widely viewed as important in European housing policy (e.g. Calavita and Mallach, 2010; Grundström and Molina, 2016; Göteborg, 2014; Stuttgart, 2015; van Ham et al., 2016), as it is deemed to be a fundamental prerequisite of social cohesion. Musterd and Andersson (2005, p. 762) describe the underlying assumption, that "housing mix (a mix of housing types and tenure types) will create social mix (a mix of households according to their socioeconomic position) and that this will create better social opportunities for individuals". Social mix policy and literature either focus on income or ethnicity,

or both, as the parameters in many cases are interrelated. Skifter Andersen et al. (2016) show that housing policy and housing market composition affect ethnic segregation in four Nordic capitals, although the level of immigration also has to be taken into account. Different housing policy instruments are used to achieve social mix, among them, IH. However, Galster (2007a, p 35) describes neighbourhood social mixing policies as "based more on faith than fact". Further, Galster (2007b) finds support for mixing policies only on equity grounds, but not on efficiency grounds. Musterd and Andersson (2005) find little correlation between housing mix and social mix in a study using Swedish data. A distinction between place-based and people-based policies to reduce segregation is often made. Winston (2017) concludes that housing and neighbourhood conditions are less important to quality of life than socio-demographic factors are. Van Ham et al. (2016, p. 17) suggest that "to really make a change, policy should focus on people and not on areas", inter alia education and investments in infrastructure that enhance mobility. Further, the link between social mix and social inclusion have been questioned (e.g. Arthurson, 2002). Bolt et al. (2010) indicate that there is no straightforward link between integration of immigrants and housing segregation. Drever (2004) suggests that the correlation between social and spatial integration of immigrants can be questioned in some contexts and point to the potential larger importance of workplace and school contacts compared to home location.

The literature shows that to understand local IH policies, they must be analysed based on policy objectives and incentives provided in practical implementation, as well as in relation to the wider housing system. The research questions were formulated to enhance understanding of these topics in relation to the German and Swedish cases.

3   Methodology

The study was conducted as part of a larger research project investigating institutional prerequisites for housing development in Germany and Sweden, in response to the intense public debate on increasing housing shortage and housing policy reform in major cities in Germany and Sweden in recent years. Within the larger research setting, IH policy was identified as a relatively new, fast-moving institution which had attracted only limited research interest and was seldom discussed in relation to the prevalent housing system, and therefore would be important to study further.

The study is restricted to Germany and Sweden, as these two countries are deemed to have similar prerequisites when it comes to the project development institutional setting, the political perceptions of the role of housing in the welfare state, and demographic structures, which to a large extent decide appropriate measures and scope of action. Although the German and Swedish housing provision systems are similar in many respects, and the uncontrolled variables therefore are limited, there seems to be variation in the independent variables whose effects are of interest (Pickvance, 2001).

The literature review revealed a clear limitation of studies related to Germany and Sweden and also indicated that German cities tend to shape policy based on

local prerequisites. To be able to understand how policy is applied in depth, rather than providing an over-view of several city policies, the study was designed as a comparative case study of one German and one Swedish case. Case selection was based on critical cases, to make the relation between the cases particularly clear (Yin, 2006). In a strategic information-oriented sampling (Flyvbjerg 2006), one German best practice example (City of Stuttgart) was chosen, as well as the pilot project in Sweden (City of Gothenburg) which is the best developed Swedish policy to date. The main features of each case are described in Table 1.

Table 1. Main case features.

Feature	Stuttgart	Gothenburg
Case type	Best-practise	Pilot
Policy level	Municipal	Municipal
Policy implementation area	The whole municipality	One development project
Policy existence	8 years	6 years
Number of built projects	Multiple	None
Covered by the literature	Few studies available	Almost non-existent
Policy documentation	Solid	Scarce
Availability of interviewees	N/A	Good participation

The comparative case study used a fixed design, first describing each case in some detail, then comparing the two cases and finally analysing and trying to explain why policies were implemented differently in the two cases. The descriptions and the comparison were focused on the parameters of the research questions: policy objectives and incentives of agents. The data was extracted from the literature, policy documents, seminars and expert interviews. Housing policy documents related to urban planning, housing provision and IH policies were studied for both cases (please refer to the reference list). The Swedish data was complemented with expert interviews (Trinczek, 2009) as policy is under development and written documentation is therefore limited. Interviews were made with three representatives of the City of Gothenburg, three of the participating developers and the interest organisations the Tenants' Union and the Private Property Owners' Federation. The German case is of longer standing and well documented and therefore no interviews were deemed necessary. The data was collected and up-dated continuously through participation at seminars and conversations with involved agents in the period 2015–2018.

Although the study makes a practical and empirical contribution, as results have relevance to ongoing housing policy reform, the fact that the study is restricted to only two countries and two cities presents a clear limitation. However, the study can easily be linked to the extensive European literature on IH policies, provide a new piece in the puzzle regarding German and Swedish policy development, and hence provide material for analytical generalization. Further, research on IH in a Nordic context is very limited and this study may contribute to a deeper understanding of how this relatively new housing policy instrument fits into the Nordic city development context.

4   Case descriptions: Inclusionary housing policies in Germany and Sweden

The following four sections describe how IH policies have developed in Germany and Sweden to date, the potential impact of rent-setting principles, as well as the two case studies.

4.1   *The development of IH policies in the two countries to date*

In Germany, several cities (e.g. Hamburg, Munich and Stuttgart) apply so-called land policy models to finance investment in infrastructure, social infrastructure and affordable housing. These models set forth the basic principles for distributing tasks and costs between developers and municipalities in development agreements. The models, as opposed to case-by-case decisions in each development agreement, ensure predictability and transparency as they are implemented in all projects. In relation to housing, such models are intended to create affordable housing, preferably in socially mixed areas. Additional costs incurred by the developer due to these requirements are usually capped at two thirds of the planning-related land value increase (Drixler et al., 2014).

In practice, cities often set a goal that a certain percentage, typically 20–30 percent of the apartments in each new building, should be affordable. Models typically target rental housing, but some models also encompass ownership housing. When subsidies are given, in the form of low-cost land and/or direct investment support, rents are guaranteed for a certain period, typically 15–30 years. In some cities, it is possible to construct affordable housing in another location within a certain distance of the initial development or to transfer the liability to another developer.

Though following the broad outline described above, each city has developed its own model based on its own needs. Experience of land policy models is relatively recent in Germany. The City of Munich was the first to adopt such a policy in 1994 and has been followed by several more cities since 2009. As the German experience is relatively limited, so is the evaluation of the German models. Though success depends greatly on local prerequisites and local policy design, such policies are generally deemed a success (Friesecke, 2015). However, negotiations between cities and developers are not always without friction (Immobilienzeitung, 2017).

An assessment of German land policy models notes, for example, the following (Drixler et al., 2014): The presence of public subsidies is still a basic prerequisite for increasing the supply of affordable housing. As certain restrictions mean that the models are applied to only a limited number of projects, to have an impact on general housing affordability in the various cities, they must be applied for a longer period, as has been the case in Munich, for example. The development and implementation of land policy models presupposes sufficient planning capacity, as it is a dialogue-based process. In areas where such policies are applied, social mix is attained. Whether such policies lead to less social mix in surrounding areas has not been demonstrated. Land policy models are not viewed as a possible solution to integration problems. It has not been proved that

investors view neighbouring subsidized housing as negative. It is still an open question whether land policy models actually lead to lower land prices. Evidence from Munich contradicts this hypothesis. Investors are treated equally. Regional cooperation in metropolitan areas is necessary.

Friesecke (2015) points to a number of success factors of German land policy models, inter alia, broad agreement among the involved public and private stakeholders to create long-term stability, equal treatment of developers, transparency and clarity, reliability and regional cooperation. Further, the flexibility of land policy models "allows each city to develop its own strategy based on its own needs, but it may not be an (economically) reasonable road to success everywhere" (Friesecke 2015, p. 135). Weitkamp et al. (2017) suggest that to reach goals of city housing policy and expand affordable housing supply, IH policies have to be combined with other housing policy tools.

In Gothenburg, Sweden, an IH pilot project is being negotiated since 2013. Policy design is not yet certain, but the main issues and current state of negotiations will be described below. Also in Örebro such policy is planned to be implemented. Both the Gothenburg and Örebro model target rental housing. Smaller Swedish municipalities have also implemented projects with IH-similar structures resulting in ownership cooperative housing. The Swedish case is different from most other European countries applying IH because of its unitary housing system and large municipal land ownership.

4.2   *National rent-setting principles*

The output of the studied IH policies is mainly rental apartments, although limited ownership models are included in Stuttgart. As rent-setting principles are key to policy objectives and investment calculus, the two different systems applied in Germany and Sweden are described below. As pointed out by de Kam et al. (2014), there is also a link between allocation efficiency and policy acceptance.

In Germany, rents in the main part of the housing stock are set in direct negotiation between the landlord and the tenant. However, rent brakes (*Mietbremse*), which is a form of rent regulation in the market rate stock, have been introduced in a number of cities since 2015 (Deschermeier et al., 2016). Newly constructed housing is excluded from rent brake regulations. Strictly regulated rents are applied in social housing units (*sozialer Wohnungsbau*), to which access is reserved for predefined households, mainly on the basis of income. Five percent of the housing stock is estimated to be social housing (Droste and Knorr-Siedow, 2014). Although the amount of social housing has varied over time, along with the alteration of policies, the basic provision system has been sustained over a long period of time and is generally accepted.

Sweden has long been considered to have a unitary housing system (Kemeny, 1995), meaning that no part of the stock is reserved for specific groups on the basis of income. Rents are set according to a so-called 'user-value' system, in negotiations between the Tenants' Union, the municipal housing companies and (since 2011) the Private Property Owners' Federation (Lind, 2014). Since 2006 rents in new buildings are set according to a parallel system that applies for the

first 15 years after completion, which allows for considerably higher rents than in the stock constructed prior to the new regulation. The 'user-value' system has been in place since rent regulation was discontinued in 1968. The main allocation channels of rental apartments in the larger cities are central waiting lists organized by the municipalities. In recent years, the system has been much criticized for its division between 'insiders and outsiders', and even challenged in the EU court. However, its defenders have managed to prevent larger reform. Based on changes of social and economic contexts and changes to the housing system, it has been questioned if the Swedish system can still be called unitary (Stephens, 2017).

4.3   Case Gothenburg

Gothenburg's housing policy programme (Göteborg, 2014) includes measures related to municipal land management, reorganization of urban planning and development measures and activities of municipal housing companies. The city emphasizes social and income mix as a focal point of housing policy with the aim of reducing segregation. The districts identify families with children and senior citizens as focus groups. Students and younger households were also pointed out by the central city administration.

The goal is to construct 3,000–5,000 new apartments a year in the city, plus an additional 7,000 units as part of the city's 400-year jubilee in 2021. In 2017, 2,201 new apartments were completed, including 1,328 tenant-ownership apartments and 324 rental apartments. The four municipal housing companies aim to build 1,400 apartments a year. In 2017, 305 apartments were completed, compared to 345 in 2016 (Framtiden, 2018). A new organization has been put in place to increase completion numbers.

The main aim of the IH policy in Gothenburg is to open up the centrally located and attractive redevelopment area Älvstranden to a wider layer of the population. Under the motto "Everybody should be able to live in Älvstranden" a part of the former harbour area called "Frihamnen" has been selected as a test bed for IH policy. The objective is to create a socially mixed area. The general provision of affordable housing is only a secondary objective. However, increased policy focus on affordable housing in the last three years has strengthened the secondary objective considerably.

In Gothenburg, all land on which the IH policy is applied belongs to and is allocated by the municipal development corporation Älvstranden Development. The basic scope of developer participation is set through the concept competition at the start of the process. The details of participation prerequisites are then negotiated in the consortia agreement, in development agreements and in urban planning documentation as the project evolves.

1,100 rental apartments are planned for the pilot project area; 550 of these apartments are expected to be low-rent. Rents are set at four levels, each encompassing 25% of apartments: 1,000, 1,400, 1,850 and optional SEK/m^2 and year (equivalent to approx. 8.75, 11.70, 16.25 and optional EUR/m^2 and month). The two lower levels are seen as low levels for new housing, whereas 1,850 is

regarded as a mainstream level. Apartments with different rent levels are expected to be mixed within the same building, sharing the same entrance.

Rents will be kept fixed for 15 years, followed by a five-year step-up period, to adjust them to the user value rents applied in the rest of the Swedish rental housing stock (*bruksvärdesystemet*). As below-user value rents are an exception to the Swedish rent-setting system, a new rent-setting principle has to be established. Rent discounts tied to the tenant or inverted new construction rents (*omvänd presumtionshyra*) tied to the apartment have been suggested.

The mode of allocation of the low-rent apartments to be applied has not yet been decided upon. The Tenants' Association, which under Swedish rental law has a strong position in the negotiation of rents, advocate that apartments should be allocated according to waiting time on the central waiting list for rental apartments, called Boplats. However, a survey done by Älvstranden Development showed that households with long waiting times are generally older and more affluent than households with shorter waiting times (Boplats, 2015). Älvstranden Development therefore advocate a mixed allocation strategy in which 350 of the 550 low rent apartments will be allocated to households with lower incomes and in some cases social problems. Under the proposal, the municipal housing company is supposed to allocate 150 apartments to homeless families with children and 30 to other vulnerable households, under so-called social contracts which are time-limited, but could be converted into long-term after a trial period. In accordance with the wishes of the participating private developers, 270 apartments in their buildings are suggested to be allocated through a combination of an income ceiling (the household cannot earn more then 3–4 times the yearly rent) and waiting time on the central Boplats waiting list. However, once tenants have moved in, no further income assessment will be made. Should household income increase over time, there will be no change in rent level and the tenant will be allowed to keep the apartment.

In Gothenburg, land allocation is made exclusively to the participants in the consortium at below-market rates. Developers also receive allocation of land to build owner-cooperatives. Further, priority in the urban planning process is secured. A special task force has been formed in the municipality to guide Frihamnen and some other prioritized projects through municipal procedures. As urban planning is generally regarded as a bottleneck in the housing development process (Granath Hansson, 2015), such priority might have considerable value, although it is difficult to quantify. Promises to take part in later stages of the project are also expected to incentivize developers to participate in the pilot project.

A new central government subsidy programme, implemented in 2016/2017 but with retroactive effect from 2015, is reserved for small, "climate-smart" apartments with rents below certain thresholds. The low-rent apartments in Älvstranden might be eligible under the program. However, at the time the selection of developers was made by the city, no such subsidies existed. Developers are hence expected to manage the project set-up without subsidies, but their introduction will create an additional incentive.

Although rents of 75% of apartments are set by the municipality, 25% of rents may be set by the developer. This principle is an exception from the

Swedish rent-setting system. Developers are allowed a high degree of freedom in project design. Apartments in different rent segments are designed differently. Differentiating factors might be equipment, standard, situation within the building and size of flats. Equipment might include apartment-specific equipment, as well as access to parking and laundry facilities, for example.

The four actors that have chosen to participate in the project are the municipal housing company, a state pension-fund-owned developer (which sometimes refers to itself as "the state housing company") and two smaller private developers. The City of Gothenburg expects to develop its IH concept as the next phases of the project are implemented over the next decade. To compensate developers for loss of rental income and induce them to participate under IH policies, a set of incentives is provided in both Gothenburg and Stuttgart (Table 2).

Table 2. *Incentives towards project participation and related agents.*

Incentive	Agent	STU	GOT	Quantifiable
Municipal land allocation	City	Yes	Yes	Difficult
Lower price of land	City	Yes	Yes	Yes
Density bonus	City	No	No	Yes
Build low-rent apartments in other location	City	Yes	No	Yes
In-lieu sales of land to the city	City	Yes	No	Yes
In-lieu fees	City	No	No	Yes
Right to build ownership apartments	City	Yes	Yes	Yes
Priority in the urban planning process	City	Yes	Yes	Difficult
Promise to take part in later stages	City	No	Yes	Difficult
Differentiated rents	City/developer	Yes	Yes	Yes
Possibilities to influence project design	Developer/city	Yes	Yes	Yes
Subsidy	State/ city	Yes	(Yes)	Yes

4.4 Case Stuttgart

Stuttgart's housing policy programme Living in Stuttgart (Wohnen in Stuttgart) includes measures related to subsidy policy, land management and activities of the municipal housing company. The main aim of the policy is to increase the supply of housing, especially targeting affordable and social housing for low- and mid-income groups. Families with children and senior citizens have been identified as prioritized groups. A secondary objective is to keep and develop social mix (Stuttgart, 2013a).

Stuttgart's IH policy, called the Stuttgart Inner Development Programme (SIM), was introduced in 2011. It foresees that 20% of all newly constructed housing floor area in the city shall be subsidized housing reserved for low- and mid-income groups at pre-defined rents (Stuttgart, 2015).

The goal of Living in Stuttgart is to construct 1,800 new apartments in the city per year, of which 600 would be subsidized. In 2016, 2,125 new apartments were constructed, of which 99 were in single-family housing (Stuttgart, 2017). The municipal housing company, SWSG, produced 415 new apartments in 2015,

of which 357 were rental and 58 were owner-occupied; 217 units were subsidized (SWSG, 2016). In 2016, SWSG completed 98 new rental apartments, 11 owner-occupied apartments and 37 buildings for refugees (9 in 2015) (SWSG, 2017).

In Stuttgart, the IH policy regulates affordable housing provision in the whole city, both on private and municipal land. There are three groups of promoted housing: social housing, affordable rental housing for mid-income groups and affordable home-ownership. The basic rule is that 20% of all newly built housing floor area must fall under the local housing subsidy programme. Two distribution patterns are foreseen, either one third each of the three prioritized housing forms will be built or 50% social housing / 50% affordable rental housing and/or affordable home-ownership will be chosen. Alternatively, subsidized housing might be built within a one-kilometre radius or land must be sold to the city at a below-market price. In case housing is built elsewhere, the subsidized proportion must be 30%. When municipal land is allocated to a project, the affordable housing share might be up to 50%. It is not possible to pay a fee to avoid affordable housing requirements. Commitment periods and maximum rent levels are outlined in Table 3, along with cost reductions for affordable home-ownership initiatives. Access to subsidized housing is limited by a set of rules related to household size, household income and apartment size.

