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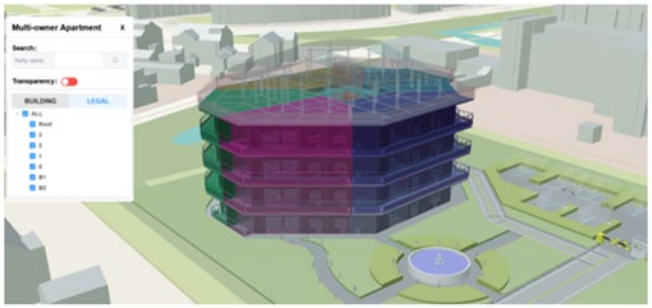
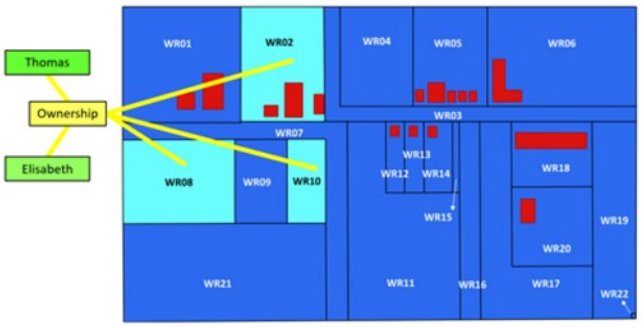
LADM in the Classroom





UNIVERSITY OF TWENTE. | ITC TU Delft kadaster

LADM in The Classroom

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Foreword

FIG is proud to endorse this publication 'LADM in the Classroom'. Building an effective and sustainable Land Administration System requires coordination among many agencies, each tasked with different functional roles, including but not limited to land tenure, land use planning, land valuation, and land development. Consistent and easy exchange of information is therefore vital. The Land Administration Domain Model (LADM) was first proposed to support the establishment of a common view on land administration across agencies involved, facilitating not only information exchange but also consistency of information across different land administration functions.

FIG has played a key role in developing the LADM standard, with contributions from multiple commissions over decades. The first edition followed an incremental approach, with expert reviews from 2002 to 2006. FIG submitted a proposal to ISO TC 211, which was accepted in 2008, leading to LADM's publication as an international standard in 2012.

The development of LADM has benefited from inputs by ISO TC 211 experts and the LADM Users Community, with findings documented in professional and scientific publications. LADM adoption is evident from its adaptations into more than forty country profiles with implementations in ten countries. Its versatility as a generic land information model is demonstrated by its specialisation into the Social Tenure Domain Model (STDM). Ongoing developments are shared through FIG congresses and workshops.

Despite the considerable progress in LADM adoption, there is a dearth of teaching and learning materials suited for students and practitioners from the land domain. A major challenge is the gap in technical skills - to be able to read and correctly interpret LADM models one must understand Unified Modelling Language (UML) class models which are, to say the least, foreign to most practitioners and students of Land Administration.

In response, the approach of this book initially eliminates the need to understand UML class models. The focus is on how information about concrete Land Administration situations can be structured within a Land Information System. All materials are based on a singular hypothetical case study giving the authors the flexibility to demonstrate a wide variety of scenarios. The cadastral map and other data are made available as a QGIS project enabling their reuse for teaching and other purposes such as rapid prototyping for brainstorming or demonstrating ideas. The illustration of LADM concepts through concrete cases helps the reader to understand how abstract Land Administration concepts such as rights, restrictions, and responsibilities can be realized in an actual Land Administration system.

Dr. Diane Dumashie

FIG President

Preface

The ideas behind this book originate from the our experiences teaching Land Information Modelling using the LADM in the Land Information Systems and Models (LISM) course at ITC. During the Covid period we learned that there is a need for teaching materials that can be used both online and onsite. This has resulted in this LADM book with a set of presentation slides. The slides refer to the figures in the book. The book explains examples of people to land relationships from the map, then their representation in a database. Finally, the LADM is explained in UML. All this is further supported by possible exercises in a real database environment.

This book aims at sharing knowledge and introducing interested parties to the land administration domain model. The book and figures may be useful in giving explanations of the LADM in presentations. The contents of the book can also be useful when making proposals for tests, research or validations in reports or other documents.

The target audience includes students, teachers, trainers and professors at universities and vocational schools, designers and developers of land administration supporting software in governments and companies, and all those involved in land administration: surveyors, lawyers, conveyors, users of land administration information and other interested professionals such as ICT experts.

Christaan Lemmen, Malumbo Chipofya, and Andre da Silva Mano

Enschede, April 2025

Acknowledgments

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The authors would like to thank all contributors to this book project for their support.

1. Introduction

1.1 LADM in the Classroom

The Land Administration Domain Model (LADM) is an International Standard published by the International Standardisation Organisation ISO as ISO 19152. The first edition was published in 2012 (ISO, 2012) a second edition is under development. The standard specifies a collection of land administration concepts common to most land administration systems across the world, as well as relationships between these concepts. Technically, the standard is presented and visualised in the Unified Modelling Language (UML) by which UML classes are used to represent the main concepts in LADM. The use of UML allows experts and professionals in land administration to share knowledge and to communicate the structure and meaning of land information with experts and professionals in information and communication technology (ICT) and other professions. This means that land administration experts and professionals need to master UML to make clear to ICT experts and professionals how land administration in their country or administrative region is structured.

In this book, we provide the relevant definitions focussing first on the core LADM concepts of Parties (rightsholders), RRRs (rights, restrictions and responsibilities), basic administrative units, and spatial units. We introduce our approach to learning and teaching the LADM starting from a cadastral map with visually linked rights and (entitled) parties. The translation of LADM organised data into a database consisting of tables is the next level of understanding. As a next step the link between a database and its tables and UML diagrams is presented. This is followed by transactions in LADM. Transactions need to be supported. This is important because people to land relationships are dynamic due to buying and selling of land rights, inheritance, establishment of new rights, etc. Formal, informal and customary rights are considered as well as valuation information and spatial plan information. Finally the LADM is introduced in UML.

The figures presented in this book are available as slides for lectures.[1] A database with the data from cases in this book is also available for free download. Efforts have been made to ensure that the datasets have a low entry barrier. All the datasets are distributed using open specifications. Exercises accompanying this book assume the use of QGIS and PostgreSQL/Postgis [2] - see next section on how to access the datasets.

[1] https://ladm.itc.utwente.nl/ladm_classroom

[2] https://www.qgis.org/

https://www.postgresql.org/

https://postgis.net/

1.2 A Simulated Environment

Welcome to the municipality of 'Waterriver' (Figure 1), a hypothetical location with lands and buildings where people live and work and sustain their livelihood through agriculture, industry or services. There is tenure security through a transparent and inclusive land administration system. Property rights on land are well documented. The municipality finances its wide range of activities from income out of property tax. In Waterriver there is spatial planning in place, spatial plans are developed in participatory approaches. The land administration in Waterriver was established a long time ago. The people of Waterriver understand its importance.

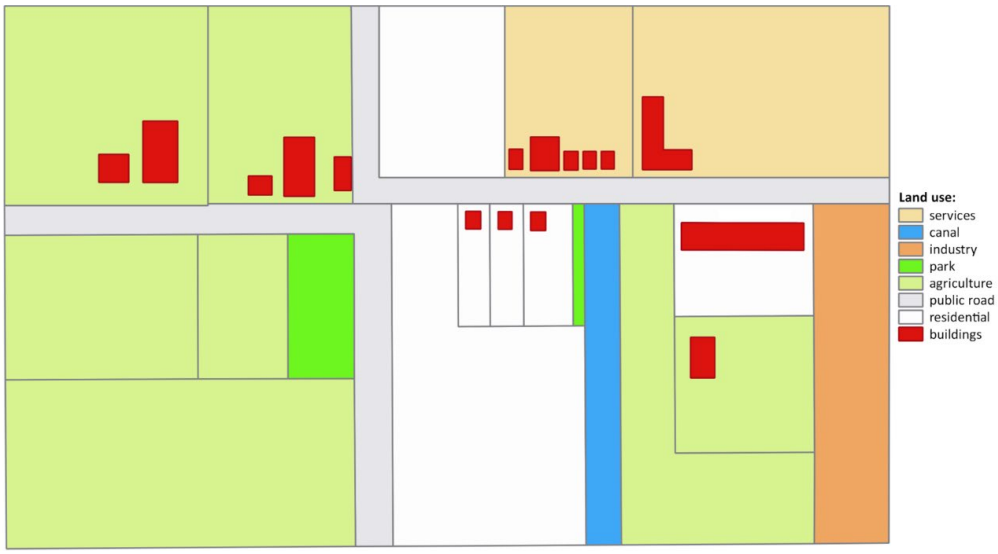

Figure 1. Municipality of Waterriver - a hypothetical location

Land administration is the process of determining, recording and disseminating information about the relationship between people and land (ISO, 2012). This relation can concern land tenure, land value and land use (UN ECE, 1996) in urban, rural and marine environments. Often land administration is implemented through a distributed set of land information systems, each supporting data maintenance activities and the provision of information. There is a Land Registry – managing the conveyancing process, a Cadastre for maintenance of the cadastral map; a Planning Department – regulating land and property development and a Tax Department – gathering land tax. In the case of Waterriver the information on land tenure, land value and land use is managed by one single organisation.

The datasets behind the depiction in Figure 1 can also be downloaded from https://ladm.itc.utwente.nl/ladm_classroom (Da Silva Mano, 2024). The link will take you to a GitHub repository where you can download the latest release. Refer to Annex 4 for detailed information on downloading and using the datasets.

Please note that this book can be used without the datasets. The datasets are simply an implementation that allows a practical exploration not only of the cases described in the next pages but also of new cases the instructor may want to demonstrate.

2. The Land Administration Domain Model (ISO 19152:2012)

2.1 Conceptual Model

The LADM is a conceptual data model for land administration. The development of the LADM was initiated by the International Federation of Surveyors (FIG) and the model is published by the International Standardisation Organisation (ISO) - Technical Committee 211 on Geographic information/Geomatics.

Figure 2. Analogue land Administration archives can be difficult to search and update. LADM supports the digitalization of land administration systems.

A common feature of land administration archives and document repositories is their tendency to grow over time and, due to the complexity of land information, become increasingly difficult to search (see Figure 2). The LADM offers a comprehensive functionality that supports the documentation of the relationships between people and land in a land administration (ISO, 2012; Lemmen et al., 2015). LADM is used to support the development of land administration systems, including the development of software applications, workflows, databases and user interfaces for land administration purposes (tenure security, land tax, spatial planning, etc). LADM, therefore, supports the digitalization of analogue land administration systems.

LADM is about the core and essence of Land Administration (LA): data about people, data about land (including space above and below land and water surfaces) and data about the relationships between people and land. This relation can concern land tenure, land value and land use. The ownership can be private or public.

People-to-land relationships can be expressed in terms of persons (or parties) having (social-) tenure relationships to land. A 'social tenure relation' can be seen as an 'informal right' with community legitimacy.

The illustrations in the following sections use the same colour scheme as used in Figure 3. Spatial units are visualised in blue on maps and in UML diagrams in this book. Parties are presented in green and rights and basic administrative units in yellow. Also restrictions and responsibilities are in yellow. Rights, restrictions and responsibilities (definitions in the next paragraph) are abbreviated to RRR in LADM. The associations (connections) are indicated as black lines. These colours are used systematically in this book. See legend in Figure 3.

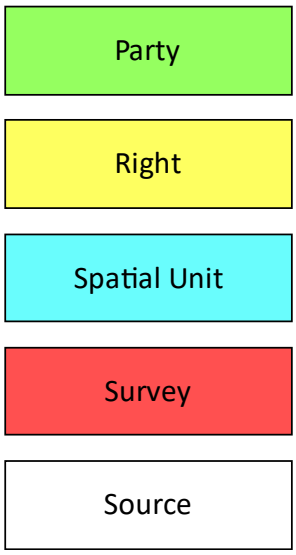

Figure 3. Legend for LADM diagrams.

2.2 Party

In LADM a **'party'** is a person or organisation that plays a role in any land administration process.

A person can be a natural person that is a holder of a right on a spatial unit (parcel). Apart from being rightsholder a party can have a role in the land administration process. surveyor, conveyor, notary, registrar, grassroot surveyor, paralegal, a chief, etc. Roles depend on the context.

On the other hand, a non-natural person can be an organisation. This may be a company, a municipality, the state, a tribe, a farmer cooperative (cooperation), or a church community (with each organisation represented by a delegate: a director, chief, CEO, etc.).

A **'group party'** is formed when a group of parties (of any number) must, together, be considered as single party within a land administration system. A group party can be seen as an abstract, virtual, or "on paper only" entity that represents its registered members in any relationship that it is involved in.

A **'party member'** is a party registered and identified as a constituent of a group party. This allows documentation of information about the nature of membership. This is not mandatory: there can be defined or undefined membership.

A party or group party should be assigned a unique identifier (pID) when registered or recorded. See Annex 1.

2.3 Rights, Restrictions and Responsibilities (RRRs)

Rights, restrictions and responsibilities are collectively referred to as RRRs.

In LADM a **'right'** is a formal or informal entitlement to perform an action (a formal or informal entitlement to be able to do something or some things).

People-to-land relations or land rights may provide a formal or informal entitlement to own or do something on a specific spatial unit (land parcel). Examples of land rights are: formal ownership, usufruct, freehold or leasehold, etc. It can also be a social tenure relationship like occupation, tenancy, informal rights, customary rights, indigenous rights, and possession. A right can be an Islamic land right (e.g. miri or milk).

There can be a share in a right. In LADM, fractions are used to express shares, not percentages. When using percentages, the sum of those shares does not need to be equal to 1 in all cases. Compare, for example, a case with three shares: 1/3, 1/3, 1/3 and 33.3%, 33.3%, 33.3%. A share 1/1 implies it is full ownership. This could be even explicit in the database, but in this book that approach is not used for clarity reasons. See paragraph 6.2 for further explanation of fractions.

A **'restriction'** is a formal or informal obligation on the land owner to refrain from performing an action.

Examples of restrictions are situations where it is not allowed to build within 200 metres of a fuel station or a buffer zone along a road or highway where it is not allowed to establish buildings. A mortgage is a restriction to an ownership right.

Servitudes (right of way) can be seen as restrictions, The land owner is not allowed to use the road for other purposes then access to a third spatial unit. In other situations it may be allowed that a right of access (path across a field) is reformed every time the field is ploughed and the crops are planted. Essentially the spatial location is irrelevant as long as the intended legal outcome can occur: the ability to get from A to B by travelling over someone else's land. The landowner can change the use of the field (housing for example). However, the legal requirement of the right of access would still need to be respected in case of change of use.

A **'responsibility'** is a formal or informal obligation on the land owner to allow or perform an action. Owner implies leaseholder, usufruct holder, etc.

Examples are the responsibility to clean a ditch or water canal on private land, to keep a snow-free pavement, to remove icicles from the roof during winter, or to maintain a monument.

A RRR should be assigned a unique identifier (rID) when registered or recorded, see Annex 1.

2.4 Basic Administrative Unit (BAUnit)

Apart from parties, rights and spatial units the LADM includes 'basic administrative units' (BAUnits). The term 'basic administrative units' is derived from the term 'basic property unit'[3]. Because properties require formal registration the term 'basic administrative units' is used, because this may include informal registrations.

A **'basic administrative unit'** (BAUnit) is an administrative entity, which can be subject to registration (by law), or recordation (by informal or customary right), consisting of zero or more spatial units against which, one or more, unique and homogeneous rights, responsibilities or restrictions are associated, as included in a land administration system.

In this definition 'unique' means that a right, restriction, or responsibility is held by one or more parties (e.g., owners or users) for the whole basic administrative unit. 'Homogeneous' means that a right, restriction or responsibility (ownership, use, social tenure, lease, or easement) affects the whole basic administrative unit. For a restriction zero parties are a possibility, e.g. a right of road may exist on a BAUnit without a relation to a party. Ownership rights or land use rights are examples of homogeneous rights.

There are countries that have land registry, but have no cadastre and a cadastral map does not exist. Access to the registry is based on a party identifier (pID) or on BAUnit identifier (uID). Spatial units are not explicitly represented in the land administration because there is no cadastral map. This means that a BAUnit can consist of zero units with spatial representation. See Figures 4 and 5 for examples of BAUnits in relation to spatial units.

Restrictions and responsibilities can be associated with their own BAUnits, each with their own type of spatial unit. Note: There may be a need for extensions of the definition of BAUnits in different countries.

A BAUnit should be assigned a unique identifier (uID) when registered or recorded. See Annex 1.

Examples of BAUnits are:

- a condominium unit comprising two spatial units, this could be an apartment and a garage
- a farm lot comprising one spatial unit (one parcel of land)
- a land consolidation area
- a right-of- use unit with several right holders and restricted objects, or:
- a windmill farm on the sea in one spatial unit combined with cable to the land as another spatial unit together form two spatial units in one BAUnit.

[3] https://inspire.ec.europa.eu/featureconcept/BasicPropertyUnit

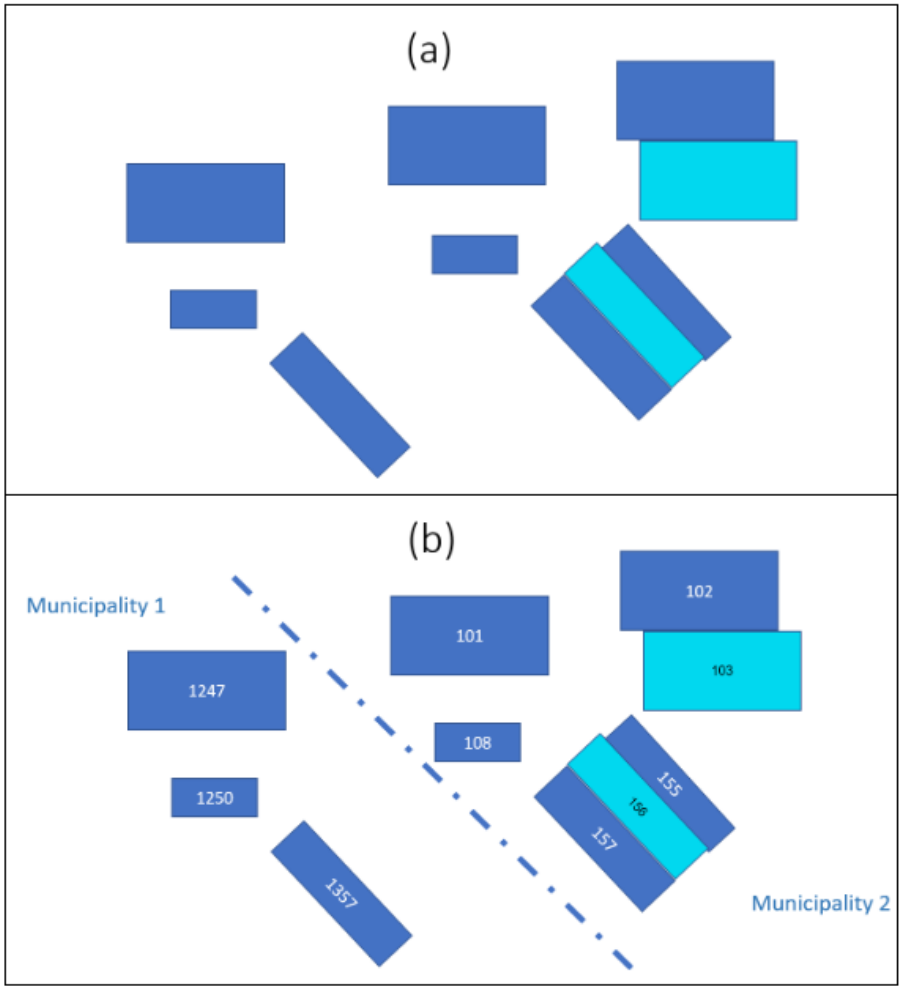

Figure 4.(a) One farmer has spatial units in ownership (dark blue) and in lease (light blue). (b) Three spatial units are in municipality 1, seven in municipality 2, five in ownership and two are leased.

2.5 Spatial Unit

Spatial units are the areas of land (or water, air, underground) where the people-to-land relationships apply. The term *land parcel* usually has a formal definition and is applicable for formal land rights. Apart from formal rights the LADM may include informal or customary rights. Or marine rights. For this reason the term 'spatial unit' is used, this. Spatial units is a neutral term.

In LADM a **'spatial unit'** is a feature type related to land administration with associated spatial and thematic attributes.

Spatial units can be represented as a text (i.e. 'from this tree to that river'), as a single point or set of points, as a set of (unstructured) lines, as a surface or polygon,as a 3D volume, etc.), see Annex 2 for examples. Surveys concern the identification of spatial units in the field based on a field survey or by identification on an aerial photograph, a satelite image or a topographic map.

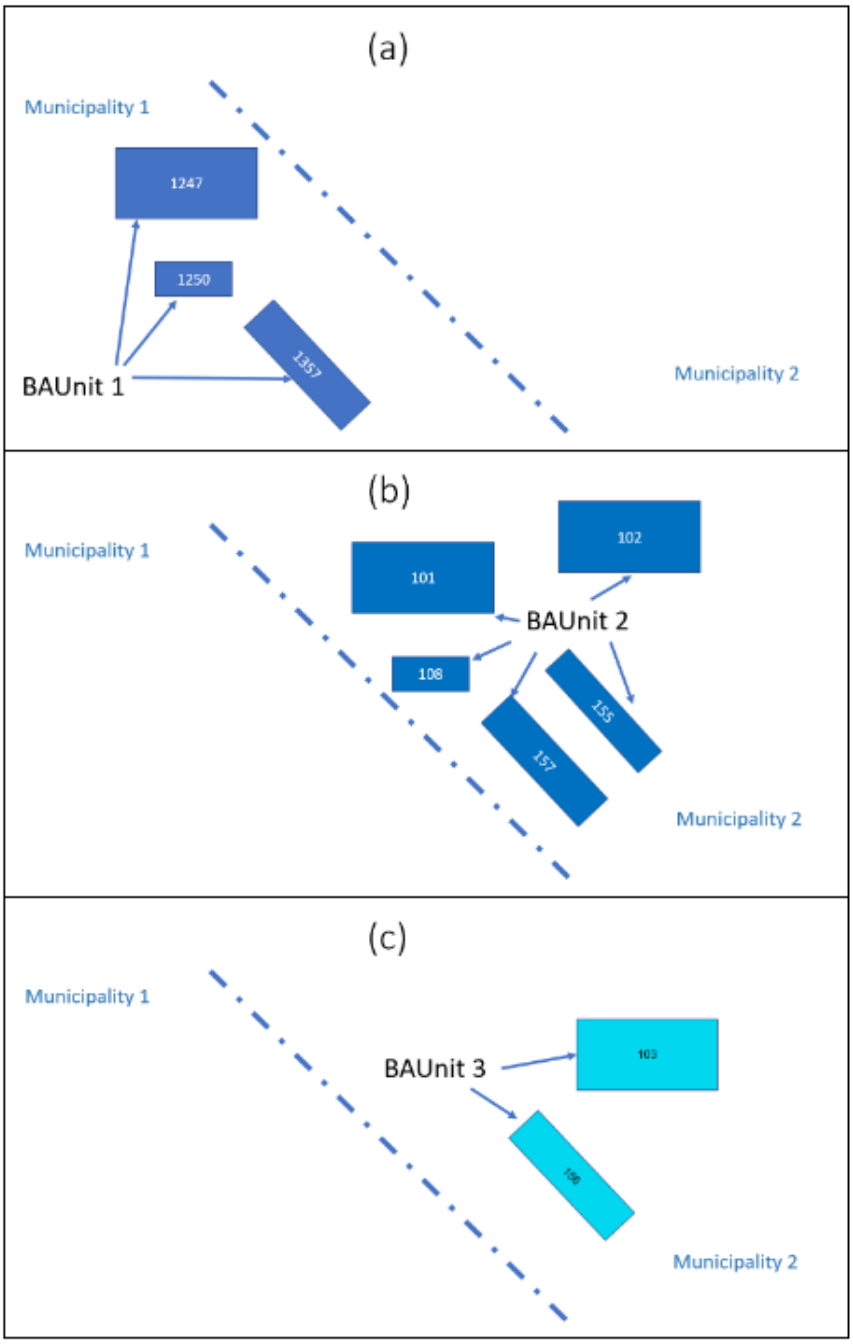

Figure 5. For taxation purposes there are three basic administrative units created for registration. BAUnit 1 in municipality 1. BAUnit 2 and BAUnit 3 in municipality 2. For taxation the basic administrative units are considered as units that can be related to tariffs. The leasehold has another tariff for taxation then the leasehold.

Rights may be overlapping, or may be in disagreement. Land conflicts could be visualised (using cartographic symbols or overlapping polygons) on a cadastral map. If the dispute is upheld then the cadastral map would be updated to show the new state of ownership.

A **'spatial unit group'** is any number of spatial units, considered as an entity.

A spatial unit group can form an administrative zone such as a section, a canton, a municipality, a department, a province, or a country in a federal state. A spatial unit group may concern an area where a spatial plan is under development.

A spatial unit should be assigned a unique identifier (suID) when registered or recorded. See Annex 1.

Figures 4 and 5 give examples of BAUnits associated with spatial units. For taxation purposes there are three basic administrative units created for registration. BAUnit 1 in municipality 1. BAUnit 2 and BAUnit 3 are in municipality 2. For taxation the basic administrative units are considered as units that can be linked to tariffs. The leasehold has another tariff for taxation then the ownership, that is why there are different basic administrative units for leasehold and ownership (freehold). Tariffs can be different per municipality.

2.6 Source

A **'source**' is a document providing legal and/or administrative facts on which the documentation of a party, a RRR or baunit or a spatial unit is based on.

A source can be administrative, for example a deed, a title, a court decision, etc. or spatial, for example a field work of a surveyor, or a satellite image or an orthophoto with drawn boundaries on top of it. In principle any kind of document may be added as a source.

A source should be assigned a unique identifier (sID) when registered or recorded. See Annex 1.

2.7. Transaction

People-to-land relationships are dynamic and subject to change. Transactions are (for example): buying/selling, establishment of mortgage, inheritance, valuation and taxation, update of attributes or sending a confirmation. The registration of the result of a land consolidation project, a land readjustment project or another form of spatial planning is a transaction..

Those changes require maintenance of the database. Those updates of the database are integrated in workflows. Updates should be implemented in such a way that they bring the database from a consistent state before transaction to a consistent state after the transaction. See chapter 5.

2.8 Versioned Object

All information in a LADM based database gets timestamp attributes. The date and time of insertion and deletion of all attributes is included. This allows for example reconstruction of the information at a certain moment back in time or making an overview of changes within a certain period of time.

2.9 Multilayer

LADM allows a multilayered organization of spatial units. Each layer, called 'level' in LADM, is a collection of spatial units with geometric and/or topologic and/or thematic coherence. For

example, a land administration dataset might have spatial units organized into three levels: one level with cadastral parcels, one level with buildings, and one level with disputes.

3. People to land relationships

3.1 How is the reality represented in the database: nine cases

In order to simplify administration of land rights, the registrar of lands in Waterriver (and in other municipalities) has used the LADM model as foundation for the Land Administration System. In LADM parcels with uniform rights and the same right holder are packaged into basic administration units: that is a group of spatial units.

Figure 6 shows the starting point in presenting cases. A (or a group of) spatial unit(s) and their ID's are highlighted on the cadastral map with related rightholder(s) withname(s) and the right type.

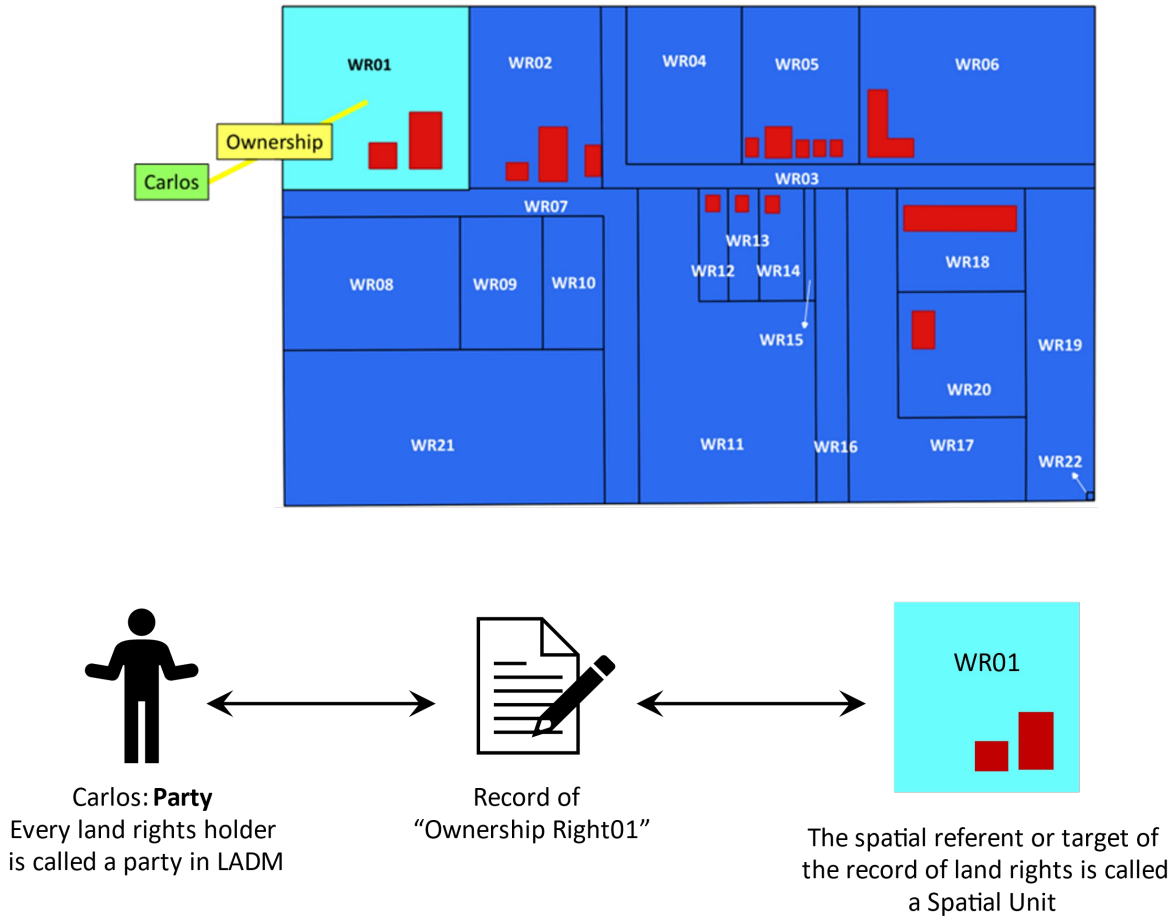

Figure 6. A spatial unit (parcel) with its id "WR01"highlighted on the cadastral map with the related party "Carlos" and the party's name and the right type "ownership right".

From the introduction of BAUs a box representation is introduced now, this representation is called an 'instance level diagram'. These diagrams present static snapshots of individual objects, also called instances, (not classes) in the LADM. It shows exactly what points to what. See Figures 7 and 10.

Figure 8 shows how all this can be represented in tables. Database records are in LADM colours in this figure.

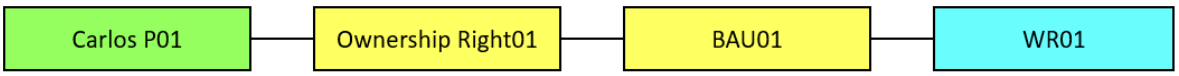

Figure 7. Instance level diagram.

A party represents a person. Because different people can have identical names, each person's record must have a unique identifier or party identifier (pID). In fact parties, rights, restrictions, basic administrative units and spatial units all have unique identifiers. Along with transactions, these are the key indexes which are used to describe state and state change. This is not meant to be the internal database identifier that is used for database management. That internal id is represented in each database table in the column to the left. See Figure 8.

	p_id	name
1	P01	Carlos
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

	bau_id
1	BAU01
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

Figure 8. LADM tables in the database: (a) Party table (b) Right table (c) BAUnit table (d) Spatial unit table.

Rights may be overlapping, or may be in disagreement. Land conflicts could be visualised (using cartographic symbols or overlapping polygons) on a cadastral map. If the dispute is upheld then the cadastral map would be updated to show the new state of ownership.

A **‘spatial unit group’** is any number of spatial units, considered as an entity.