Table 3. Commitment periods, maximum rent levels and cost reductions in Stuttgart.

Type	Commitment length (years)	Max. rent (EUR/m² and month)	Other measures
Social housing	15	7.5	
Affordable housing	15	8.5 (9)	
Affordable homeownership	10	N/A	30% reduction of infra-structure provision cost

The above model is capped by the planning related land value increase. One third of the estimated land value increase created by urban planning is reserved for the developer. The remaining two thirds finance 1) urban quality; 2) costs of urban planning, infrastructure provision (including social infrastructure) and green spaces, and; 3) affordable and social housing. The policy applies to projects encompassing more than 450 m² or approximately five housing units. Projects encompassing 450–1,350 sqm. (5–15 units) shall include affordable housing. Projects larger than 1,350 sqm. also have to include social housing. Developers are obliged to start construction within three years.

The policy is applied in the whole city when new urban planning creates a land value increase. The basic principle is that one third of the land value increase stays with the developer as an investor incentive. The remaining two thirds might be used for urban planning, technical and social infrastructure, green space and social and affordable housing, according to the development agreement between the city and the developer.

Low-interest-rate loans are made available for all social and affordable housing units within the programme. For social housing units, it is also possible

for the city to provide complementary financing. The federal state of Baden-Württemberg also provides subsidies for social housing development. When development takes place on land initially owned by the municipality and 50% shares of affordable housing are expected, land is sold at below-market levels.

Causality and limits in cost distribution, transparency and equal treatment of investors are pointed out as important principles by the city. Each development proposal is evaluated separately and a certain flexibility depending on the circumstances of each case is foreseen. Negotiations on SIM conditions are expected to run parallel with development planning such that it does not lead to prolonged development processes (Stuttgart, 2015).

5   Findings and discussion

Below, policy objectives, incentives and policy design, as well as policy effectiveness and alternative structures, are analysed and discussed. An overview of similarities and differences between the cities is provided in Table 4.

Table 4. Comparison of the two cases.

Parameter	Stuttgart	Gothenburg
IH policies in other cities in the country	Yes	No (but under consideration)
Policy implementation area	The whole city	One development area
Year of implementation	2011	Under negotiation since 2013
Policy objectives	Expansion of affordable housing supply Social mix	Social mix Expansion of affordable housing supply
Housing allocation to low- and medium income households	Yes	Yet unclear
Existing social and affordable housing framework	Yes	No
Extent of municipal land ownership	Limited	Large
Policy applicable to municipal land	Yes	Yes
Policy applicable to private land	Yes	No
Non-monetary incentives to developers	Yes	Yes
Monetary incentives to developers	Yes	Yes
Leading developers	Private	Municipal and semi-public

5.1   Policy objectives

The underlying norms of IH policies in Stuttgart and Gothenburg seem very similar: low- and mid-income households would benefit from a larger affordable housing supply and mixed-income housing areas, and therefore IH policy objectives should be to create such housing. There seems to be a clear focus on equity rather than on efficiency (cf. Galster, 2007b).

However, the translation of norms into proceedings in the form of policy formulation and implementation does vary between the two cities. In Stuttgart,

the IH policy is fitted into an established social and affordable housing model, whereas in Gothenburg, established rent-setting and allocation principles are tentatively renegotiated and a new type of subsidy is tested.

Germany has an existing institutional framework for social and affordable housing rent-setting and target group definition that has been in place for many years and, although the scope of provision is often discussed, the system as such is generally accepted. In Sweden there is strong resistance against defining target groups on the basis of income, both from politicians and the Tenants' Union, as it does not agree with the unitary housing model. In Gothenburg, below-market rents in part of the project are generally accepted, although the official way to fit them into the existing "user-value" system is under discussion. However, the wish of project participants to define target groups on the basis of income is contested by influential agents.

An essential part of evaluating housing policy outcome is to investigate whether objectives are attained. To assess whether target groups and the intended level of affordability are reached, there must be an objective to compare outcomes to. Based on predefined target groups and rent levels, German policy makers can prove positive or negative outcome of housing policies. Swedish policy makers, on the other hand, at present will be able to prove whether or not the affordable housing supply has been expanded, but they cannot ascertain whether the affordable housing created is also occupied by households with low- and mid-range incomes. As pointed out by de Kam et al. (2014, p. 397), acceptance and societal support of IH depends on the capacity of the policy to define a target group and to "retain the benefits […] for eligible households exclusively, for a reasonable number of years". In the Swedish case, effective targeting and the societal support tied to it cannot be guaranteed.

In an attractive area like Älvstranden in Gothenburg, development will either be market priced at high levels or rents will be set according to the separate system for new-build, which will be attainable only to above-average-income households. To create social mix in the area, low- and mid-income households must be assisted to enter the local housing market, which is also why the IH policy was introduced. Should no income testing occur, and the affordable apartments be distributed according to waiting-list rules, a majority of mid- and above-average income households are expected to occupy the affordable housing created, and social mix will not be attained. Alternatives that are up for discussion are a combination of an income ceiling and waiting lists and allocation to households chosen by the municipal social authorities.

In this specific case, it can be concluded that the slow-moving institution of the Swedish unitary housing system prevents or at least prolongs effective implementation of new fast-moving institutions such as IH policies. As Roland (2004) points out, appropriate fast-moving institutions should be chosen with consideration to slow-moving institutions. Should the ideal of unitary housing policy prevail in Sweden, IH should probably not be part of affordable housing policy, as it cannot be ascertained that it is effective. Instead, alternative ways to increase affordable housing supply and to promote social mix could be explored.

However, in the German case, IH policy is geared in such a way that an expansion of affordable housing supply is ascertained for a certain period of time for the benefit of the target group.

Further, based on the literature on social mix and housing policy (cf. Musterd and Anderson 2005 and others), it must be regarded as uncertain whether mixed-income neighbourhoods have the intended impact on social and ethnic integration. Results in different projects are bound to differ. A German study shows that German IH policy has a positive impact on social mix, but that IH is not deemed an appropriate tool to achieve ethnic integration (Drixler et al., 2014). Follow-up studies should not only analyse whether mixed-income neighbourhoods are achieved, but also try to measure results of social integration, that is, to determine the extent to which people not only live side by side but also interact. As social mix is the primary goal of Swedish IH policy, alternative strategies might also be explored.

5.2 Incentives and policy design

The major incentive difference between Stuttgart and Gothenburg is land allocation. German IH policies are applied on private and public land, with greater restrictions when public land is allocated. At present, Swedish IH policy is applicable to public land only. In this context, it should be noted that the City of Stuttgart has only limited land ownership, whereas the City of Gothenburg owns an estimated 70–80% of all land planned for housing within its jurisdiction (Caesar, 2016). Although including private land in the policy might be regarded as a limitation of private property rights, the decision of the city is based on what is regarded as an important public interest and that the process to reach policy objectives would otherwise be too long. Obviously, the decision to limit private property rights was part of the process when introducing the IH policy. Should the City of Gothenburg choose to expand the IH policy to the whole city, developers that do not own land, for example, smaller developers that are not financially strong enough or new market entrants, would to some extent be forced to accept conditions as it would otherwise be impossible for them to do business in the city. Land owners, usually larger developers with a longer presence in the city, will have greater chance to avoid restrictions. To avoid such market distortion, the City of Gothenburg would probably have to impose restrictions on private land also should they decide to expand the policy. It is clear from Swedish debate on the pilot project that such limitation of private property ownership rights will meet strong opposition. It should also be noted that, should the policy be expanded to the whole city, it is probable that Gothenburg will reach objectives more quickly than Stuttgart as restrictions on public land are greater and more project development takes place on public land in Gothenburg than in Stuttgart. However, in Sweden, developers might avoid participating in IH programmes in Gothenburg as they might relocate to other jurisdictions (cf. Hughen and Read, 2014). In Germany, such action would be more difficult as a number of cities now apply IH policies.

IH policies are simultaneously driven by political conditions and market forces and are thus sensitive to pressure from both. In a strong market environment

IH policies might be an appealing political strategy to increase affordable housing supply without substantial public investment. However, when markets decline, developer resistance might increase and general political support for affordable housing policies might be uncertain (Calavita et al., 1997). The amount of housing produced is therefore expected to vary over time (Mulliner and Maliene, 2013). A recent Swedish study proposes that IH policy might only be successful in the most attractive locations and at times of good market outlook (Danell and Olausson, 2016). The Stuttgart IH policy explicitly provides for flexibility and case-by-case decisions based on, inter alia, financial grounds (Stuttgart, 2013b; cf. Calavita et al., 1997). It should be noted that some incentives offered in other countries, such as density bonuses, are not officially part of policy in the two cities.

The Swedish IH pilot project is dominated by publicly owned actors, which contradicts the assumption that IH should produce affordable housing mainly through private housing development. Should IH policy be further developed in Sweden, more private participation would be expected to motivate the use of the model. In the Gothenburg model, the scope of participation and compensation is not fully quantified at the outset, but is negotiated between the parties as the project evolves. It is up to the developer to opt out if along the way it becomes apparent that the project will not be profitable enough to justify participation. Potential land value increases based on urban planning do not come into play (cf. De Kam et al., 2014; Schuetz, 2009), as the land belongs to the municipality and is only paid for once the local plan has come into force. In Stuttgart, planning related land value increases cap participation on private land. Although values might be adjusted in the development process, a clear indication of the expected scope of participation is conveyed by the municipality to the developer at an early stage. Transparency on decisive investment parameters is probably seen as a basic requirement by many developers, and lack of such quantifications (or indications) might reduce the number of potential participants, reducing potential competition.

Planning capacity has been identified as a scarce resource in German and Swedish cities (Granath Hansson, 2015). An assessment of German IH models (Drixler et al., 2014) notes that the implementation presupposes sufficient planning capacity, as it is a dialogue-based process. When IH polices are implemented in cities where planning capacity is limited, cities will have to prioritize IH projects. It is highly probable that other projects will then face longer planning processes. Whether this is acceptable or not, and what effects this might have on housing construction, should be taken into consideration by cities.

Furthermore, Drixler et al. (2014) and Whitehead (2007) state that public subsidies are a basic prerequisite for increasing the supply of affordable housing. Public subsidies might come as land provision or financial subsidies. As we can see in the two cases, both types of subsidies have been included, although financial subsidies have come in as a bonus after the start of negotiations in Gothenburg.

Drixler et al. (2014) point out that policies need to be in place for some time before they are able to produce larger amounts of affordable housing. This view is shared by high-level city officials in Gothenburg: "Many models and a number of projects will be needed before we will reach a model that can be described as

a model for long-term socially sustainable housing" (GP, 2015). For the Swedish programme to gain momentum, it has to be substantially expanded, also beyond the Älvstranden area.

The City of Stuttgart has, after an initial two-year trial and development period, implemented a complete model applicable in the whole city, which promotes transparency and predictability. The introduction of one policy for all projects in the city might have increased stress on municipal functions, but it also led to a quicker learning curve. Further, when Stuttgart introduced its IH policy it could point to the perceived success of such a policy in Munich, which might have increased acceptance. The approach of the City of Gothenburg and its choice of only one pilot project were shaped by the initial focus on income mix in that certain area. However, as the first IH pilot project in the country, it has received nation-wide attention and has been seen as an important indicator in the development of affordable housing policy in the whole country. This has attracted considerable interest among agents that would not normally comment on or engage in individual projects, something which might not have reduced strain on agents directly involved in the project or improved chances of success.

5.3   Policy effectiveness and alternative strategies

According to de Kam et al. (2014), the implementation of IH policies will depend, inter alia, on whether they are considered to be more attractive than alternative policies, the size of the development surplus and how the planning system allocates property and development rights. In the Swedish case, it should be observed that the norms of IH policies are questioned not only by private developers but also by the Tenants' Union and politicians. Planning gain is argued to be of minor importance because of large public land ownership, and the municipal planning monopoly provides the city of Gothenburg with substantial power to implement policy. Moreover, the larger part of housing in the pilot project will be produced by public entities. Should these circumstances prevail, direct development of public housing might be more time and cost efficient when it comes to expanding affordable housing supply. As the city has control of land and urban planning, it might assist its municipal housing company and other interested public companies to start producing immediately instead of participating in lengthy negotiations. In order not to exclude interested non-public parties, stringent land allocation competitions might be used with the same demands as in the present project, but for designated lots of land. In order to achieve the principal goal of social mix in the Älvstraden development area, emphasis should be put on also attracting private developers, as low-rent apartments concentrated in the public stock only might lessen overall impact on social mix in the area.

As land ownership is not concentrated to public entities in Stuttgart, the city has a narrower scope of action and planning gain can be activated more transparently. Although IH policies were initially contested, the use has now spread to so many cities that it can be considered an accepted housing policy tool. Should the size of the development surplus be reduced, for example, in an economic downturn, the policy might be subject to renegotiations, however, as

has been the case in the UK, for example. At implementation, the city had already included policy flexibility that could be activated in more difficult projects or in worsening market situations. Political parties that regard private property rights as important might, should they come into power, also lessen the impact of IH (Calavita et al., 1997). Further, policy efficiency over time is limited by the fact that below-market rents are only applied to the first rental contract signed after completion and by the 15-year time limits (De Kam et al., 2014).

Based on the study, it is concluded that, if the unitary housing system is to be sustained in Sweden, measures that generally increase housing supply should be further promoted, rather than ineffectively targeted policies. Measures to expand housing supply have been in focus both under the former liberal government and the present red-green government. The basic thought behind such policy is that a quickly and substantially expanding housing supply put downward pressure on housing prices and possibly also rents (although this might be contested with reference to the Swedish rent-setting system). Filtering might also increase housing allocation efficiency. However, given market and institutional prerequisites in Sweden today, the scope of housing supply expansion that can be realized has its limits. Present and planned construction is not expected to satisfy demand in the near future, especially not in light of the extent of affordable housing need due to population increase. Further, such policy is not expected to open up high-end neighbourhoods to below mid-income households. Therefore, further discussions on the Swedish housing system and its development are needed. The Älvstranden project is a contribution to this debate.

6   Conclusions

Although IH policies in Germany and Sweden generally have very similar objectives and incentive structures, underlying slow-moving institutions decide fundamental traits of the fast-moving institution of IH. In the Swedish case, allocation methods of low-rent apartments under the unitary housing system might prevent targeted polices such as IH. Current resistance against targeted policies, which many agents in Sweden see as part of an undesirable dual housing system including social housing, must be seen as a part of a larger discourse on the survival of the unitary model. In the German case, IH is integrated into the existing social and affordable housing system. Therefore its social objectives are not contested, although the limitation of private property rights and the incentive structures of developers are bound to be discussed.

Irrespective of the housing system, the extent of public land ownership might also be a decisive factor in whether to implement IH policies or not. In Stuttgart, where public land ownership is limited, IH policies might be an effective way to produce affordable housing, as alternatives are limited, including finding inexpensive land for public production. As Gothenburg municipality owns most of land available for housing development, has a planning monopoly and large public housing companies with a good financial standing, it might find other, quicker and possibly less costly, ways to develop affordable housing. For example, measures aimed at increasing housing supply could be introduced on a greater scale, and

municipal housing companies might be assisted to reach their production targets and expand their affordable housing provision.

In light of the population increase in attractive cities and towns and the increasing affordable housing shortage, further discussions on effective ways of producing larger amounts of affordable housing is needed in both Germany and Sweden. Hence, further research on the functioning of IH and similar policy instruments could be fruitful.

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Towards Automation
of the Swedish Property Formation Process:
A Structural and Logical Analysis of Property Subdivision

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Abstract. *The ongoing digitalization of public administration and increased automation of legal decision-making bears promise to benefit citizens, businesses and other stakeholders through simpler and more efficient civil processes, and thus has great impact on the urban planning and building process. However, automation of decision-making that is directed or constrained by normative systems such as laws, regulations and policies, requires a detailed and accurate representation of these concepts and their constituent parts, and the domain to which they are applied. This paper combines two perspectives on formalisation and classification of legal relations within the urban planning and building domain. In a cross-disciplinary fashion, the paper analyses and describes a small part of this domain at a higher level of abstraction and formalization using two different analysis instruments. Using these tools, we perform structural and conceptual as well as logical analyses of two specific snapshots of a fictitious property subdivision case in Sweden, focusing on the legal relations between different entities and parties involved in the specific situations. The structural analysis uses the Land Administration Domain Model ISO 19152:2012 standard formalism, and the logical analysis is based on the notion of atomic types of legal relations. The paper discusses some of the strengths and weaknesses of the two tools regarding the formal representation of rights, restrictions and responsibilities of different parties in the land administration domain, as well as how the tools relate to each other and how they can be aligned. This paper takes one step towards a deeper understanding of the domain, and identify areas for future research that may provide better conditions for efficient and transparent use of geospatial information, and automation of the property subdivision process and other related civil processes.*

Keywords: cadastre, land management, digitalisation, automation, subdivision, real property, LADM, normative positions

1   Introduction

The growing interest in e-government, i.e. the digitalization of public administration, has great impact on the urban planning and building process, and goes hand in hand with increased automation of decision-making in legal domains. The automation and semi-automation of legal decision-making has potential not only to reduce costs of public administration, but also to facilitate accuracy and transparency of public decision-making and benefit citizens, businesses and other stakeholders through simpler and more efficient civil processes. In the Swedish property registration domain, featuring a high number (around 800,000) of annual transactions such as registrations of title and mortgages, systems for automated decision-making in simple cases, where the requirements are easily checked by a computer, are already in place. In the real property formation domain, characterized by significantly fewer (around 16,000 annually) but generally more complex transactions that require more difficult legal decisions, automated decision-making systems have not yet been developed to any greater extent. However, since property formation is one of the bottlenecks in the Swedish urban planning and building process, digitalization of real property processes for automated decision-making is an area of interest to Lantmäteriet (The Swedish Mapping, Cadastral and Land Registration Authority). Many recent Swedish research and development projects (see for example Smart Built Environment (2019), Boverket (2019), Ekbäck (2019) and Olsson et al. (2018)) have aimed to contribute to making the urban planning and building process more streamlined, transparent and collaborative. This is in line with the UN Sustainable Development Goal 11 (Make cities and human settlements inclusive, safe, resilient and sustainable), which includes enhancing *"inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries", and supporting "positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning"* (UN, 2015).