A spatial unit group can form an administrative zone such as a section, a canton, a municipality, a department, a province, or a country in a federal state. A spatial unit group may concern an area where a spatial plan is under development.

A spatial unit should be assigned a unique identifier (suID) when registered or recorded. See Annex 1.

Finally this can be represented in tables that can be related to each other, see Figure 9.

	p_id	name
1	P01	Carlos
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

	bau_id
1	BAU01
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2				
3				
4				
5				
6				
7				
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15				
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20				
21				

Figure 9. All tables combined.

Examples on how to identify parties and spatial units are given in Annex 1.

3.2 Relationships without BAUnit

The BAUnits are not used in the Social Tenure Domain Model, this a specialisation of the LADM is applicable in land administration under development. In this case a right is linked directly to a spatial unit. See Figure 10 where Right02 applies to the spatial units WR02, WR08 and WR10. ‘Rights’ are called ‘social tenure relationships’ in the Social Tenure Domain Model, in that way informal and customary rights can be included. Those social tenure relations may be converted to formal rights under LADM later.

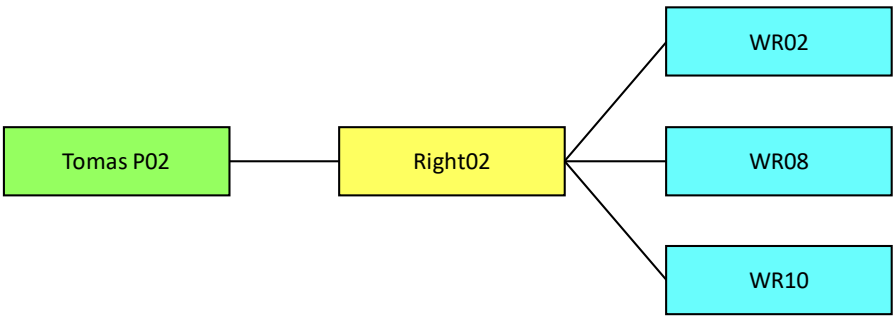


Figure 10. Right02 from right holder P02 applies to the spatial units WR02, WR08 and WR10. There is no BAUnit.

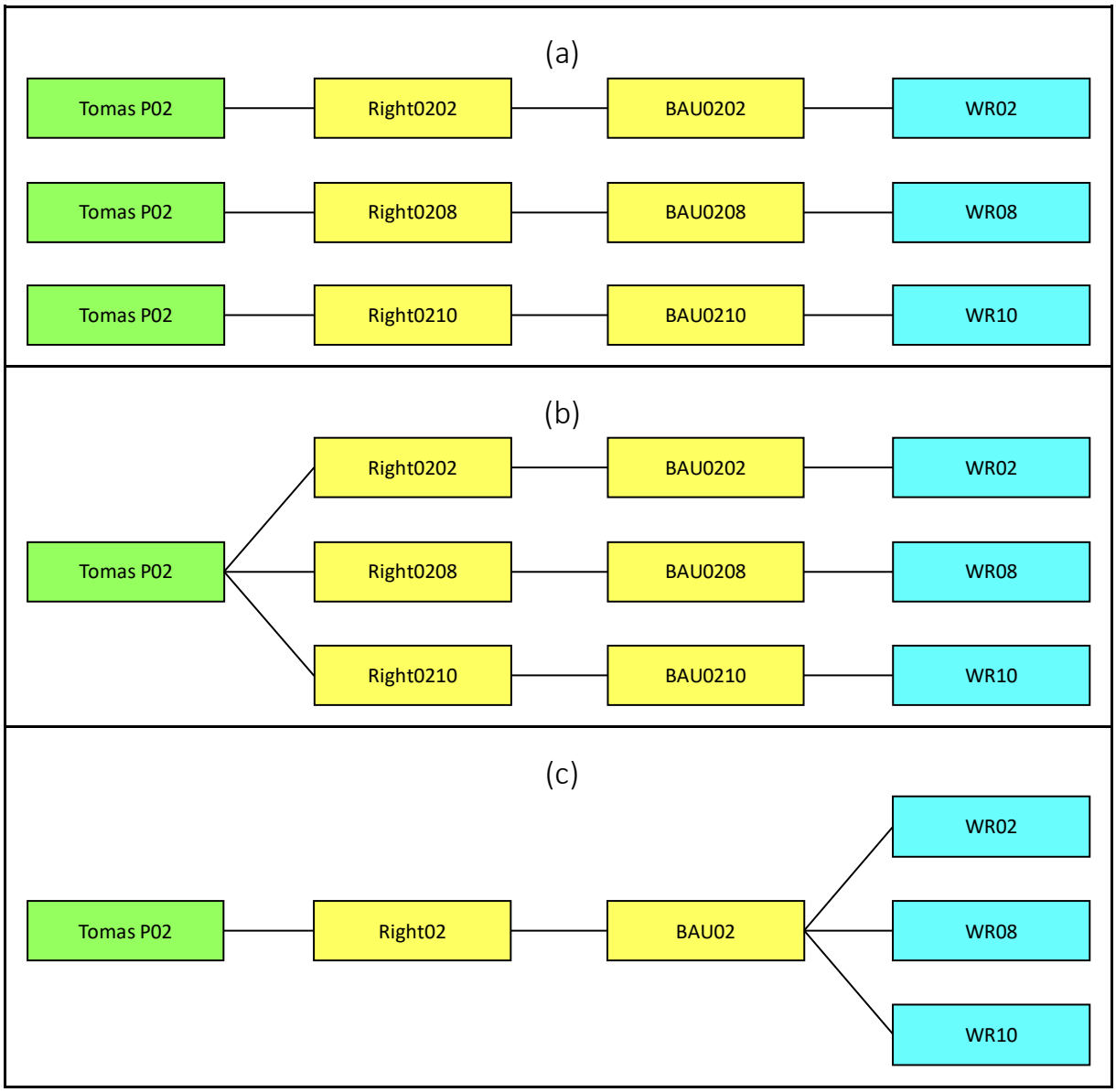


Figure 11. People to land relations represented with BAUnits. The cases (a), (b) and (c) concern representations of the same situation in the field.

3.3 Relationships with BAUnit

Figure 11 visualises people to land relations, now with BAUnits included. The cases (a), (b) and (c) concern representations of the same situation in the field. Case (a) includes a recordation of the SpatialUnits WR02, WR08 and WR10 with separate BAUnits and rights to the same party (Party P02). In case (b) the duplication of information on the party is avoided. Case (c) aggregates the rights to one right (Right02) and to one BAUnit (BAU02) which bundles together all three spatial units (SpatialUnit WR02, SpatialUnit WR08 and SpatialUnit WR10) with the same right.

4. The Map and the Database

4.1 The cadastral map of the municipality of Waterriver

In this chapter we lay out the visualisation of the formal legal situation in Waterriver showing a total of 15 parties, 17 rights, 2 restrictions, 13 basic administrative units and 22 spatial units. Note: the cases shown may be registered in different ways in different countries. This is possible in LADM and can be worked out in so called 'Country Profiles', see Kalogianni (2021).

The Cadastral Map of the Municipality of Waterriver (Figure 12) shows the 22 different spatial units (land parcels) representing where different parties hold ownership rights. Each parcel has a unique ID that is represented inside each parcel (where possible) on the cadastral map.

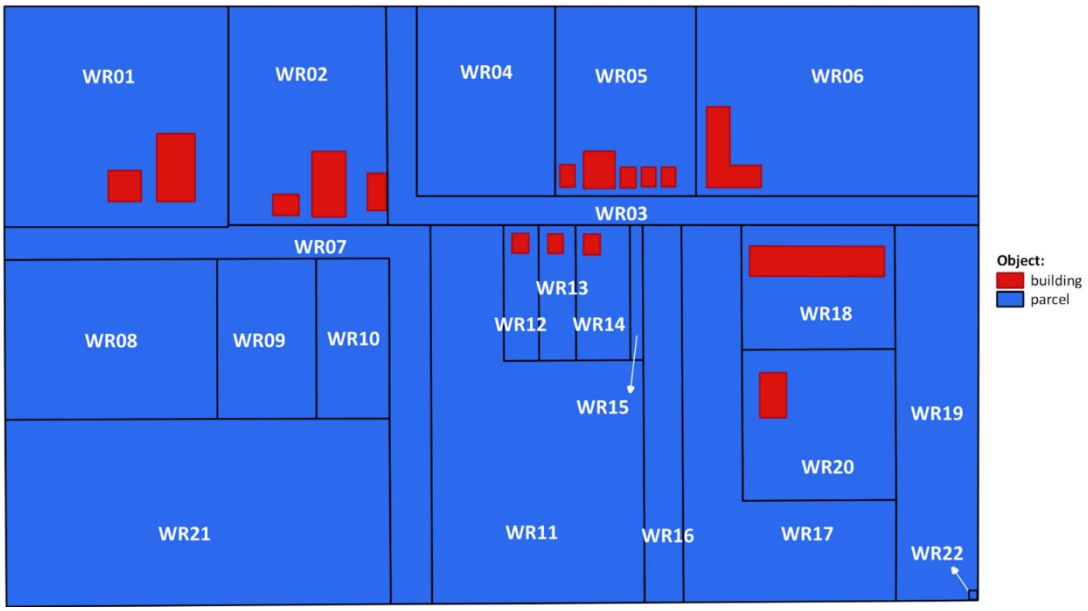


Figure 12. The cadastral map of the Municipality of Waterriver.

The unique identifier contains a cadastral municipal code for the municipality ('WR' from Waterriver) and an unique parcel identifier within the municipality. The cadastral map is digitally accessible after the analogue map has been converted to a computerised environment.

Not only private owned lands can be represented and identified as parcels on the cadastral maps, also public lands (as public roads, land where schools and other public buildings are build) are identified, documented and represented (see Figure 13). A school is at spatial unit (parcel) WR06, the municipal buildings and services are at spatial unit WR05. And water in WR15.

The whole territory of the municipality is included, all lands within the municipality are represented in the Land Administration System. The is 'complete coverage', public lands are also represented in the system.

If all lands and related land rights of all municipalities are included in a land administration there should a nationwide seamless cadastral map. It may take some effort to achieve this because after digitisation there can be 'gaps' and 'overlaps' between represented areas represented digitised from different analogue maps.

For Waterriver the represented spatial units don't have ‘gaps and overlaps’.

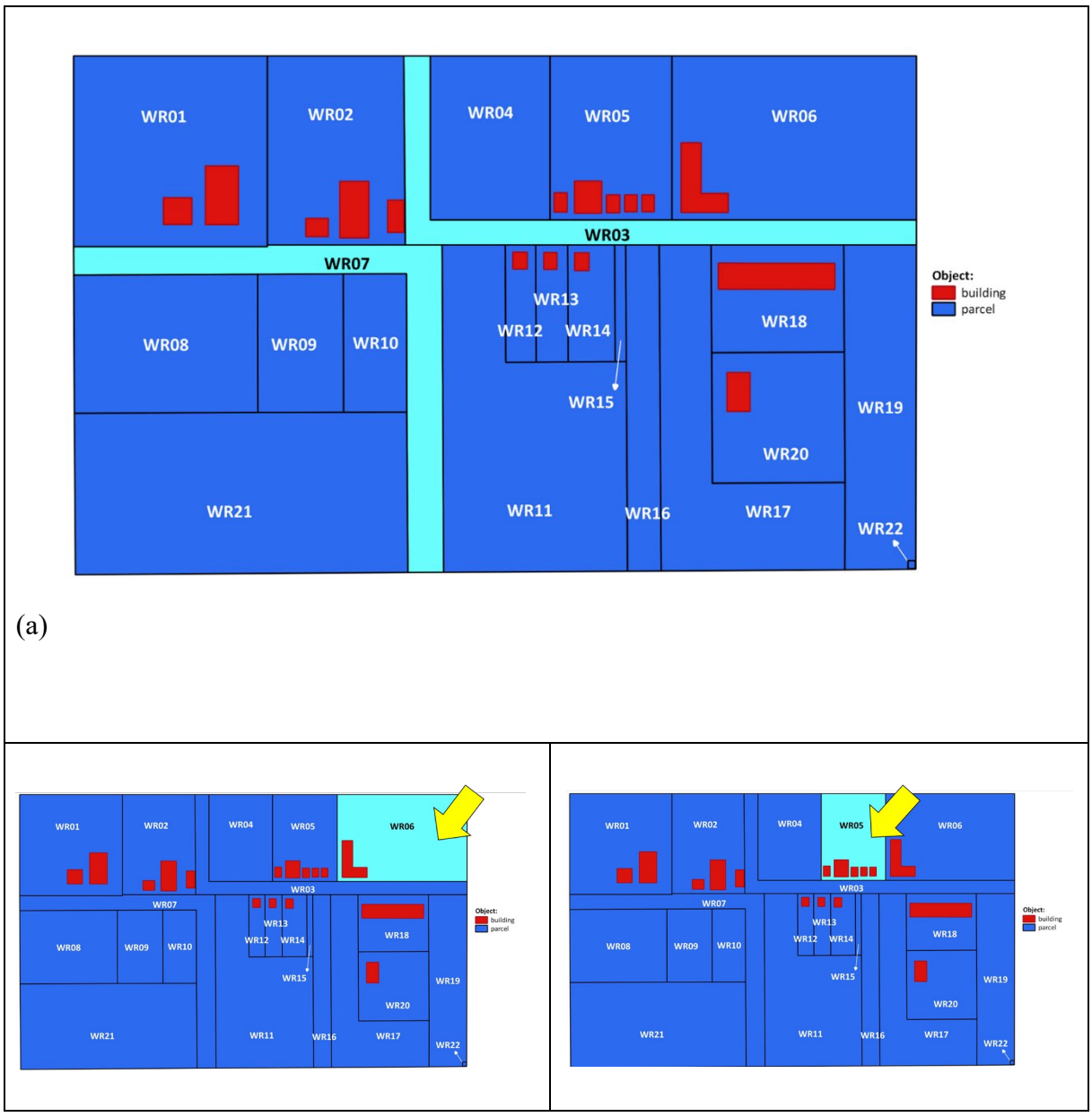


Figure 13. Public land in Waterriver: (a) Public roads (b) School area (c) Land with municipal buildings and services.

The law says that all spatial units (parcels) should be accessible from and to public roads, those are the parcels WR03 and WR07. The parcel WR20 does not have access to the public road, see Figure 14. This means that you have to cross another parcel to get access to a public road. This right to cross somebody's land has to be formalised in order to avoid conflicts.

Parcel WR22 is very small, only 1 sqm. Normally there is a minimal area for a parcel or spatial unit (defined by law or customs).

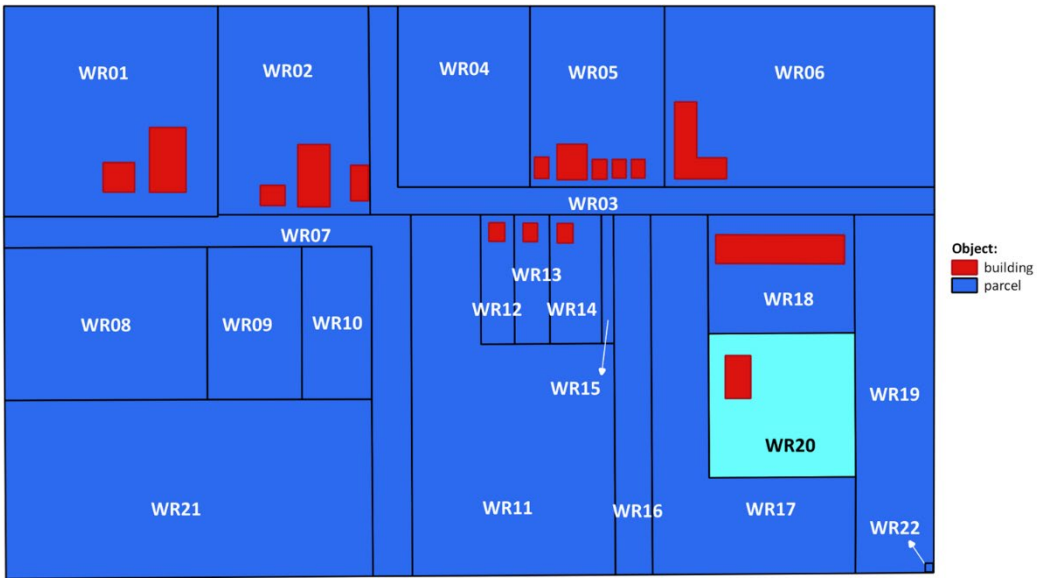


Figure 14. WR20 does not have access to a public road.

4.2 Tenure Case One: Carlos

Carlos has a right of ownership on a spatial unit (land parcel) in the municipality of Waterriver. See Figure 15.

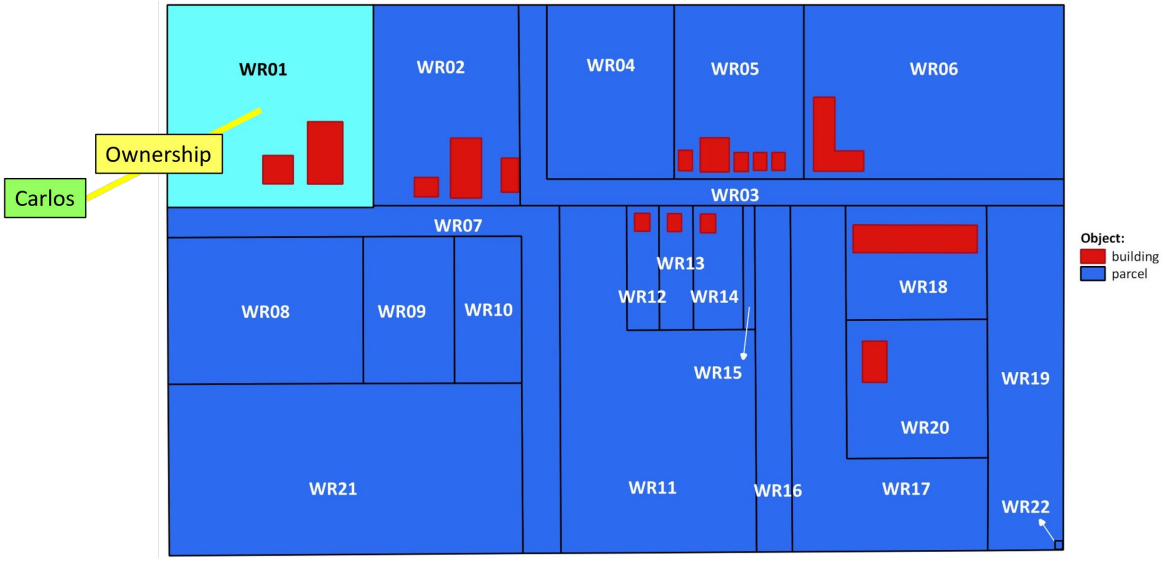


Figure 15. Carlos has a right of ownership on spatial unit.

The instance level diagram related to this case is presented in Figure 16. One can see here that the right of ownership applies to a basic administrative unit, not directly to the spatial unit WR01.

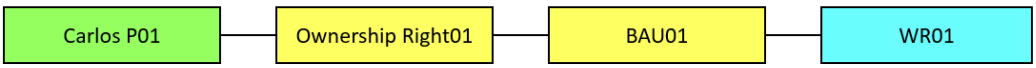


Figure 16. Instance Level Diagram of Case One.

Apart from spatial units also parties, rights and basic administrative units get a unique identifier in the land administration of the municipality of Waterriver where this case is registered.

In this case Carlos gets an id “P01”. “P” is from “Party”. The right is of type “ownership” and has as id “Right01”.

The basic administrative units gets “BAU01” as id. In this case the basic administrative unit BAU01 is composed out of one spatial unit which is identified as WR01.

The database contains four tables to include attributes on parties (p_id and name), rights (r_id, type and share), basic administrative units (bau_id) and spatial units (su_id, area and geometry, see also annex 2). Each table represents a class in LADM. Note: LADM has more classes and more attributes than shown in the example cases here in Figure 17.

	p_id	name
1	P01	Carlos
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

	bau_id
1	BAU01
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				

Figure 17. Case 1 represented in the four database tables: party table, right table, basic administrative unit table and spatial unit table.

More data will be added to the database tables progressively with the introduction of each new case below. In this book the relationships between database tables and records in the tables are illustrated in a simple, straightforward way. Real database implementations are, more complex.

4.3 Tenure Case Two: Elisabeth and Thomas

Elisabeth and Thomas are married and together they own the basic administrative unit to which spatial units WR02, WR08 and WR10 belong - as can be seen on the cadastral map in Figure 18.

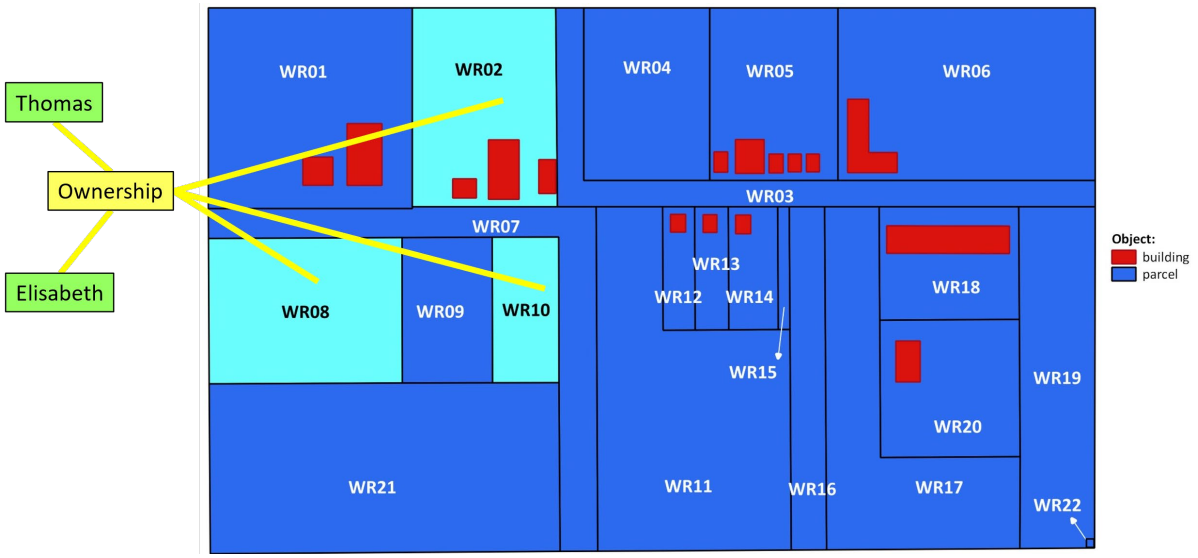


Figure 18. Thomas and Elisabeth have a property right on spatial units WR02, WR08 and WR10.

In the land administration this case is registered with both Elisabeth (P03) and Thomas (P02) owning a share ½ with an ownership right (Right02) to a basic administrative unit, in this case BAU02. See Figure 19. It is further registered that BAU02 consists of the spatial units WR02, WR08, WR10. One property, three spatial units (parcels).

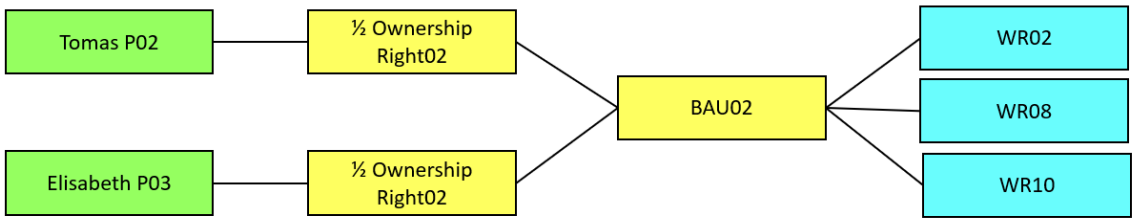


Figure 19. Thomas and Elisabeth have shares in the property right onBAU02. BAU02 consists out of spatial unitsWR02, WR08 and WR10.

The shares are included in the table with rights, see Figure 20. In this table the earlier case with Carlos is still represented. The actual case with Thomas and Elisabeth is highlighted in LADM colours. The same approach will be used now for other cases.

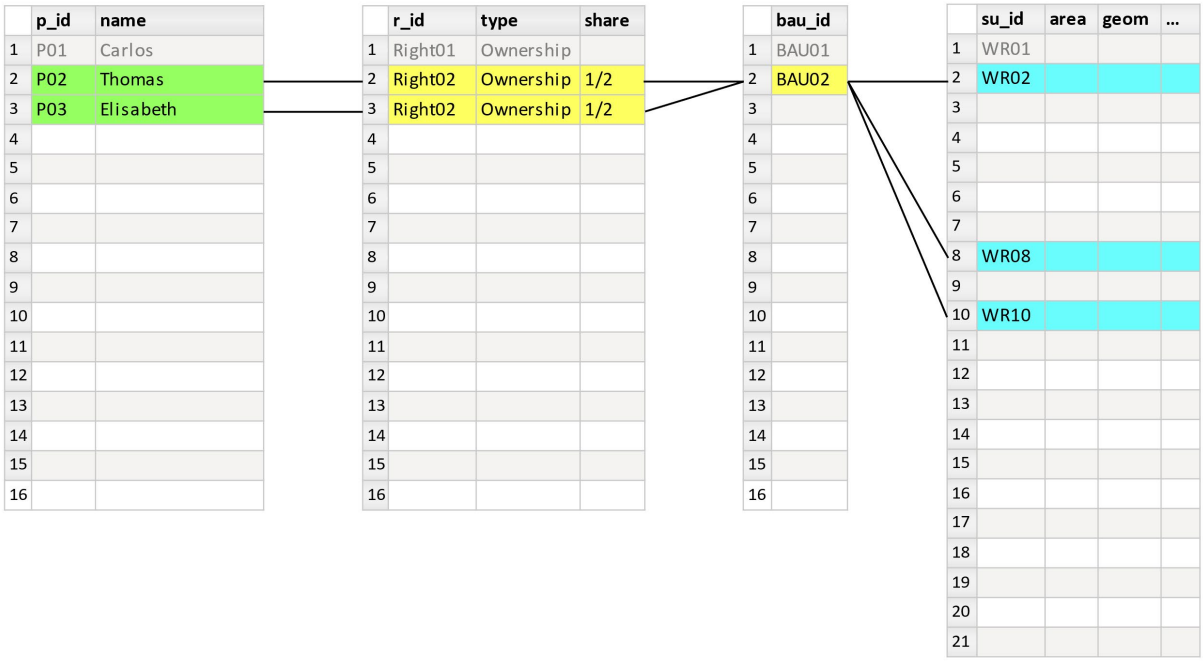


Figure 20. Both shares in Right02 of Elisabeth and Thomas are represented in two records in the second table from the left.

4.4 Tenure Case Three: the municipality Waterriver

The municipality of Waterriver (P04) is a non-natural party.

This party (P04) has a property right on the BAU03 consisting of the public roads (WR03 and WR07), the parcel of the municipal buildings (WR05), the parcel with the municipal school (WR06), the park (WR15) and the water canal in WR16.

This situation is visualised on the cadastral map in Figure 21.

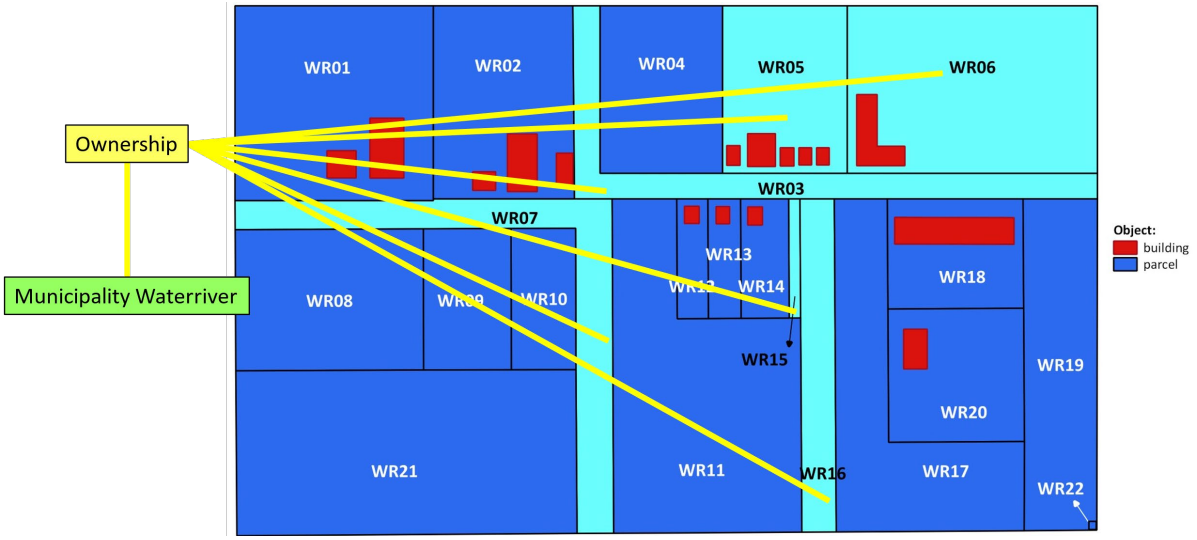


Figure 21. The Municipality of Waterriver in its role as land owner.

These six spatial units (alias is parcels) compose one basic administrative unit (BAU03) as shown in Figure 22.

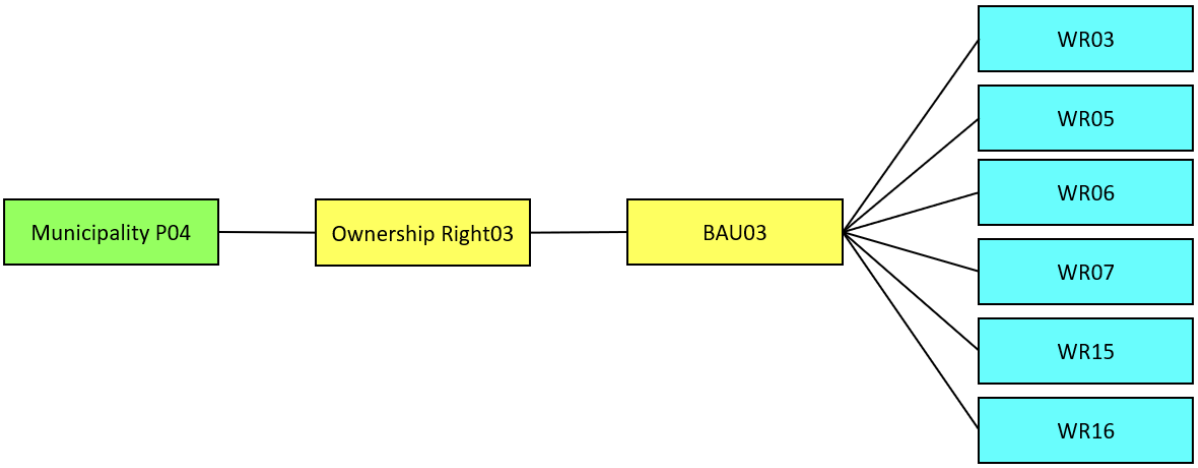
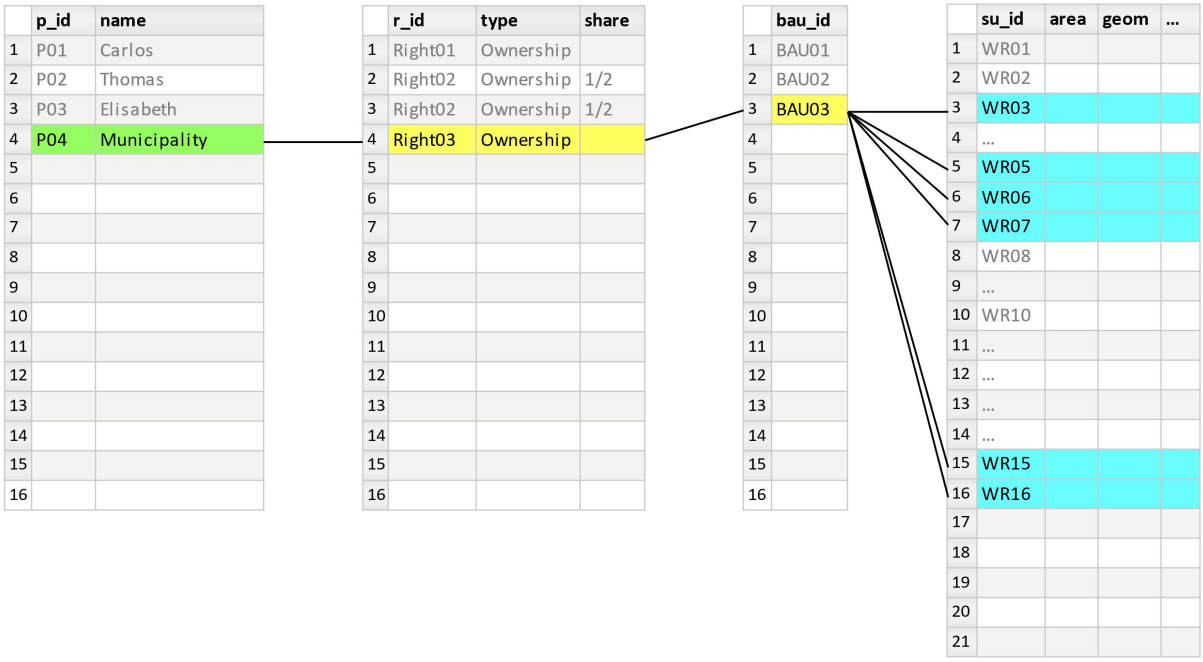


Figure 22. Instance Level representing the case of the municipality of Waterriver.

In Figure 22 the municipality as a party has the id P04. The municipality holds an ownership right (Right03) to a basic administrative unit (BAU03) that is composed of spatial units WR03, WR05, WR06, WR07, WR15 and WR16.

Inclusion of this case in the database results in further filled tables see Figure 23. The records of earlier cases (Carlos, Elisabeth and Thomas) can be seen there as well.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	

	bau_id
1	BAU01
2	BAU02
3	BAU03

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	...			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	...			
10	WR10			
11	...			
12	...			
13	...			
14	...			
15	WR15			
16	WR16			
17				
18				
19				
20				
21				

Figure 23. The municipality of Waterriver as recorded in the LADM based database.

4.5 Tenure Case Four: The Cooperative (Cooperation) and Anna

In Waterriver there is a farmers cooperative, in this book also called 'cooperation'. The cooperative is a legal entity which owns land with the purpose to use it for agriculture. The profits of this activity are shared by the members (farmers) of the cooperative (cooperation) on an annual basis or may be used for investments in the further development of the cooperative. For WR04 there is a shared ownership with Anna. The spatial units WR09, WR11, WR17, WR20 and WR21 are fully owned by the cooperative in two basic administrative units. In total this case analyses the rights to three basic administrative units, BAU04, BAU05, BAU06. See Figure 24.

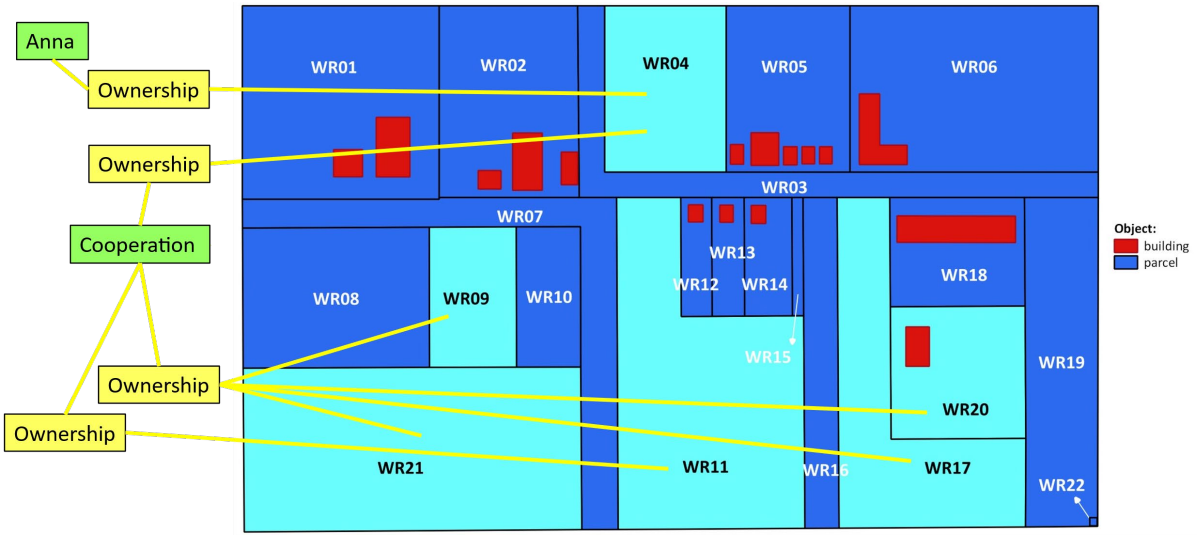


Figure 24. The cooperative owns two basic administrative units. One including WR09, WR17, WR20 and WR21 and one including WR11. Another basic administrative unit includes the spatial unit WR04 in shared ownership with Anna.

The case for BAU04

The share in the ownership right of BAU04 with WR04 for 9/10th by Anna and by 1/10th by the Cooperative (Cooperation) can be modelled as in Figure 25:

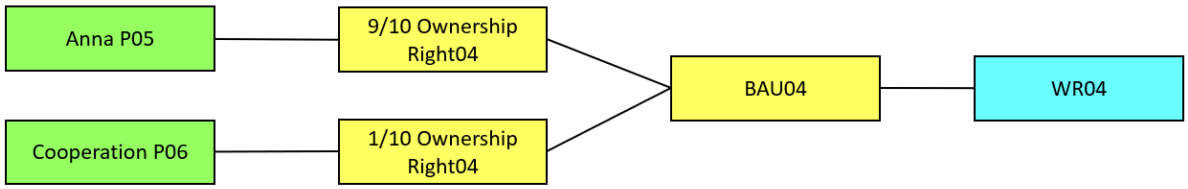
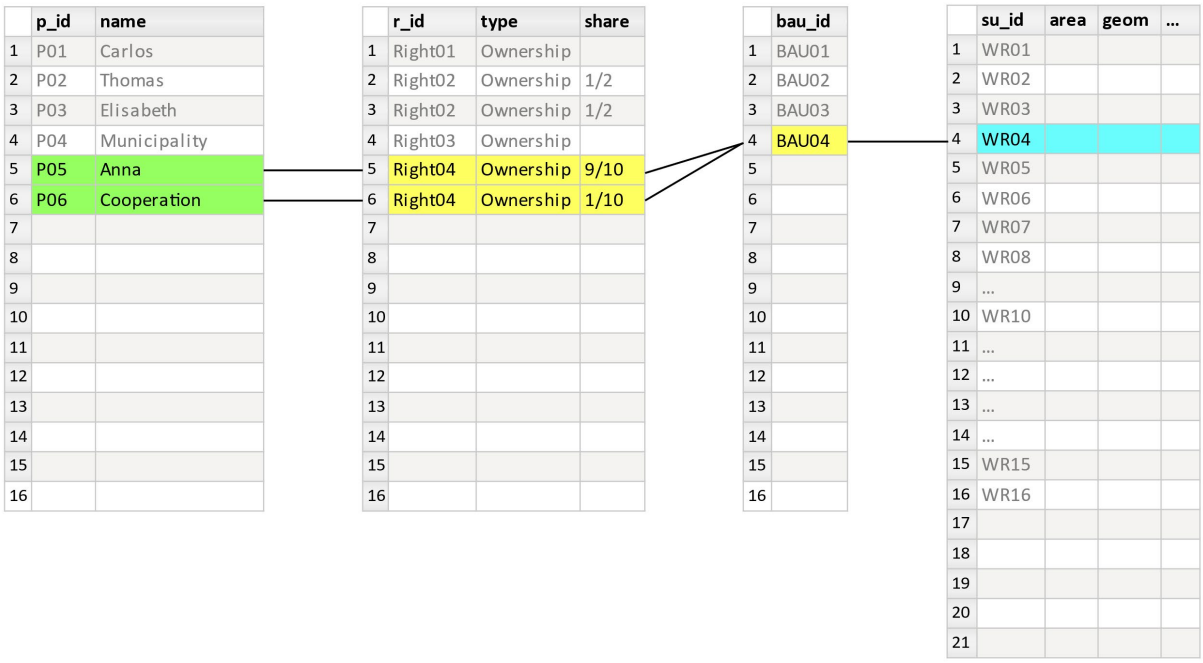


Figure 25. Share in the ownership right of BAU04 with WR04 owned by 9/10th by Anna and by 1/10th by the Cooperative.

In the database the first option (as in Figure 25, that is a joint ownership by Anna and the Cooperative) is represented now as follows (Figure 26):



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	...			
10	WR10			
11	...			
12	...			
13	...			
14	...			
15	WR15			
16	WR16			
17				
18				
19				
20				
21				

Figure 26. Joint ownership by Anna and the Cooperative.

An alternative modelling is possible where the parties Anna and the Cooperative are members of a group party: a Consortium consisting of Anna and the Cooperative. Anna holds a 9/10th share in the Consortium and the Cooperative holds a share of 1/10th in the Consortium. See Figure 27. Documented agreement between Anna and the Cooperative is needed as input for the registration of the Consortium. In that case the Consortium would get an identifier).

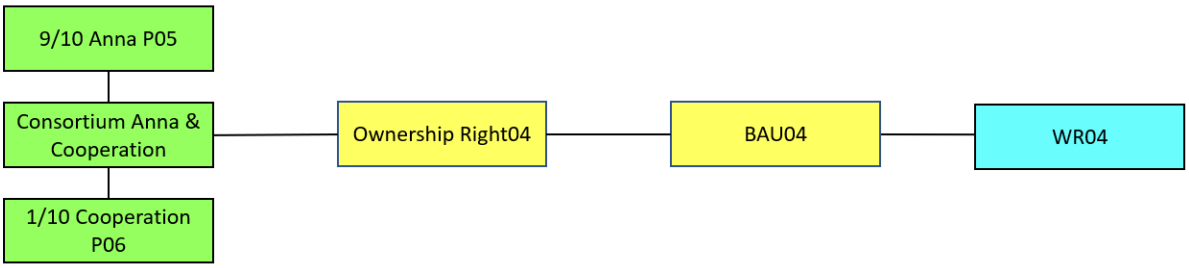


Figure 27. A Consortium between Anna (shareholder for 9/10th) and the Cooperative (1/10th).

The case for BAU05 and BAU06

Anna does not hold further ownership rights to basic administrative units in Waterriver. The Cooperative does. The Cooperative also owns the basic administrative units BAU05 and BAU06. BAU05 is composed of WR09, WR17, WR20 and WR21. And BAU06 of WR11. All together we get the situation as depicted in Figure 28 and the database state displayed in Figure 29.

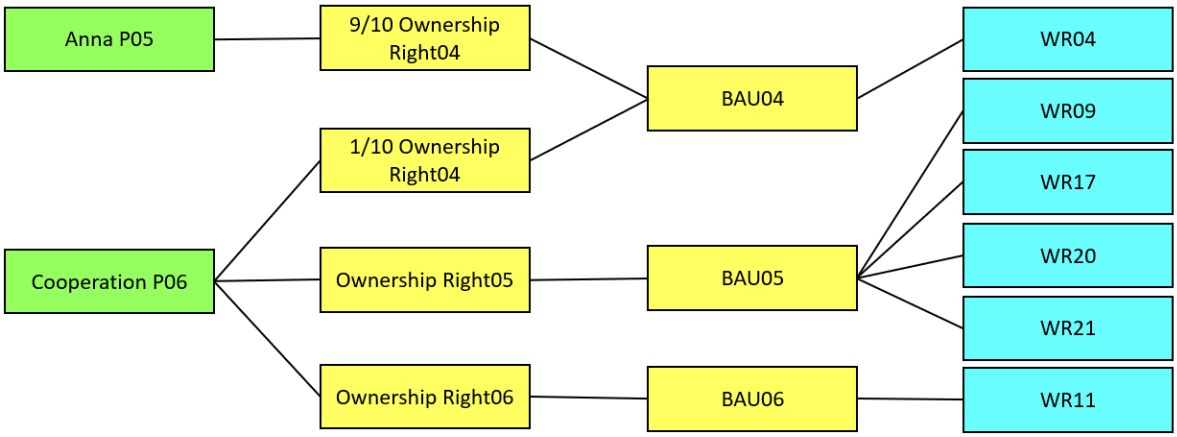
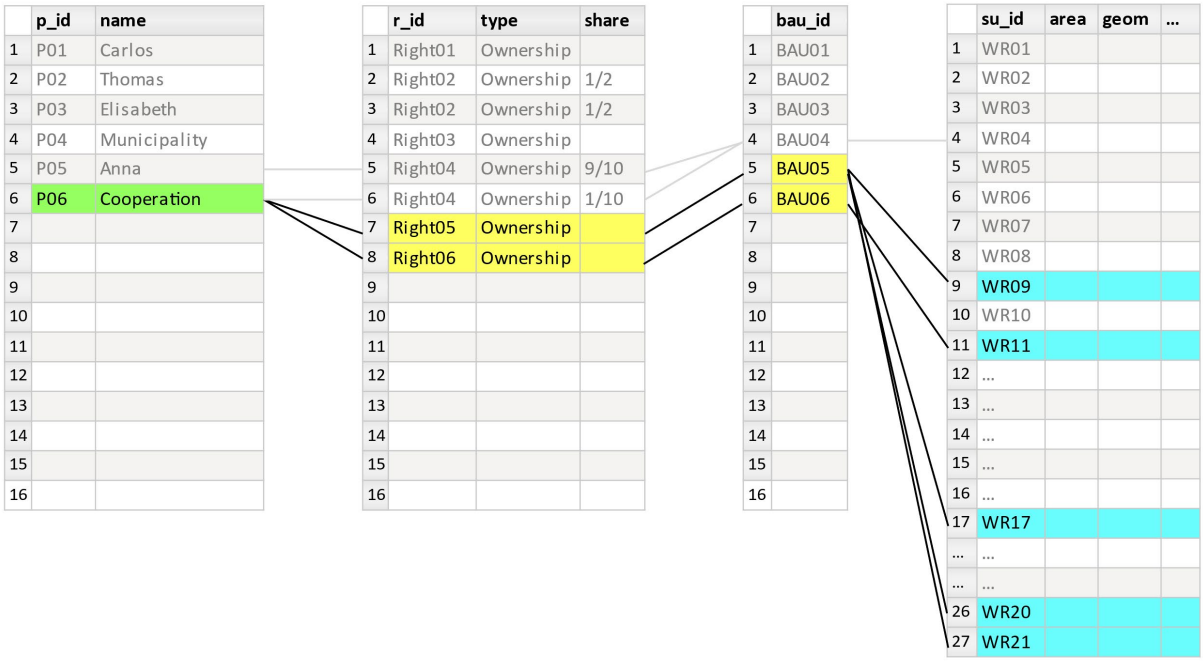


Figure 28. Joint ownership of BAU04 by Anna and the Cooperative. Ownership of BAU05 and BAU06 by the Cooperative.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9			
10			
11			
12			
13			
14			
15			
16			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	...			
13	...			
14	...			
15	...			
16	...			
17	WR17			
...	...			
...	...			
26	WR20			
27	WR21			

Figure 29. The database with the Ownership of BAU05 (with WR09, WR17, WR20 and WR21) and with BAU06 (with WR11) by the Cooperative.

4.6 Tenure Case Five: The Capital Bank

In case four the spatial unit WR11 has been introduced. It is in BAU06 owned by the cooperative.

Apart from the ownership right there is also a mortgage (restriction), a usufruct and an ownership right on BAU06 (with Spatial Unit WR11). This combination of rights is presented on the cadastral map in Figure 30.

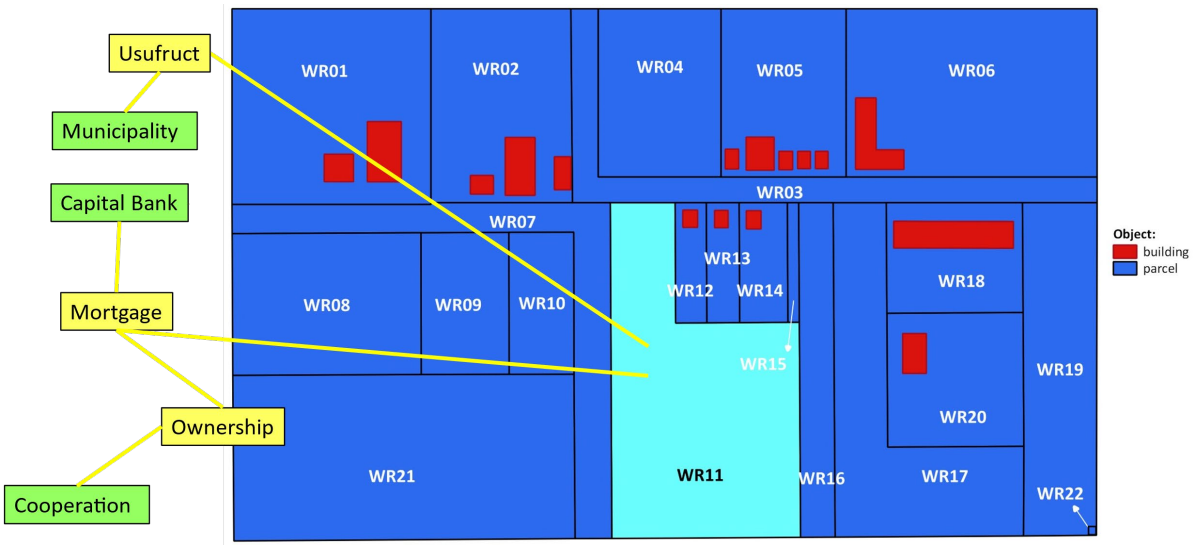


Figure 30. Apart from the ownership right on the WR11 in BAU06 (also shown in Figure 24) there is also a usufruct right and a mortgage (on BAU06, see figure 31).

Apart from the ”Ownership Right06” itself, there is a ”Mortgage Restriction01, to the ownership ”OwnershipRight06”. Further the municipality of Waterriver has an usufruct on BAU06 consisting of spatial unit WR11. See Figure 31.

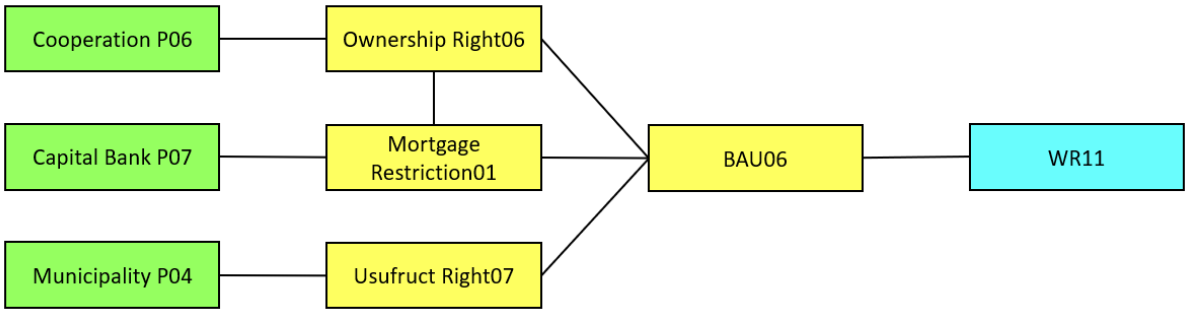


Figure 31. An ownership right, a mortgage and a usufruct right are established in BAU06.

An alternative representation in modelling could be to link the usufruct, ”Right07”, to the ownership right, ”Right 06” (same as mortgage ”Restriction01).

Note: the Capital Bank cannot claim full ownership of BAU06 because it is also restricted by a usufruct.

The representation of this situation in the database is visualised in Figure 32.

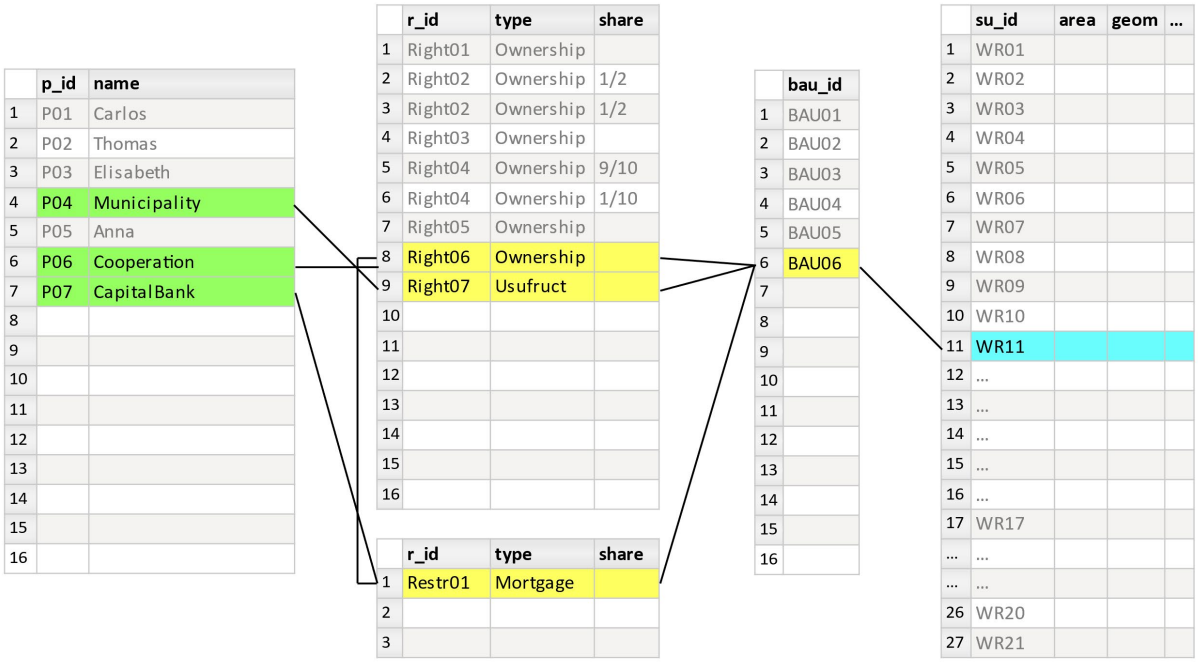


Figure 32. The mortgage and the usufruct on BAU06.

4.7 Tenure Case Six: The Housing Company

The Housing Company supports its target group by establishing leaseholds on its parcel (spatial unit) where its houses are built on. The residents can then use it for forty years with an option for extension. Inheritance of the leasehold is possible, the leasehold can be sold by the leaseholder – but of course not the ownership of the BAUnit.

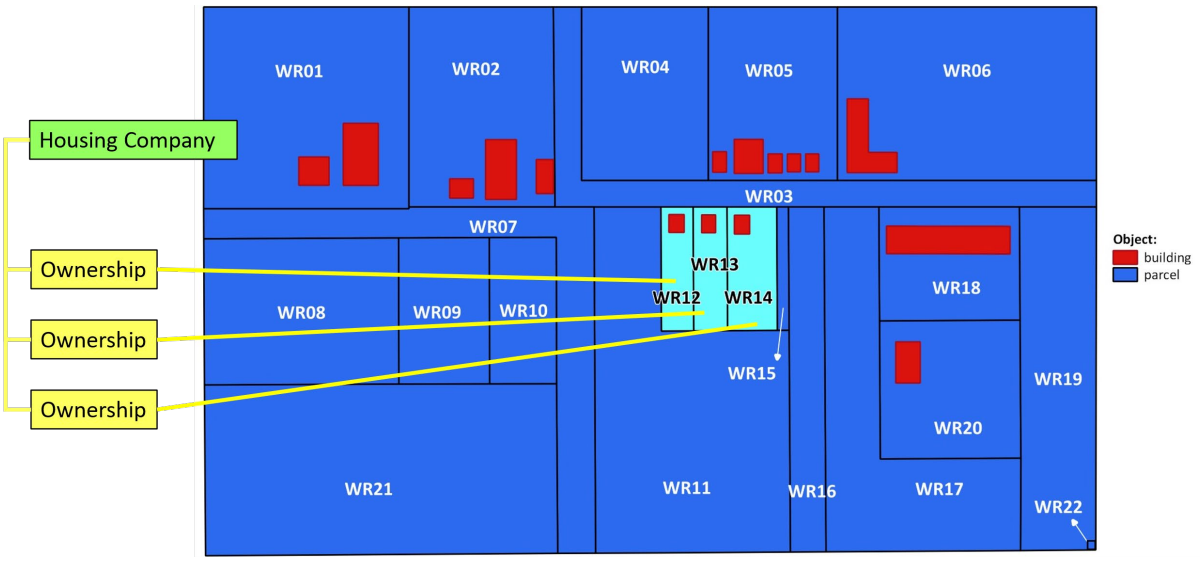


Figure 33. In Waterriver the Housing Company owns three basic administrative units. Each basic administrative unit consists out of one parcel (spatial unit) with a house built on it.

In Waterriver the Housing Company owns three basic administrative units with each one spatial unit (parcel) with houses 'attached', see Figure 33. Note: the ownership situation is presented here in Case Six, to be continued with the leasehold in Case Seven.

The instance level in Figure 34 gives a detailed overview. Ownership Right08 of the Housing Company (with the id Party08) concerns BAU07 with spatial unit (parcel) WR12 related. Same for Right09 on BAU08 with WR13 and for Right10 on BAU09 with WR14.

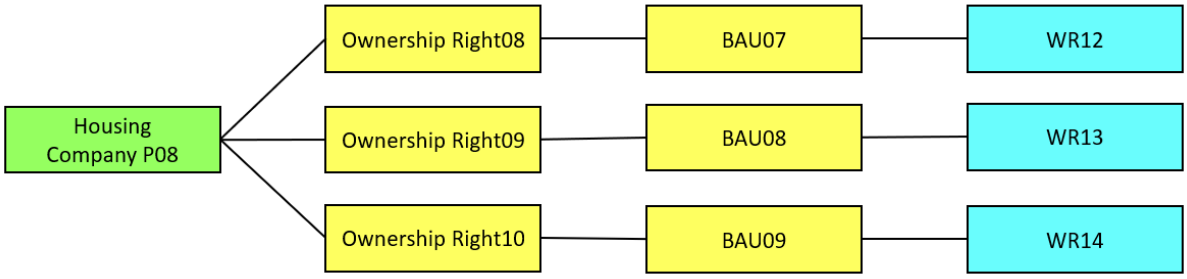


Figure 34. The Housing Company has three ownership rights each of them on a BAUnit with one single spatial unit (parcel).

The case as presented in Figure 34 is included in the database as shown in Figure 35.

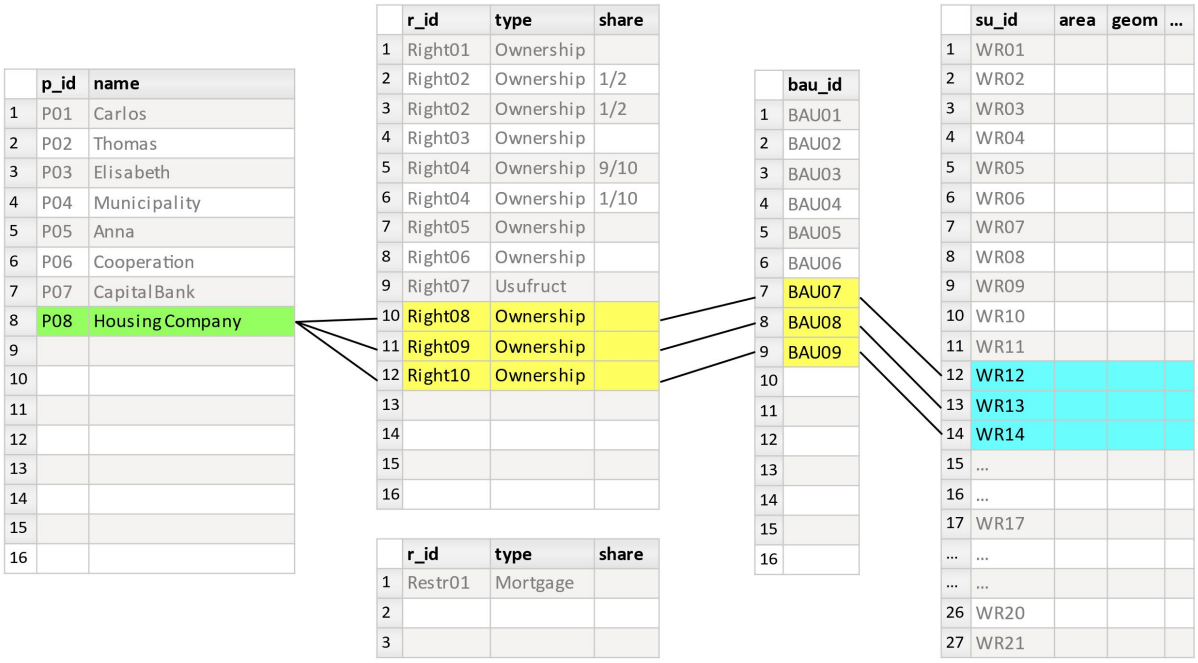


Figure 35. The ownership situation of the Housing Company.

The case of the leasehold related to the Housing Company is now shown in Case Seven.

4.8 Tenure Case Seven: The Housing Company and its leaseholders

On each of the three BAUnits (BAU07, BAU08, BAU09) owned by the Housing Company there is a leasehold right established. The holders of that right are Maria and Johan (together) and Anton and James. See Figure 36.

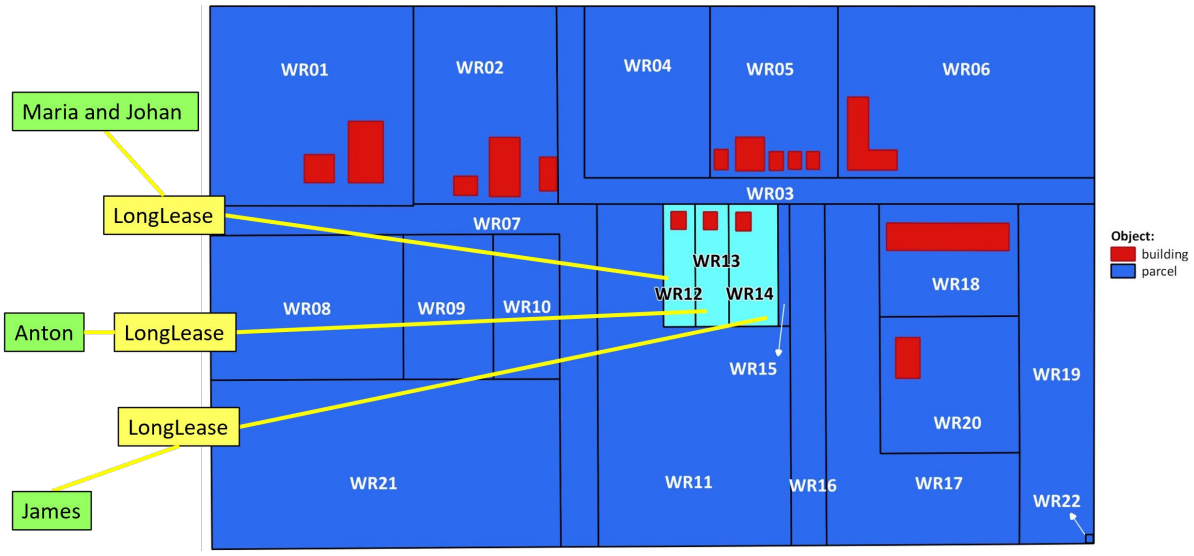


Figure 36. On each of the BAUnits of the Housing Company there is a leasehold established apart from the ownership right by the Housing Company itself.

The three situations for:

- Maria and Johan,
- Anton and
- James

together with the Housing Company are now introduced. First Maria and Johan – they hold a long lease on the BAU07 with WR12 included. See Figure 37 for this situation on the map.