Automation of decision-making that is constrained by normative systems[1] requires a formal representation of both the normative systems and the domain to which they are applied. A natural tool for structural analyses of the domain of real property processes is the Land Administration Domain Model (LADM) ISO 19152:2012 standard, whose purpose is to serve as a conceptual basis for development and/or maintenance of effective and efficient land administration systems. A structural analysis of the domain is, however, not enough. Automated application of normative systems requires not only a representation of the domain to which they are applied, including the rights, restrictions and responsibilities (in the following, as in the standard, collectively referred to as RRRs) of different parties in different situations, but also a formal representation of the normative

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[1]   In the following, the term *normative system* will be used for a collection of normative sentences, such as a body of legislation or a specific law, a local regulation or a policy. An individual item (e.g. a legal paragraph or a policy rule) in a normative system will be referred to as a *norm* for short. Thus, the term norm is used in a more general sense than in the everyday use as an unwritten 'social law'.

systems themselves and their constituent parts. For this, tools based on deontic logic (the branch of logic that deals with concepts such as permission and obligation) can be used.

1.1   Property formation

Property formation aims to make possible efficient land use and thereby to promote dynamic urban development. Property formation is a complex domain, and includes for example real property subdivision, amalgamation, reallotment, partition, and other processes. A property subdivision process is the most common process that assigns land for future use. For example, the number of newly formed real property units created through subdivision during 2018 in Sweden was 15,022, while 645 property units were created by partition and 203 by amalgamation (Lantmäteriet, 2019).

Property subdivision creates new real property units by dividing a real property unit into a (limited) number of smaller ones. The result of this process, which will be described in more detail in Section 3, is newly formed property units with unique property identifiers. In the case discussed in Section 3, a subdivision of a property unit is made, where the original owner (seller) keeps ownership of the residual property (i.e., the original but now smaller property after subdivision) while another person (buyer) becomes owner of the subdivided lot. Moreover, each property unit might also be associated with a variety of property rights attached to an owner, a right holder or some other real property unit. A natural first step to speed up the property subdivision process is automation of such decision situations. In the case example, the decision situation for the cadastral surveyor is uncomplicated, and the decision is straightforward, but this is not always the case. The assessment of certain law criteria, such as the requirement in the Swedish Property Formation Act that property formation shall be performed so that each property unit becomes *enduringly suited to its purpose* (FBL, 1970, 3 chap. 1 §), is in many cases non-trivial and often requires demanding judgments that are not easy and straightforward to formalize. To handle this kind of complexity requires combining different analysis tools, aimed for structural and logical analysis, and the development of more sophisticated theoretical frameworks.

1.2   Aim, scope and method

As already noted, a prerequisite for automation of decision-making that is directed or constrained by normative systems is a detailed and accurate representation of the normative systems as well as of the domain to which the normative systems are applied, including the relationships between different (types of) concepts in the domain. Unfortunately, the importance of especially the former is often overlooked in practice, and the authors are not aware of any previous work that attempts to integrate both in the land administration domain. To address this issue, the theoretical and conceptual framework for digitalization and automation of the urban planning and building process needs to be further developed. This includes bringing the tools for structural and conceptual analyses of the land administration domain and the tools for logical analyses of normative systems (and the legal positions

of different parties in different situations that follow from them) closer to each other. A suitable method for this is to perform a number of interrelated case studies of selected subprocesses, including the property formation process. Within such a 'process case study' it is possible to single out a number of process 'snapshots' (i.e. specific situations in the studied process) to be structurally and logically analysed. For such a process snapshot, a 'situation case study' may be performed, in which the types of entities and parties involved in the specific situation, as well as their relationships and their legal positions, are analysed and formally described. The aim of this paper is to take a first step towards developing this theoretical and conceptual framework, by performing a situation case study within the property subdivision process. The point of departure is a specific property subdivision case, in which the types of entities and parties involved in the specific situation, as well as their relationships and their legal positions, are analysed and formally described. The formalism offered by the Land Administration Domain Model (LADM) ISO 19152:2012 standard (see Section 2.3 in this paper), as well as the logic-based theory of normative positions (see Section 2.4 and 2.5) are utilized for this. In a cross-disciplinary fashion, the paper thereby combines two different perspectives on the formalisation and classification of such legal positions.

Joining and aligning analysis tools and formalisms from two different research areas, the paper aims to gain insight on the strengths and weaknesses of the two tools regarding the formal representation of rights, restrictions and responsibilities of different parties in the case at hand. The attempt is to outline the further work needed to gain a better understanding of the land administration domain (including how to analyse and describe it at a higher level of abstraction and formalization using partly new analysis tools). The long-term goal is to contribute to efficient and transparent use of geospatial information in, and increased automation of, currently manual civil processes that will benefit many actors within the urban planning and building process.

Cadastral (and other) authorities can make decisions manually by one or more decision-making officers or by automated procedures (FL, 2017, 28 §). It is outside the scope of this paper to describe how the motives for the decisions made in the investigated cadastral processes are documented or archived by the authorities. Furthermore, research concerning the emergence and importance of real property rights due to social, political and economic factors has been conducted through several decades (see e.g. Ekbäck, 2009; Libecap, 1989 and Umbeck, 1981) and will not be investigated in this paper.

This paper is structured as follows. Section 2.1 discusses the notions of (land use) rights and real property ownership, and Section 2.2 discusses property ownership as an intermediate concept. Sections 2.3–2.5 present the theoretical frameworks and formalisms that will be applied for describing and analysing rights, restrictions and responsibilities in a property subdivision case. A specific property subdivision case is presented and structurally and logically analysed in Section 3. Section 4 discusses the analysis and its implications for automation of the property subdivision process and identify topics for future work, and Section 5 concludes the results.

2   Theoretical framework

Land is a limited resource and has to be administered in order to regulate the various private and public interests of individuals, companies or the State. The way land is administered includes decisions on access to land, land rights, land use and land development. Human activities (housing, farming, husbandry, forestry, recreation etc.) presuppose certain rights. These rights are defined according to law or custom. This section discusses the notion of (land use) rights and presents some theoretical frameworks and formalisms for describing and analysing rights.

2.1   *Land use rights and real property ownership*

Real property legislation, and in a broader context land use legislation, is concerned with regulating what may be done with land. "Real" in real property usually is associated with something solid, fixed and permanent, which has to do with land. Land use rights are links between the legal owner(s), the right, restriction or responsibility and the area(s) of land in question, and thus have at least three dimensions: what is included in a right, who is the holder of this right and the physical extension this right has (Larsson, 2010). A recent discussion of the real property concept and the relation owner, right and property, as well as its relation to digital processes, can be found in Ekbäck (2019).

There is no universally accepted definition of the term *right*, but a right has been given a number of rather similar definitions, such as an "action, activity or class of actions that a system participant may perform on or using an associated resource" (ISO, 2007, Section 4.38), "a claim or title to or an interest in anything that is enforceable by law" (Gifis, 1984, p. 416), and "[a]right to a specific property, whether tangible or intangible" (Garner, 1891, p. 1096). A *restriction* has been defined as a formal or informal obligation to refrain from doing something (ISO, 2012, Section 4.1.19), "[...] a limitation [...] placed on the use or enjoyment of property" (Garner, 1891, p. 1089).[2] A *responsibility* has e.g. been defined as a "formal or informal obligation to do something" (ISO, 2012, Section 4.1.18), "a liability" (Garner, 1891, p. 1087), and "an obligation" (Gifis, 1984, p. 408).[3]

As previously mentioned, land use rights often follow from (or is interconnected to) real property ownership. Thus, real property ownership is a central notion concerning the relation between person and land. The authors are not aware of a commonly accepted definition of 'ownership', but it has been argued that ownership can be described as the greatest possible interest in a thing which a mature system of law recognizes (Honoré, 1987). A common approach is to regard real property ownership as a right of its own, 'ownership right', which in turn is a combination of several rights. Together in a 'bundle' these rights form the concept of real property ownership: The right of unlimited possession of the property;

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[2]   An example is a building restriction prohibiting building within 200 metres of a fuel station (ISO, 2012, Section 4.1.19).

[3]   An example is the "responsibility to clean a ditch, to keep a snow-free pavement or to remove icicles from the roof during winter, or to maintain a monument" (ISO, 2012, Section 4.1.18).
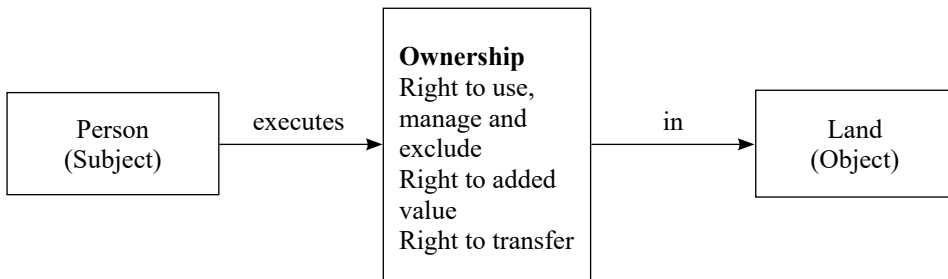
Figure 1. *The concept of ownership in land (Paasch, 2012, p. 24).*

the right to use the property; the right to manage the property and exclude others from the property; the right to added value of the property; the right to transfer the property to somebody else according the the owner's choice (see e.g. Honoré (1987), Snare (1972), Bergström (1956), and Hohfeld (1917; 1913)). The concept is illustrated in Figure 1.

2.2 *Real property ownership as an intermediate concept*

Another way to treat the notion of real property ownership is to regard it as a so-called *intermediate (legal) concept*, also known in the literature under names such as 'intermediaries', 'ground-consequence-terms', 'middle terms' or 'coupling terms'.[4] According to Lindahl (1985), it is an old observation that a number of legal concepts, e.g. contract, ownership and tenure, are linked both to certain legal facts and to certain legal consequences, and thus can be regarded as syntactic tools for formulating legal rules and 'vehicles of inference' for legal reasoning. In fact, ownership is a classic example of an intermediate concept, whose function (and, thus, meaning) is tied to its role as a vehicle of inference linking factual grounds for ownership with legal consequences of ownership. In this view, the term *being the owner of* functions as a bridge or transition between different conceptual systems, one containing facts[5] (e.g. events, actions, or circumstances) and one containing normative positions[6] like obligations, claims, legal powers, etc. According to this view, ownership is attached to certain facts, and different normative positions are attached to ownership. In other words, the term ownership (like other intermediate concepts) connects legal information of two different sorts, factual (descriptive) and normative, and is in itself neither a purely descriptive nor a purely normative concept. This idea is illustrated by the scheme shown in Figure 2 where O denotes ownership, $G_1, \ldots G_p$ denote factual (legal) grounds for ownership and $C_1, \ldots, C_n$ denote legal consequences of ownership. Each G_{iS} may represent circumstances

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[4] The term *intermediate concept*, for concepts that lie conceptually in between purely descriptive and purely normative concepts, derives from the discussion between Scandinavian legal philosophers Ekelöf, Ross, Wedberg and others. An overview of this discourse is given in, for example, Lindahl and Odelstad (2013, Section 1.7).

[5] 'Is-objects' in the terminology of Lindahl and Odelstad (2013, p. 552).
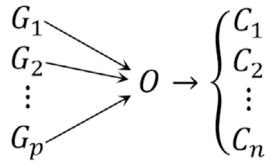
[6] 'Ought-objects'.

Figure 2. *A schematic view of ownership (O) as an intermediate concept, linking its grounds G_1, G_2, ... , G_p to its consequences C_1, C_2, ... , C_n (Lindahl & Odelstad, 2013, p. 553).*

that hold, or events or actions that take place, in a particular situation. G_i often takes the form of a condition on a number of agents[7], such as a binary condition $g_i(x,y)$ involving two agents x and y. For example, if g_i represents the condition *having inherited from*, then $g_i^u(x,y)$ may be read as *x has inherited property unit u from y*.

In Figure 2, G_1, G_2, ... , G_p express different legal grounds for x being the owner of (e.g.) a property unit u, and C_1, C_2, ... , C_n express different consequences of x being owner of u (cf. Odelstad, 2017, p. 34). Examples of legal grounds for ownership of u may be having lawfully purchased u or having inherited u. Some possible legal consequences of ownership of u are mentioned above; e.g. having the right of unlimited possession of u and having the right to transfer (ownership of) u to somebody else. It thus seems that the view of ownership as a 'bundle of rights' mainly focuses on the normative side of the concept.

According to the scheme, it holds for all i, $1 \leq i \leq p$, and all j, $1 \leq j \leq n$, that

G_i implies O
O implies C_j

Thus the communicative function of O is to link the grounds G_1, ... G_p to the consequences C_1, ..., C_n. This syntactical tool offers economy of expression since it only requires $p+n$ implications instead of $p*n$ compared to formulating the rules by attaching each G_i to each C_j (Lindahl & Odelstad, 2013, p. 231). It is not uncommon that intermediate concepts form chains, so that what constitutes a consequence of a certain concept in turn constitutes a ground for another concept. For example, as illustrated in Figure 3, the condition *having inherited* u has certain legal grounds, such as *being the sole heir to* u and *being the heir to* u *according to will*, and certain consequences, such as *being the owner of* u. Thus, *having inherited* u is a ground for *being the owner of* u, which in turn has various legal consequences. *Inheritance of property* u and *ownership of property* u thus form part of a chain or network of intermediate concepts.

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[7]   Here, *agent* is used as a generic term for various legal parties such as persons, groups, organisations, or other entities capable of action. The term *actor* will mainly be used to indicate an agent that is in some sense 'active' in a particular scenario.
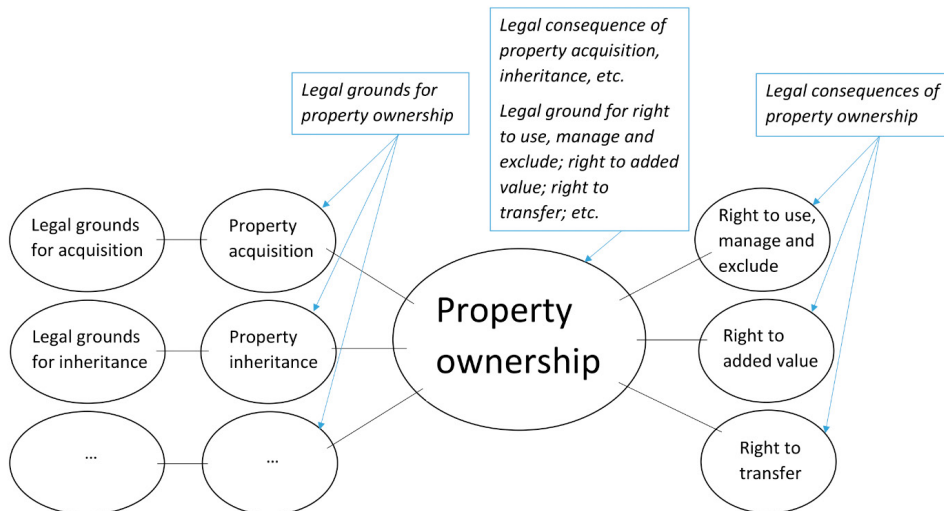
Figure 3. *A network of intermediate concepts. (Cf. Figure 23 in Lindahl & Odelstad, 2013). As in Figure 2, the intermediate concept is placed to the right of its grounds and to the left of its consequences.*

A particularly interesting class of intermediate concepts are the so-called *open* intermediate concepts, i.e. concepts whose grounds are not wholly specified ('ground-open intermediate concepts') or whose consequences are not ('consequence-open intermediate concepts'); see for example Lindahl and Odelstad (2013, Section 1.7.5). Regarding real property ownership, it seems reasonable to believe that in most legal systems and traditions, both its grounds and its consequences are fairly well specified, but the exact extent to which real property ownership is a ground-open and/or consequence-open intermediate concept might vary from one legal system to another. A more interesting example is the condition *being enduringly suited to its purpose* (see Section 1.1) which Section 4 will discuss further. In a decision process, a ground-open intermediate concept is of special significance, since it functions as a 'point of decision' where it must be decided if the grounds of the concept are fulfilled, and thus its normative consequence applies.

2.3 The Land Administration Domain Model

The Land Administration Domain Model, LADM, ISO 19152:2012 (ISO, 2012), is an international standard and a tool for structuring land administration. It is not limited to any legal system or tradition, thus possible to use as a reference model regardless of a nation's legal system. The LADM is developed by the International Organization for Standardization, ISO, and even accepted as a national standard by a number of countries and as a European standard. The purposes of the model are several; to be used as a conceptual basis for development and/or maintenance of effective and efficient land administration systems and to enable communication and transfer of real property and land administration terms based on a shared
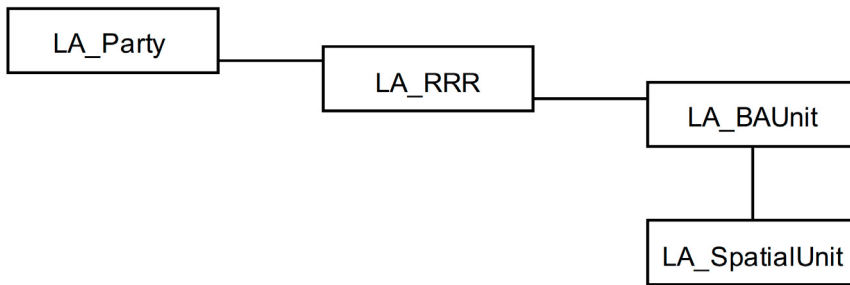
Figure 4. *LADM's LA_Party, LA_RRR, LA_BAUnit and LA_SpatialUnit (ISO, 2012, p. 9).*

vocabulary. In LADM, RRRs are seen as general relations between a (legal) person and land. The LADM does not focus on technical implementation of IT systems for land management, but describes the legal and spatial relations between e.g. a right-holder (e.g. an owner of a real property) and the RRRs that affect a specific piece of land. The basic LADM classes are

- Party (a person or organization playing a role in a rights transaction (ISO, 2012, p. 4)),
- RRR (a right, restriction or responsibility (ISO, 2012, p. 5)),
- BAUnit (a basic administrative unit subject to registration or recordation or customary or social entity with RRRs associated to it (ISO, 2012, pp. 2–3)), and
- SpatialUnit (one or multiple areas of land and/or water, or one or multiple volumes of space (ISO, 2012, p. 6)).

In Figure 4, the classes have the prefix "LA_" attached to them to make them unique in the ISO series of geographic information standards.

LADM is an important part of the foundation for automation within the cadastral field, since it offers a standardized terminology for describing entities in the domain and their relationships, including different types of rights (or absence of rights) of different parties in particular situations. To build further on this foundation, a logical analysis of the notions of RRRs is close at hand.

2.4 Fundamental jural relations

A natural point of departure (see for example Paasch, 2012) for a logical analysis of RRRs is the work by Hohfeld (1913; 1917) on the "fundamental jural relations" (often also referred to as "fundamental legal conceptions") *right*[8] (claim), *privilege*

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[8]   A note on terminology: The term 'right' is somewhat ambiguous, since it is sometimes used in the generic sense of what in Section 2.3 was referred to as 'right, restriction or responsibility' (RRR). In the following, the more specific term 'claim' ('claim-right') is used instead of 'right' when referring to the fundamental jural relation, while 'legal position' will be used for the generic term that also includes restrictions and responsibilities, i.e. the absence of claim-rights. In other words, a (claim-) right is a kind of legal position, but not
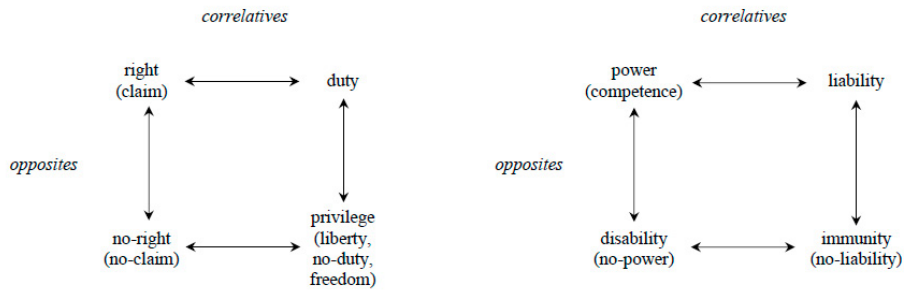
Figure 5. *Hohfeld's fundamental legal conceptions (adapted from Sergot, 2001, Figure 1).*

(liberty, freedom), *power*, and *immunity*, and their 'correlatives' *duty*, *no-right* (no-claim), *liability*, and *disability*. See Figure 5.

A common view is that the so-called first-order 'Hohfeldian incidents' Privilege and Claim (shown in the left part of Figure 5) directly regulate what actions people may perform, while the second-order incidents Power and Immunity (right part) regulate the introduction and changing of other incidents. That some agent x has a power versus some other agent y means that x has the 'legal capacity' (according to some legal system) to alter y's Hohfeldian incidents, and that x has an immunity versus y means that y lacks the legal capacity to alter x's Hohfeldian incident. Privilege and Power are sometimes referred to as "active" rights, i.e. rights that concern the actions of the bearer of the right, while Claim and Immunity are referred to as "passive" rights that regulate the actions of others.

The fundamental legal conceptions are correlated to each other[9] in the following way (cf. Figure 5):

–   If x has a Claim versus y regarding some state of affairs F, then y has a Duty versus x regarding F.
–   If x has a Privilege versus y regarding F, then y has a No-claim versus x regarding *not:F*, i.e. the negation of F.
–   If x has a Power versus y regarding F, then y has a Liability versus x regarding F.
–   If x has an Immunity versus y regarding F, then y has a Disability versus x regarding *not:F*.

Also note that some fundamental legal conceptions are the 'opposites' of others:

–   If x has a Claim versus y regarding F, then x does not have a No-claim versus y regarding F.
–   If x has a Privilege versus y regarding F, then x does not have a Duty versus y regarding *not:F*.

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- If x has a Power versus y regarding F, then x does not have a Disability versus y regarding F.
- If x has an Immunity versus y regarding F, then x does not have a Liability versus y regarding *not:F*.

As an example, let us assume that subdividing the property unit u_O into two property units, the residual property (here denoted u_R) and the new subdivided property (u_D), is in line with the current municipal development plan. Let us further assume that both u_R and u_D are deemed enduringly suited to their purposes. Then if a person x owns u_O, x has (versus any person y that does not own u_O) a legal position of type Immunity with respect to subdividing u_O into u_R and u_D. In other words, y does not have a Power versus x regarding x's subdividing u_O, i.e. y does not have the legal capacity to make x subdivide u_O. Furthermore, x also has a legal position of type Immunity with respect to *not* subdividing u_O into u_R and u_D. That is, y does not have a Power versus x regarding not subdividing u_O; y does not have the legal capacity to prevent x from subdividing u_O. Hohfeld regarded the fundamental legal conceptions as "the lowest common denominators of the law" that could be used to express jural relations exhaustively and with high precision. It appears that what in LADM is referred to as restrictions and responsibilities may be expressed as no-claims, duties, disabilities or liabilities in Hohfeld's terminology. The fundamental legal conceptions and their correlatives thus seem to have the potential to capture the notions of RRRs (see Section 2.3) with higher precision. The observation, that what is expressed as a right for one party may also be expressed as a restriction or responsibility for some other party, is also in accordance with the LADM (ISO, 2012).

2.5 The theory of normative positions

A logical reconstruction of Hohfeld's theory was suggested by Kanger (1957) who combined the standard operator 'Shall' from deontic logic, i.e. the logic that deals with concepts such as obligation and permission, and the action operator 'Do'. This combination together with the negation operation 'not' gives us a powerful language for expressing normative sentences. For example, Shall Do(x, *not:F*) can be interpreted as 'it shall be (the case that) x sees to it that not F' or 'it shall be that x brings it about that not F'. Similarly, not:Shall Do(x, F) can be read as 'it is not the case that it shall be that x sees to it that F' or 'it is not the case that it shall be that x brings it about that F'. Hohfeld's fundamental jural relations may be formally stated in this language, and when combined with standard logical connectives, they can be used to express complex conditional normative sentences. Despite its compactness, the logical formalism has great expressive power that makes it possible to formulate and analyse normative systems with high precision. This, in turn is a prerequisite for automated application of norms, i.e. what Olsson et al. (2018, Sect. 2.3) refer to as "rule checking".

Table 1. Hohfeld and Kanger (based on Lindahl 1977, p. 49).

Kanger	Hohfeld		Kanger
Claim Counter-claim Counter-inununity Immunity	Right	Duty	Not Counter-freedom Not Freedom NotPower NotCounter-power
Not Claim Not Counter-claim Not Counter-immunity Not Immunity	No-right	Privilege	Counter-freedom Freedom Power Counter-power

Kanger distinguished between four simple types of legal positions (claim, freedom[10], power, immunity) and four simple 'counter-types' (counter-claim, counter-freedom[11], counter-power, counter-immunity), where "counter" refers to the negation of some event or state of affairs. Thus, the expression 'x has versus y a privilege regarding not F' is synonymous to 'x has versus y a counter-privilege regarding F' (Lindahl, 1977, p. 43), where F may denote (cf. the example in Section 2.4) that the property u is subdivided into u_1 and u_2. The relationship between Hohfeld's and Kanger's primitive concepts is shown in Table 1.

In the logical language described above, Kanger's explication of Claim(x, y, F) is Shall Do(y, F)[12] and the explication of Privilege(x, y, F) is not:Shall Do(x, *not:F*)[13]. The explication of each of the eight simple types is shown in Table 2, where May P is used as an abbreviation of 'not:Shall not:P', and the generic symbol F is replaced by a condition $f(x,y)$ representing some binary relation f that may hold between x and y.

Note that for Privilege, Counter-privilege, Power and Counter-power it is the rights-bearer x that is 'active' in the sense of 'seeing to it that'. These types express x's freedom and capacity. Claim, Counter-claim, Immunity and Counter-immunity express obligations of the counterparty y, who is the active agent. Also, note that, for example, the explication Shall Do(y, F) of Claim(x, y, F) only explicitly references one of the agents involved, in this case the counterpart y. However, it is common that F represents some condition f on a number of agents, such as the binary condition *having received the down payment for property u*. In this case, Shall Do(y, $f(x,y)$) can be interpreted as follows: 'y shall see to it that x receives the down payment for u from y'. This implicitly represents that x has a claim on y regarding receiving the down payment for u.

A list of legal positions regarding $f(x,y)$ may be constructed by forming the conjunction of each simple type, either negated or unnegated, and removing those conjunctions that are logically inconsistent given the underlying logic of Shall, May and Do. This list contains 26 'atomic' legal positions (see Section 3.4. for

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[10]   Here, 'privilege' will be used instead of 'freedom'.
[11]   'counter-privilege'.
[12]   'y shall see to it that F'.
[13]   'it is not the case that x shall see to it that not F'.

Table 2. *Kanger's explication of the simple types of rights. (See for example Lindahl, 1977, p. 43.)*

Simple type	Explication	Active agent
Claim(x, y, $f(x,y)$)	Shall Do(y, $f(x,y)$)	y (counterparty)
Privilege(x, y, $f(x,y)$)	not:Shall Do(x, *not*:$f(x,y)$), i.e. May not:Do(x, *not*:$f(x,y)$)	x (rights-bearer)
Power(x, y, $f(x,y)$)	May Do(x, $f(x,y)$)	x
Immunity(x, y, $f(x,y)$)	Shall not:Do(y, *not*:$f(x,y)$), i.e. not:May Do(y, *not*:$f(x,y)$)	y
Counter-type	**Explication**	
Counter-claim(x, y, $f(x,y)$)	Shall Do(y, *not*:$f(x,y)$)	y
Counter-privilege(x, y, $f(x,y)$)	not:Shall Do(x, $f(x,y)$), i.e. May not:Do(x, $f(x,y)$)	x
Counter-power(x, y, $f(x,y)$)	May Do(x, *not*:$f(x,y)$)	x
Counter-immunity(x, y, $f(x,y)$)	Shall not:Do(y, $f(x,y)$), i.e. not:May Do(y, $f(x,y)$)	y

examples). Kanger's typology of atomic types of normative relations between two agents and a state of affairs was developed by Lindahl (1977) into three systems of types of *normative positions*. That *x* versus some counterpart *y* has a certain type of normative position with respect to, e.g., the state of affairs *f(x,y)* means that *x* has, or does not have, certain (types of) rights versus *y* as regards *f(x,y)*. The simplest of these systems of types of normative positions, the so-called *one-agent types of normative positions*, is shown in Table A1 in the appendix.

Although not without its problems as a theory of rights (see, e.g., Makinson, 1986), the so-called Kanger-Lindahl theory of normative positions is generally regarded (Sergot, 2013, p. 355) as the most comprehensive and best developed attempt to formalize Hohfeld's fundamental jural relations, which may be expressed as logical combinations of normative positions.

3   Subdivision of a real property unit: A 'Situation Case Study'

Since property formation is central to the urban planning and building process, property subdivision (which, by far, is the most common case of property formation in Sweden) is selected as the object of study. A Swedish property formation process is generally divided into the four phases *initiation*, *preparation*, *decision* and *registration* (see for example Figure 31 in Vaskovich, 2012, for an overview). The analysis focuses on the decision phase of the property subdivision process, described in Section 3.1. Two 'Situation Case Studies' analyse snapshots of the property subdivision process, along with the types of entities and parties involved in the specific situations. Furthermore, the case studies formally describe the relationships and legal positions of said entities and parties. The paper studies (i) the situation where the cadastral surveyor is about to take the cadastral decision, and (ii) the situation just after the decision has entered into force. The goal of the analysis is to be more acquainted with the selected decision situation, in order to get a better understanding (and formal

description) of the domain of the property subdivision process. A challenge here is to delimit the scope of the analysis. Explicitly mapping out all the legal positions that hold between all different parties and objects, is way beyond the scope of this paper. The aim is not to perform an exhaustive analysis of the decision situation, but to compare and discuss different tools for analysis and formal representation of legal positions between different parties. Therefore, Sections 3.3–3.5 focus on a subset of the legal positions that is manageable, yet rich enough to illustrate the 'analytic capacity' and expressiveness of the different analysis tools. Section 3.6. further discusses this approach.

3.1   The property subdivision process

A subdivision process is exclusively performed through decision of a cadastral surveyor. A completed subdivision may only be changed by another decision of a surveyor or through a court decision. The surveyor is in general rather free to arrange the subdivision process in the way seen as most suitable, not being bound by statutory regulations in this aspect.

During the subdivision process, the cadastral surveyor makes several legal decisions, *viz.* the cadastral decision, the cost-distribution decision and the completion decision. The central decision is the actual cadastral decision to form a new property unit for e.g. housing purposes, which legalises (the existence of) the newly formed property (FBL, 1970, 4 chap. 25 a §). The decision must be made by the surveyor after all details of subdivision are investigated, i.e. after, among others, preparation, rearrangement of related property rights and the necessary surveying have been done. The decision includes the assessment of the requirement in the Swedish Property Formation Act that a newly formed real property unit must be *enduringly suited to its purpose* (FBL, 1970, 3 chap. 1 §), which includes being suitably designed and having (potential) access to both a road and acceptable sewerage arrangements and water supplies. Therefore, the surveyor takes the size of the new land plot and the future access to road, water and sewerage systems under particular consideration. Moreover, the surveyor assesses whether a requested subdivision is consistent with the existing municipal detailed development plan as well as with public land policy. If needed, the surveyor may (choose to, or be required to) consult with the municipality (typically regarding sewerage, water supply and/or development plan issues), the Road Authority (typically regarding road access), and the County Board (regarding environmental protection).

As soon as the cadastral decision is taken, a bundle of respective property rights is legally attached to the new property unit. When the appeal period expires, the cadastral surveyor finalises the registration of the new property unit. Subdivision completes by the respective entry regarding newly formed property units into the real property register.

The following Section 3.2 describes a fairly normal and uncomplicated property subdivision case, based on certain simplifying assumptions. The aim is to highlight important parts of the process and show how it may be carried out in this specific case. In general, the process can be much more complex.
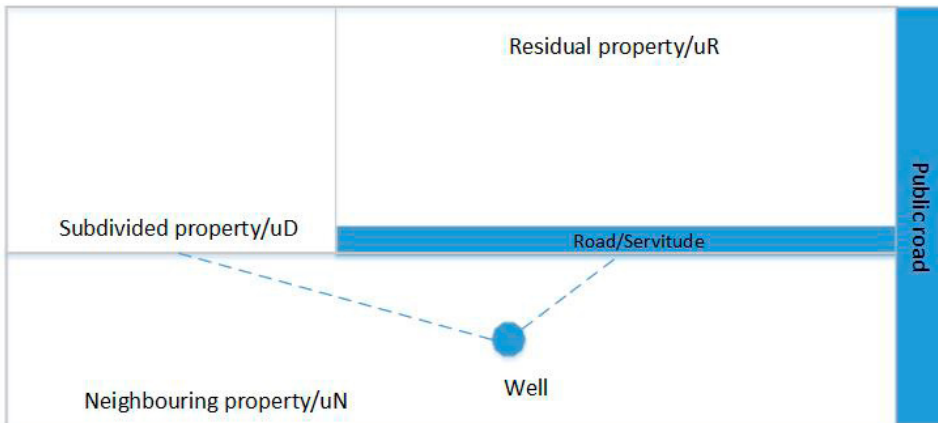
Figure 6. *A schematic overview of the intended situation on the ground after subdivision. (The dashed lines indicate u_R's and u_D's right-of-use servitudes.)*

3.2   Case description

The owner of a property (the 'original' property, in the following referred to as u_O) would like to subdivide the land parcel into two smaller property units, with the aim of keeping ownership of one part (the 'residual' property, u_R) and selling the other (the 'subdivided' property, u_D) to the buyer. The buyer plans to build a house on u_D, and a preliminary building permit has already been applied for and granted by the municipality. There is no mortgage attached to u_O, and there will be no mortgage attached to u_D. A servitude with u_O as the dominant property and the neighbouring property u_N as the servient property grants the owner of u_O the right of access to and use of the well situated on u_N. (See Figure 6 for an overview of the intended situation after subdivision.)

In the case presented here, the seller and the buyer make purchase arrangements and sign a purchase contract before subdivision, and then submit an application for subdivision. As soon as the application is registered at Lantmäteriet, a new cadastral dossier is created and the case is assigned to a cadastral surveyor. The cadastral surveyor examines the general conditions of subdivision, including a bundle of attached property rights, and the requirement that the new property unit is *enduringly suited to its purpose*. As already mentioned, this means that a newly formed property unit needs (potential) access to water supply and sewerage arrangements as well as free passage from the property (i.e. right of way). The requested subdivision must also be consistent with the existing municipal detailed development plan as well as with public land policy.

To ensure right of way for the owner of the subdivided property u_D over the residual property u_R to the public road, a new servitude has to be created.[14]

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[14]   Instead of creating servitudes, it would be possible to create a so-called joint facility, i.e. a construction (facility) beneficial for two or more real property units (AL 1973). Since it is more common to use servitudes to secure rights of access when very few properties are involved, and to avoid unnecessary complexity in the example, the study abstains from creating a joint facility here.

Likewise, to ensure the owner of u_D the right of use to the well on the neighbouring property u_N, a servitude (with u_N as the servient property and u_D as the dominant property) can be created if an agreement is reached with the owner of u_N. The existing servitude ensuring right of use of the well on u_N to the owner of u_O is not affected by the property subdivision process and will thus remain unchanged, since it still belongs to u_O (now called u_R). The new servitudes are given unique designations and database id's in the real property register.

Subdividing the original property u_O into u_D and u_R results in a new cadastral boundary being created to separate the properties. The area of u_O is thus changed (i.e. reduced) in the property formation process, but the residual property u_R keeps u_O's property unit designation and database identification number in the real property register. Some of u_R's former cadastral boundaries now mark the subdivided property together with the new created boundary dividing the properties[15], thus creating a closed geographic area. u_D receives a new database identification number and a new real property designation within the series used for the cadastral district in which the property is located.

As part of the property formation process, the cadastral surveyor has to ensure that the subdivided property u_D will be connected to a sewage network or otherwise be able to discharge of its waste. In this example, the buyer has chosen to construct a small plant for sewage discharge treatment on the property. A permission for the construction of such a facility has been obtained from the municipality´s environmental department prior to the subdivision.