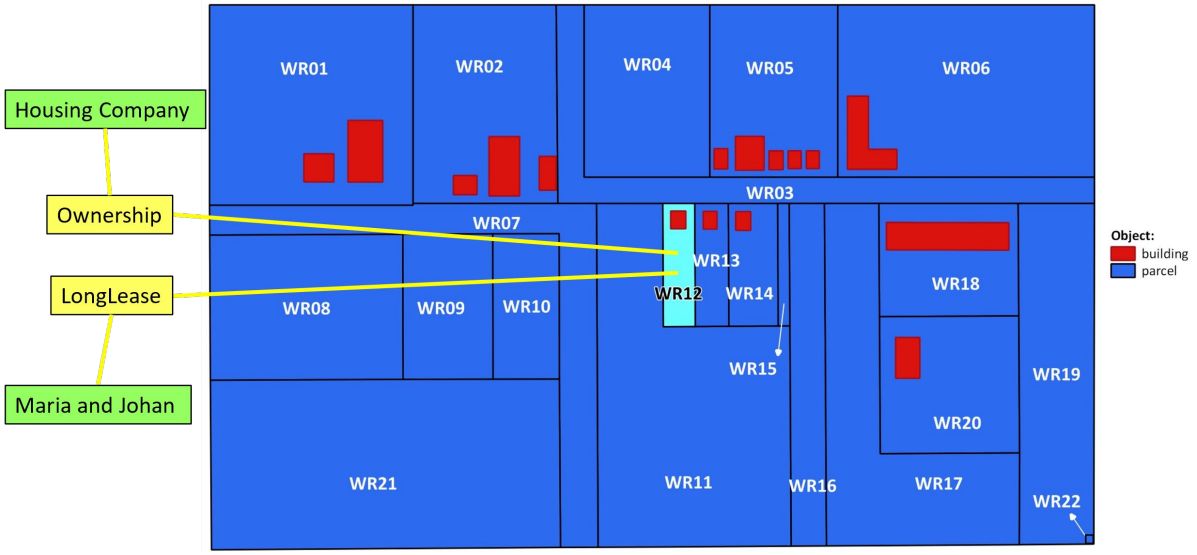


Figure 37. Maria and Johan – hold a lease on the BAU07 with WR12 included.

Both Maria (P09) and Johan (P10) hold a share in the leasehold (Right 11) to BAU07 with WR12 related. The ownership is with the Housing Company (P08). See Figure 38. Both have a share equal to ½, the sum of their shares is equal to 1.

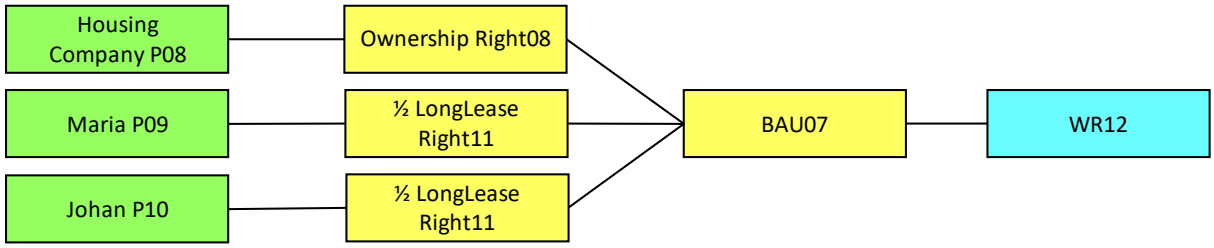


Figure 38. Both Maria, P09, and Johan, P10, hold a share in the leasehold (Right 11) to BAU07 with WR12 related.

The tables in Figure 39 show the representation in the database. The ownership Right08 is shown once more combined with the leasehold Right11. Two records are needed for the representation of Right11 because of the shares.

	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11		
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15			
16			

	r_id	type	share
1	Restr01	Mortgage	
2			
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
...	...			
...	...			
26	WR20			
27	WR21			

Figure 39. The leasehold Right11 with two records in the right table because of the two shares.

The Housing Company P08 is owning the basic administrative (BAU08) unit related to the spatial unit WR13. Anton (P11) has a leasehold associated with the same basic administrative unit. See Figure 40.

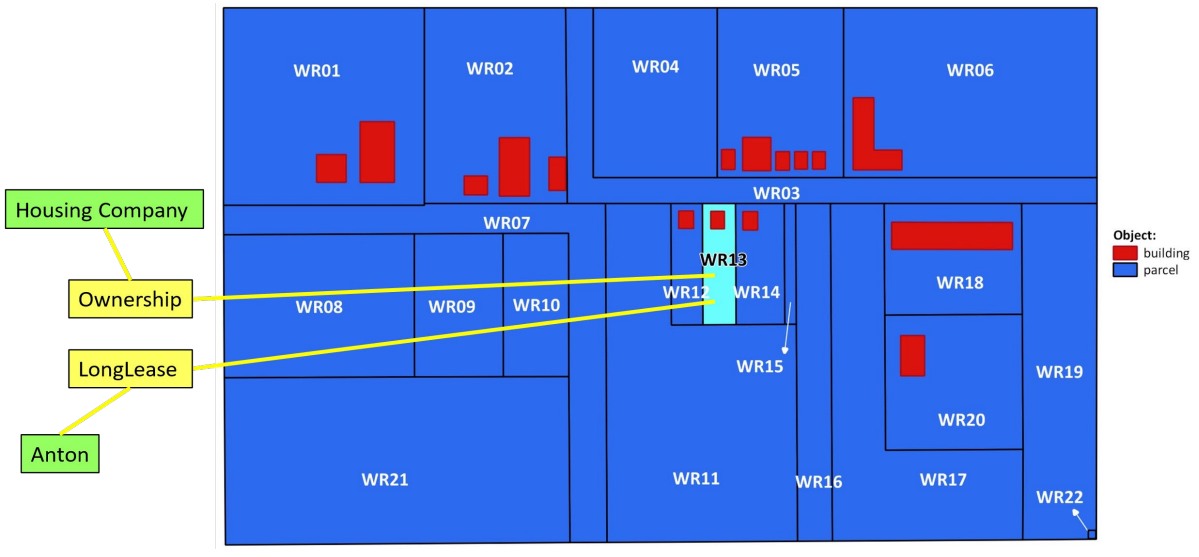


Figure 40. The Housing Company owns the basic administrative unit associated with WR13. There is a leasehold (right12) with Anton (P11). See also Figure 41.

Antons relationship with land and house is visualised in Figure 41:

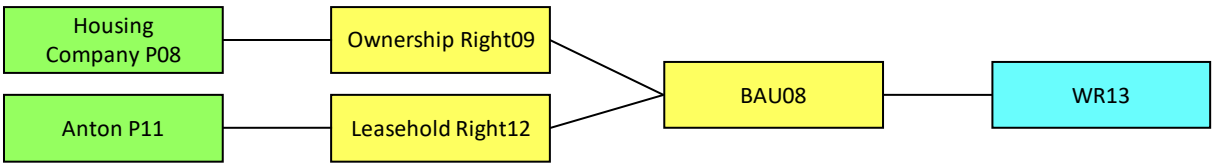
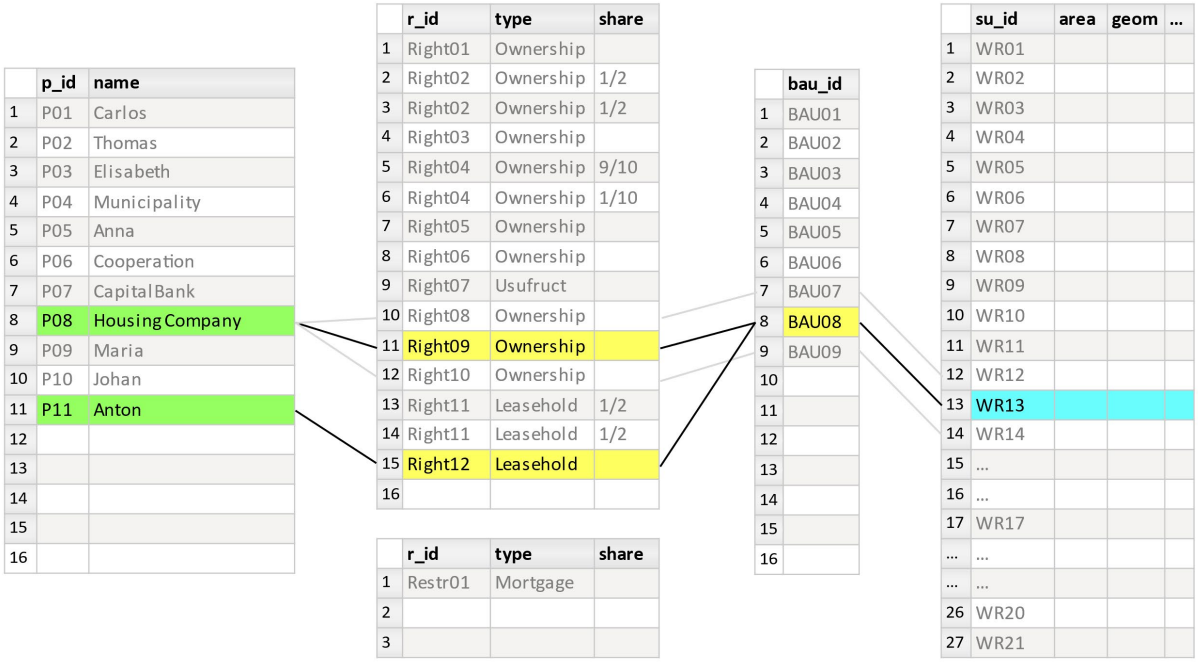


Figure 41. Anton's relationship with land: P11 has a leasehold (Right12) on BAU08 with parcel WR13.

The representation Anton's leasehold in the database is represented in in Figure 42.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16			

	r_id	type	share
1	Restr01	Mortgage	
2			
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
...	...			
...	...			
26	WR20			
27	WR21			

Figure 42. Anton's land rights situation in the database.

There is a mortgage on Anton's lease as can been seen in Figure 43 below.

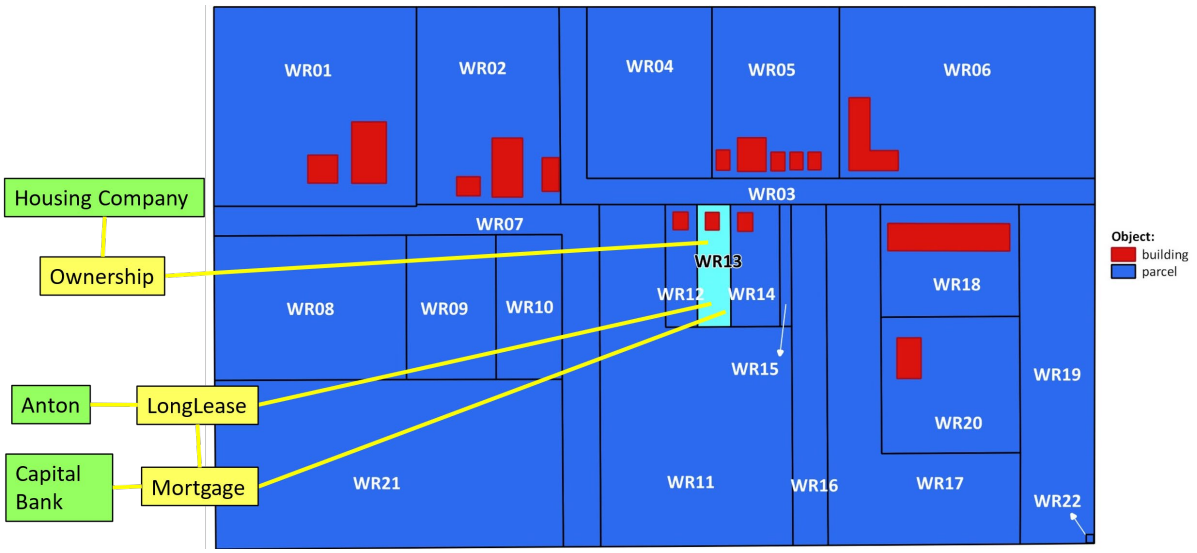


Figure 43. There is a mortgage on Anton's lease.

The mortgage (”Restriction02”) is explicitly associated to the concerned leasehold (”Right12”) and not to the ownership right 09.

The Capital Bank is the money provider. If Anton fails to pay the interest (and redemption) on the mortgage, the Capital Bank can go to court with the mortgage agreement. The value of the leasehold right is the collateral in this situation. The bank can ask to auction off the leasehold. This approach is country specific. Figure 44 illustrates the details of the situation.

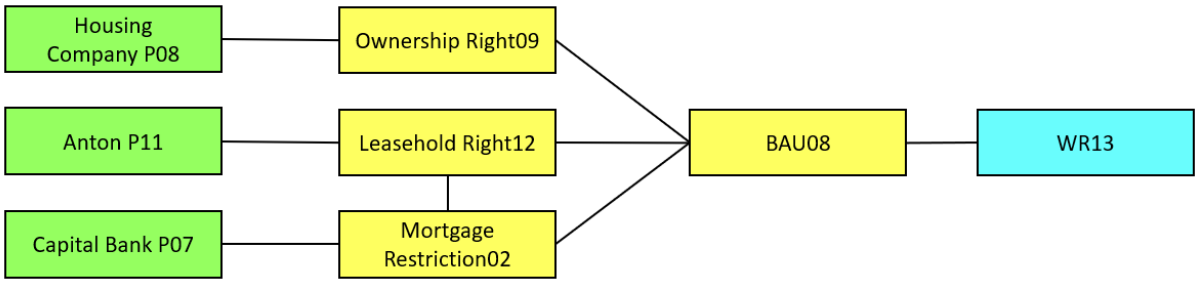
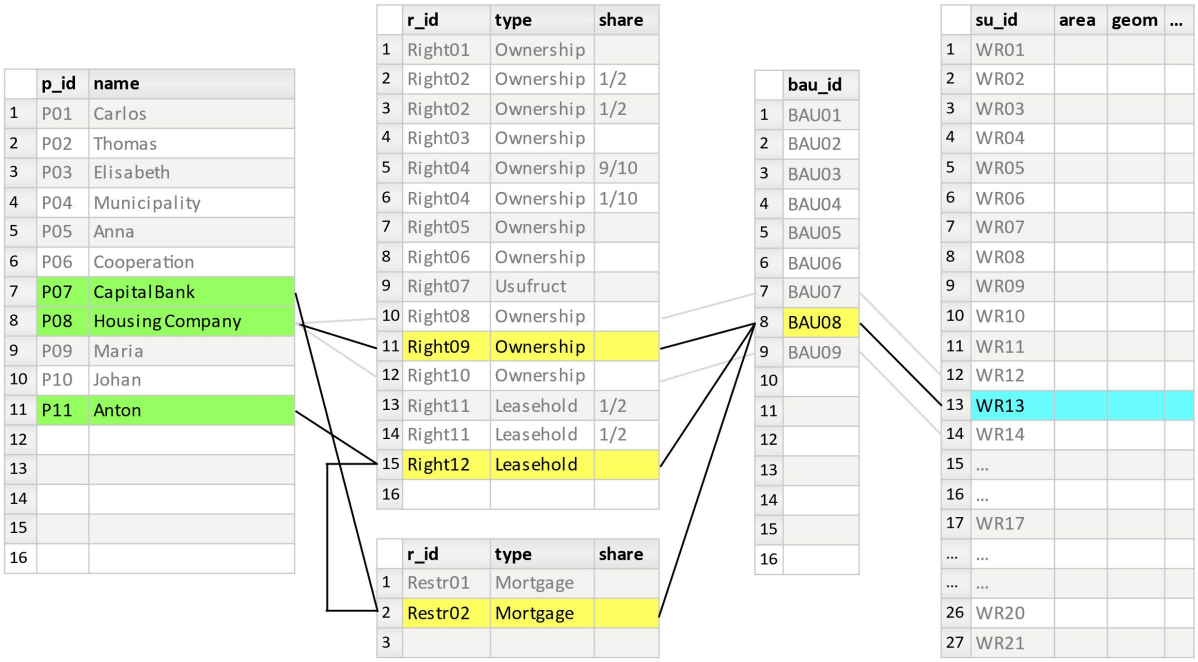


Figure 44. Anton's mortgage agreement with the Capital Bank.

In the database the situation looks as shown in Figure 45.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	Capital Bank
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12		
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16			

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
...	...			
...	...			
26	WR20			
27	WR21			

Figure 45. Anton's mortgage agreement with the Capital Bank.

The Capital Bank now has a mortgage ("Restriction01") to BAU06 and a mortgage ("Restriction02") to BAU08, see Figure 46.

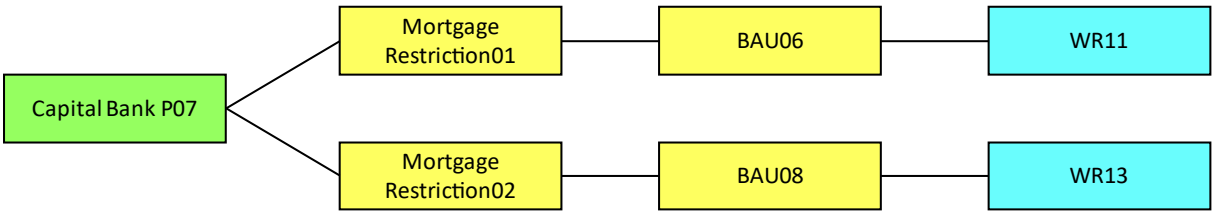


Figure 46. The Capital Bank as money provider.

Finally, James (P12), holds a leasehold ("Right 13") on BAU09 with WR14 related. See the map of this situation in Figure 47.

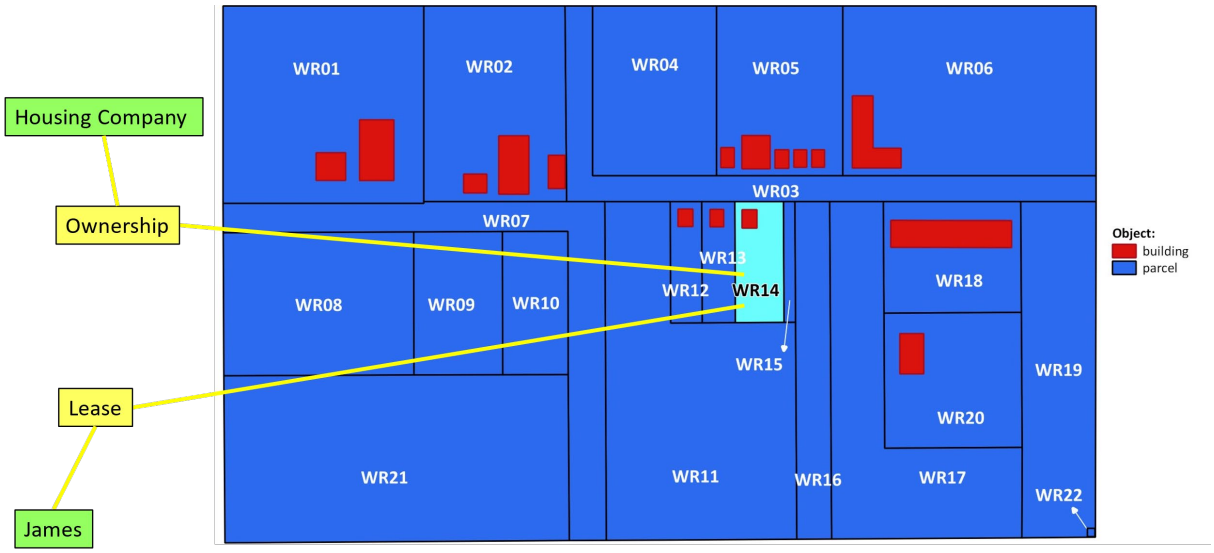


Figure 47. The leasehold of James.

The instance level diagram of this situation is represented in Figure 48.

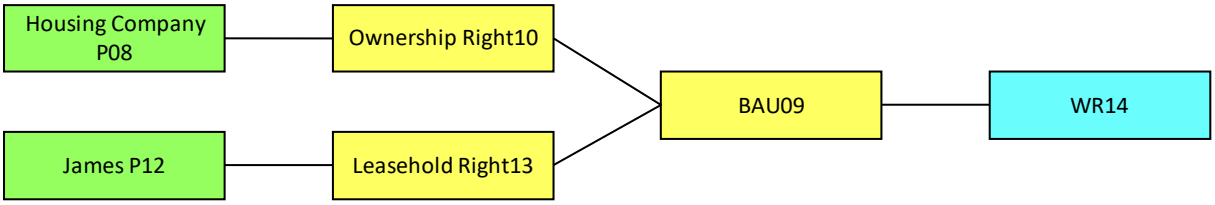
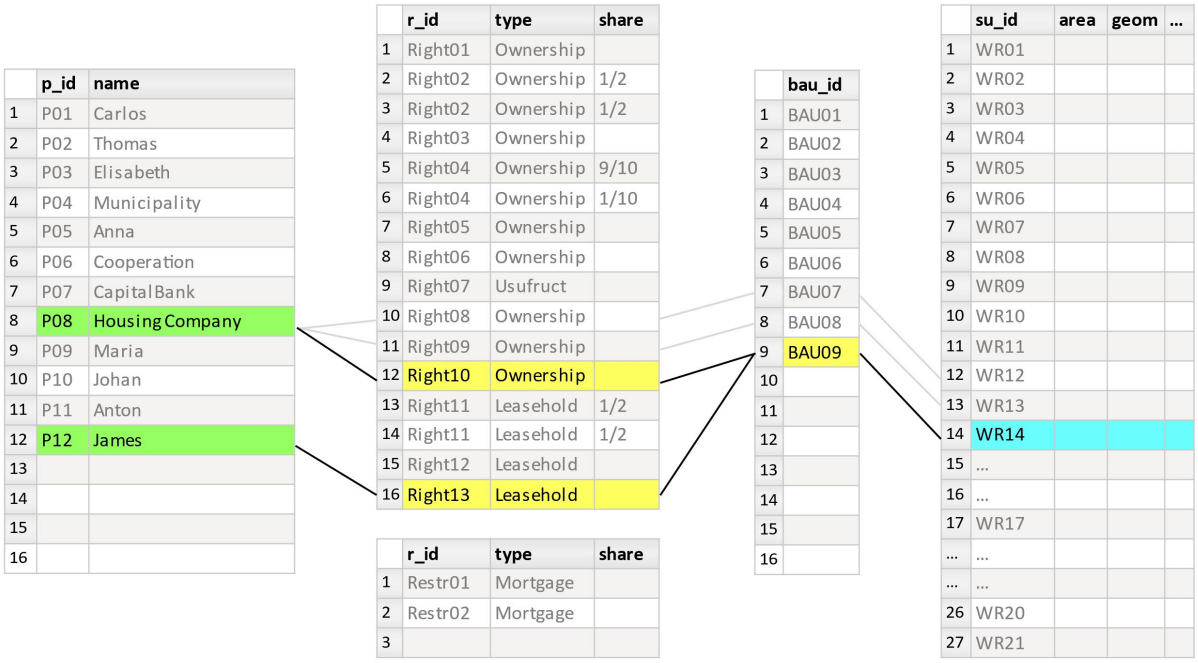


Figure 48. The leasehold (right13) of James(P12) associated to BAU09 with WR14 related.

The representation in the database of this situation in Figure 49.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13		
14		
15		
16		

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
...	...			
...	...			
26	WR20			
27	WR21			

Figure 49. The situation of James in the database.

4.9 Tenure Case Eight: The Apartment Building

There is an apartment building in Waterriver. There are different ways to register apartments, apartment buildings and the land where the building is established. One example is given here. Normally such a solution is part of the LADM country profile.

The individual owners of each apartment are members (mandatory) of the Association of Owners. This association has a board composed of members of the association: a president, a secretary and a treasurer. The board acts on behalf of the members.

The association owns all common property, for example the parcel where the apartment building is located. Separately, members own individual properties. See Figure 50 where this example is illustrated on the map.

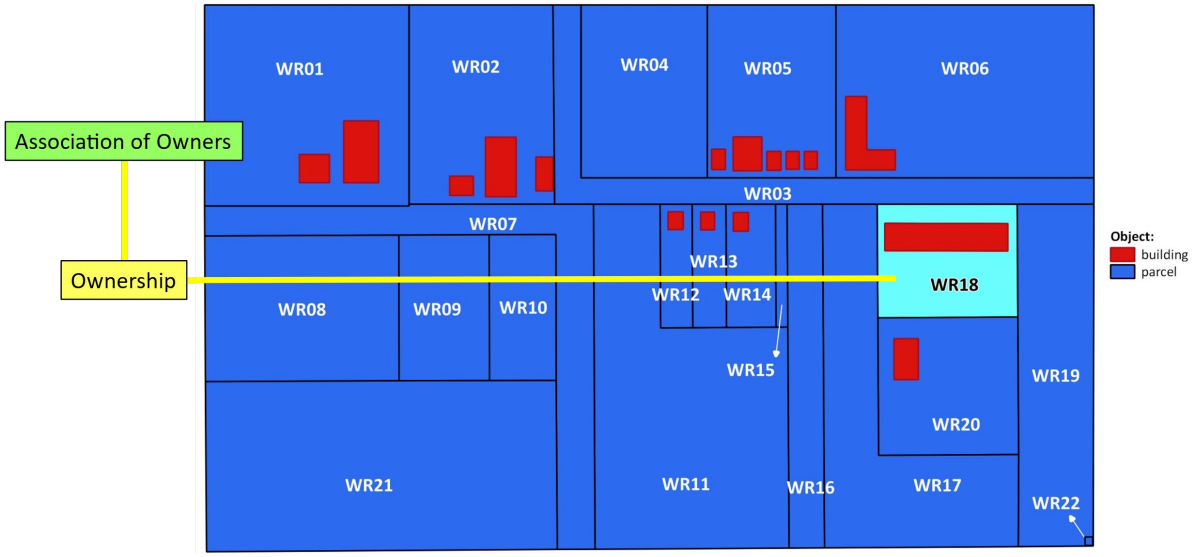


Figure 50. The Association of Owners owns all common property, for example the parcel WR18 with the apartment building.

The Association of Owners is registered in the land administration as a party (P13) with an ownership right (Right14) to BAU10 with parcel WR18. See Figure 51.

The association as such is registered in the land administration as a non-natural person.

The members of the board must be 'retrievable', there are different ways to organise this. As said: it may be that the association is registered in the land administration itself. In that case each update in the composition of the board must be included in the land administration. Or the board members may be in a register of associations – this may be with the Chamber of Commerce. Other options are possible, depending on the arrangements within the country, e.g. in the population register. In LADM this type of external information is included in "external classes".

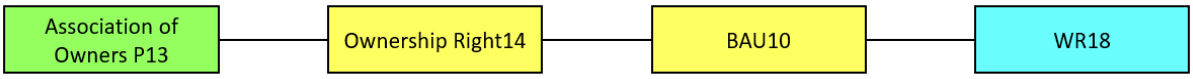
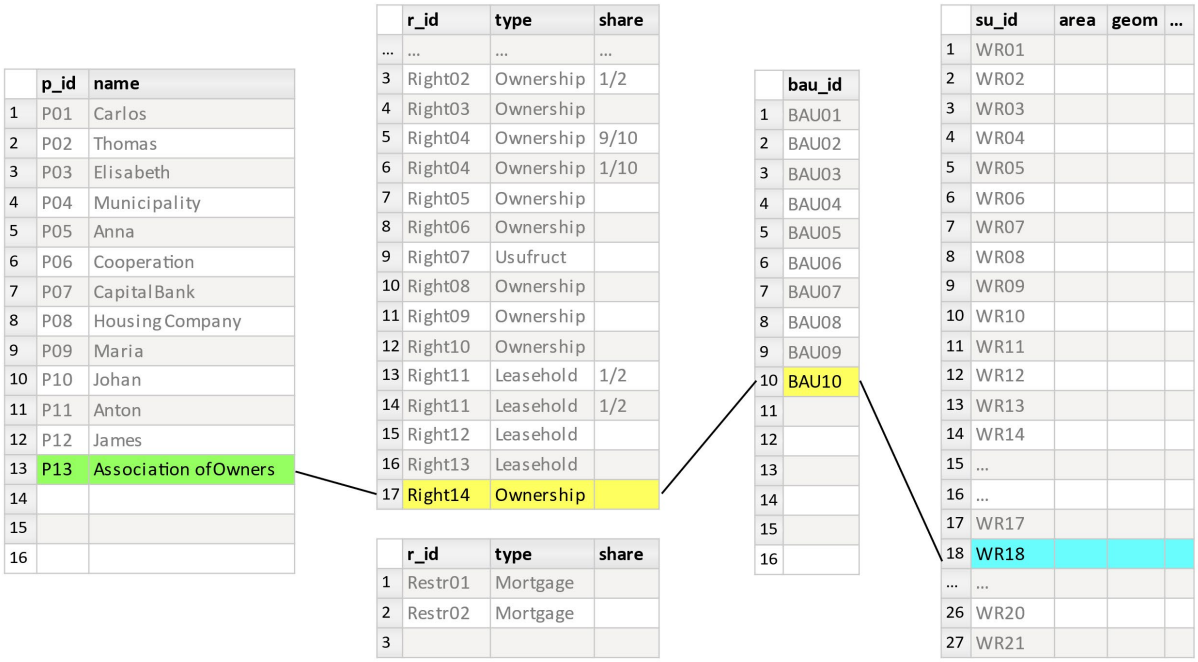


Figure 51. The Association of Owners is registered in the land administration as a party with an ownership right. The Association is a non-natural person.

Figure 52 shows the database with the Association of Owners and its right to BAU10 with WR18 included.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	HousingCompany
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association ofOwners
14		
15		
16		

	r_id	type	share
...	...	...	...
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	
12	
13	
14	
15	
16	

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
18	WR18			
...	...			
26	WR20			
27	WR21			

Figure 52. The Association of Owners in the database - with its right to BAU10.

The Association of Owners also owns the common areas in an apartment building (with 3 floors). That concerns the roof, the apartment galleries and the elevator house. See Figure 53.

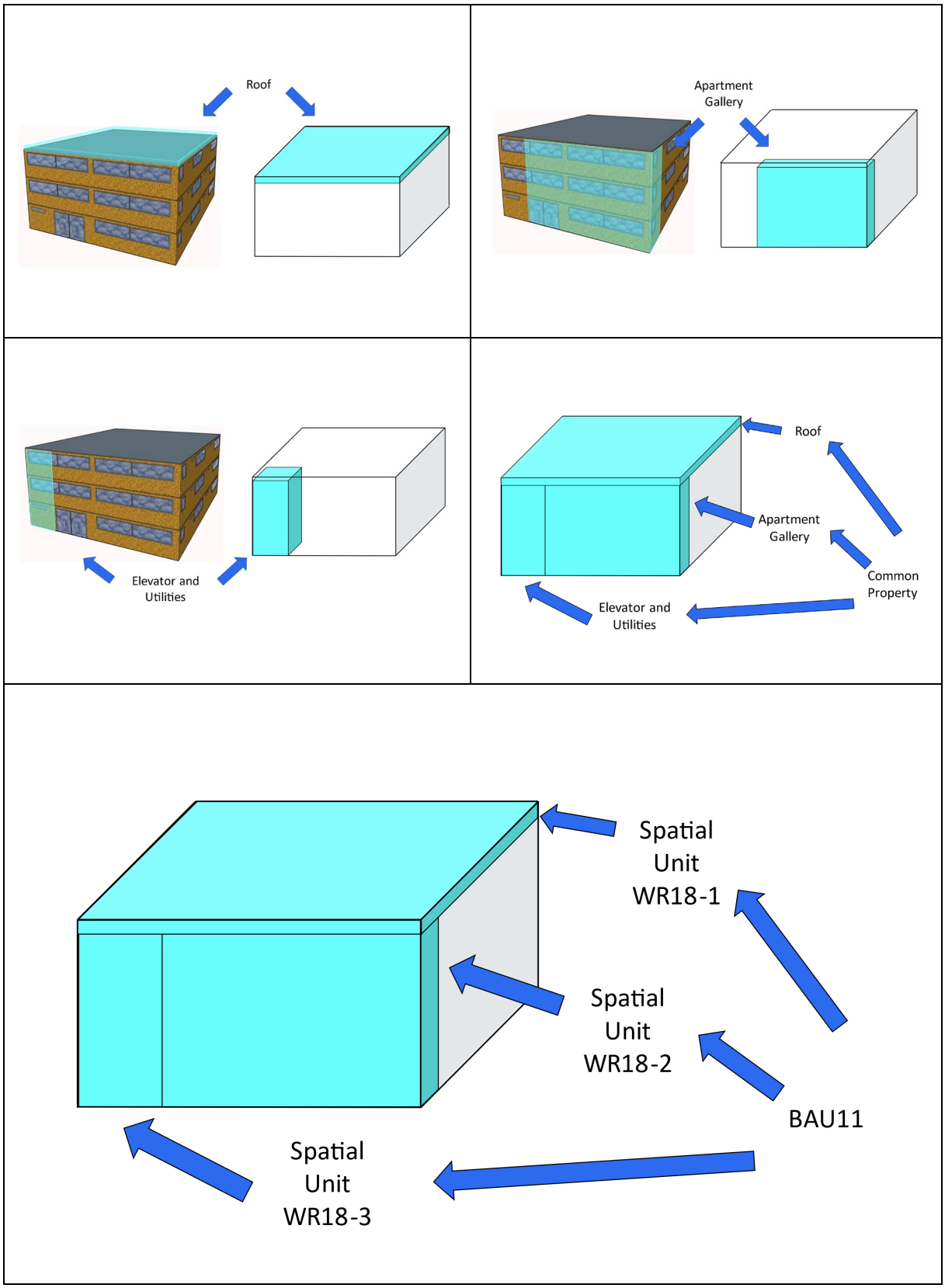


Figure 53. Apart from the parcel WR14 the Association of Owners owns the common areas in the Apartment Building. That concerns the roof WR18-1(a), the apartment galleries WR18-2(b) and the elevator house WR18-3(c).