To summarise, the buyer (in the following referred to as a_B) is assumed to sign an agreement with a_N, the owner of u_N, regarding right of access to the well also for the owner of u_D, i.e. that a_N agrees to the creation of a new servitude for this purpose. The creation of a servitude that grants the owner of u_D access to the road on u_R, is likewise assumed, as well as that preliminary building permits for a new building and a sewage discharge facility have been obtained. Furthermore, this property formation is assumed uncomplicated in the sense that it is entirely in line with the current municipal detailed development plan and public land policy, and no consultation with other authorities is necessary.

3.3 Preamble to analysis: Actors and entities

The 'Situation Case Study' is prepared for by first identifying in the case description the parties (actors and stakeholders) that are directly involved in or affected by the decision:

- a_S: Actor S (Seller, Owner of original property u_O, Owner of residual property u_R)
- a_B: Actor B (Buyer, Owner of future subdivided property u_D)
- a_N: Actor N (Owner of neighbouring property u_N)
- a_C: Cadastral surveyor

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[15] In some cases, a technical surveyor visits the property to demarcate the boundaries physically on the ground.
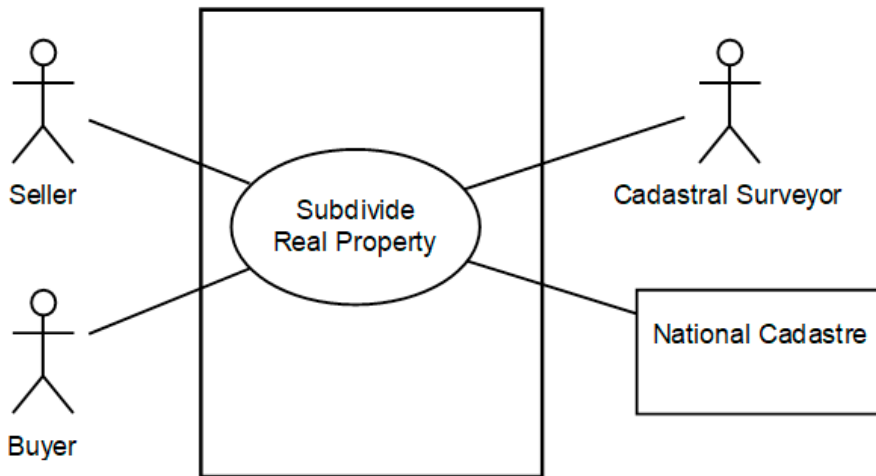
Figure 7. *Use case diagram showing the main actors of Subdivide Real Property.*

Other parties that can be extracted from the case description, but do not occur explicitly in the analysis, include other neighbours, a technical surveyor, the Municipality, the County Board, the Road Authority, and the State.

The Use Case diagram in Figure 7 shows the main actors of the real property subdivision process. Zooming in on the particular decision situation, the cadastral decision, it can be seen that some actors are more directly involved than others are. The cadastral surveyor a_C is the main actor in the sense of being the decision maker, while the seller a_S and the buyer a_B are also central actors that are directly affected by the decision. To some extent, other stakeholders such as an owner of a neighbouring property or some other private citizen (who, for example, for some reason opposes the formation of the new property) are also affected, whereas the previously mentioned public authority parties are not directly involved in or affected by this step of the process.

Next, central concepts are identified that occur in the case description. The following entities occur explicitly in the analysis:

- d: Cadastral dossier
- u_O: Original property (before subdivision)
- u_R: Residual property (original property after subdivision)
- u_D: Subdivided property
- w_N: Water source (well) on neighbouring property
- $s_{w;O}$: Water source easement/servitude (u_O vs. u_N)
- $s_{w;R}$: Water source easement/servitude (u_R vs. u_N)
- $s_{w;D}$: Water source easement/servitude (u_D vs. u_N).

Examples of other entities that can be extracted from the case description, but do not occur explicitly in the analysis, are the subdivision application, the road on the residual property, the preliminary building permits for a building and a sewerage arrangement on u_D, and 'technical' entities such as cadastral boundaries and database id's.
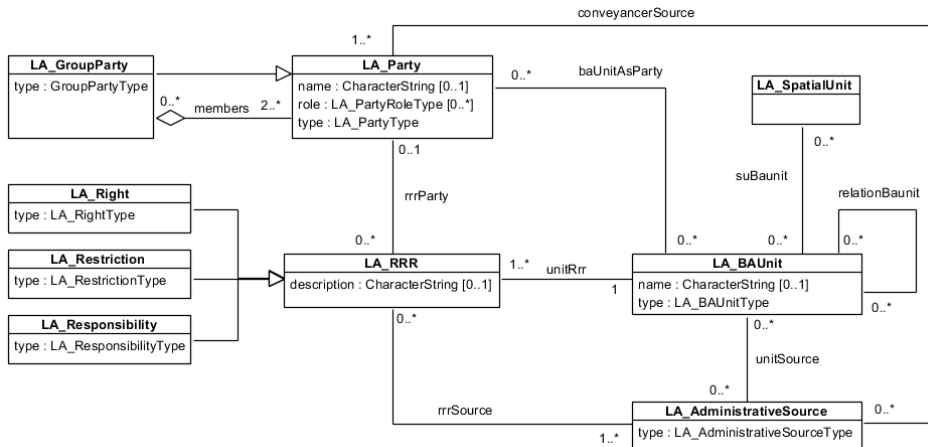
Figure 8. *A class diagram of relevant parts from the LADM (adapted from ISO, 2012, Figures 9, 10 and 11).*

3.4   Structural analysis using LADM terminology

This section structures the case of property subdivision from Section 3.2 with the help of LADM object diagrams, i.e. UML diagrams following the LADM standard (ISO, 2012). The notations from Section 3.3 are utilized, slightly adapted. The original owner, and seller of the subdivided part, will be denoted aS in the diagrams (not a_S as in the text). This and similar adaptations are made to make the diagrams more readable. Further, the class names of the LADM (e.g.LA_BAUnit) are utilised, but package names (e.g. Administrative) are not written out. Thus, LA_BAUnit stands for the class whose full name according to the LADM standard is Administrative::LA_ BAUnit.

A starting point for modelling the case according with LADM is the class diagram in Figure 8, which is adapted from Figures 9, 10, and 11 in the LADM standard (ISO, 2012). The classes are drawn from three of LADM's main packages (Party, Administrative, and Spatial Unit). As the case study focuses on RRRs, spatial relationships are not included in the models. E.g., the fact that a passageway over some property must spatially be 'within' this property, will not be represented in the models. (See, e.g., ISO (2012, Figure C.21) for an example.)

Although UML class diagrams are static structure diagrams, it is worth noting that the LADM can be used for state-based modelling as well as event-based modelling, see Appendix N of the LADM standard (ISO, 2012). Section 3.4.1 represents the situation before subdivision, and Section 3.4.2. the situation after subdivision.

3.4.1   Situation before subdivision

Before subdivision, the seller a_S owns the original property u_O. A servitude attached to the original property u_O and the neighbouring property u_N grants a_S the right to use the well situated on u_N. LADM can model the servitude as a restriction on the
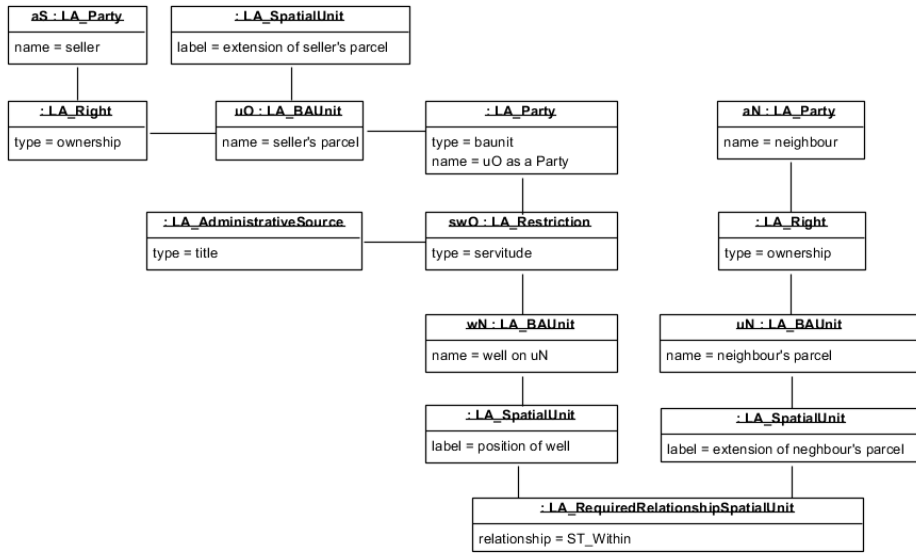
Figure 9. *An object diagram showing the situation before subdivision.*

neighbouring property, in the sense that the ownership rights of the neighbour a_N are restricted. Further, in the (non-normative) code list LA_RestrictionType there is a type *servitude*. The choice to represent a servitude as an instance of LA_Restriction is discussed in Section 3.6.

Figure 9 follows the approach of Figure C.21 of the LADM standard (ISO, 2012), although in a different context. The well on the neighbour's property is represented by the LA_BAUnit instance w_N, which is spatially located within the neighbour's property. According to the class diagram and other specifications in the LADM, each instance of LA_Restriction is associated to (linked to) exactly one LA_BAUnit, and to one (or none) LA_Party.[16]

The LA_Restriction object is associated to an instance of LA_AdministrativeSource, where the latter represent documents (in this case files in the cadastral dossier d) internal or external to the land administration organization. Not shown in the figure is the association between the administrative source for the original servitude and the cadastral surveyor (LA_Party) who once established it.

3.4.2   Situation after subdivision

When the original property u_O has been subdivided into a remaining part u_R and a subdivided part u_D, both properties will have the right to access the neighbour's

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[16]   A difference from Figure C.21 of the LADM standard is that we do not link the owner a_S of the original property u_O directly to the Restriction object $s_{w,O}$. Instead, we follow Swedish law, which says that it is u_O that has the servitude, not the owner of u_O. (In order to follow the LADM specifications, we had to insert an LA_Party object representing u_O acting as a party, *viz.* the nameless object between u_O and $s_{w,O}$.)
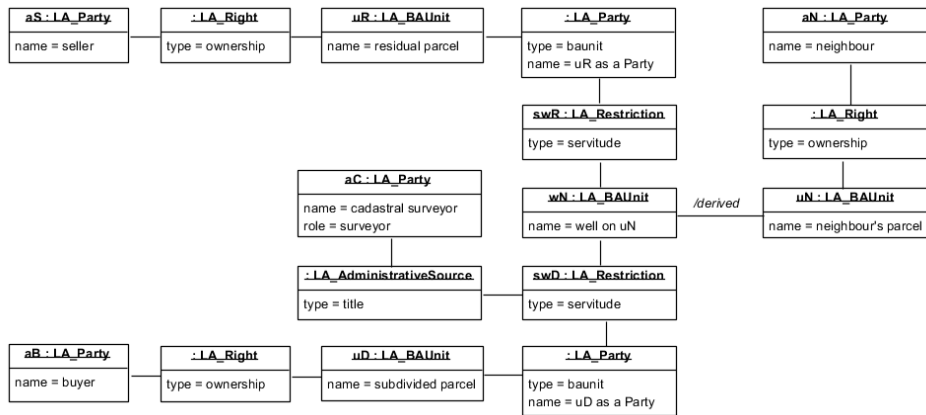
Figure 10. *An object diagram showing the situation after subdivision.*

well. In Figure 10, this has been represented as the two properties each having a unique servitude on u_N.[17]

For simplicity, Figure 10 excludes the instances of classes SpatialUnit and RequiredRelationshipSpatialUnit from the object diagram. Instead, a link is drawn directly from w_N (the LA_BAUnit representing the well) to u_N (the LA_BAUnit representing the neighbour's parcel). This might be seen as a link derived from a spatial relationship that is not shown. Section 3.6. discusses the spatial relationship between the two BA_Unit objects u_R and u_N further.

3.5 *Logical analysis of atomic types of rights*

To perform a logical analysis of the legal relations that hold between different parties (see section 3.3) regarding different conditions is not a simple task. The list of possible conditions to examine is practically endless, and each condition may be instantiated with different combinations of parties, and in different situations (e.g. before or after subdivision of u_O). However, some conditions that might be relevant to consider can be inferred from the process and case descriptions in Sections 3.1 and 3.2:

1. using the well on u_N
2. using the road on u_R
3. subdividing u_O into u_R and u_D
4. receiving agreed payment for u_D
5. retracting an application to subdivide u_O into u_R and u_D
6. appealing a decision to subdivide u_O into u_R and u_D
7. appealing a decision to deny subdivision of u_O into u_R and u_D.

The following analysis, based on the fundamental jural relations and their logical explications (or, as will be discussed in Section 3.6, a generalisation of these notions) that were presented in Section 2.4, focuses on items 1 and 3. As in

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[17] An object diagram showing the situation where the two properties u_R and u_D have a common servitude on u_N would be slightly different, e.g. using the LADM LA_GroupParty class to group the two real properties as a single party (not shown).

Section 3.4, this section starts with the situation before subdivision of u_O into u_R and u_D, and then look at the situation after.

3.5.1 Situation before subdivision

First, this section looks at the condition *using the well on u_N* and the two parties a_S and a_N. If x is an agent, let $w_N(x)$ represent the event *x uses the well on u_N*.[18] Which simple types of legal relations hold in this situation between the seller a_S and the neighbour a_N regarding $w_N(a_S)$, i.e. a_S's using the well on u_N? Given the assumptions in 3.3, which includes the existence of a servitude for the owner of u_O (i.e. a_S) to use the well on u_N, it seems reasonable to say that a_S does not have a duty (versus a_N) to not use the well. It is natural to express this as the fundamental jural relation

$$\text{not:Duty}(a_S, a_N, \textit{not:}w_N(a_S)), \tag{1a}$$

which (since Privilege and Duty are 'opposites'; cf. Figure 5) is the same as

$$\text{Privilege}(a_S, a_N, w_N(a_S)). \tag{1b}$$

By substituting the binary condition f in Table 2 for the unary condition w_N, a possible logical explication is obtained of (1ab):

$$\text{May not:Do}(a_S, \textit{not:}w_N(a_S)) \tag{2}$$

This can be read as 'it may be that a_S does not see to it that a_S does not use the well on u_N'. It also seems reasonable to claim that a_N lacks capacity to prevent a_S from using the well. Below it is suggested how to express this as a fundamental jural relation, together with a possible logical explication:

$$\text{not:Power}(a_N, a_S, \textit{not:}w_N(a_S)) \tag{3a}$$
$$\text{Alternatively put: Immunity}(a_S, a_N, w_N(a_S)) \tag{3b}$$
$$\text{not:May Do}(a_N, \textit{not:}w_N(a_S)) \tag{4}$$

A possible interpretation of (4) is 'it is not the case that a_N may see to it that a_S does not use the well on u_N'. By similar reasoning applied to the remaining simple types of legal relations, leaving out the details for brevity, Table 3 shows the suggested analysis.

Table 3. *Simple legal relations between a_S and a_N (before subdivision) regarding $w_N(a_S)$.*

Simple type	Possible logical explication
Privilege($a_S, a_N, w_N(a_S)$)	not:Shall Do(a_S, *not:*$w_N(a_S)$)
Counter-privilege($a_S, a_N, w_N(a_S)$)	not:Shall Do(a_S, $w_N(a_S)$)
not:Claim($a_S, a_N, w_N(a_S)$)	not:Shall Do(a_N, $w_N(a_S)$)
not:Counter-claim($a_S, a_N, w_N(a_S)$)	not:Shall Do(a_N, *not:*$w_N(a_S)$)
Power($a_S, a_N, w_N(a_S)$)	May Do(a_S, $w_N(a_S)$)
Counter-power($a_S, a_N, w_N(a_S)$)	May Do(a_S, *not:*$w_N(a_S)$)
Immunity($a_S, a_N, w_N(a_S)$)	not:May Do(a_N, *not:*$w_N(a_S)$)
Counter-immunity($a_S, a_N, w_N(a_S)$)	not:May Do(a_N, $w_N(a_S)$)

---

[18] Despite some risk of confusion; in previous sections w_N is also used to denote a domain entity, *viz.* the well on u_N.

From this follows that the atomic type of legal relation between a_S and a_N (before subdivision) with regard to a_S's using the well on u_N is the following:

$$\text{Privilege \& Counter-privilege \& not:Claim \& not:Counter-claim \&}$$
$$\text{Power \& Counter-power \& Immunity \& Counter-immunity.} \tag{5}$$

Looking instead at the parties a_B and a_N and the event $w_N(a_B)$, by similar reasoning is is suggested that the atomic type of legal relation between a_B and a_N (before subdivision) with regard to a_B's using the well on u_N is the following:

$$\text{not:Privilege \& Counter-privilege \& not:Claim \& not:Counter-claim \&}$$
$$\text{not:Power \& Counter-power \& not:Immunity \& Counter-immunity.} \tag{6}$$

A similar analysis regarding the same event but instead considering the parties a_S and a_B, suggests the following atomic type of legal relation between a_S and a_B (before subdivision) with regard to $w_N(a_B)$:

$$\text{Privilege \& Counter-privilege \& not:Claim \& not:Counter-claim \&}$$
$$\text{not:Power \& not:Counter-power \& not:Immunity \& Counter-immunity.} \tag{7}$$

The difference between (5), (6) and (7) is further discussed in Section 3.6.

Similar analyses (not shown here due to lack of space) may be performed for other combinations of parties, as well as for the listed conditions 2, 4, 5, 6, and 7. An important observation is the following: the atomic legal relations regarding conditions 1–2 and 4–7 are significant for decisions on whether some party at some point does or does not act in compliance with applicable regulations and agreements[19], but they do not affect (i.e. put restrictions on) the actual cadastral decision that our example focuses on. In contrast, condition 3, *subdividing u_O into u_R and u_D*, is directly related to the cadastral decision. The paper will therefore examine examine this condition instantiated with the cadastral surveyor a_C, and consider the two parties a_S and a_C. Let $s_{O,R,D}(x)$ represent the event *x subdivides u_O into u_R and u_D*.

Table 4. *Simple legal relations between a_S and a_C regarding that a_C subdivides u_O into u_R and u_D.*

Simple type of legal relation	Possible logical explication
Privilege(a_S, a_C, $s_{O,R,D}(a_C)$)	not:Shall Do(a_S, $not{:}s_{O,R,D}(a_C)$)
Counter-privilege(a_S, a_C, $s_{O,R,D}(a_C)$)	not:Shall Do(a_S, $s_{O,R,D}(a_C)$)
Claim(a_S, a_C, $s_{O,R,D}(a_C)$)	Shall Do(a_C, $s_{O,R,D}(a_C)$)
not:Counter-claim(a_S, a_C, $s_{O,R,D}(a_C)$)	not:Shall Do(a_C, $not{:}s_{O,R,D}(a_C)$)
Power(a_S, a_C, $s_{O,R,D}(a_C)$)	May Do(a_S, $s_{O,R,D}(a_C)$)
Counter-power(a_S, a_C, $s_{O,R,D}(a_C)$)	May Do(a_S, $not{:}s_{O,R,D}(a_C)$)
Immunity(a_S, a_C, $s_{O,R,D}(a_C)$)	not:May Do(a_C, $not{:}s_{O,R,D}(a_C)$)
not:Counter-immunity(a_S, a_C, $s_{O,R,D}(a_C)$)	May Do(a_C, $s_{O,R,D}(a_C)$)

---

[19] For example, a court decision on whether a_N at some point was entitled to prevent a_B from using the well. (Before subdivision, a_N has this right, but no longer after.)

Given the assumptions in 3.2 (that u_R and u_D are considered enduringly suited to their purposes, etc.), which simple types of legal positions regarding $s_{O,R,D}(a_C)$ hold between the seller a_S and the cadastral surveyor a_C? Leaving out the details, Table 4 shows the suggested analysis.

As Section 3.6 will discuss, the analysis in Table 4 can be questioned, but if it is accepted the atomic type of legal relation between a_S and a_C regarding the event $s_{O,R,D}(a_C)$ is the following:

$$\text{Privilege \& Counter-privilege \& Claim \& not:Counter-claim \&} \atop \text{Power \& Counter-power \& Immunity \& not:Counter-immunity.} \tag{8}$$

Given that this atomic legal relation holds in the cadastral decision situation, the cadastral surveyor has a duty to perform the requested subdivision, i.e. a_C's room for manoeuvre is restricted in this situation.

3.5.2   Situation after subdivision

First, looking at the condition w_N, how do the atomic types of legal relations discussed in the previous section change as a result of performing the subdivision? After subdivision, the servitude for the owner of u_O (now called u_R) to use the well on u_N remains attached to u_R. Therefore, the atomic type of legal relation between a_S and a_N regarding $w_N(a_S)$ that holds after subdivision is the same as before, *viz.* (5). The same type of legal relation now also holds between a_B and a_N regarding $w_N(a_B)$, due to the creation of a similar servitude for (the owner of) u_D, i.e. the type of atomic relation changes from (6) to (5). The legal relation between the parties a_S and a_B regarding $w_N(a_B)$ is not changed during the subdivision process, i.e. the type of atomic legal relation (7) still holds.

As for the condition $s_{O,R,D}$, *subdividing u_O into u_R and u_D*, it no longer represents a meaningful condition: the event $s_{O,R,D}(x)$ is not possible for any agent x, since the property u_O no longer exists in its original form. Therefore, after subdivision it is not meaningful to talk about the atomic legal relation between any two agents as regards $s_{O,R,D}(x)$.

3.6   *Experiences and reflections*

Sections 3.4 and 3.5 apply two different analysis tools to analyse and describe two 'snapshots' of the subdivision process. Although being simplistic in many ways, the case is still both realistic and rich enough to put the formalisms to the test, and no claims are made that the analyses are exhaustive. Here, the paper will reflect upon perceived strengths and weaknesses of the two formalisms, as well as their potential relation.

The analysis in Section 3.4 gives several insights regarding LADM as a tool for structural analysis. The LADM standard describes many useful 'off the shelf' tools for modelling the example situation(s). The paper has included notions of class diagrams (Figure 8) and object diagrams (Figure 9 and Figure 10), the latter to describe two specific situations related to the case, *viz.* the situation immediately before resp. immediately after the cadastral decision regarding subdivision. As Section 3.4 already mentions, object diagrams have not been utilized in the same

way as in the property subdivision example illustrated in Figure C.38 in the LADM (ISO, 2012).

For structurally analysing two situations of the example process, the LADM offers the possibility to represent formally (and with high precision) various RRRs of different parties in relation to each other and to land. The extension to the LADM classification proposed by Paasch et al. (2015) offers even higher level of precision, for example making it possible to model the right-of-use to the well on the neighbouring property (i.e. $s_{w,O}$ in Figure 9) as an *LA_PartyToPropertyRight* or perhaps an *LA_PropertyToPropertyRight* (see Figure 11 in Section 4). Since the focus of the LADM is conceptual rather than technical, and the standard was designed to give room for national implementations that adhere to different legal traditions, there are several degrees of freedom to its application, and the examples discussed in the standard sometimes give limited guidance. For example, Section 3.4.1 utilized the RRR subclass Restriction to model the servitudes in Figure 9 and Figure 10. However, since the paper refers to the owner of u_O (resp. u_D) having a right to access the well for water, it might be perceived as more natural to model this with an instance of the Right class (attached to the dominant property) than an instance of the Restriction class. The paper refrained from this for two reasons. First, in order to follow the example C.21 of the LADM standard, and secondly, since the RestrictionType code list has an entry *servitude*, while the RightType code list has not. It is not clear from the description of the standard if any of the two options should be preferred, so it appears that the servitudes could have been modelled both as (subclasses of) LA_Right and LA_Restriction, perhaps depending on perspective. This freedom may be a benefit for a conceptual analysis, but at the same time a challenge when approaching technical implementation. Due to this and to the focus on concepts and static situation descriptions, the LADM support for further automation of land administration processes is rather limited.

Note that the two BA_Unit objects u_R and u_N in Section 3.4.2 originate from u_O, and that the two LA_SpatialUnit objects in Figure 10 together constitute the original LA_SpatialUnit object in Figure 9. These relationships could be represented in the diagram by means of a LA_RequiredRelationshipBAUnit and a LA_RequiredRelationshipSpatialUnit, respectively. These relationships could be very important in various context, but were omitted from Figure 10 to reduce the complexity.

As demonstrated, the LADM with extensions can be used to structurally with high level of granularity model different categories of (e.g. public and private) RRRs, and how they are attached to different parties and administrative units. As Section 3.5 shows, the structural analysis can be complemented with a logical analysis that adds better support for legal reasoning. Through the analysis a deeper insight is gained into how to (with very high precision) state basic legal positions of different parties regarding some state of affairs or event in logical language. By doing so, it is possible to exhaustively formalise the leeway of the agents involved in the decision situation, and thus take another step towards increased automation of legal decision processes. Consider again, for example, the simple types of legal

relations (5), (6) and (7) regarding the condition *using the well on u_N* (abbr. w_N) in Section 3.5:

$$\text{Privilege \& Counter-privilege \& not:Claim \& not:Counter-claim \&} \atop \text{Power \& Counter-power \& Immunity \& Counter-immunity.} \tag{5}$$

$$\text{not:Privilege \& Counter-privilege \& not:Claim \& not:Counter-claim \&} \atop \text{not:Power \& Counter-power \& not:Immunity \& Counter-immunity.} \tag{6}$$

$$\text{Privilege \& Counter-privilege \& not:Claim \& not:Counter-claim \&} \atop \text{not:Power \& not:Counter-power \& not:Immunity \& Counter-immunity.} \tag{7}$$

Before subdivision, (5) is the type of legal relation between a_S and a_N with regard to a_S's using the well on u_N, (6) is the type of legal relation between a_B and a_N with regard to the same event, and (7) is the type of legal relation between a_B and a_N with regard to a_B using the well on u_N. The difference between (5) and (6) is due to the existing servitude that gives a_S a right-of-use (manifested as a Privilege, a Power and an Immunity) that a_B does not have. The reason for the difference between (5) and (7) is that a_S does have legal capacity regarding his/her own use of the well on u_N, thanks to the well servitude, but not regarding a_B's use of the well. (The servitude does not give a_S the right to permit another person to use the well.)

Regarding the condition *subdividing u_O into u_R and u_D* (abbr. $s_{O,R,D}$), some of the suggested simple legal relations in Table 4 are rather straightforward, while others are not. It is not evident, for example, how to understand the notions of Power and Counter-power in this case. In the current situation, does a_S versus a_C have 'legal capacity' (power) regarding that a_C subdivides u_O? As for Counter-power, does a_S versus a_C have capacity regarding that a_C does not subdivide u_O? In Table 4 it is suggested that both Power(a_S, a_C, $s_{O,R,D}(a_C)$) and Counter-power(a_S, a_C, $s_{O,R,D}(a_C)$) hold.

The analysis in terms of simple legal relations may be translated to logical language through Table 2. Note, however, that the conditions *using the well on u_N* (w_N) and *subdividing u_O into u_R and u_D* ($s_{O,R,D}$) are unary conditions, i.e. conditions on one agent x. Kanger's logical explication of the fundamental jural relations (Section 2.5) originally presupposes binary conditions, i.e. conditions on two agents x and y. Thus, by generalising to unary instead of binary conditions, as in Table 3 and Table 4, the formalism is stretched a bit. This is not a limitation, since the main purpose of the logical analysis was nothing more than demonstrating how to put the logical language to work, but should be kept in mind when interpreting the result of the translation. For example, in the situation before subdivision, it seems reasonable to say that

$$\text{Counter-claim}(a_N, a_B, w_N(a_B)) \tag{9a}$$

or, in other words,

$$\text{Claim}(a_N, a_B, \textit{not:}w_N(a_B)) \tag{9b}$$

holds, i.e. that a_N (versus a_B) has a claim regarding that a_B does not use the well on u_N. On the other hand, equally reasonably, it holds that

$$\text{not:Claim}(a_S, a_B, \textit{not:}w_N(a_B)), \tag{10}$$

i.e. it is not the case that a_S (versus a_B) has a claim regarding that a_B does not use the well. However, the generalised explication of (9ab) is

$$\text{Shall Do}(a_B, \textit{not:}w_N(a_B)), \tag{11}$$

while the generalised explication of (10) is

$$\textit{not:}\text{Shall Do}(a_B, \textit{not:}w_N(a_B)), \tag{12}$$

i.e., there is a logical contradiction. Thus, when generalising the logical explication of simple types of legal relations to unary conditions, either the rights-bearer or counterparty may 'disappear' from the logical analysis, which may be potentially problematic. Regarding the interpretation of Power and Counter-power in Table 4, the generalised explication of Power(a_S, a_C, $s_{O,R,D}(a_C)$) is May Do(a_S, $s_{O,R,D}(a_C)$), which may be interpreted as 'it may be the case that a_S sees to it that a_C subdivides u_O'. The fact that a_S has the right to have u_O subdivided (provided that all necessary prerequisites are fulfilled) seems to already be adequately modelled by the simple type Claim, and what it would mean in the present situation that 'a_S sees to it that a_C subdivides u_O' is not wholly clear. The explication of Counter-power(a_S, a_C, $s_{O,R,D}(a_C)$) is May Do(a_S, $\textit{not:}s_{O,R,D}(a_C)$); 'it may be the case that a_S sees to it that a_C does not subdivide u_O'. In this case, one might perhaps say that a_S has the right to withdraw the subdivision application, and thus may see to it that a_C does not subdivide u_O. (See also the example in Section 2.4.)

It could be argued that by performing a logical analysis of this simple decision situation, one takes a sledgehammer to crack a nut. In fact, the complexity of mapping out all the legal positions of different parties with respect to different conditions in the decision situation seems to be way out of proportion to the complexity of the actual decision. Besides, sorting out this complexity by hand is likely a very difficult and time-consuming task. These are valid objections, but it should be kept in mind that the aim here is to take a first step towards developing the theoretical and conceptual framework for digitalization and automation of the urban planning and cadastral process. By one step at a time applying the analysis tools to a number of situation case studies, this domain becomes more and more familiar, and at the same time the strengths and weaknesses of the applied tools become more evident. The rapid development of modern machine-learning techniques potentially offers a new kind of tools that for example makes it possible to derive formal descriptions of the normative systems that regulate the property formation decision-making from unstructured or semi-structured legal text and/or descriptions of real subdivision cases. A prerequisite for employing such approaches, however, is a thorough understanding of the domain, regarding both structure and logic.

An interesting question is how the two analysis tools relate to each other, i.e. how they 'fit together'? Since they have different purposes, i.e. conceptual and structural vs. logical analysis, they can be regarded as complements to each other rather than competitors. It is natural to ask whether it would be possible (and, if so, useful) to add support in the LADM for expressing RRR's as atomic types of legal relations, in order to allow for even more fine-grained analyses and smoother co-existence and integration of the two formalisms.

4   Discussion

The analyses in Section 3 focus on a subset of the domain and a subset of the legal positions that hold in the selected decision situation. (A more comprehensive analysis of the selected decision situation and/or decision process is beyond the scope of this paper, and thus left for future work.) This approach might seem limiting, but it should be noted that the legal positions of different parties in specific situations are rarely explicitly written down in legal text like laws or other normative systems. In the process of formulating a normative system that is internally consistent and precise, it may certainly be helpful to be able to formally express (some or all of) the legal positions that hold in a particular situation. However, Lindahl and Odelstad (2013, p. 547) argue that a set of sentences that contain individual names is not an appropriate representation of a normative system, since normative systems express general rules where no individual names occur. (Lindahl & Odelstad, 2013, p. 547) The application of a particular normative system to a particular situation usually does not require being able to map out all legal positions 'by hand'. Instead, the specific legal positions of the parties with respect to different states of affairs or events should follow from application of general regulations to the specific situation. What is needed for automated application of normative systems is therefore (i) a theory of representation of normative systems consisting of individual general norms, together with (ii) a mechanism for deducing specific legal positions of different agents by applying general norms to specific situations, (iii) a mechanism for checking the compliance of the agents' actions with these legal positions, and (iv) a computational framework for instrumentalising these components into executable code. One example of how to deal with items (i) through (iv) is briefly discussed below.

Individual items of a normative system, i.e. what is here referred to as norms, are often formally expressed as conditional sentences of the simple form

$$P \text{ implies } N(Q),$$

where P and Q are descriptive sentences, often conditions on a number of agents, and N is a norm-creating operator. If the left part P of the implication holds, then the right part $N(Q)$ is in effect, and potentially regulates the behaviour of some agent(s). The norm-creating operator N may be a deontic operator such as Shall and May, or an operator based on atomic types of legal relations (see Sections 2.5 and 3.5) or one-agent types of normative positions (see Table A1). Odelstad and Boman (2004) employ an algebraic version of the theory of normative positions, based on the notion of a condition implication structure (*cis*). In the *cis* approach to the formal representation of normative systems (item i), a conditional norm is represented as an ordered pair $\langle p, Nq \rangle$ where p (the 'ground' of the norm) and q are descriptive conditions and Nq (the 'consequence') is a normative condition on a number of agents. Applying an individual norm $\langle p, Nq \rangle$ is done through instantiating the ground p with the parties x_i involved in the particular situation, and checking if $p(x_1, x_2, \ldots, x_n)$ holds in this situation. If so, the following derivation scheme (see

Odelstad & Boman, 2004, p. 146) is used to infer a consequence in the form of a normative *n*-ary condition instantiated with *n* agents:

$$p(x_1, x_2, \ldots, x_n)$$
$$\frac{\langle p, Nq \rangle}{Nq(x_1, x_2, \ldots, x_n)}$$

The last step is to check whether the agents' actions comply with the normative consequence $Nq(x_1, x_2, \ldots, x_n)$. Hjelmblom (2015) demonstrates possible mechanisms for norm instantiation and rule checking, i.e. items (ii) and (iii), instrumentalised into a computational framework (item iv).

It can be noted that norms of the more complex form

$$P_1 \text{ implies: } P_2 \text{ implies } N(Q),$$

occur frequently in law; not least in normative systems containing intermediate concepts (see Section 2.2). For example, P_1 could denote that there is a servitude attached to the property unit u_O regarding right-of-use of the well on u_N, P_2 could denote that a_S is the owner of u_O, and $N(Q)$ could denote the atomic legal relation (5) in Section 3.5.1. The consequence of P_1 is itself a conditional norm, since it is conditional on P_2, the intermediate concept *being the owner of u_O*. Jurists often call such consequences *hypothetical legal consequences*. For a discussion of the formal treatment of norms with hypothetical consequences, see for example (Lindahl and Odelstad, 2000) and Odelstad (in press).

During its development as well as after its publication in 2012, the LADM has been the subject of numerous research activities, with topics ranging from technical implementation issues and the registration of real property to legal and organisational aspects. Liedholm Johnson et al. (2015) showed that it is relevant to use a standardized approach for obtaining an overview of, and thus comparing the multifaceted nature of, private and public interests in land. A survey (Paulsson & Paasch 2015) showed that there has been limited focus on research on legal and organisational matters, such as how to organise and manage interests in land. The rather coarse classification in the LADM today could benefit from a higher level of specialisation by adding an extended classification, as mentioned in Paasch and Paulsson (2015) and Paasch et al. (2015). Both discuss a proposed development of the LADM, an extension focusing on expanding the standard's terminology for providing a more detailed classification of land use than possible in the original standard. Figure 11 shows a possible extension of the LADM's legal right class, showing an extended classification for privately and publicly imposed rights.

An interesting line of work would be to examine the possibility (and usefulness) to extend the LADM even further with support for expressing RRR's as simple types of legal relations with regard to some state of affairs or event, for example by adding more subclasses or more developed property code-lists.