The land administration in Waterriver supports 3D registration of cadastral objects (as parcels and apartments) apart from the 2D registration. The 2D registration is most common, but the 3D registration is necessary in multi-owner apartment complexes. The apartment building is registered as a 3D object.

The roof, galleries and elevator house are considered to be separate spatial units: WR18-1 represents the roof, WR18-2 represents the galleries and WR18-3 represents the elevator house, see Figure 53. The spatial units get an index added to the ground parcel WR18 as identifier.

WR18-1, WR18-2 and WR18-3 compose a separate basic administrative unit with common properties inside the apartment building: BAU11. See Figure 54.

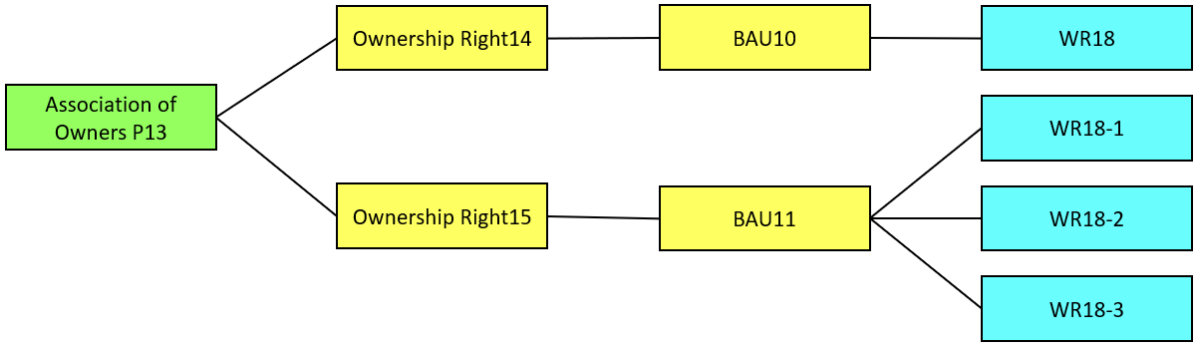
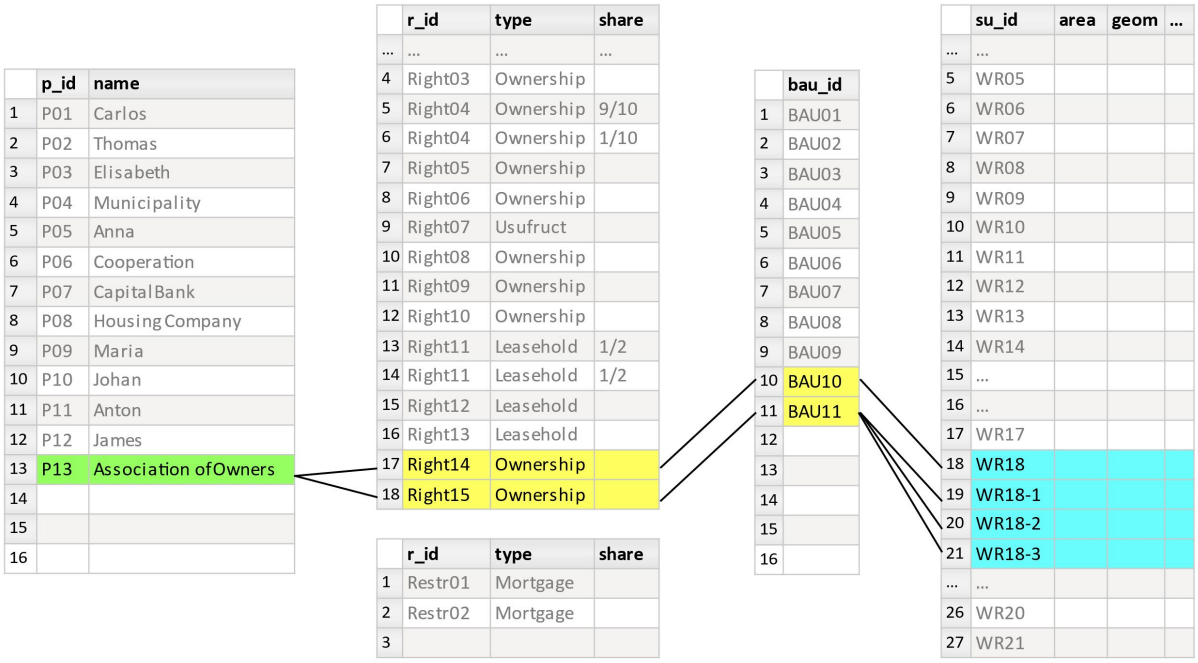


Figure 54. BAU10 (with Right14) concerns the 'ground parcel' (WR18) of the Association of Owners (P13). BAU11 with (Right15) concerns the common properties of the Association of Owners inside the apartment building: WR18-1 is the roof, WR18-2 the gallery and WR18-3 the elevator space.

Note: the association of owners owns two BAUnits (BAU10 and BAU11). This can be included in one or two titles. Further aggregation is also possible:then the ownership rights are combined as well as the BAU's. One BAU may include four spatial units (WR18, WR18-1, WR18-2, WR18-3). All represented in one title. The source can be 'BIM based', where Building Information Modelling was used in the design and checked for correct realisation in the building in reality.

In the database this situation looks as visualised in Figure 55.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	HousingCompany
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association ofOwners
14		
15		
16		

	r_id	type	share
...	...	...	...
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	
18	Right15	Ownership	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	BAU11
12	
13	
14	
15	
16	

	su_id	area	geom	...
...	...			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
18	WR18			
19	WR18-1			
20	WR18-2			
21	WR18-3			
...	...			
26	WR20			
27	WR21			

Figure 55. The common properties of the Association of Owners visualised in the database.

Monique is the owner of an apartment, a parking lot and a laundry room. See Figure 56. Monique is a member of the association of owners.

The apartment, the parking lot and the laundry room concern one property but

they are considered as separate spatial units. WR18-4 represents the apartment, see Figure 56 (a), WR18-5 represents the parking lot, see Figure 56 (b), and WR18-6 represents the laundry room, see Figure 56 (c). The complete property is shown in Figure 56 (d) The spatial units get an index added to the ground parcel WR18 as identifier. See Figure 56 bottom.

Note: the individual spatial units can be part of a transaction. The parking lot may be sold to another party. This requires that the BAU11 needs to be subdivided.

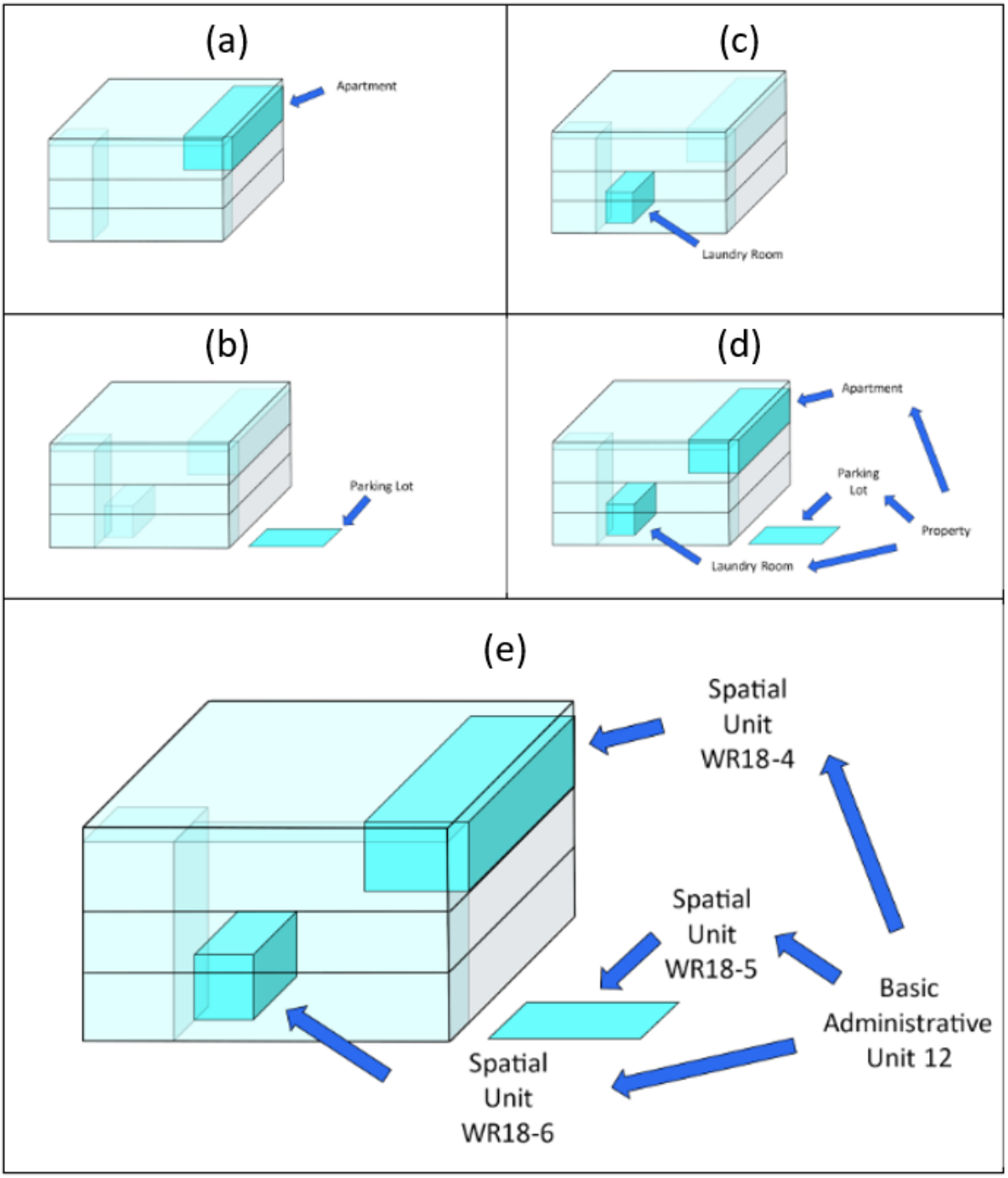


Figure 56. Monique owns BAU12. That concerns the apartment WR18-4 (a), the parking lot WR18-5 (b) and the laundry room WR18-6(c).

Figure 57 visualises the case: BAU12 (with Right16) concerns the ownership of Monique (P14). This concerns: WR18-4, Monique's apartment, WR18-5, the parking lot and WR18-6 the laundry room. The parking lot can be considered as a 3D volume, see Annex 2.

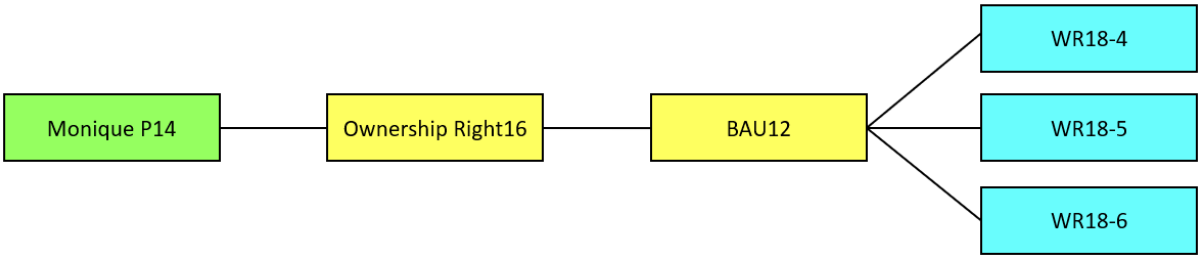


Figure 57. BAU12 (with Right16) concerns the ownership of Monique (P14). This concerns: WR18-4, Monique's apartment, WR18-5, the parking lot and WR18-6 the laundry room.

Figure 58 shows the representation in the database of Monique's (P14) ownership (Right16) to BAU12 with spatial units WR18-4, Wr18-5 and WR18-6.

	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association ofOwners
14	P14	Monique
15		
16		

	r_id	type	share
...	...	...	...
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	
18	Right15	Ownership	
19	Right16	Ownership	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	BAU11
12	BAU12
13	
14	
15	
16	

	su_id	area	geom	...
...	...			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
18	WR18			
19	WR18-1			
20	WR18-2			
21	WR18-3			
19	WR18-4			
20	WR18-5			
21	WR18-6			
...	...			
26	WR20			
27	WR21			

Figure 58. Monique's property in the apartment building.

Monique is a member of the Association of Owners. See Figure 59. This association owns the common properties. Shares of members of the association are defined. Note: there can be the same situation as in case four now: Anna and the Cooperative: shares could be related to the right (look back to Figure 25) or to the Party (as in Figure 27).

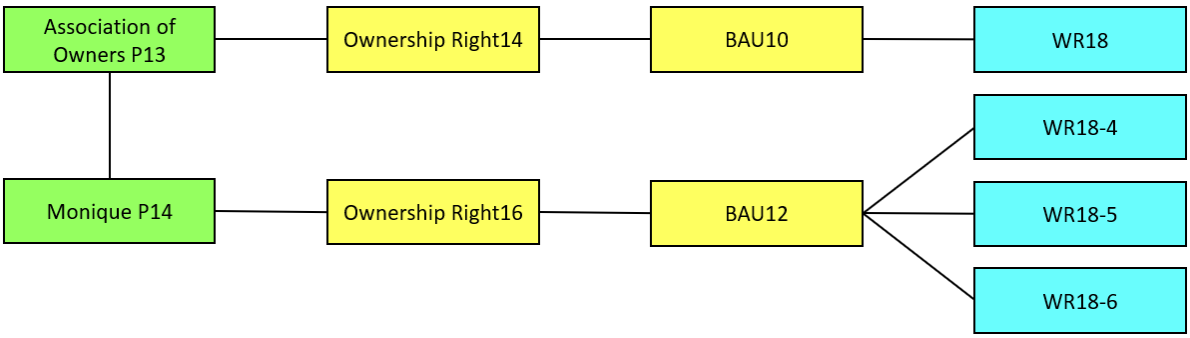
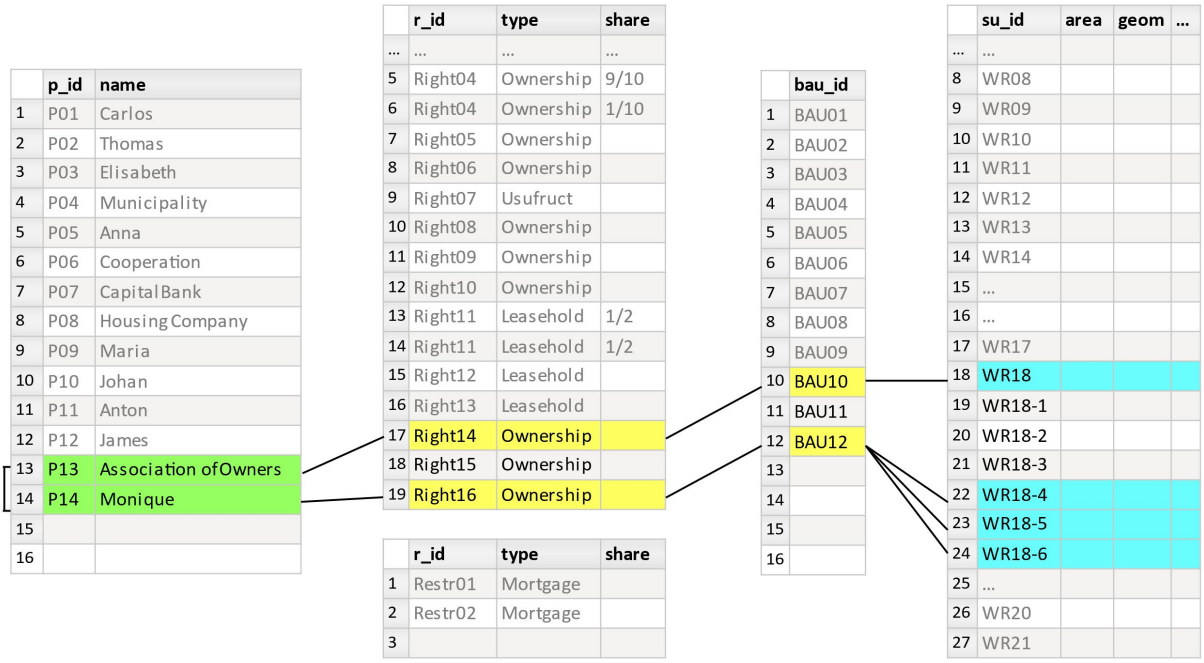


Figure 59. Monique is co-owner in the Association of Owners. The Association is owner of common properties.

See Figure 60 for the representation of Monique's situation combined with the Association of Owners situation in the database.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	HousingCompany
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association ofOwners
14	P14	Monique
15		
16		

	r_id	type	share
...	...	...	...
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	
18	Right15	Ownership	
19	Right16	Ownership	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	BAU11
12	BAU12
13	
14	
15	
16	

	su_id	area	geom	...
...	...			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
18	WR18			
19	WR18-1			
20	WR18-2			
21	WR18-3			
22	WR18-4			
23	WR18-5			
24	WR18-6			
25	...			
26	WR20			
27	WR21			

Figure 60. Monique's properties. The share in the common property is not visualised. Monique owns BAU12, she has a title. The association of owners has a title as association, there is no title for the individual share in the common properties.

4.10 Tenure Case Nine: Eco Investment

Eco Investment invests in sustainable development. For testing and development purposes, a site is available in Waterriver on parcel WR19. The company could buy a very small parcel of land some time ago, with id WR22. This was owned by a utility company. See Figure 61 for this situation on the cadastral map.

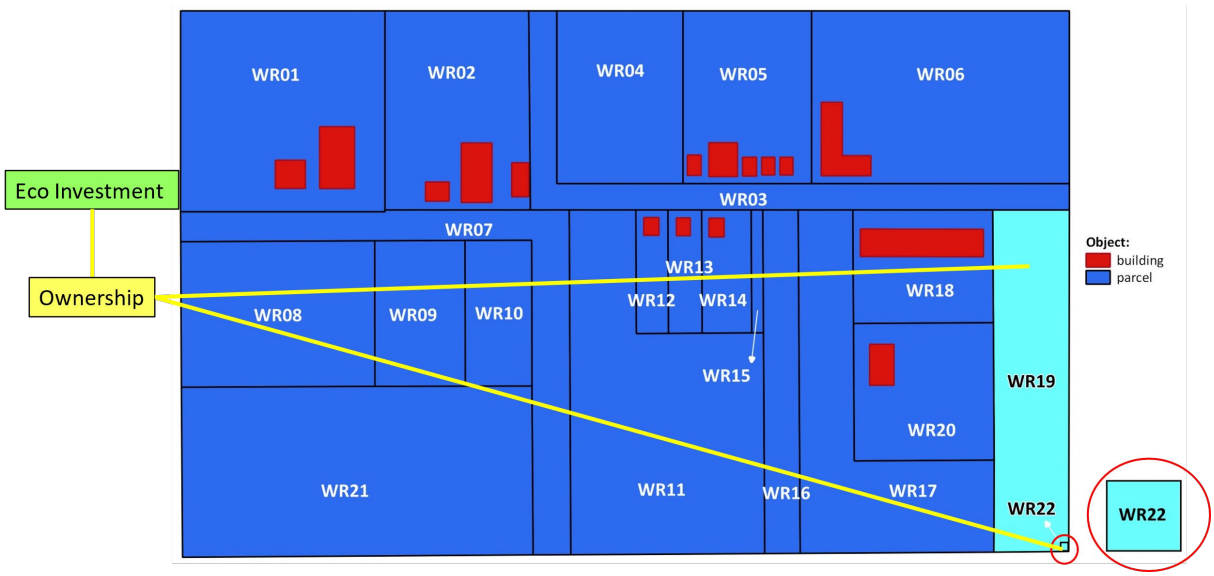


Figure 61. Eco Investment owns a BAUnit with 2 spatial units (parcels) related: WR21 and WR22.

Eco Investment (P15) holds the ownership (Right17) on BAU13 with parcels WR19 and WR22. See Figure 62. All the time it should be remembered that "parcel" is an alias of "spatial unit". This alias is used when formal property rights are concerned.

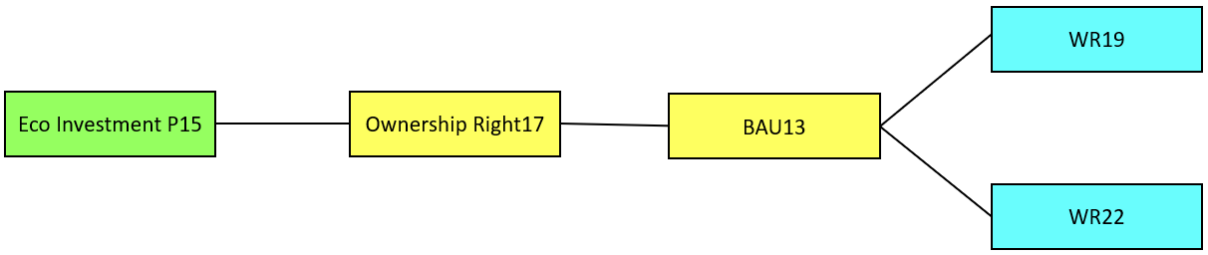


Figure 62. Eco Investment is identified as P15, the company has holds ownership (Right17) on BAU13 with spatial units WR19 and WR22.

Eco Investment is identified as P15. It should be observed that the party table includes both natural and non-natural parties. An alternative approach could be to split those groups into two tables. Those tables (one for population and one for business and may be one more for different governmental institutions) could be external.

See Figure 63 for Eco Investment as represented in the database.

	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	HousingCompany
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association ofOwners
14	P14	Monique
15	P15	Eco Investment
16		

	r_id	type	share
...	...	...	...
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	
18	Right15	Ownership	
19	Right16	Ownership	
20	Right17	Ownership	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3			

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	BAU11
12	BAU12
13	BAU13
14	
15	
16	

	su_id	area	geom	...
...	...			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
18	WR18			
19	WR18-1			
20	WR18-2			
21	WR18-3			
22	WR18-4			
23	WR18-5			
24	WR18-6			
25	WR19			
26	WR20			
27	WR21			
28	WR22			

Figure 63. Eco Investment in the database for land administration.

Eco Investment has a restriction (a servitude) on BAU13 (with WR19 and WR22), see Figure 64. In this servitude the spatial unit WR20 is served with access to a public road.

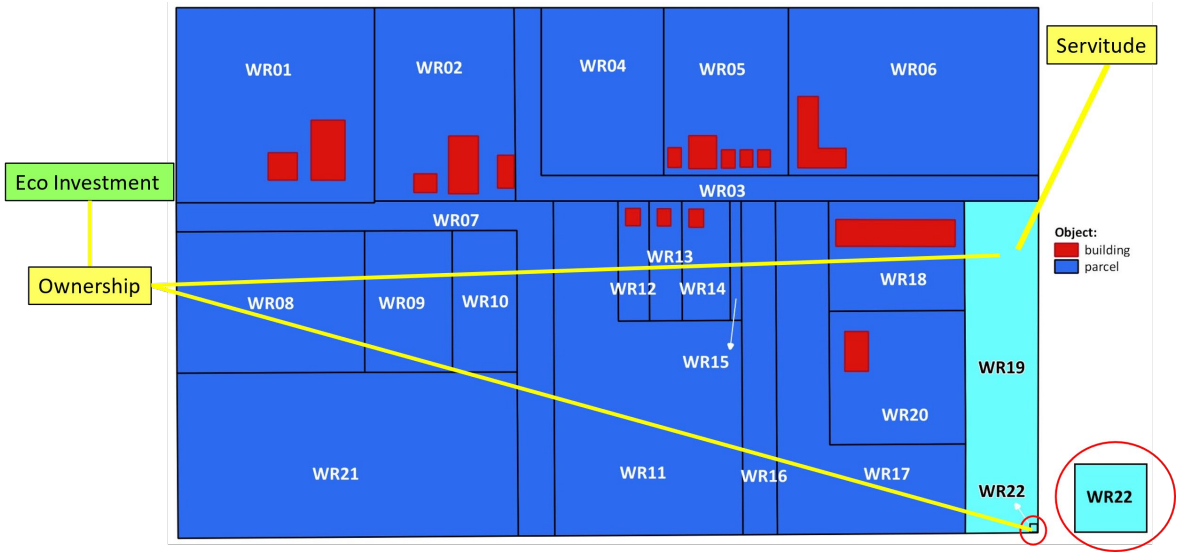


Figure 64. There is a restriction - a right of road on BAU13 (with WR19 and WR22).

The location of the access road in WR19 to WR20 is unknown. This servitude is “inherited” from the earlier spatial unit that included both WR19 and WR22.

In this example of a registration of a restriction (Restriction03) there is no party required. See Figure 65. If BAU13 (or a part of it) is sold the related servitude will be included – even if its location is unknown, or when it is only described in words.

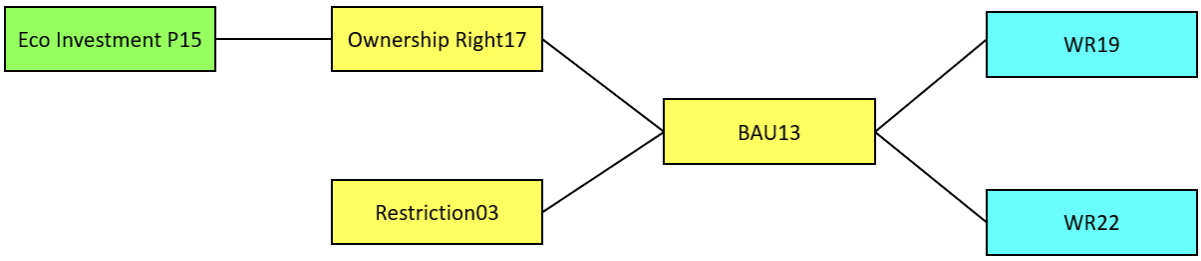


Figure 65. A right of servitude is established on BAU13. The location of the servitude is unknown, it is not on that map.

This situation looks as follows in the database (Figure 66):

	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	CapitalBank
8	P08	HousingCompany
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association ofOwners
14	P14	Monique
15	P15	Eco Investment
16		

	r_id	type	share
...	...	...	...
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	
18	Right15	Ownership	
19	Right16	Ownership	
20	Right17	Ownership	

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3	Restr03	Servitude	

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	BAU11
12	BAU12
13	BAU13
14	
15	
16	

	su_id	area	geom	...
...	...			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	...			
16	...			
17	WR17			
18	WR18			
19	WR18-1			
20	WR18-2			
21	WR18-3			
22	WR18-4			
23	WR18-5			
24	WR18-6			
25	WR19			
26	WR20			
27	WR21			
28	WR22			

Figure 66. The restriction (Restr03) on BAU13 is not associated to a Party. It is related to the land, that is the basic administrative unit with spatial units WR19 and WR22.

5. Transactions

5.1 Overview

The inclusion of Cases One through to Nine in the database results in the overview as shown in Figure 67. This includes data on parties, rights, basic administrative units and spatial units. These are called ‘core classes’ in the LADM.

The complexity of the interrelationships between people and land becomes clear from the figure below.

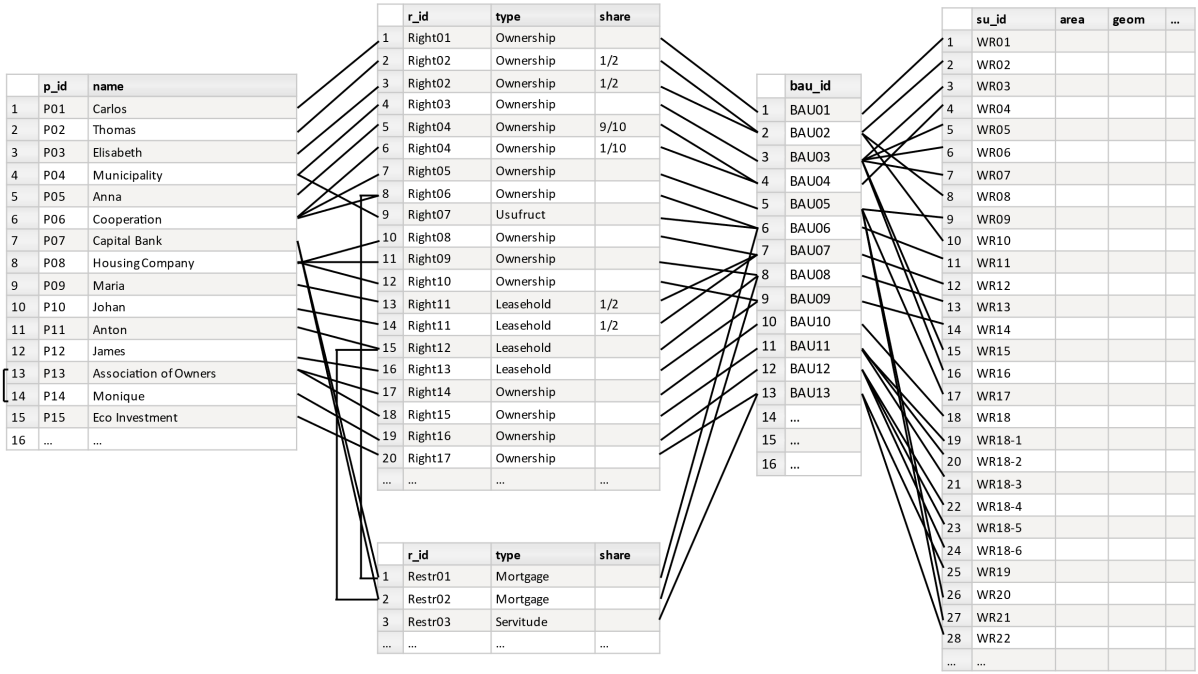


Figure 67. Cases One till Nine represented in the database.

People to land relationships are dynamic. For example, people buy and sell property rights to land, people inherit land and divide it in portions for their children and/or other heirs, people get married and acquire joint property on which they mortgage, new rights are established when a municipality issues land for possible new construction, and new rights of use can be established. There are many more types of changes in the people-to-land relationships are possible.

For the data in the database to remain an accurate representation of reality, the dynamics in the relationships between people and land must be tracked in the database.

In the next paragraphs some examples will be given: buying/selling a property, merging two spatial units, establishment of a servitude and subdivision of a spatial unit. In these examples the focus will be on the transactions resulting in updates of the data in the database. Such a change is the result of a series of activities of stakeholders in an update process or workflow. See an example from Denmark in Figure 68. This concerns the activities related to a sale of a

parcel (Zevenbergen and Stubkjær, 2005), The last activity is this diagram 'Final Registration' includes the transaction in the database.