The logical analysis presented in Section 3.5 was based on Kanger's typology of atomic types of legal relations. As mentioned in Section 2.5, this typology was developed by Lindahl (1977) into three systems of types of *normative positions*. Recently, this theory has attracted attention within computer science and has been
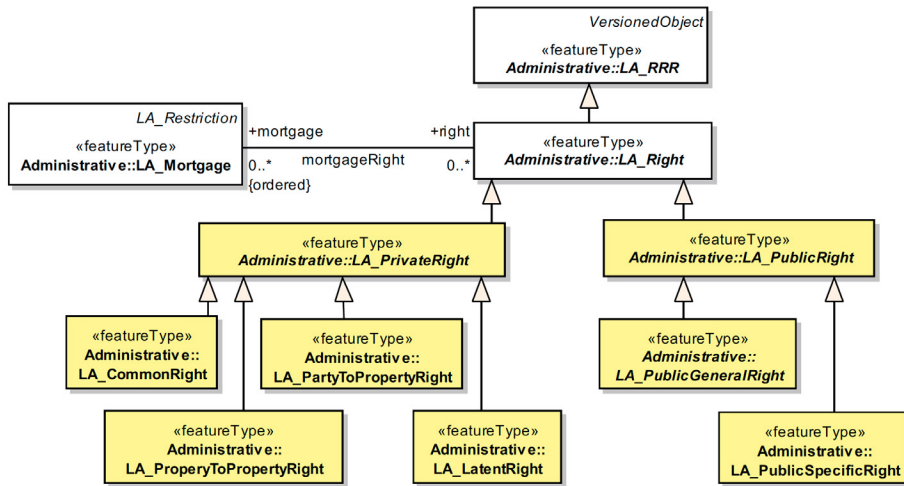
Figure 11. *Specialization of the LADM's legal right profile (white) with an extended clas-sification of privately and publicly imposed rights (yellow) (Paasch et al., 2015, p. 684).*

been put to work by, e.g., Jones and Sergot, Krogh and Herrestad, and Odelstad and Boman (see for example Sergot, 2013, Krogh & Herrestad, 1999, and Odelstad & Boman, 2004). As already mentioned, the latter work is based on an algebraic version of Lindahl's system of *one-agent types of normative positions* (see Table A1). In the algebraic approach, a normative system in its simplest form is represented as a so-called Boolean joining system where conditional norms are represented by ordered pairs ('joinings') which correlate descriptive conditions with normative conditions. It is straightforward to perform the analysis in Section 3.5 in terms of one-agent types of normative positions instead of atomic legal relations, and formulate corresponding normative systems as algebraic entities. Together with the work by Hjelmblom (2015), which demonstrates how to instrumentalise this approach into executable code, this prepares the ground for automated decision-making.

When developing automated decision-making systems within such complex areas as the urban planning and building process, and in particular property formation, it is important to consider and analyse in detail both technical, legal and organizational aspects. Ongoing projects seem to mainly focus on technical, and to some extent organizational, issues (Ekbäck, 2019), which makes it even more important to consider the legal aspects. The urban planning and building process consists of many different decision processes and includes different kinds of decisions. Some of them (such as the surveyor's cadastral decision as an example, or a building permit approval by a municipality) are related to specific cases and are taken by individual officials, while others (for example establishing municipal detailed development plans or comprehensive plans) are made by local assemblies. What these decisions processes all have in common is that they are directed and constrained by a legal framework which in the Swedish setting

includes laws such as the Real Property Formation Act, the Planning and Building Act, the Joint Facilities Act, the Administrative Procedure Act, the Environmental Code, the Land Code, etc. This legal framework constitutes a normative system with which all decisions must comply, i.e. the law must always be obeyed, but the latitude given by the legislation can vary considerably. In the case of the cadastral decision discussed in this paper, the scope of action for the cadastral surveyor is very narrow: if the formal requirements for property formation are fulfilled, then the surveyor must approve the application. In other cases, for example regarding establishing local regulations or municipal development plans, the scope of action given by the legislation can be much wider, with room for making political choices (based on different preferences or ideological stances) between several options. Ekbäck (2019) discusses how digital processes could handle the many qualitative assessments that are required by law, where the variables that must be evaluated are neither quantifiable nor well defined, or may be based on normative political positions. He claims that change of property ownership and property transactions would be somewhat easier to make automated since no particular qualitative assessments are needed, but raises the question whether or not it would be possible to design the technology to handle the balance between different public and individual interests. This paper hopes to further contribute to this discourse, by suggesting that these neither quantifiable nor well-defined variables are to be understood as open intermediate concepts (see Section 2.2), and by discussing the theory of such concepts and their role in the decision-making process. Ground-open intermediate concepts are of special significance, and require special attention, since they function as 'decision points' in a decision process (Odelstad, 2019, pp. 106f). In the property subdivision process, for example, the cadastral surveyor must aggregate information of different sorts in order to decide on whether the factual grounds of, e.g., the previously mentioned condition *being enduringly suited to its purpose* apply in the specific case[20], and thus its legal consequences are in effect. This potentially includes weighing together different legal facts and balancing sometimes conflicting interests. (This approach to open intermediate concepts, analogous to that of weighing together different aspects in a multi-criteria decision problem, is outlined in Odelstad, 2002, ch. 12-3.)

Thus far, the paper has discussed one potential approach to the logical analysis and automated application of normative systems within the land administration domain, based on the algebraic approach to norms by Lindahl and Odelstad (2013) and its instrumentalisation by Odelstad and Boman (2004) and Hjelmblom (2015). Naturally, there are other interesting approaches to the formal representation and instrumentalisation of normative systems, such as Input/output logic (see the overview by Parent & van der Torre, 2013). Two recent examples within the land administration domain are the work by Lee et al. (2016) and Malsane et al. (2015) on formalising and digitalising building requirements and regulations. However, a particularly interesting feature of the work by Lindahl and Odelstad

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[20] I.e., that there are no legal impediments to forming the new property, as regards its suitability.

is that it is an application of their so-called Theory of Joining Systems (TJS). Since one of the aims of the development of this theory was "to provide tools for a rational reconstruction of a legal system with intermediaries" (Lindahl & Odelstad, 2013, p. 625), TJS and its application to normative systems containing intermediate concepts has the potential to be a useful part of the framework for digitalization and automation of the urban planning and building process.[21] Further development of the theory includes developing an algebraic version of the system of *n*-agent types of normative positions (Lindahl, 1977), to potentially address some of the limitations (briefly discussed in Section 3.6) of the simple one-agent system, and investigating the formal treatment of norms with hypothetical legal consequences. Further work (including computational logic considerations) on the instrumentalisation of the theory into executable logic programs is also of interest.

This paper has presented a simple case on property formation and a starting point for how an automated decision process could be achieved. However, when adding more complexity, as often is the case in real life situations, and including the assessments made by various authorities in several steps, additional considerations would have to be made. The required information and documentation as a basis for the assessment and decision-making has to be more standardized. In many cases, a combination of automation and manual assessments of more qualitative aspects might be necessary, at least during the initial phases before further development of the automated system. For example, formal analyses as performed here, together with analyses of relevant normative systems regarding the occurrence of open intermediate concepts, may lay part of the groundwork for semi-automated decision-making where a computer identifies decision points and presents a complex decision situation (and possibly suggest or recommend a particular decision) to a human decision maker, who then makes the necessary judgments and trade-offs. This, in turn, is an important step towards further automation of complex decisions.

5   Conclusion

This paper uses two different analysis instruments to perform structural and logical analyses of two specific snapshots of a fictitious property subdivision case in Sweden, focusing on the legal relations between different entities and parties involved in the specific situations. The structural analysis used the LADM ISO standard formalism, and the logical analysis was based on Kanger's atomic types of legal relations. By (i) combining two perspectives on formalisation and classification of legal relations within the urban planning and building domain, (ii) discussing some of the strengths and weaknesses of the two tools regarding the formal representation of RRRs of different parties in this domain, and (iii) discussing how the tools can be aligned, the paper has presented one way to analyse

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[21]   Lindahl and Odelstad (2013, p. 546) argue that "[a] theory of representation for normative systems will be incomplete unless attention is paid to the role of *intermediate concepts* within the system (for example, the role of legal concepts such as ownership)".

and describe the land administration domain at a higher level of abstraction and formalization using different analysis tools.

Furthermore, the paper has provided suggestions of future research in several directions, including to model the general subdivision process by mapping out the (kinds of) different parties involved in or affected by the process and analysing what kind of decisions emerge where in the process. Another direction is to analyse further the normative systems (such as Swedish laws, regulations and municipal development plans) that regulate the process and how they form networks or strata of intermediate concepts.

Similar analyses of a wider range of subdivision process snapshots as well as analyses of other property formation processes are one suggested future research path. The paper has highlighted the need for more basic research on the theoretical tools themselves, such as to explore possible extensions of the LADM standard, and to further develop the Theory of Joining Systems (TJS) and put it to work within the land administration domain. Another suggestion for further work is the instrumentalisation of TJS into executable prototypes, and investigation of the possibility to use machine-learning approaches within the theoretical and conceptual framework developed here. This paper has taken one step towards a deeper understanding of the domain, and outlined some of the work needed to proceed even further, in the hope of providing better conditions for more efficient and transparent use of geospatial information, and increased automation of the property subdivision process and other related civil processes.

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Appendix 1

Table A1. Lindahl's set of one-agent types of normative positions.
(Standard logical connectives are used for conjunction and negation.)

T_1	May Do(x,F) ∧ May[¬Do(x,F) ∧ ¬Do(x,¬F)] ∧ May Do(x,¬F)
T_2	May Do(x,F) ∧ May[¬Do(x,F) ∧ ¬Do(x,¬F)] ∧ ¬May Do(x,¬F)
T_3	May Do(x,F) ∧ ¬May[¬Do(x,F) ∧ ¬Do(x,¬F)] ∧ May Do(x,¬F)
T_4	¬May Do(x,F) ∧ May[¬Do(x,F) ∧ ¬Do(x,¬F)] ∧ May Do(x,¬F)
T_5	May Do(x,F) ∧ ¬May[¬Do(x,F) ∧ ¬Do(x,¬F)] ∧ ¬May Do(x,¬F)
T_6	¬May Do(x,F) ∧ May[¬Do(x,F) ∧ ¬Do(x,¬F)] ∧ ¬May Do(x,¬F)
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Effects of Land Consolidation in Norway

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Abstract. The main objective of this paper is to analyse the various effects of land consolidation and its impact on rural development in Norway. It is important to note that in Norway land consolidation remains the exclusive domain of the court system. Three cumulative requirements must be fulfilled before land consolidation can proceed in Norway. 1) The Land Consolidation Court may effectuate land consolidation if at least one property or easement in the land consolidation area is difficult to use gainfully at the current time and under the current circumstances; 2) The Land Consolidation Court may only proceed in this way in order to make the property arrangements in the land consolidation area more advantageous, and; 3) For any given property or easement, the land consolidation settlement shall not result in costs and other disbenefits that are greater than the benefits. All three criteria must be fulfilled. This paper presents and analyses cases taken before the Norwegian Land Consolidation Court using case studies, surveys and qualitative interviews with property owners and judges at the land consolidation courts. It is based on a literature review and secondary data collected by researchers and Master's students working on land consolidation in Norway in the period from 1992 to 2015, focusing on rural areas. The observed effects of land consolidation are separated into economic and spatial, legal, environmental and social effects. The analysis shows that the effects of land consolidation are difficult to estimate or to calculate. Future research should focus on developing better methods for both valuations and impact studies.

Keywords: land consolidation, economic effects, spatial effects, juridical effects, social effects, environmental effects, rural development

1 Introduction

The main objective of this paper is to analyse the various effects of land consolidation and its impact on rural development in Norway. The legally defined aims of land consolidation vary from country to country. According to Vitikainen (2004, p. 25–26), the general objective is nonetheless to improve land division and promote the appropriate use of real estate. This is done by consolidating plots through land exchange to form plots that are better adapted to their proper

use. Land consolidation in Norway has an even wider general objective. Land consolidation can be defined as measures that can change properties, physically or organisationally, to improve their utility to the owners (Sky and Bjerva, 2018, p. 21). Norwegian definition of land consolidation is therefore broader than in many other European countries. A fundamental principle, and not only in Norway, is that no party shall suffer losses as a result of a land consolidation case (Oldenburg, 1990, p. 183). This constitutes an important prerequisite for the final decision concerning any given land consolidation plan. It is therefore important to have control and overview of the effects of land consolidation.

The measures used in land consolidation in Norway are listed in the Land Consolidation Act (Ministry of Agriculture and Food 2013). The Act comprises 10 separate measures that can be used individually or together in each case. According to the definition, land consolidation can be divided into physically and organisationally changes.

Physically changes (with reference to the Land Consolidation Act): Project-related land consolidation in conjunction with private and public projects; Conservation-related land consolidation as the result of the public authorities imposing constraints on the exercise of ownership rights (both Section 3-2); Modifications to property and perpetual easements (Section 3-4); Establishing joint ownership (Section 3-5); Dissolution of joint ownership and joint use (Section 3-6); and Division of property (Section 3-7).

Organisationally changes (with reference to the Land Consolidation Act): Rules on joint use (shared use arrangements) (Section 3-8); Orders to carry out joint measures and joint investments (Section 3-9); and Creating owner associations and establishing articles of association (Section 3-10).

The first dedicated land consolidation act was enacted in 1821 and the Norwegian Land Consolidation Court has been regarded as a special court since 1882. Although land consolidation is organised within the judicial system and the organisation and the objectives of land consolidation vary from country to country, the actual land consolidation process is surprisingly similar internationally (Sky, 2015, p. 81). The process in rural and urban areas of Norway is also similar and can be said to include the following stages (partly after Rognes and Sky, 2004, p. 61): applying for land consolidation; preliminary decision on whether the case shall proceed; informing the cadastral authority that a land consolidation claim has been made; clarifying the boundaries and easements and mapping of the consolidation area; performing a valuation of anything that is covered by the exchange; preparing a draft consolidation plan after input from the parties involved; presenting the plan to the parties for discussion; comments from the parties; making alterations to the plan that the land consolidation court deems right and proper in response to comments; and formal adoption of the plan. After the land consolidation plan is adapted, marking out of all new boundaries in the fields; and formal conclusion of the land consolidation proceeding in court. When the case is enforceable, the land consolidation court informs the cadastral authority (municipality) of the outcome of the case; and the outcome is recorded in the land registry.

Before land consolidation can proceed in Norway, three cumulative requirements have to be fulfilled: 1) The Land Consolidation Court may effectuate land consolidation if at least one property or easement in the land consolidation area is difficult to use gainfully at the current time and under the current circumstances; 2) The Land Consolidation Court may only proceed in this way in order to make the property arrangements in the land consolidation area more advantageous, and; 3) For any given property or easement, the land consolidation settlement shall not result in costs and other disbenefits that are greater than the advantages. It should be pointed out that these requirements apply to land consolidation in most countries (Sky, 2015). Based on the three requirements, it is important to map out what effects each individual land consolidation case will have, both overall and for each owner. This is especially important in view of the requirement that no-one shall lose out from land consolidation.

Several different approaches to determining the effects or benefits of land consolidation exist, for instance, looking at the socioeconomic effects or at the economic impacts on private interests. This paper focuses on the effects on private interests. The effects can be classified as economic, spatial, legal, social and environmental. Methods to analyse spatial effects have the strongest theoretical underpinning. Due to the close relationship between economic and spatial effects, these effects will be treated together. A shift towards methods that analyse land consolidation based on several criteria, also called multi-criteria evaluation, has been identified (Huylenbroeck and Martens, 1990).

This paper is structured as follows. Section 2 gives a short description of the methods used in the different studies, and the scope. Section 3 present studies of each effect in greater detail. This section provides references to international research on the effects of land consolidation, before going on to present the findings. Section 4 compiles the major findings of the studies in a table, and discusses the findings further. Lastly, Section 5 draws conclusions based on the findings.

2   Method

This paper is based on a literature review and secondary data collected by researchers and Master's students working on land consolidation in Norway in the period from 1992 to 2015, focusing on rural areas. The extensive research material is detailed in Table 1.

Steinsholt (1994) and Espås and Lande (1992) performed both an economic and spatial analysis. Steinsholt carried out an in-depth study of project-related land consolidation for public roads, including studying different layouts on plots. He divided his analyses into effects on the private owners and on the road authority. Espås and Lande did an in-depth single case study of fragmented plots in a cultural landscape, characterised by stone fences. Geelmuyden (1994) did a case study and a landscape analysis on how land consolidation affected the landscape.

Jevnaker (2015) studied six project-related land consolidation cases and interviewed six land consolidation judges and five civil servants from the railway authority and the public roads authority. Gulliksen (2012) also studied project-related land consolidation. She studied the largest project so far in Norway,

which included 19,500 ha for a military training field. She interviewed the land consolidation judge who presided over the case and eight affected parties.

Hoddevik (2012), Myrvold (2012), Kollstrøm (2014) and Lyseng (2012) studied effects of joint measures and joint investments and the establishment of private common roads. Hoddevik studied economic, environmental and social effects, through eight case studies. All her cases were located in the western part of Norway and she held 38 interviews. Myrvold conducted four case studies and interviewed 16 parties. Kollstrøm investigated four case studies, which were appealed to the land consolidation court of appeal, where he interviewed the land consolidation judges in each case. He also interviewed the applicant in three of the cases (the last one did not wish to be interviewed), and the appellant in each case. Lyseng conducted six case studies, combined with interviews of land consolidation judges and 24 parties.

Gulbrandsen (2011) examined the long-term effects of joint use resulting from land consolidation. The study consisted of 30 cases. Four of the cases were used as pilot studies as a basis for his survey, and the remaining 26 for the survey itself. The survey was a net selection and included 85 participants, with a response rate of 86 percent (73 answers).

Oppegaard (2011) performed an in-depth single case study of land consolidation of joint measures of constructing of water pipes and sewages.

Table 1. *Authors listed in alphabetical order and summary of the research method and the data.*

Authors	Research method	No. of cases/ respondents
Espås and Lande (1992)	In-depth single case study	Single case
Geelmuyden (1994)	In-depth single case study	Single case
Gulbrandsen (2011)	Case study and survey	30 cases, 73 answers (response rate 86 percent)
Gulliksen (2012)	In-depth single case study and interviews	Single case and 9 respondents
Hoddevik (2012)	In-depth case study and interviews	8 cases and 38 respondents
Jevnaker (2015)	In-depth case study and interviews	6 cases and 11 respondents
Kollstrøm (2014)	In-depth case study and interviews	4 cases and 11 respondents
Laskemoen (2011)	Survey	107 answers (response rate 42,5 percent)
Lyseng (2012)	In-depth case study and interviews	6 cases and 24 respondents
Myrvold (2012)	In-depth case study and interviews	4 cases and 16 respondents
Oppegaard (2011)	In-depth single case study and interviews	8 respondents
Roalkvam (2003)	In-depth case study and interviews	2 cases and 25 respondents
Steinsholt (1994)	In-depth case study	4 cases

Oppegaard interviewed the land consolidation judge, one representative from the municipality, a lawyer representing one of the parties and five parties.