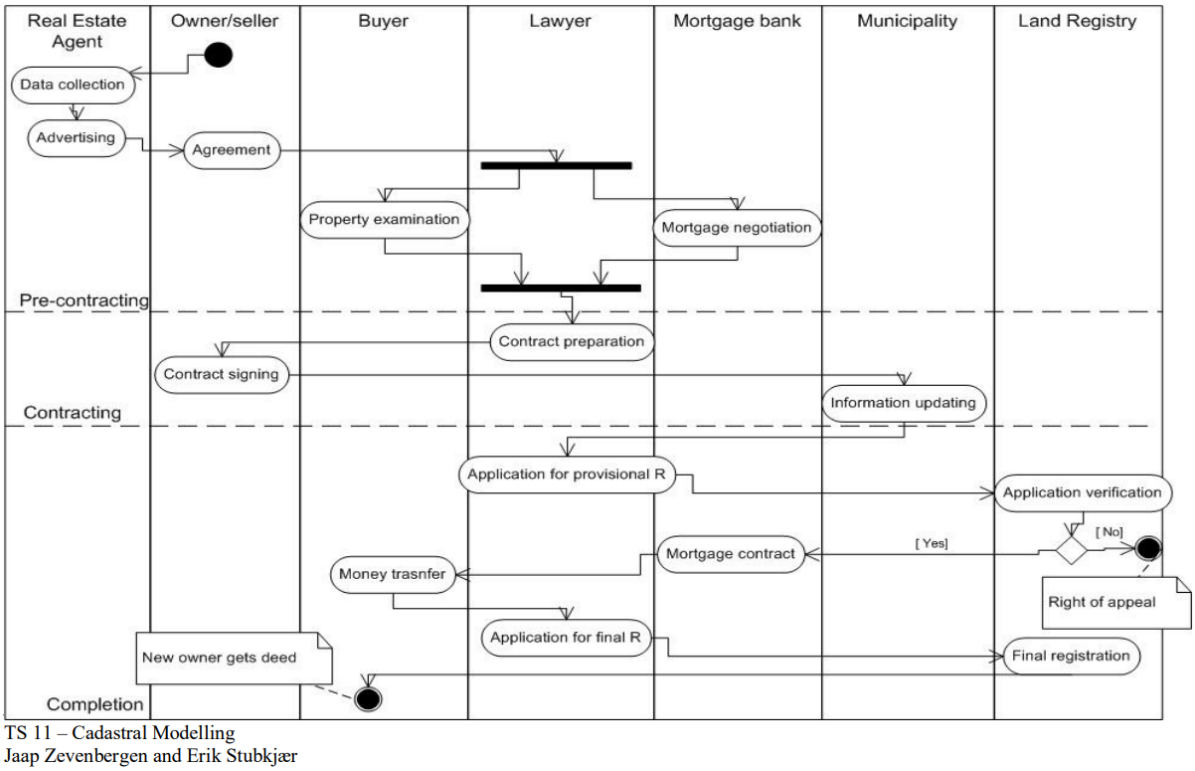


Figure 68. Activity diagramm of a sale transaction. Example from Denmark. Stakeholders can be seen on top of each swimming lane.

Stakeholders in this use case are: real estate agent, owner/seller, buyer, lawyer, mortgage bank, municipality and land registry. See Figure 68 on top of each "swimming lane".

5.2 Transaction Case One: Carlos sells WR01 to Monique

The representation of Carlos in the database is introduced in Tenure Case One.

Now Carlos sells his ownership right on BAU01 with related parcel WR01 to Monique (see Figure 69).

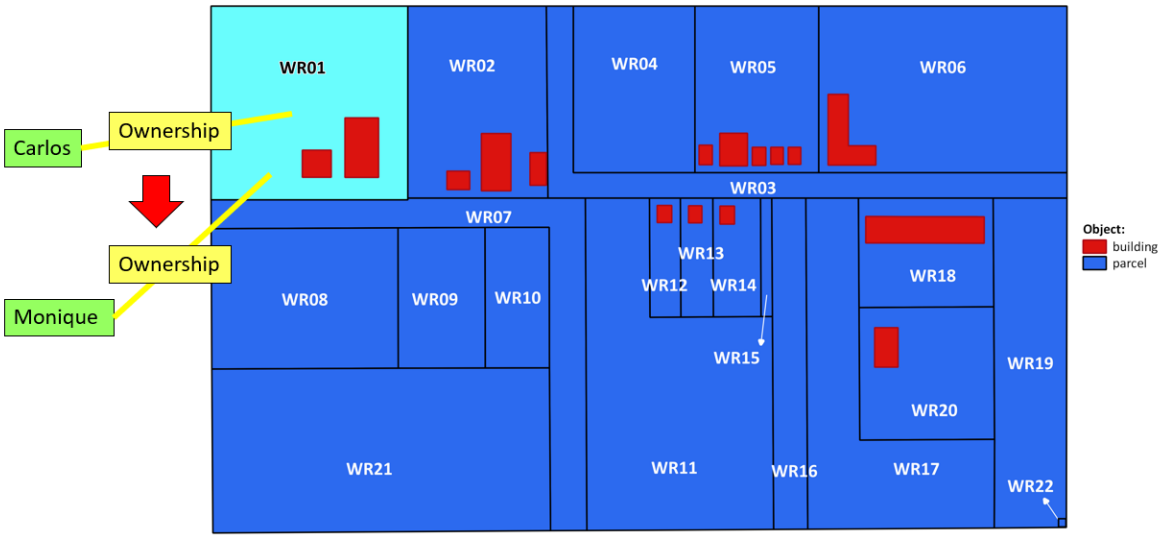


Figure 69. Carlos sells WR01 to Monique.

In this paragraph the impact of this transaction in the database is illustrated using two examples of processing the transaction: one example with new identifiers for rights and basic administrative units and one example where those identifiers do not change. The approach that is used depends on implementation choices, and even other approaches are possible. This is a matter of implementation of the LADM as described in a country profile.

Carlos (with identifier P01) sells his ownership right (Right01) on WR01 in BAU01 to Monique on 26 August 2021. The new identifier for the ownership right is Right18, the rID did change in this example, because it is seen as a new right. Note: it is also possible not to see it as a new right and keep it to Right01 (see below for this case).

The new identifier for the basic administrative unit is BAU14. See Figure 70. The arrow represents the transaction. The situation before the transaction is represented above the arrow, the situation after the transaction is represented below the arrow.

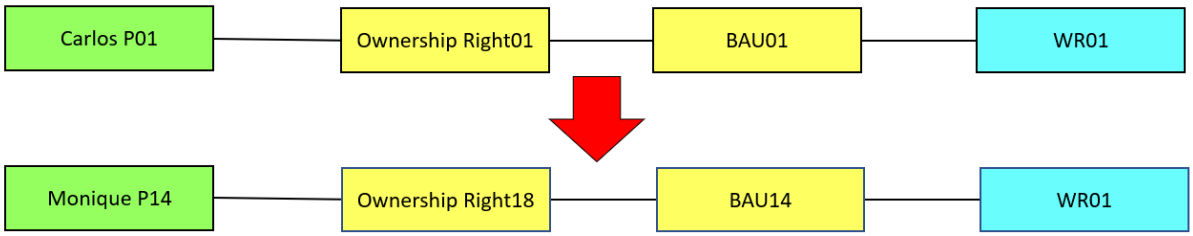


Figure 70. Transaction Case One. Carlos sells to Monique. In this example the right and the basic administrative unit get new id's (Righ18 and BAU14) because there is a new rightholder. In this approach the right associated to Carlos is not the same as the right associated with Monique. Same for the basic administrative unit.

Carlos became right holder some time ago, his right was recorded in the land administration database at 08:29 on 03 April 2015 . This concerns the "database transaction" with database date and time, see Figure 71. Note: the "real transaction" took place in the notary's office two days earlier.

Transaction Case One results in a situation where the representation of the party Carlos in the database ends on 26 August 2021, at 14:04.

At the same moment as the representation of the party Carlos (as owner of BAU01) in the database ends representation of the party Monique (as owner of BAU14) is created in the database. See Figure 71.

This is also valid for Right01, this right is versioned in the database on 26 August 2021 at 14:04. And Right18, which is created at the same date and time: 20120826, 14:04. See Figure 71.

And for BAU01, deleted at the same time in the database and BAU14, created at the same date and time: 26-08-2021, time 14:04. See Figure 71.

	p_id	name	begin_lifespan	end_lifespan
1	P01	Carlos	20150403, 08:29	20210826, 14:04
2	P14	Monique	20210826, 14:04	99999999, 23:59

	r_id	la_right_type	begin_lifespan	end_lifespan
1	Right01	Ownership	20150403, 08:29	20210826, 14:04
2	Right18	Ownership	20210826, 14:04	99999999, 23:59

	u_id	la_baunit_type	begin_lifespan	end_lifespan
1	BAU01		20150403, 08:29	20210826, 14:04
2	BAU14		20210826, 14:04	99999999, 23:59

Figure 71. Transaction Case One: Carlos (P01) sells to Monique (P18). The database commit is at 20210826, 14:04. The right gets a new id (Righ18) as well as the BAUnit (BAU14).

Note: object identifiers p_id, r_id and u_id are not the same as database id's (in the most left columns). Object identifiers are relevant for the land administration, database identifiers are

relevant for the operation of the database management system. Object identifiers are important in communication between the government and citizens and between professionals and the government, etc.

Now, after Transaction Case One the complete property situation for Monique, is as in Figure 72. Compare also Figure 59.

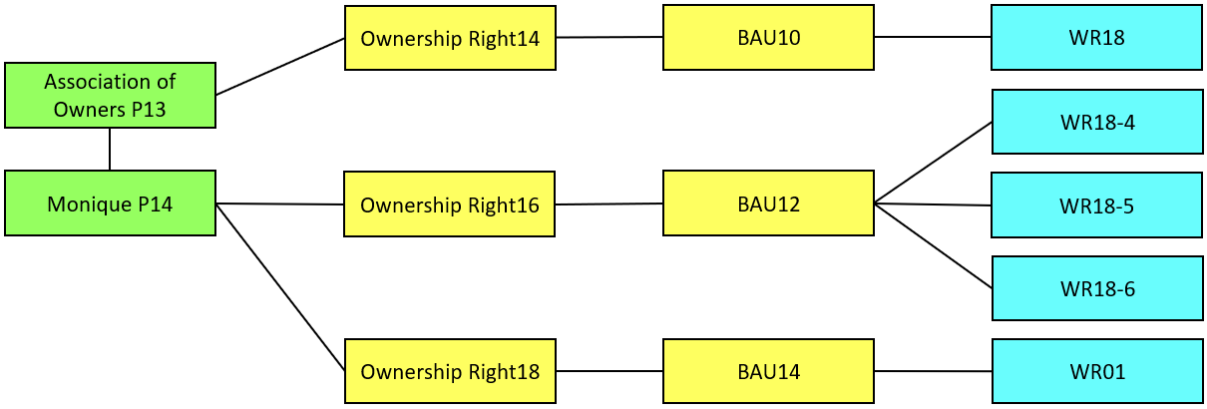


Figure 72. New situation for Monique after buying BAU14 with WR01 from Carlos.

The representation of the situation before and after Transaction Case One in the database is as in Figure 73. The situation before the transaction is above the arrow, the situation after the transaction is below the arrow.

After the database commit of the buying/selling transaction of BAU01 (with WR01 related) the Right01 is not valid anymore. It is deleted at 20210826, 14:04. At that moment the new Right18 is created in the database. At the same moment (20210826, 14:04) where BAU01 is deleted and BAU14 is created. See Figure 73 (begin_lifespan is called here t_min, end_lifespan is called here t_max).

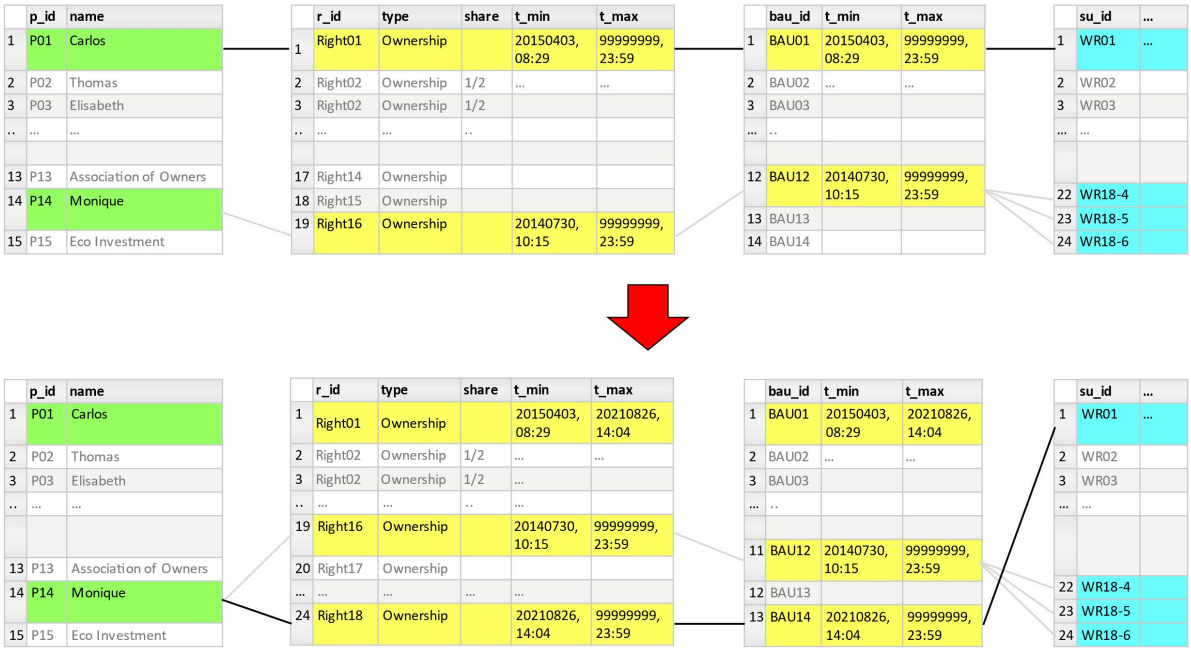


Figure 73. The situation with new record and identifiers in the database.

LADM allows alternative options for identification of parties, rights etc. and for managing identifiers. This is a design choice. Identifiers as such are mandatory, not optional. Object identifiers have to be assigned by the data provider based on agreed and known rules.

The same buying/selling transaction between Carlos and Monique is now presented once more but with an alternative approach in identification and identifiers of rights and of basic administrative units. Now those identifiers remain the same before and after the transaction. See Figure 74.

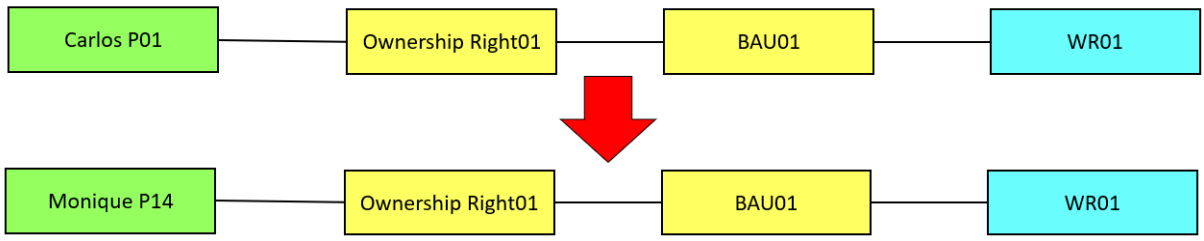


Figure 74. Alternative realization of transaction case one. Carlos sells his right on BAU01 (with parcel WR01) to Monique. The right, the basic administrative unit and the spatial unit do not get new ids in this example.

This approach in identifiers means that the transaction as such can not be recognised from the identifiers. But begin_lifespan (or: t_min) can be used in combination with the identifier of the right and or the identifier of the basic administrative unit for this purpose. This combination makes identifiers of right and BAU unique.

After this transaction is processed in the database there is a database commit (the updating of a record in the land administration database) of this transaction at date 26-08-2021 and time 14:04.

This commit implies that Carlos was known in the database as owner of BAU01 with parcel WR01 between 03-04-2015, 08:29 and 26-08-2021, 14:04.

In other words: 03-04-2015 08:29 is the begin_lifespan (or: t_min) and 26-08-2021 14:04 (or: t_max) is the end_lifespan of the representation of Carlos as a party in the land administration database. When the right of Carlos is deleted the right of Monique is created. See Figures 75 and 76.

	r_id	la_right_type	begin_lifespan	end_lifespan
1	Right01	Ownership	20150403, 08:29	20210826, 14:04
2	Right01	Ownership	20210826, 14:04	99999999, 23:59
3				

Figure 75. Begin_lifespan. The date of creation of an attribute, in this case Right01. End_lifespan is the date of deletion. An actual attribute gets a maxtime and maxdate.

As a consequence Monique is represented in the database with identifier P14 as soon as this transaction is committed. The identifiers Right01, the BAU01 and the WR01 remain the same.

But combined with begin_lifespan the moment of the change in right holder of Right01 can be recognized: Right01 before 20210826, 14:04 is something else then Right01 after that date and time. See Figures 75 and 76. Inclusion of time attributes as part of the rID (rightID) makes the identifier unique.

In the database this transaction looks as in Figure 76. The representation of the party Carlos in the database gets end_lifespan 20210826, 14:04 (the representation of Carlos in the database did begin at begin_lifespan 20150403, 08:29).

At the same moment of the end_lifespan of the representation of the party Carlos in the database the party Monique is created for the right 01.

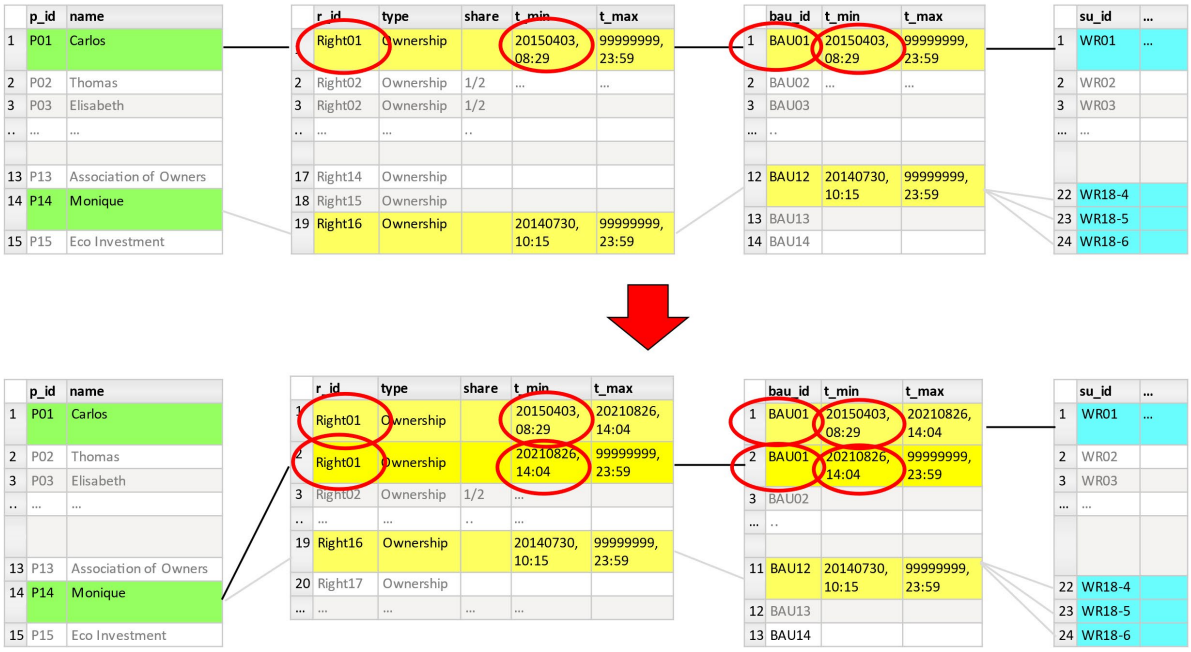


Figure 76. Transaction Case One in the database. Carlos sells BAU01 with WR01 to Monique. The right identifier and the basic administrative unit identifier remains unique in combination with begin_lifespan (t_min). End_lifespan is t_max.

With the attributes begin_Lifespan (t_min) and endLifespan (t_max) history can be maintained. Nothing is really deleted in the land administration database.

In this LADM based applications can manage history: the actual land administration is included in the database together with historical land data.

Note: in a paper based system those historical data have to be crossed out in pen.

Management of history in summary:

- An object gets a begin_Lifespan when it is created and a endLifspan when it is deleted
- A newly created object gets maxdate and maxtime as end_lifespan
- This means that the object is “actual”, not “historical”
- A deleted object gets the date and time of deletion as end_lifespan
- In this way queries are possible that allow selection of all objects between a ‘begin date and time’ and ‘an end date and time’
- This is only possible if all objects have ‘begin_Lifespan date and time’ and ‘end_Lifespan date and time’
- That’s why newly created objects get a maximal possible date and maximal possible time as end_Lifespan, it makes the query executable

Begin_lifespan and end_Lifespan are related to (almost) all records in a LADM based database.

If it is not yet deleted the end_Lifespan is the highest possible date that the database can manage and the maximum time. Maximal time is 23:59; there could be more decimals. In actual implementation, these values are stored in decimal number format combining the date and time into a single value calculated from a fixed starting date such as the first moment of the year 0 AD.

5.3 Transaction Case Two: Merge WR19 and WR22

Transaction case two concerns a merge between spatial units WR19 and WR22, because WR22 is no longer needed for utilities. See Figure 77.

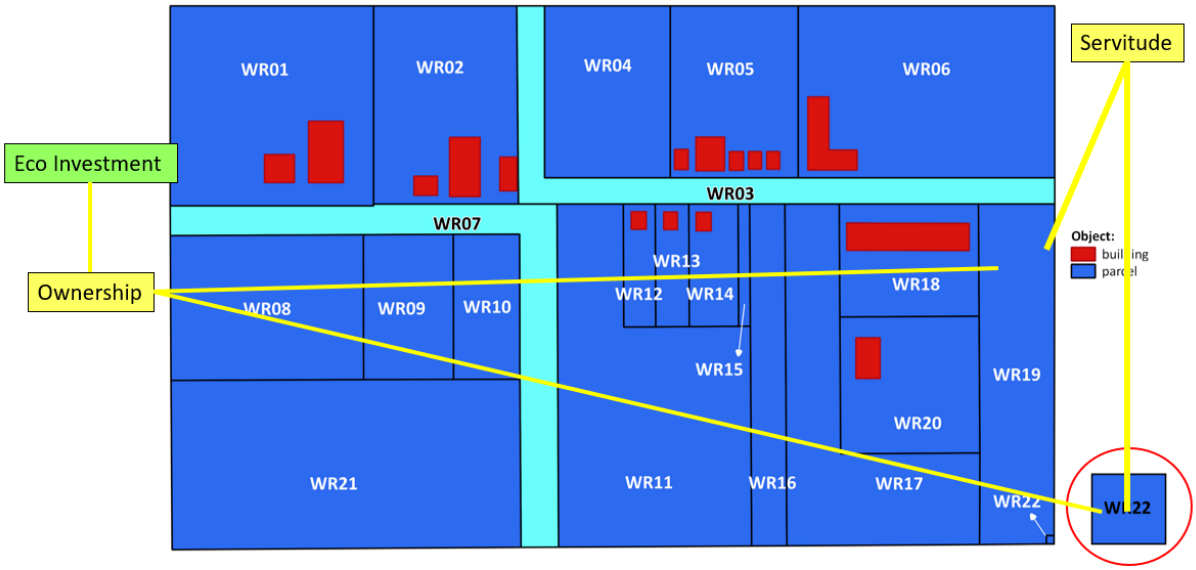


Figure 77. WR19 and WR22 will be merged. WR22 should remain accessible.

Also after the merge the spatial unit WR22 needs still to be accessible: the servitude remains as a real right. The location of the servitude is within the polygon of WR19. This is the obligation that the owner of WR19 has for their neighbour in WR22. However, it is not precisely located.

After the merge of WR19 and WR22 a new Spatial Unit WR23 is created, see Figure 78.

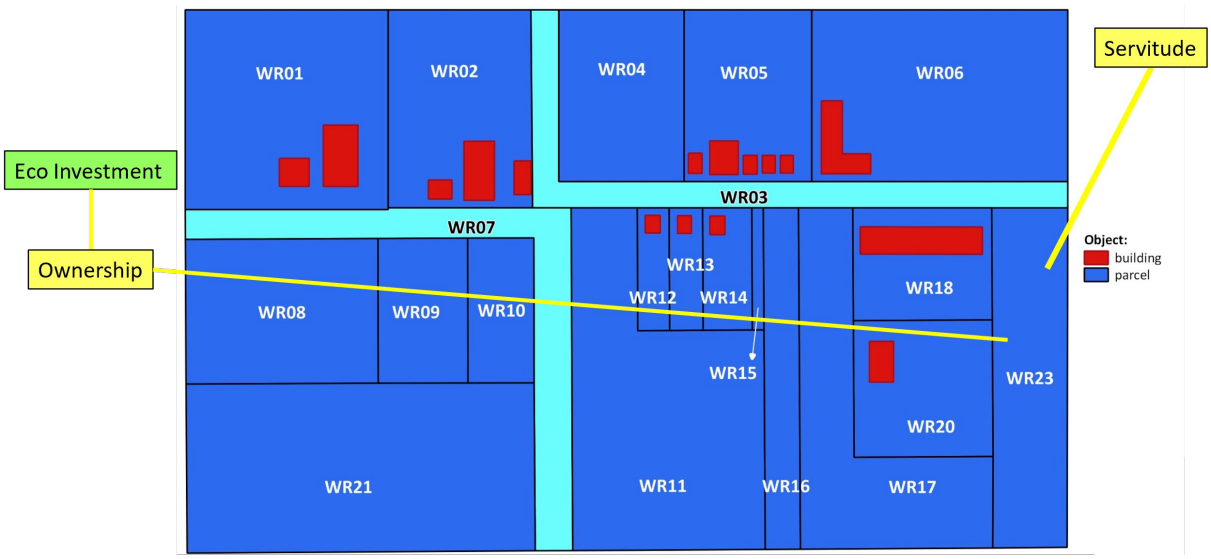


Figure 78. After mergingWR19 and WR22 the new spatial unit (or parcel) WR23 is created.

The identifiers of rights, basic administrative units and spatial units can be changed. Right17 becomes Right19. Restriction03 (the servitude) becomes restriction04. BAU13 becomes BAU15. WR19 and WR22 become WR23. See Figure 79.

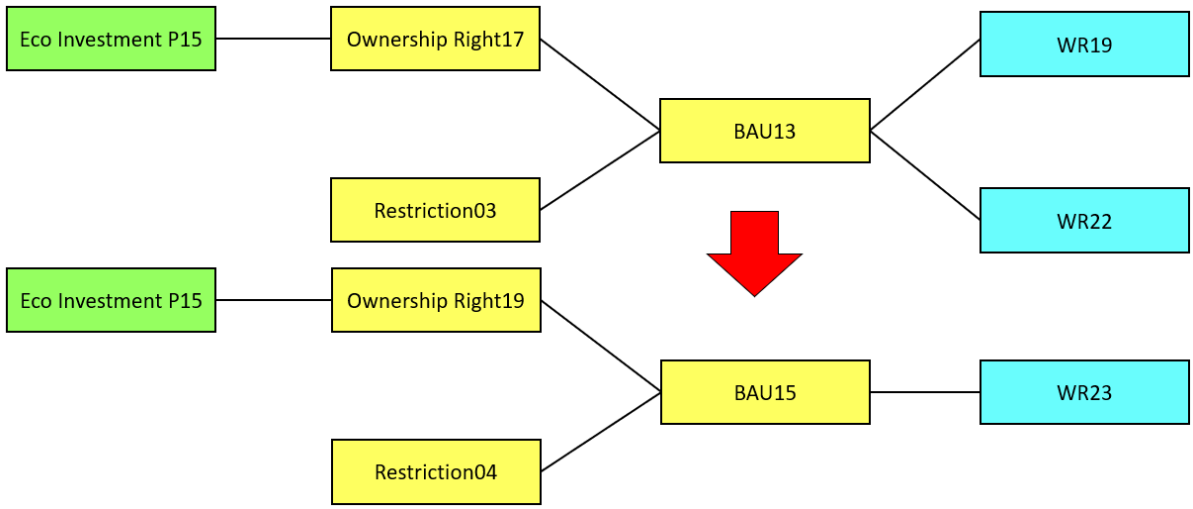


Figure 79. Transaction Case Two, in this example with new identifiers for the ownership right, the restriction, the basic administrative unit and the spatial unit after the merge of WR19 and WR22.

The Right17 was created in the database on 3th july 1998 at 13:15 together with BAU13. The Restr03 was created decades ago on 6th of August 1981. See Figure 80 that represents the transaction.

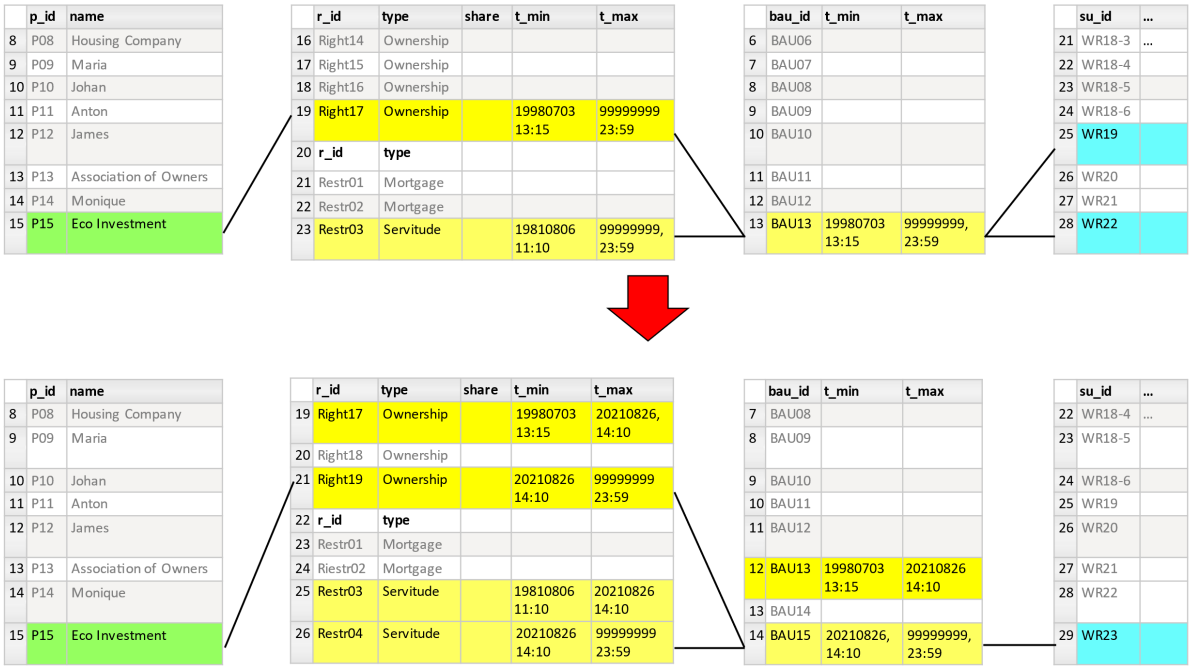


Figure 80. Transaction Case Two: merge WR19 and WR22 to a new parcel WR23. Right17, Restr03 and BAU13 are deleted in the database at 20210826 14:10. Right19, Restr04 and BAU15 are created at the same date and time.

Then the parcels WR19 and WR22 were merged to the new parcel WR23 on 26th of August 2021, this is not visible in Figure 80. WR19 and WR22 were deleted and WR23 was created from the database at that day, also not visible in Figure 80.

BAU13 was deleted in the database on 26th of August 2021, 11:10. BAU15, where WR23 is related to, was created at the same date and time. See Figure 80 below the arrow that represents this transaction.

Right17 was deleted in the database on 26th of August 2021, 11:10 and Right19 was created at the same date and time in the database. See Figure 80 below the arrow that represents the transaction.

Restr03 was deleted in the database on 26th of August 2021 and Restr04 created at the same date and time in the database. See Figure 80 below the arrow that represents the transaction.

In the following example the same ”merge transaction” is discussed: WR19 and WR22 are merged into WR23. The spatial unit identifier changes, simply because it is another unit. The identifiers of the ownership right (Right17), the restriction (Restr01) and the basic administrative unit (BAU13) remain the same in this example after merging. See Figure 81.