Laskemoen (2011) studied the social effects of land consolidation involving the dissolution of joint ownership and joint use. She performed a survey with 252 participants, with a response rate of 42.5 percent (107 answers).

Roalkvam (2003) performed two case studies of traditional land consolidation issues as fragmented holdings in the infields. In one case study he interviewed 11 parties and in the other one he interviewed 14 parties. Unlike the other studies, Roalkvam has a more general and theoretic approach. In his study the respondents had to describe their relationships to the properties, for instance if they were full-time or part-time farmers, or had other relationships to the properties. They had to describe both the positive and negative effects of the land consolidation and on that basis conclude if the land consolidation overall had been beneficial or not.

3 Effects of land consolidation

3.1 *Economic and spatial effects*

3.1.1 *Literature review*

Land consolidation is important for ensuring the economic viability of rural areas, see Van Huylenbroeck et al. (1996, p. 300), Crecente et al. (2002, p. 141–142), Leń and Król (2016, p. 237) and Janus and Markuszewska (2017, p. 151), or Gonzalez et al. (2007) who focus on both spatial and economic effects. Several international surveys have calculated transport time before and after land consolidation. Burton (1988, p. 131–147) calculated the effect on transport times and working hours for villages in Cyprus. Burgmaier et al. (1995, p. 22–24) focused on the reduction in working hours and found improvements of 20-25 percent after land consolidation in Trochtelfingen in Germany. They compared the time spent working before and after land consolidation by means of working time studies. Gonzalez et al. (2007) have developed a method that combines size, shape and fragmentation of plots. This allows one to calculate the effects of changes to the layout of plots. The effect of different layouts is a type of spatial effect. Sky (1995 and 2002, p. 83–91) developed methods and tools for analysing the operational costs of plots of different size, shape, and distance (location) from the operational centre of the farm. The operational costs are expressed in terms of man and machine hours, and equipment per unit of land for different layouts of plots, and different crops. Once the work hours have been calculated, it is easy to calculate the economic effect.

3.1.2 *Findings*

In their studies, Steinsholt (1994) and Jevnaker (2015) both found that land consolidation had positive economic impacts on public and private owners. The benefits for the public sector are a reduction in monetary compensation payable to landowners since the alternative is expropriation, and lower costs for building crossings in conjunction with, for instance, railways or motorways. Steinsholt (1994, p. 29) also highlights the reduction in the number of crossings. Jevnaker

points out that both the railway authority and the public roads authority stressed what they called a "goodwill effect". The goodwill effect can be described as the authorities attempt to help reducing the disadvantages and maintaining a good layout of properties. This effect is characterised by monetary compensation in combination with land consolidation (Jevnaker 2015, p. 46, 49). Another effect is a new layout of properties. Steinsholt (1994, p. 27) concluded that there were substantial economic effects for landowners who were active farmers. The effects for the public roads authority was a reduction in construction costs and lower monetary compensation payable to the owners (Steinsholt, 1994, p. 29–31). However, the effects of these types of land consolidation in forest areas are less beneficial. This is because these areas have less value and the disbenefits are consequently smaller than in agricultural areas (Jevnaker, 2015, p. 70).

In a case study of land consolidation of joint measures of constructing of water pipes and sewages, Oppegaard (2011, p. 74) found some similar effects. The land consolidation court organised the parties and they reached a settlement quickly compared to a traditional expropriation case. Land consolidation resulted in lower transaction costs and the litigation costs were lower than in the event of expropriation.

Hoddevik (2012, p. 101) found that investment in joint roads triggered positive economic effects, but it was difficult for the parties to estimate the exact value. Especially in one case, which was a private road to an area with leisure homes with no access to a road before land consolidation, a real estate agent documented that the road to the leisure homes increased the value of the properties considerably. The majority of the parties considered it reasonable for their properties to be part of the land consolidation case. Laskemoen (2011, p. 118) also asked about the parties' self-assessment regarding the value of their properties after the land consolidation. She found that 43 percent said that they were better off, 48 percent said that the value was unchanged and 9 percent said that the value had dropped. It should be remembered, however, that participants are protected against economic losses in land consolidation cases in Norway, regardless of the parties' subjective assessments.

Espås and Lande (1992) studied the effects of land consolidation undertaken in a cultural landscape. Lista, a coastal area in the southwest of Norway, is known for its stone fences, agricultural areas, and active farming communities. They found that it was economically efficient to increase the plot size in this area up to 1,8 ha (Espås and Lande 1992, p. 74). Further increase of plot size was relatively little profitable. If the environmental and aesthetic conditions of the landscape were taken into account, the preferable plot size was 1.2 ha. This shows that environmental effects may interact with and affect the economic impacts. Espås and Landes spatial analysis is based on Christoffersen (1988) and his analysis of the economics of agricultural use of plots of different sizes and shapes. Gulliksen (2012, p. 64) also found that larger plots had a positive economic effect for forestry, but did not conclude on any ideal plot size. Kollstrøm (2014, p. 105) found that a common road in a forest area had effects beyond making the forestry more efficient. It also facilitated big game hunting and other uses.

3.2 Legal effects

3.2.1 Literature review

The judicial and legal effects of land consolidation are not widely discussed in the literature. Norway has, compared to other countries, many disputes regarding boundaries and rights of use (Sky 2015, p. 89). Clarifying boundaries and easements is therefore an important aspect of Norwegian land consolidation. That, in addition to reduced fragmentation, the dissolution of joint ownerships and a reduction in the number of property boundaries, is an important judicial effect (Bonner 1987, p. 16). Land consolidation therefore often reduces the number of court cases and conflicts over property boundaries and easements. Another potential legal effect, is that the number of owners may be reduced by land consolidation. That is often the case in Cyprus (Burton and King 1982, p. 197), for instance. Abandoned properties, which the owner does not wish to farm, can be sold. No coercive measures for this exist in Norway, and although the Land Consolidation Act has provisions enabling the land consolidation court to facilitate purchases and sales, this rarely happens.

An advantage that is highlighted and mentioned as very important is that the property will be registered in the cadastre and the legal situation will be clarified after land consolidation (Archer, 1992, p. 294). Clarifying the land tenure, marking the boundaries and registering the properties in the cadastre are also important in Norwegian land consolidation. In some cases this is the most important effect.

3.2.2 Findings

Myrvold (2012, p. 101) found that the rules established by the land consolidation court were not subsequently followed by the parties in cases of joint measures and joint investments in a private road. The parties had the impression that the decision of the land consolidation court was to be seen as providing guidelines and therefore not legally binding (Myrvold 2012, p. 102). Kollstrøm (2014, p. 59, 110) also found that the parties had problems with both understanding and following the statutes decided by the land consolidation court. Gulbrandsen (2011, p. 70), on the other hand, found that the legal effect had the biggest impact on the parties and the statutes made the legal situation stable and predictable for the future. That again resulted in positive economic, social and environmental side effects. Lyseng (2012, p. 87) found that in five out of six cases, the rules on joint use functioned as intended. In the sixth case, the rules only partly functioned because they were misinterpreted. She did not point out any specific effect, but she highlighted the need for good organisation, which includes both legal and social effects.

Steinsholt (1994, p. 35) pointed out legal effects such as clarification of property boundaries with roads in project-related land consolidation. Roalkvam (2003, p. 74) found that legal effects such as clarification of property boundaries was important for the parties involved in land consolidation.

3.3   Social effects

3.3.1   Literature review

Social effects are described as how land consolidation affects individuals and the relationships between people. The social effects of land consolidation are discussed in Van Huylenbroeck et al. (1996, p. 299), Goodale and Sky (1999), Coelho et al. (2001), Crecente et al. (2002, p. 142–143), Luo and Timothy (2017, p. 506–507) and elsewhere. In 1988, European experts in land consolidation were gathered in Germany. In a summary of key trends in European land consolidation, the need to take social effects into account was highlighted (Läpple, 1992, p. 10). Strong ties to and social relationships to individual plots are found in most cultures (Bonner, 1987; Burton, 1988; Behar, 1986).

3.3.2   Findings

Gulliksen (2012) found a good example of the strong relationships that the parties involved in land consolidation cases have with their plots. She studied project-related land consolidation, where most of the area was forest. Bear in mind that the layout of forest areas is different from agricultural areas. Gulliksen identified negative social effects in situations where people in favour of land consolidation exchanged plots with those who were against land consolidation (Gulliksen 2012, p. 60).

Laskemoen (2011) studied the social effects of land consolidation in conjunction with the dissolution of joint ownerships and joint use. Her study found a mix of both positive and negative social effects. The relationship between the parties was unchanged in 51 percent of the cases, worsened in 39 percent and improved in 10 percent (Laskemoen 2011, p. 104). However, these results may be biased, as Laskemoen used the term counterparty in her survey, instead of the more neutral term party/parties. This means that respondents may have answered this question based on an understanding that the survey's focus was only on their relationships with the parties they disagreed with and not their relationships with the parties in general.

The findings in Hoddevik's (2012) study differ substantially from those of Laskemoen. Hoddevik (2012, p. 98) asked the parties if their social relationships had changed after land consolidation. As many as 69 percent reported a positive effect, 25 percent said there had been no change and six percent said that the effect on their social relationships was negative. It is evident that the parties' relationships to the properties and possible changes to the properties can lead to changes in their social relationships. Unlike the study Laskemoen did in 2011, Hoddevik saw a positive change to social relationships. The parties clearly emphasised their happiness with the result and that the land consolidation process itself was crucial in terms of maintaining a good relationship between the parties. Oppegaard (2011, p. 78) highlighted the fact that the parties reached a settlement as a positive social effect. Roalkvam (2003, p. 71), on the other hand, found that several parties reported a negative social effect. It can be difficult to argue that one should get a better result of land consolidation than the neighbour should.

As described in Section 3.2.2, Myrvold (2012) found that the statutes established by the land consolidation court were not subsequently followed by the parties, partly because they were seen as guidelines, but also because the parties considered keeping good social relationships to be more important than following the statutes (Myrvold 2012, p. 103). This shows how the different effects interact with and affect each other.

3.4 Environmental effects

3.4.1 Literature review

The environmental effects of land consolidation are not widely discussed, but Sonnenberg (1996), Crecente et al. (2002, p. 143–144), Wang et al. (2015, p. 609–616), Leń and Król (2016, p. 235–237) and Ettanen and Vitikainen (2016) give some important contributions. Environmental effects often affect people other than those who are directly affected by land consolidation (King and Burton (1983, p. 495). Bullard (1990, p. 31) argues that some of the positive effects of past land consolidation cases may become the environmental problems of the future, such as increased danger of erosion because of larger plots, monoculture, removal of border zones between plots, etc. These issues are well-known, and have been investigated in several projects in Norway (Geelmuyden 1994; Sky 1995).

In the 1970s, the Netherlands developed a multi-criteria evaluation method, taking into account visual impacts, historical qualities, ecology and social conditions in addition to economics (Janssen and Rietveld, 1985). Around 1990, The Agricultural University in Wageningen in the Netherlands tested a model to calculate income from agricultural production for various potential landscape changes (Moolenaar, 1990). This project concluded that major changes in the cultural landscape decreased rather than increased income. In conjunction with the FIG-congress in Helsinki in 1990 a resolution was adopted which emphasised that one should pay attention to the environment in connection with the implementation of land consolidation and that the relationship between the environment and land consolidation should be documented (Tenkanen 1991, p. 16).

3.4.2 Findings

In the context of environmental effects, building a road causes landscape effects. Hoddevik (2012, p. 97) showed that the land consolidation court took this into consideration and the vast majority of the interviewed parties mentioned that the land consolidation court took into account the terrain when the road was placed in the landscape. In such cases it is necessary with an official permit before the land consolidation court issues its final ruling. The environmental authorities therefore had to approve the project before the road was built.

Kollstrøm (2014, p. 89) also emphasises environmental effects and the fact that, according to the Land Consolidation Act, the municipality both handles and coordinates this issue and finally approves the route. Very often, forestry roads are subsidised by the public authorities, up to a ceiling of 75 percent of the cost.

Geelmuyden (1994, p. 31–32) highlighted that there can be conflicts between the positive economic effects and the negative effect on the landscape. She mentioned the negative environmental effects caused by the removal of stone fences and other linear elements in the landscape, such as border zones and ditches.

4   Discussion

The major findings of the studies are summarised in Table 2. As it is not possible to calibrate the various assessments that the authors have made, the effects are not graded beyond positive, negative or neutral.

This paper shows that there are fluid boundaries between the different effects of land consolidation in Norway and that they can affect each other. This is especially true of spatial and economic effects. This has been studied in depth by Steinsholt (1994) in his analysis of project-related land consolidation. Since no-one should lose out due to land consolidation, the economic effects have the highest importance. The other types of effects will, however, still influence whether or not land consolidation should proceed.

Further effects exist that are not easy to place in the categories presented in this paper. One example is one of the effects that Gulliksen (2012, p. 64) found in her study. The major effect was the timeframe: the case lasted for almost 10 years. That led to uncertainty. This is, however, much longer than the average duration of Norwegian land consolidation cases. Crecente et al. (2002, p. 146) concluded that Norwegian land consolidation was, on average, faster than in other comparable countries. The main reason why this case lasted so long was that it was the largest project-related land consolidation to date in Norway, which included 19,500 ha for a military training field.

Table 2. Authors listed in alphabetical order and their major findings, (+) = positive effect, (–) = negative effect and (0) = no effect). Open fields mean that the effect was not the subject of the survey.

Authors	Economic and spatial effects	Legal effects	Social effects	Environ-mental effects
Espås and Lande (1992)	+			
Geelmuyden (1994)	+			–
Gulbrandsen (2011)		+		
Gulliksen (2012)	+	+	–	
Hoddevik (2012)	+		+	+
Jevnaker (2015)	+			
Kollstrøm (2014)	+	0		+
Laskemoen (2011)	0		–	
Lyseng (2012)		+	+	
Myrvold (2012)		0	+	
Oppegaard (2011)	+		+	
Roalkvam (2003)		+	–	
Steinsholt (1994)	+	+		

King and Burton (1983, p. 489–490) refer to empirical studies of the economic effects of land consolidation in Finland, Switzerland, Austria, France and India. Their conclusions are that costs are reduced and that the economic yield thus increases. Nevertheless, the effects vary a great deal and depend on the time at which they are measured after the land consolidation case is finished. The problem with such surveys is that they are not corrected for the general development of the economy and society and the yearly fluctuations in crops. It can be difficult to assess the benefits and disbenefits of the various effects of land consolidation. It is necessary to ascertain the difference in conditions before and after land consolidation. Some conditions change immediately, such as reductions of the length of property boundaries, better layouts of plots and shorter distances from plots to the farm centre, while other things only happen after some time. For example, there may be a reduction in input factors in production and increased crop yields due to the effect off fewer borders. Undoubtedly, the effect of land consolidation can have multiple dimensions. This is also the case in Norway. In addition, people have differing relationships to their properties.

Discussion about the theoretical economic benefits of land consolidation is frequent. This is based on the following assumptions: a plot after land consolidation is homogenous, the farmer strives to improve his or her welfare, which is possible thanks to an assumed reduction in transportation and working hours combined with lower administrative costs (King and Burton 1983, p. 485–486). After land consolidation, the farmer saves time spent on transportation and the cost of moving heavy equipment from one plot to another. It also becomes easier to monitor the plots, working hours are reduced and work is easier to perform as a result of a better layout of plots. This assumes that the farmer adapts as described, is economically rational, appreciates the benefits of increased specialisation and adapts accordingly. However, behavioural research shows that this is not always the case and this can lead to a mismatch between the theoretical calculations in a land consolidation case and the actual outcome. The owners can have completely different preferences when it comes to what is useful for them. Both Kollstrøm (2014) and Myrvold (2012) give examples of the parties simply not understanding the new legal situation after land consolidation, which makes it difficult for the parties to both see and value their gain. It was therefore neither positive nor negative effects.

The study shows that the individual landowner or right holder is not concerned with the socio-economic benefits, and will primarily consider his own situation before and after the land consolidation (Roalkvam, 2003; Hoddevik, 2012; Laskemoen, 2011). Roalkvam (2003) found that the effects varied, depending on the parties' relationships to the properties and concluded that it is important to perform an individual analysis of each party (see also Goodale and Sky, 1999).Two identical properties can have different benefits of land consolidation because of differences in liquidity and access to capital (Roalkvam 2003, p. 93). He questions, whether objective considerations should still be the most relevant standard, or if subjective considerations would be more accurate (see also Bærug 2009).

It is arguable whether it is within the scope of the law that a single landowner may subjectively consider the land consolidation to be useful, while objectively it proves that the property suffers an economic loss. These calculations are not simple, as measuring tools are imprecise. In Norway, however, there is a statutory requirement for objective assessment of the properties' benefits. It is important to keep in mind that one of the reasons for objective assessments is the interests of the mortgagee, which require that the property should not diminish in value due to land consolidation. Little discussion of this can be found in the international literature, probably due to great effects and public subsidies of land consolidation. From the perspective of private economic interests, an identified condition for carrying out Norwegian land consolidation is that no property should suffer loss.

5   Conclusions

Land consolidation settlement shall not result in costs and other disbenefits that are greater than the advantages. It should be noted that, this requirement applies to land consolidation in most countries. Continuous focus is placed on what can be achieved through land consolidation, therefore the methods for mapping effects and gains must be further developed. More advanced methods, like calculating the consolidation coefficient and reduction index (Crecente et al. 2002, p. 139), are not used in Norwegian land consolidation. The analysis show that the effects of land consolidation in Norway are difficult to estimate and calculate.

Future research should focus on developing better methods for both valuations and impact studies. Calculating the effect of the layout of plots before and after land consolidation is an obvious method to ensure that the parties are protected against losses. A good example of highlighting the effects of land consolidation after it has been carried out can be found, for example, in Cyprus (Demetriou, 2014, p. 136) and Spain (Crecente et al. 2002, p. 139). In Cyprus they even put up road signs with this information. It will also be interesting to investigate more closely whether the effect of land consolidation changes over time and whether the parties change attitude on how they look at land consolidation. However, the overall impression from the 13 presented studies and the analysis undoubtedly shows that land consolidation has a positive effect on rural development in Norway.

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