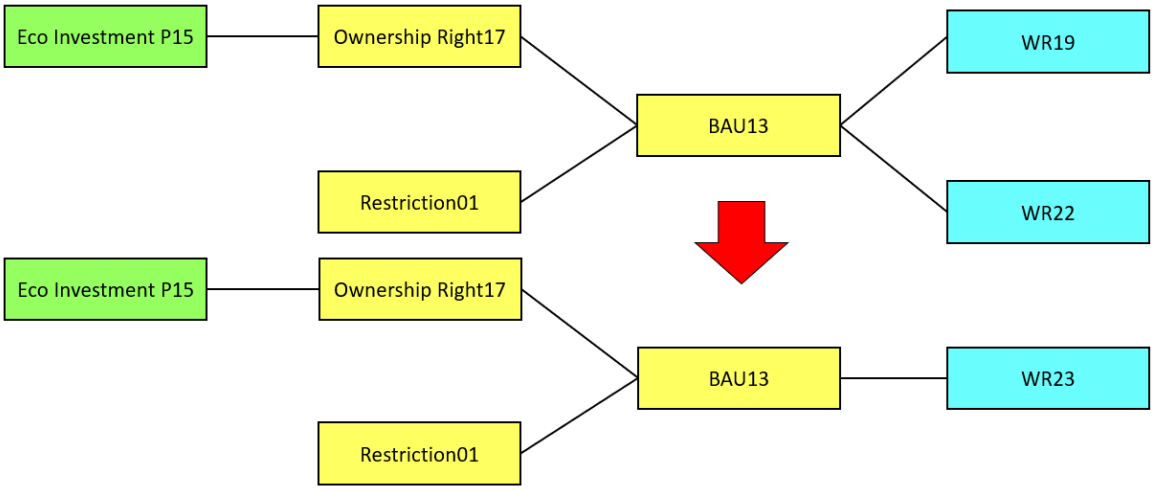
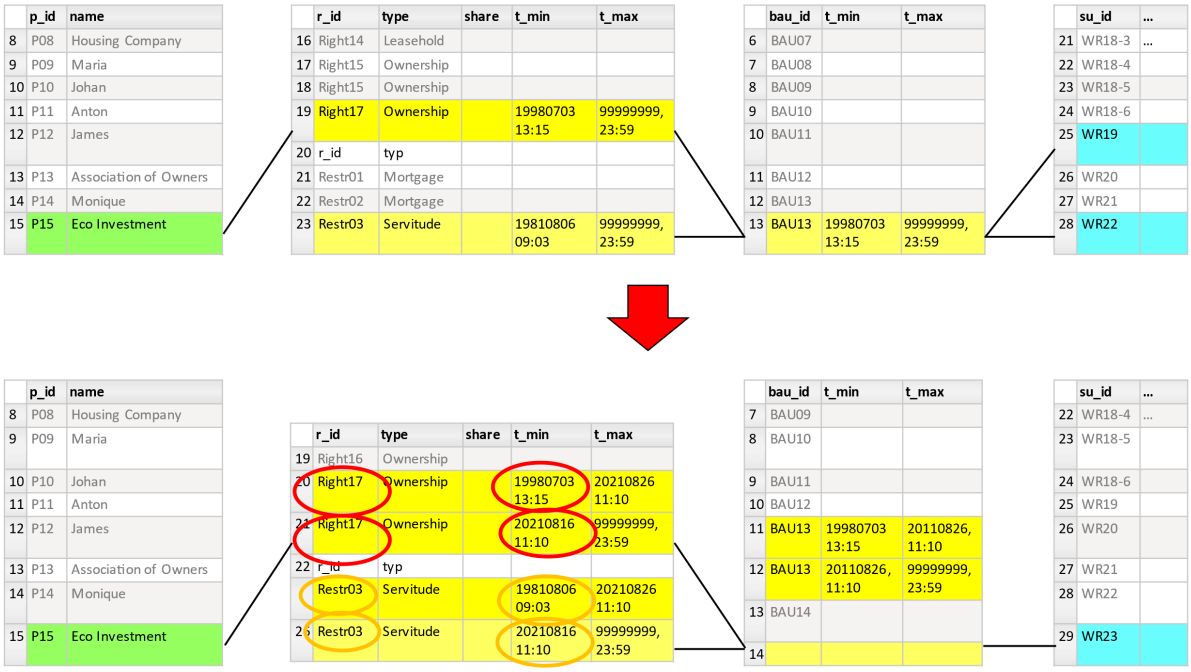


Figure 81. Transaction Case Two. The spatial unit identifier changes in this example, simply because it is another unit. The identifiers of the ownership right (Right17), the restriction (Restr01) and the basic administrative unit (BAU13) remain the same in this example after merging.

The change in the database state including timestamps is shown in Figure 82.



	p_id	name
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association of Owners
14	P14	Monique
15	P15	Eco Investment

	r_id	type	share	t_min	t_max
16	Right14	Leasehold			
17	Right15	Ownership			
18	Right15	Ownership			
19	Right17	Ownership		19980703 13:15	99999999, 23:59
20	r_id	typ			
21	Restr01	Mortgage			
22	Restr02	Mortgage			
23	Restr03	Servitude		19810806 09:03	99999999, 23:59

	bau_id	t_min	t_max
6	BAU07		
7	BAU08		
8	BAU09		
9	BAU10		
10	BAU11		
11	BAU12		
12	BAU13		
13	BAU13	19980703 13:15	99999999, 23:59

	su_id	...
21	WR18-3	...
22	WR18-4	
23	WR18-5	
24	WR18-6	
25	WR19	
26	WR20	
27	WR21	
28	WR22	

	p_id	name
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association of Owners
14	P14	Monique
15	P15	Eco Investment

	r_id	type	share	t_min	t_max
19	Right16	Ownership			
20	Right17	Ownership		19980703 13:15	20210826 11:10
21	Right17	Ownership		20210816 11:10	99999999, 23:59
22	r_id	typ			
	Restr03	Servitude		19810806 09:03	20210826 11:10
24	Restr03	Servitude		20210816 11:10	99999999, 23:59

	bau_id	t_min	t_max
7	BAU09		
8	BAU10		
9	BAU11		
10	BAU12		
11	BAU13	19980703 13:15	20110826, 11:10
12	BAU13	20110826, 11:10	99999999, 23:59
13	BAU14		
14			

	su_id	...
22	WR18-4	...
23	WR18-5	
24	WR18-6	
25	WR19	
26	WR20	
27	WR21	
28	WR22	
29	WR23	

Figure 82. Merging WR19 and WR22 to WR23. Right17 appears twice, but with different t_min values. Same for Restr03 and BAU13.

The management of identifiers and the identification of rights, restrictions, basic administrative units and spatial units depends on the object identification approach as agreed for the land administration. The same is valid for parties. Here the population register is assumed to have an approach for unique party identification. The business register may have an approach for identification of non-natural persons as companies.

5.4 Transaction Case Three: establishment of a servitude on WR17

This transaction concerns the establishment of a servitude on WR17. This servitude is needed to provide access to water for spatial unit WR20. The location of the servitude is within WR17 but not further specified. See Figure 83.

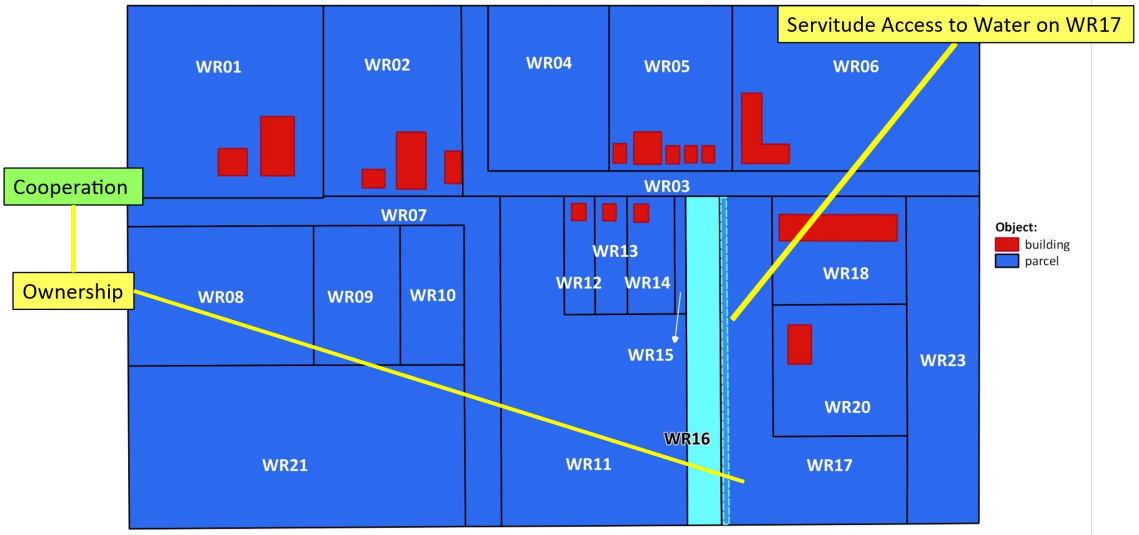


Figure 83. WR20 needs access to water. It is agreed to establish a servitude on WR17. The location of the servitude is unknown.

First BAU05 is split into two new BAUs: BAU15 with WR09, WR20 and WR21 and BAU16 with WR17. The servitude can be established on the new BAU16 with WR17 (and has no relation with the other parcels in BAU05. A new title is created with Right21 on BAU16. See Figure 84.

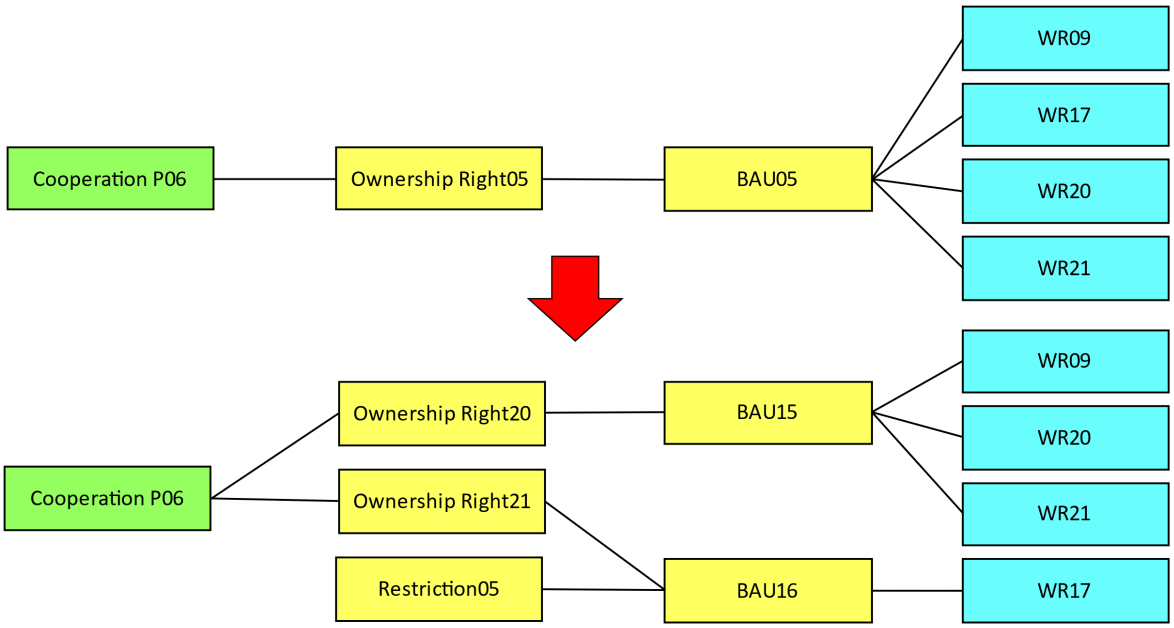


Figure 84. The new servitude is identified as Restriction 05 and applies to BAU16 with WR17. For this purpose BAU05 is split into BAU15 and BAU16. The new BAU16 is related to WR17 only. Now the new restriction is linked to Restriction05.

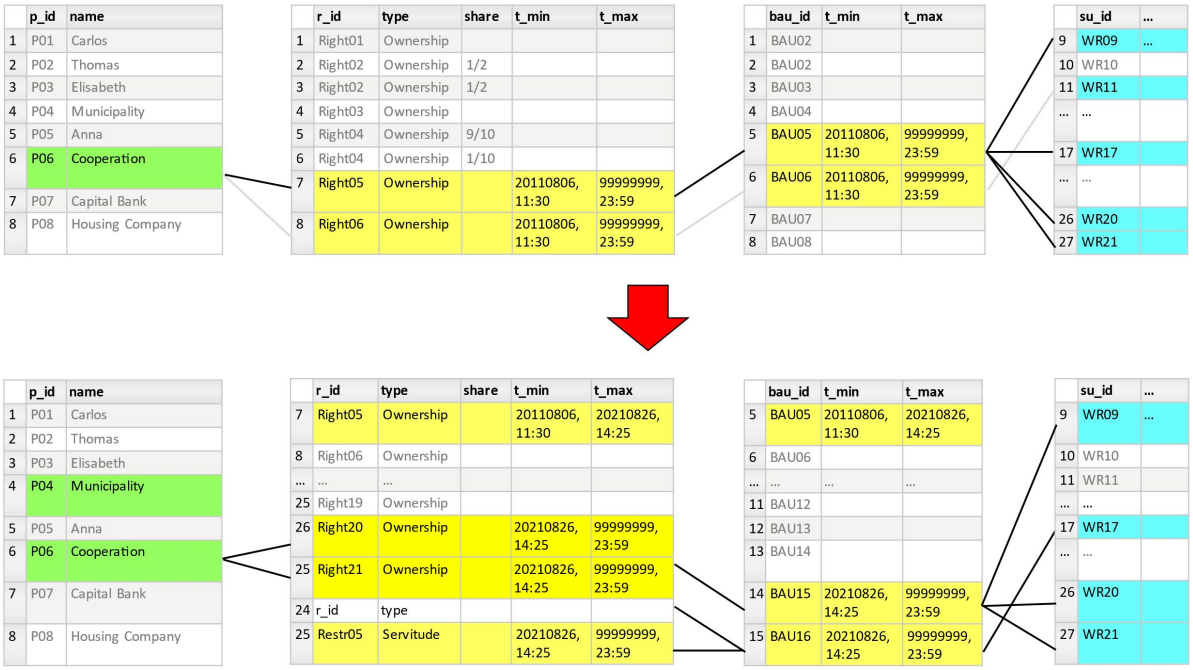


Figure 85. The new servitude is recorded in the database.

BAU05, with WR09, WR17, WR20 and WR21 is split into BAU15 with WR09, WR20 and WR21 and BAU16 with WR16. The Cooperative (P06) has a right 20 to BAU15 and a Right21 to BAU16.

Restriction05 is not associated with a party, it is related to land only (WR17).

See Figure 85 for a representation in the database of this transaction.

5.5 Transaction Case Four: Implementation of a new spatial plan

Transaction case four concerns the development and implementation of a spatial plan by the Municipality of Waterriver on spatial unit WR11. Seven new houses and a small road for access will be constructed on new spatial units (parcels). Business may be developed on those spatial units under sustainability conditions. The existing parcel WR11 will be used for this development. See Figure 86.

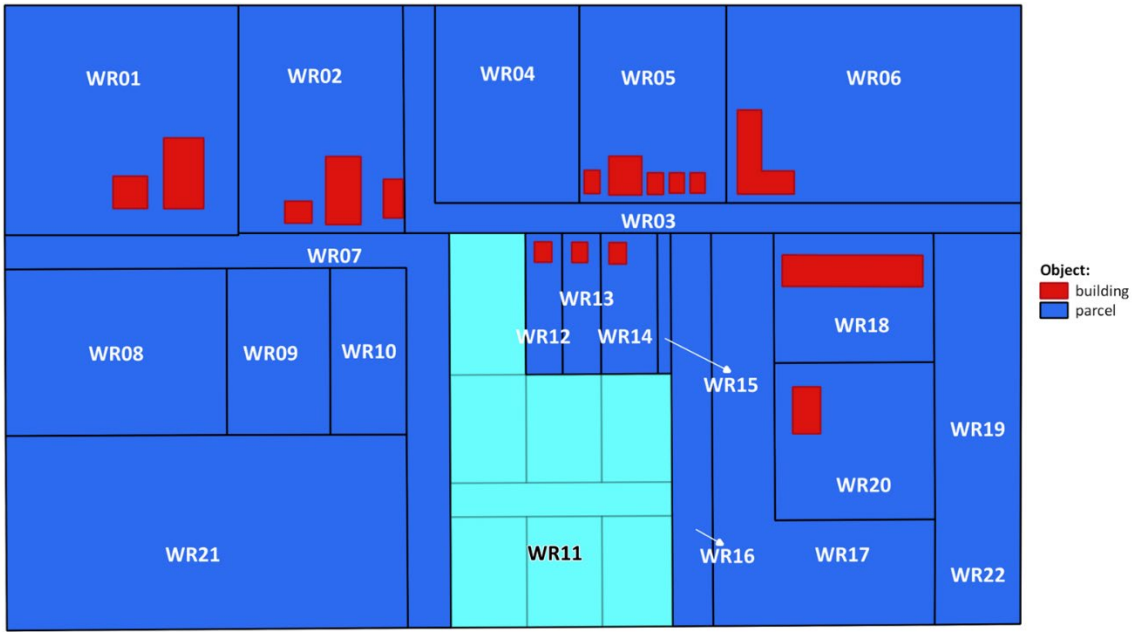


Figure 86. A Spatial Development Plan for the Municipality of Waterriver superimposed on the cadastral map. Seven new houses will be constructed on newly designed big spatial units (parcels). Apart from construction of houses business development is possible – under sustainability conditions.

In the existing situation WR11 is related to BAU06. The Cooperative has a mortgaged ownership right: Right06 with mortgage Restriction01. The Municipality has a usufruct right: Right07. See Figures 30 and 31, and Figure 87 below.

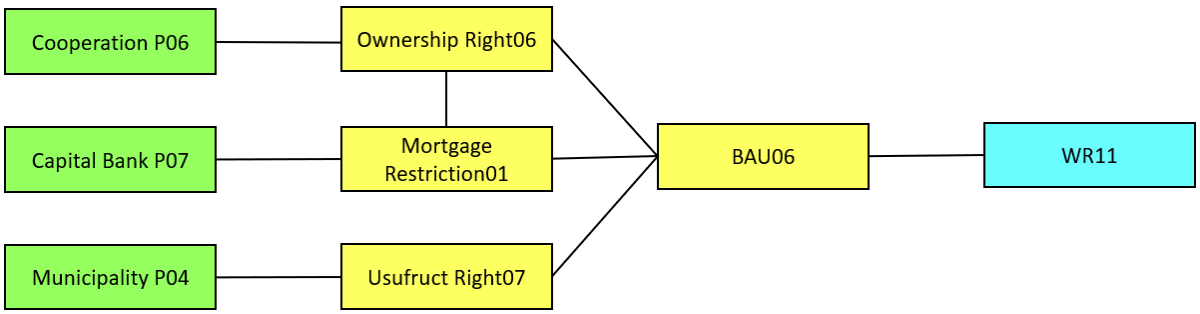


Figure 87. The Cooperative has a mortgaged ownership right and the Municipality a usufruct right on BAU06 related to WR11.

The Cooperative agreed to transfer its ownership on BAU06 with WR11 to the Municipality.

Implementation of the spatial plan means a series of updates in one transaction in the land administration:

- a discharge of mortgage Restriction01 to Right06 on BAU06
- a transfer of ownership of BAU06 from the Cooperative to the Municipality
- a dissolve/discharge of usufruct (usufruct Right07 on BAU06)
- multiple subdivisions to create the new units, that is subdivision of WR11 into 8 new Spatial units

Figure 88 gives the overview of the situation before and after those transactions.

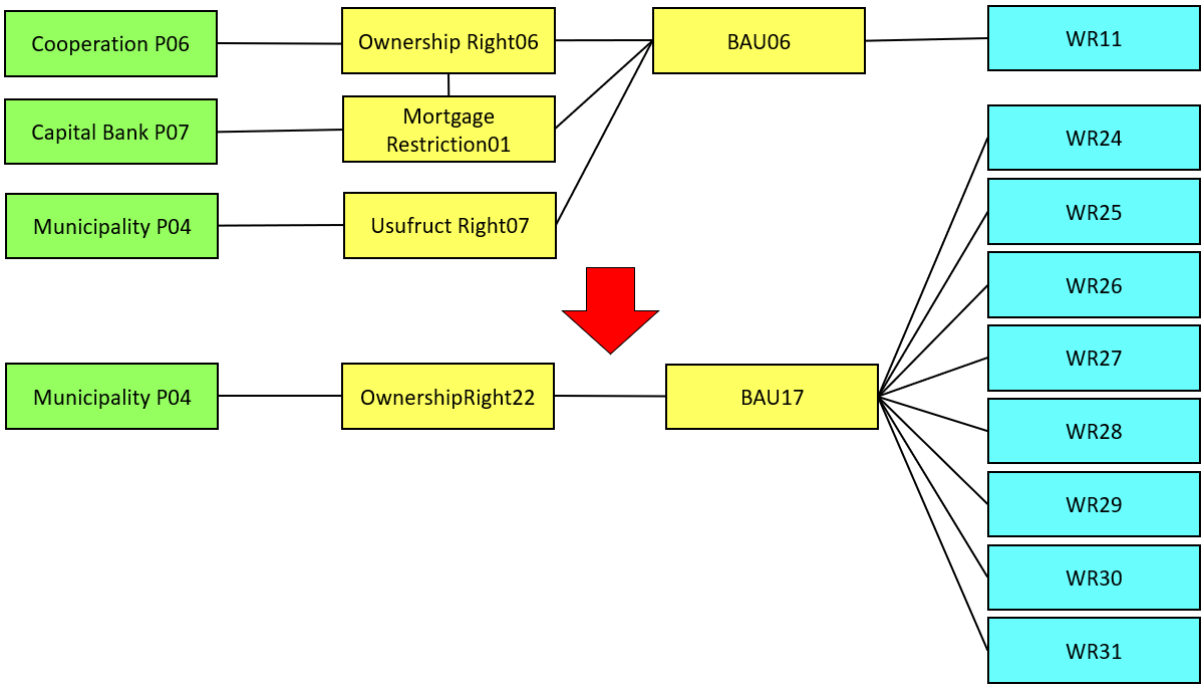


Figure 88. The usufruct on BAU06 will be ended together with the mortgage on Right06 and BAU06. Then the transfer of ownership of BAU06 from the Cooperative to the Municipality will be done. WR11 is subdivided into 7 new spatial units.

Figure 89 presents the impact in the database.

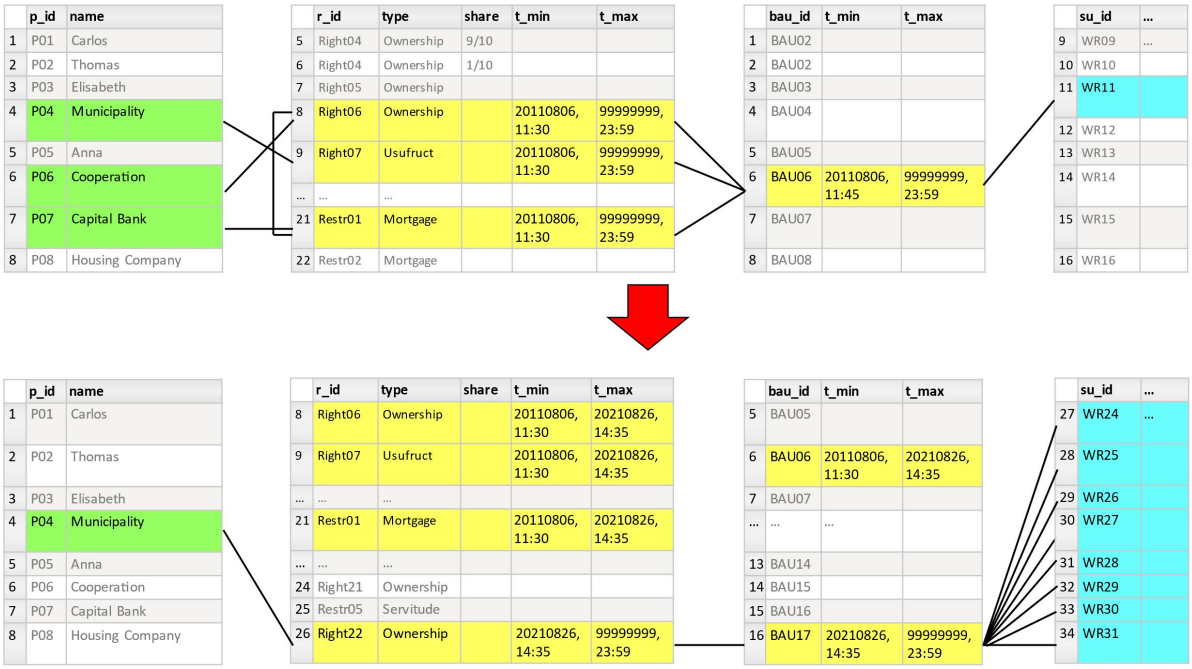


Figure 89. The transaction as visualised in Figure 86 in the land administration database.

The transaction takes place on 26th of August 2021 at 14:35. See the timestamps in Figure 89.

The transaction implies that:

- the mortgage Restriction01 on Right06 and BAU06 is ended, see t_max of Restr01 after the transaction
- the ownership of BAU06 from the Cooperative (P06) to the Municipality (P04) is transferred
- the Cooperatives' usufruct Right07 on BAU06 is ended, see t_max of Right07 after the transaction; BAU06 is deleted, see t_max of BAU06
- BAU17 is created at the same moment where BAU06 is created, see t_min of BAU17, and:
- the existing spatial unit WR11 is subdivided into 8 new Spatial units, WR24 ….. WR31, see t_min of BAU17.

See Figure 90 for the subdivision related to this transaction.

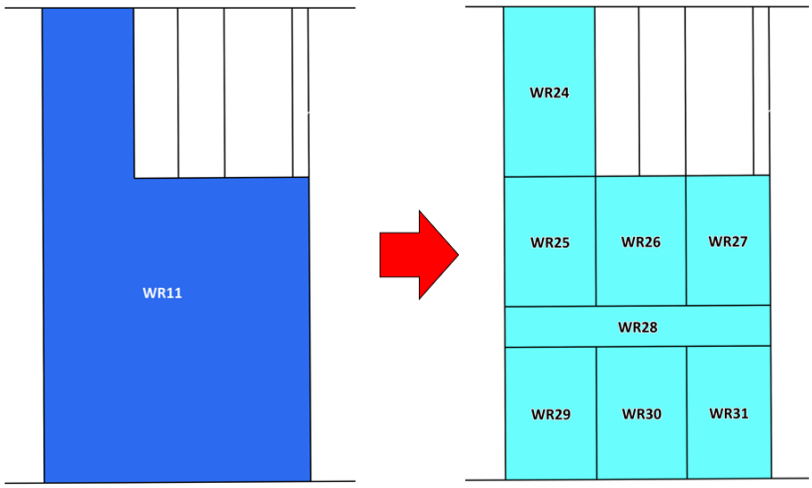


Figure 90. WR11 is subdivided into 8 new Spatial units in support to the implementation of the spatial plan.

Apart from the "legal/administrative impact" in the database (see Figure 89) there is impact in the representation of the geometry of boundaries and in visualising spatial unit identifiers on the map. Figure 91 shows the boundary points. Figure 92 the centroid points of the identifiers.

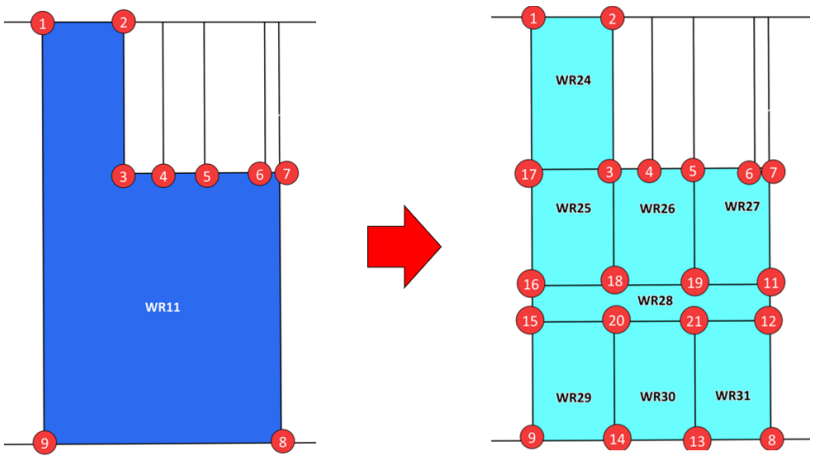


Figure 91. The subdivision means that new boundary points and boundaries need to be created.

The boundary points in the situation before and after the transaction are visualised in Figure 91 to the left (before the transaction) and to the right (after the transaction). A boundary is called BoundaryFaceString (for 2D representations) and BoundaryFace (for 3D representations) in the LADM.

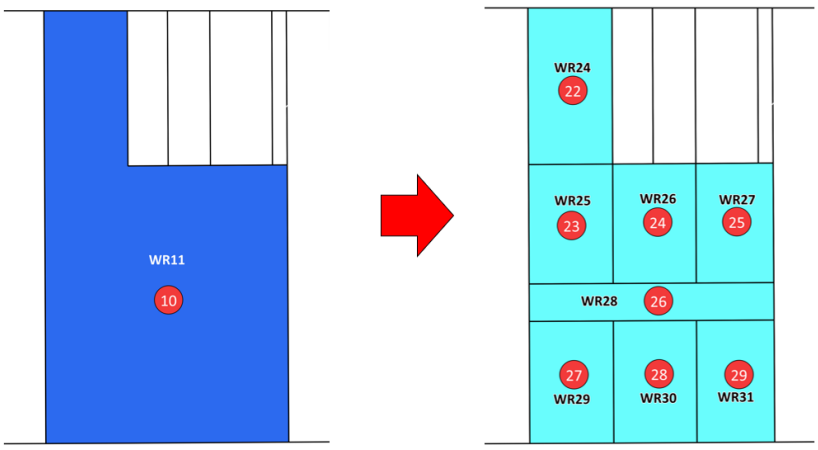


Figure 92. The centroid points of the spatial unit identifiers.

The coordinates of all points before and after the transaction are shown in Figure 93.

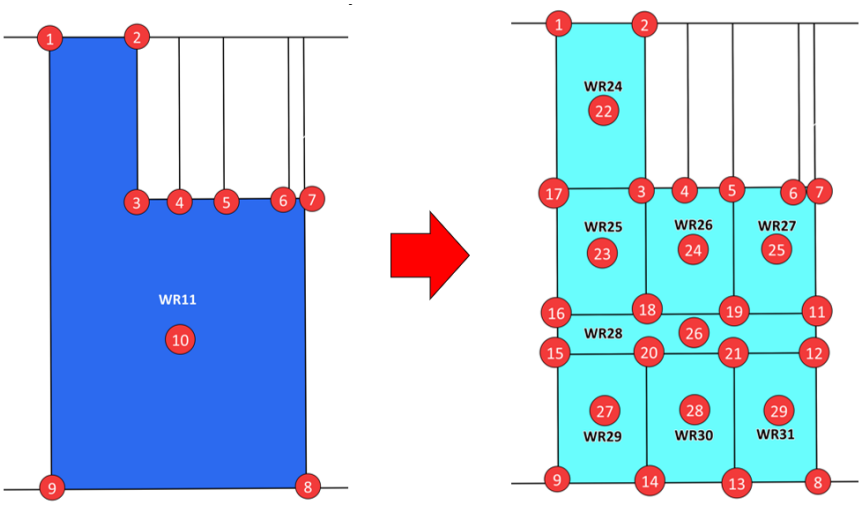


Figure 93. Coordinates of boundary points and reference points (centroid points).

The geometry of spatial unit WR11 is composed out of BoundaryFaceStrings (BFSs). Each BFS is defined by two or more points. See Figure 94 to the right. WR11 can be represented by BFS001, BFS002, ….. BFS008. In the example in Figure 94 most face strings consist out of two pints. BFS002 consists of points 2, 3 and 4. Each point has coordinates X and Y.

BFS002 also appears as BFS in WR03. BFS002 appears also as a boundary face string in WR12 (with references from the BFSs to the same coordinates X and Y). See Figure 95.

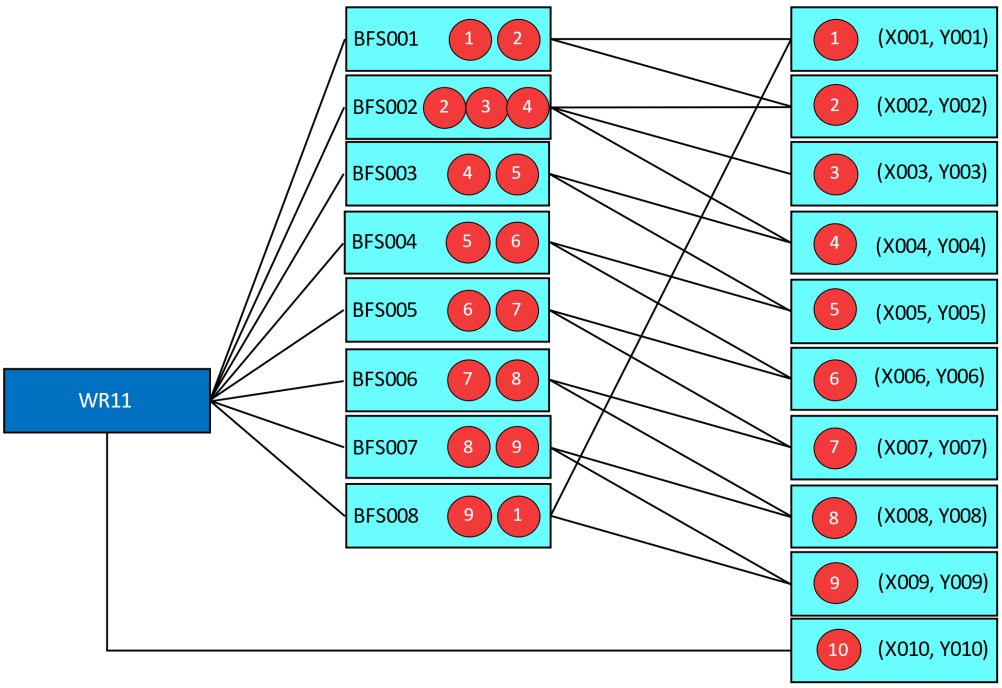


Figure 94. The geometry of spatial unit WR11 is composed of boundaryfacestraings (BFSs). Each BFS is defined by two or more points. BFS002 consists of points 2, 3 and 4. Each point has coordinates X and Y.

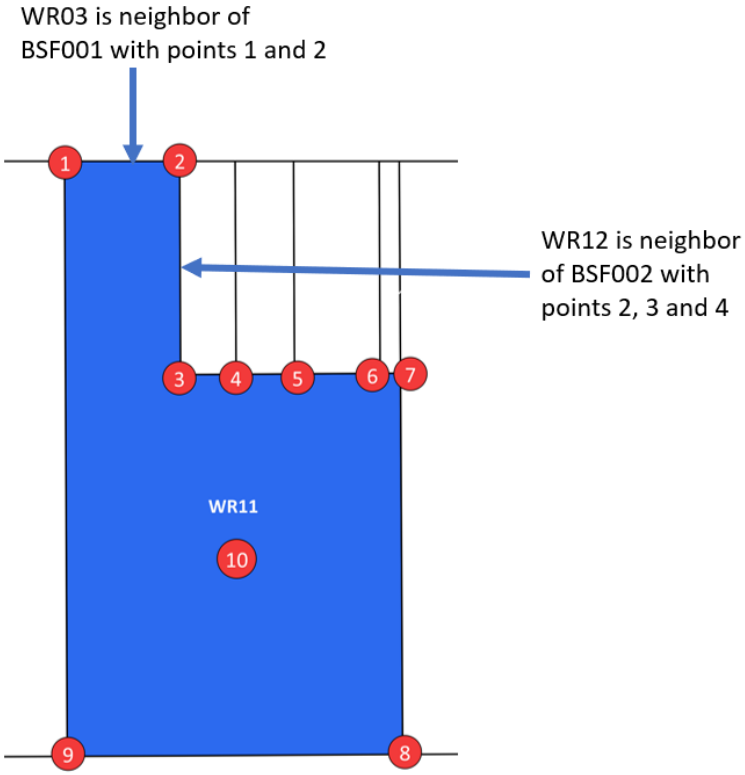


Figure 95. BFS001 also appears as BFS in spatial unit WR03. And BFS002 appears as boundary face string in WR12 (with same references to coordinates X and Y.

6. Valuation Information

6.1 Valuation information in LADM

The valuation function of land administration is also included in LADM. A value can be defined as the estimated value of a property or unit of property at a particular point in time, based on certain assumptions. Possible value types include annual rental value, assessed value, book value, cadastral value, capital value, commercial value, market value, tax value, use value, etc. A property or property unit can have more than one value.

Valuation in LADM is defined as the process of estimating the value of any property unit. The valuation function of LADM includes the identification of valuation units (e.g. parcel of land, condominium unit, building, etc.), the valuation procedures (e.g. valuation of units by individual or mass appraisal), the recording of transaction prices, the presentation of sales statistics and the handling of appeals.

In this Chapter we will present six cases to show you how valuation information is handled in LADM. In addition to the colours presented for the land tenure information in Figure 3, we introduce two colours for indicating objects related to valuation and taxation as in Figure 96.

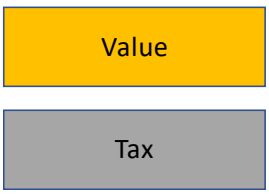


Figure 96. Valuation information objects are shown as above. In addition, taxation information (which is not directly modelled in the LADM) is shown in grey.

6.2 Valuation Case one: Valuation for taxation purposes

Property valuation can be used for various purposes, such as transactions, land consolidation, land readjustment, spatial planning, urban transformation, etc. One of the administrative purposes for which valuations are carried out is taxation. To determine the amount of tax due on a property, a value (e.g. market value, tax value) should first be calculated. This value can be used for property tax, inheritance and transfer tax, income tax and various fees. Figure 97 shows the taxable and non-taxable (e.g. government buildings, religious buildings, military properties) properties in this municipality. While there is a need to calculate the value of taxable properties annually, there is no need to do so for non-taxable properties. In addition all land transactions generate a taxable event. For instance, in the transaction case one, Carlos sold his property to Monique, and this transaction has been processed. Similarly, in the second transaction case, WR19 and WR22 have been merged, and this transaction has also been processed in the database. A servitude on WR17 has been established in the third transaction case, and this transaction is also processed. However, the process of splitting WR11 into seven new parcels in transaction case study four is still in progress and has not yet been processed in the registry.

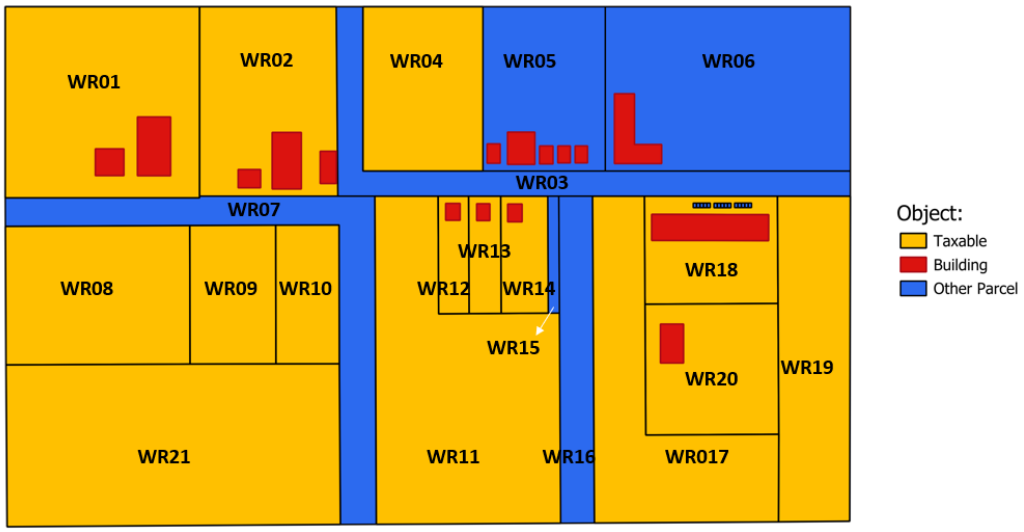


Figure 97. Valuation unit that is valued for the purposes of taxation.

The instance level diagram related to this case is shown in Figure 98. It can be seen that spatial units (WR01, WR02, WR05) are associated with basic administrative units (BAU01, BAU02 and BAU05) which are associated with valuation units (VU01, VU02 and VU05). Since VU05 (which in this case is the same as BAU05) is a non-taxable property, the value of VU05 and the tax amount for VU05 are not calculated.

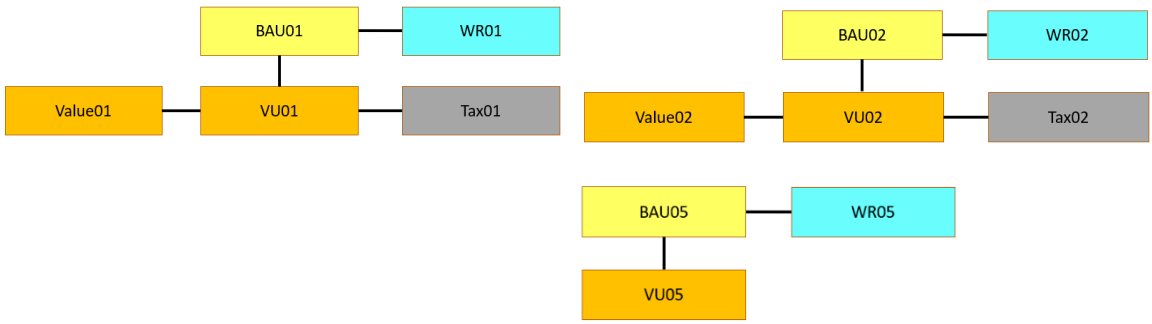


Figure 98. Instance level diagram for valuation case 1.

Monique (P14) owns BAU14 which is associated with WR01 (see Figure 99 and Figure 100). Since BAU14 (which is equal to VU01 in this case) is subject to taxation (Tax01), the value (Value01) of VU01 should be calculated.

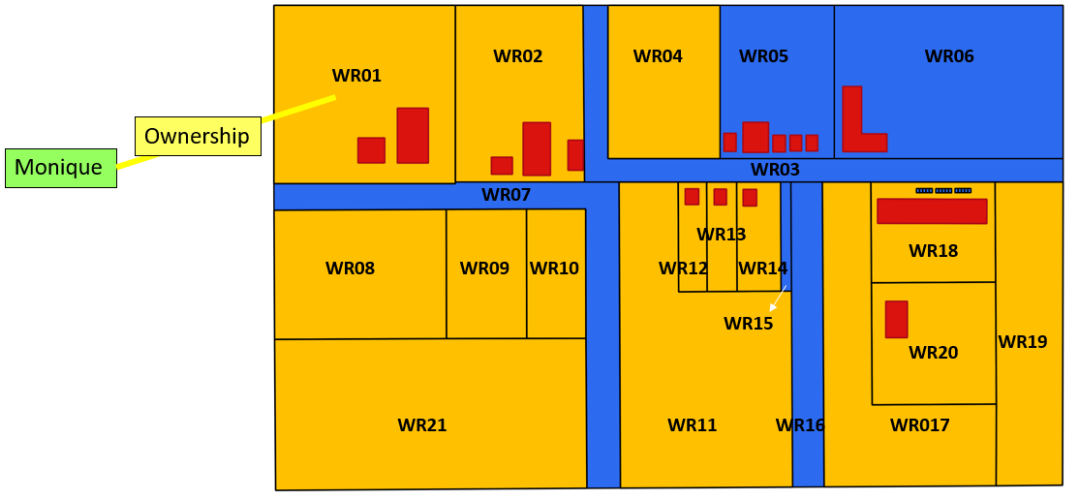


Figure 99. Monique is the owner of WR01.

The value (Value01) of VU01 is calculated as €200,000 for the year 2023. Since the amount of tax is 0.2% of the value of a property per annum in this case study area, the amount of annual property tax to be paid by Monique in 2023 is calculated as €400, see Figure 101.

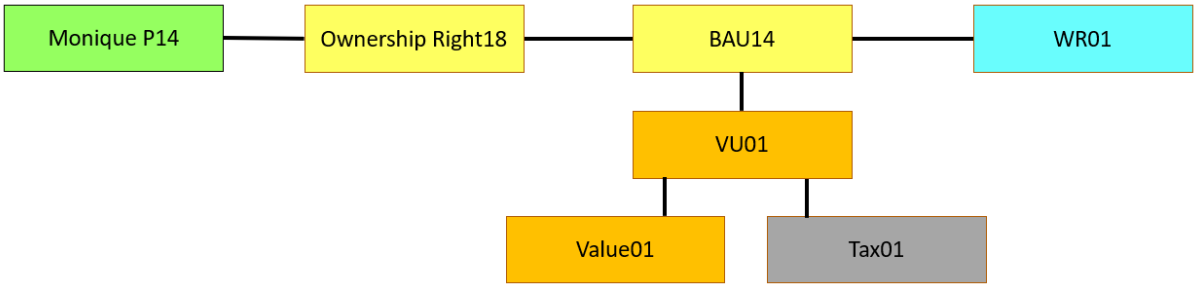


Figure 100. Monique has the ownership right over BAU14 which is same with VU01. The value (Value01) and tax amount (Tax01) of VU01 is associated with VU01.

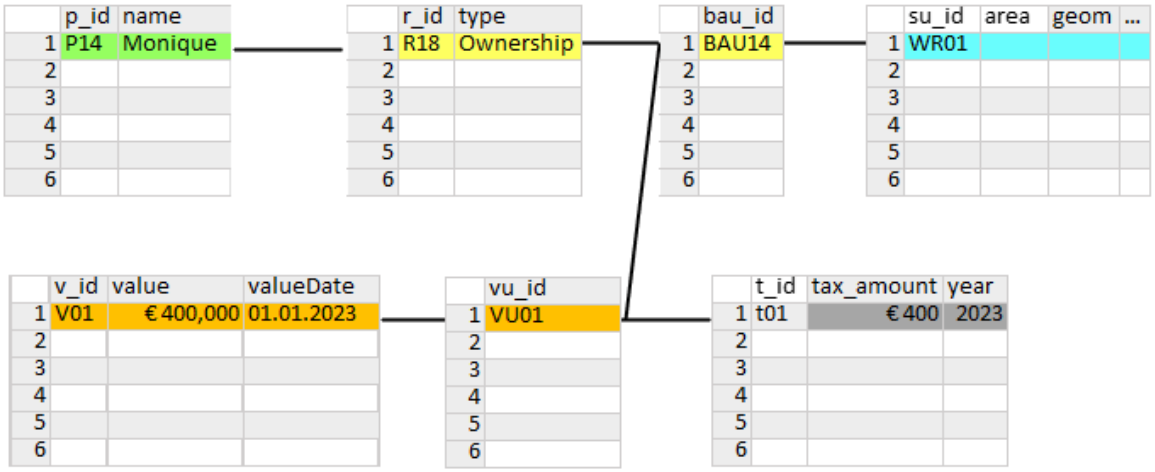


Figure 101. The value of VU01 for 2023 is calculated as €400000 and the tax amount is €400.

6.3 Valuation Case Two: Transaction price

Transaction price is the amount of consideration for the transfer of right(s) to property, excluding amounts collected on behalf of third parties. The price of selling or renting a property can be considered as transaction price. In the case of a sale/purchase, the type of transaction may be an exchange, family transfer, forced sale, inheritance, open market sale, voluntary transfer, etc.

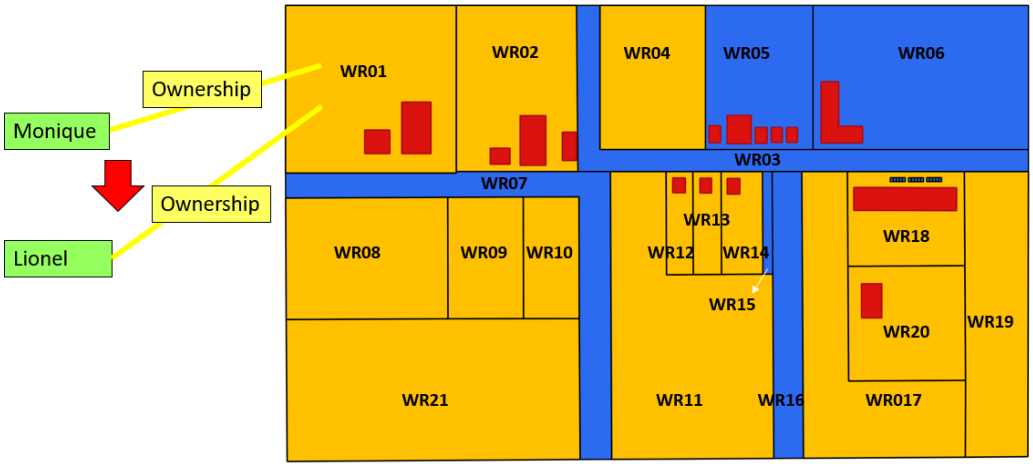


Figure 102. Recording transaction information - open market sale example.

Monique would like to sell her property (BAU14), see Figure 102. Monique and Lionel (P16) agree on the price, and they decide to sign the transaction contract on 15 March 2023 14:15:00, see Figure 103 and Figure 104.

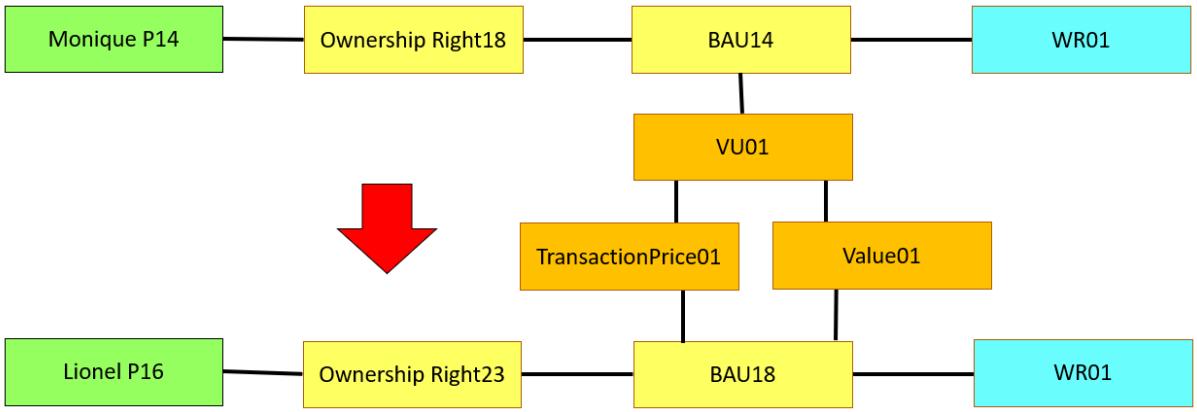


Figure 103. The transaction between Monique and Lionel.

Value may differ from transaction price. Lionel bought the BAU18 on 15 March 2023 for €420000. See the difference between the transaction price and the value of the property and the dates in Figure 104. Note that the value (Value01) of VU01 was calculated on 01.01.2023 while the transaction took place exactly on 15-03-2023 14:15:00.

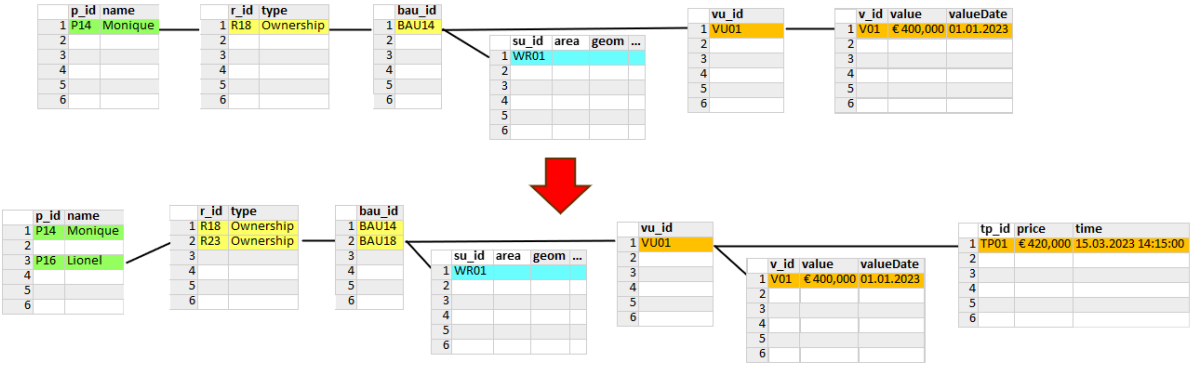


Figure 104. Lionel buys BAU18 on 15 March 2023 for €420000 (transaction price).

6.4 Valuation Case Three: Compulsory purchase

Elisabeth and Nese both have a share in the ownership of BAU19, see Figure 105. The government expropriates WR08 to build a new police station. In other words, the local government wants to apply the spatial plan, which indicates that a new police station should be built on WR08. Elisabeth and Nese both have a share in the ownership of BAU19 and therefore WR08. Government only wants to expropriate WR08 to build a new police station. Therefore, value of WR08 should be determined on the date of expropriation (01.01.2024).

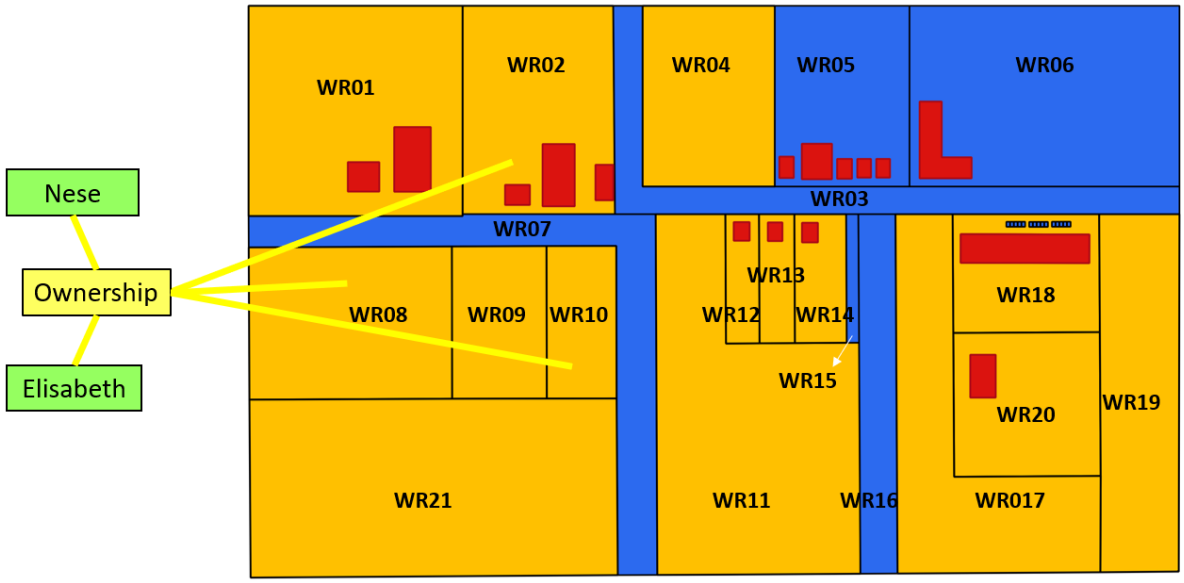


Figure 105. Nese and Elisabeth own BAU19 consisting of WR02, WR08 and WR10.

The value of WR08 (Value08) is calculated to be €500,000 on 01 January 2024. As this value is considered to be the market value of the property, the price to be paid to the owners for the expropriation is considered to be €500,000. In other words, the transaction price for the expropriation of WR08 is €500,000, see Figure 106 and Figure 107. This value can also be used

for other valuation purposes, such as land readjustment, land consolidation, real estate financing, investment analysis, urban renewal, etc.

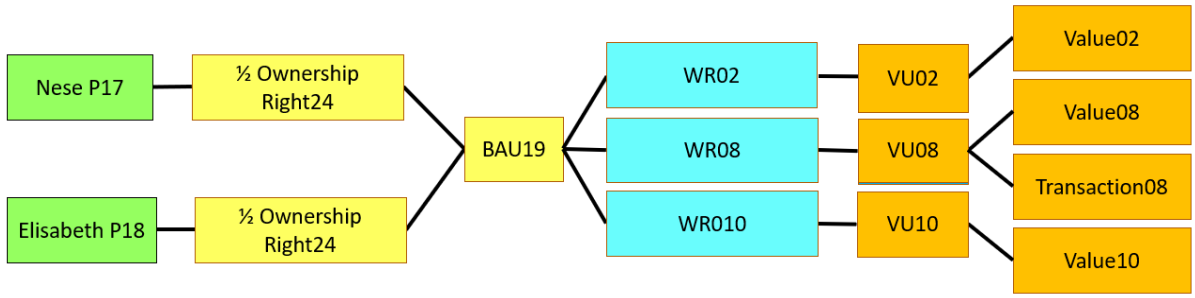


Figure 106. The value of each valuation unit. In this case each spatial unit is a valuation unit.

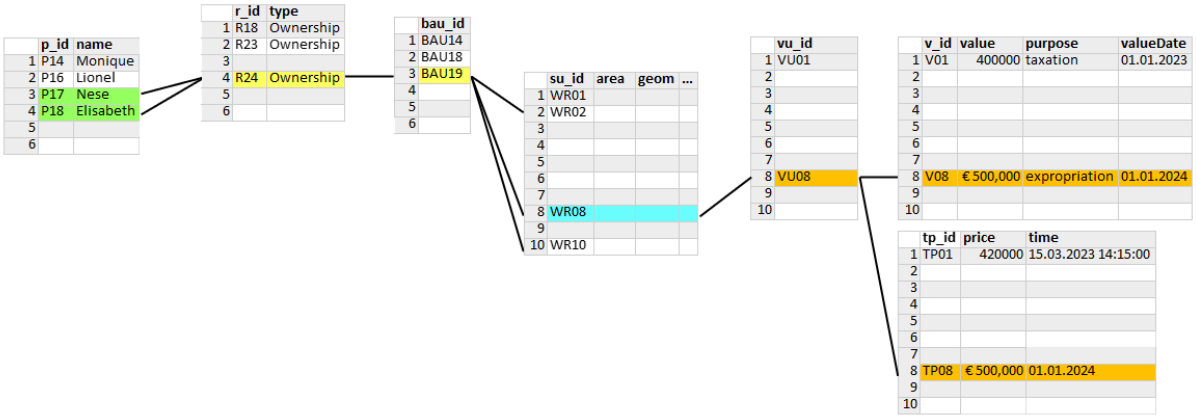


Figure 107. The value of WR08 is calculated €500000 for expropriation.

6.5 Valuation Case Four: Objects (units) of valuation

The property to be valued can be (a) land only (e.g. cadastral parcel), (b) improvements only (e.g. buildings), (c) land and improvements together as a land property, (d) land and improvements together as a condominium property. Taking into account the valuation legislation in force in each country, this list may be modified and extended.

More than one spatial unit can form a basic administrative unit. Figure 108 shows three spatial units (i.e. WR12-4, WR12-5 and WR12-6) forming one basic administrative unit (i.e. BAU12). In some cases, the valuation unit may be different from the basic administrative unit. In some countries, car parking areas (e.g. WR12-5) may have a value as they can be the subject of transactions.

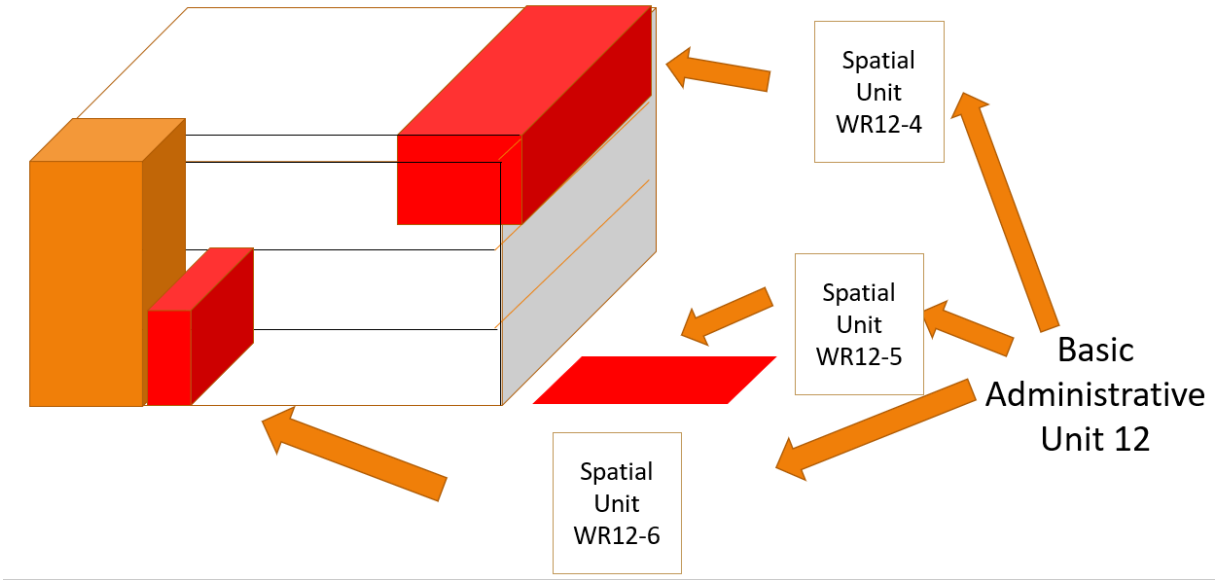


Figure 108. Spatial unit may be subject to valuation.

WR12-4 is the residential unit and WR12-6 is a storage unit, or a laundry room allocated to the owner BUA12 for special use. WR12-4 and WR12-6 together form a valuation unit (VU12-4) that has a value (Value12-4). The car parking area (WR-12-5) is a separate valuation unit (VU12-5) that has a value. The value of BAU12 is the sum of VU12-4 and VU12-5. The value of VU12-4 is calculated to be €300000 on 1 January 2024, while the value of VU12-5 is calculated to be €10000 on the same date, see Figure 109 and Figure 110.

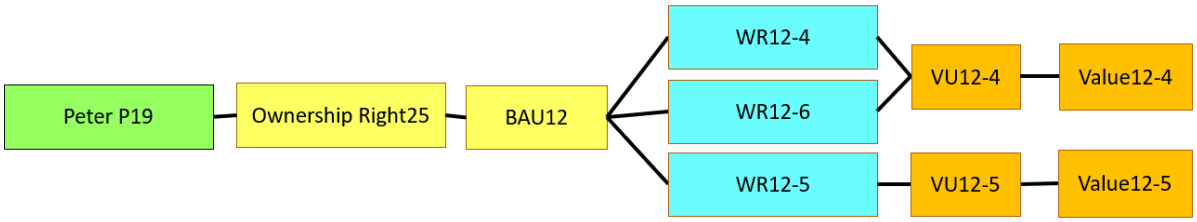


Figure 109. WR12-5 is designated as VU12-5 while WR12-4 and WR12-5 together are designated as VU12-4.

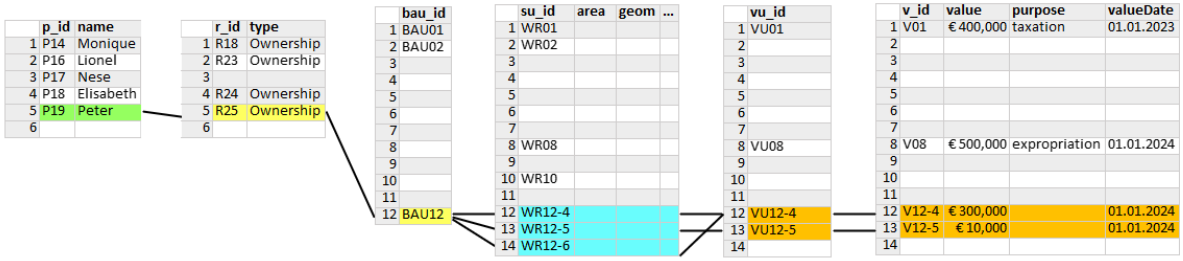


Figure 110. The value of VU12-4 is to €300000 and the value of VU12-5 is €10000.

6.6 Valuation Case Five: Valuation of social house

Cadastral units may in some cases differ from valuation units. In fact, the relationship between valuation units and cadastral units (parcels and apartments) is simple in theory but can be challenging for the valuation system. For example, there are several valuation units on a cadastral parcel for units that are rented, such as houses rented by a social housing association or business units in a multi-company building. On the other hand, it should be noted that if adjacent buildings or land parcels or apartment rights are owned and used by the same person, then these parcels and buildings and apartments together form a single valuation unit. This results in a m:n relationship between valuation units and cadastral units.

BAU20, associated with WR13, is owned social housing association see Figure 111.

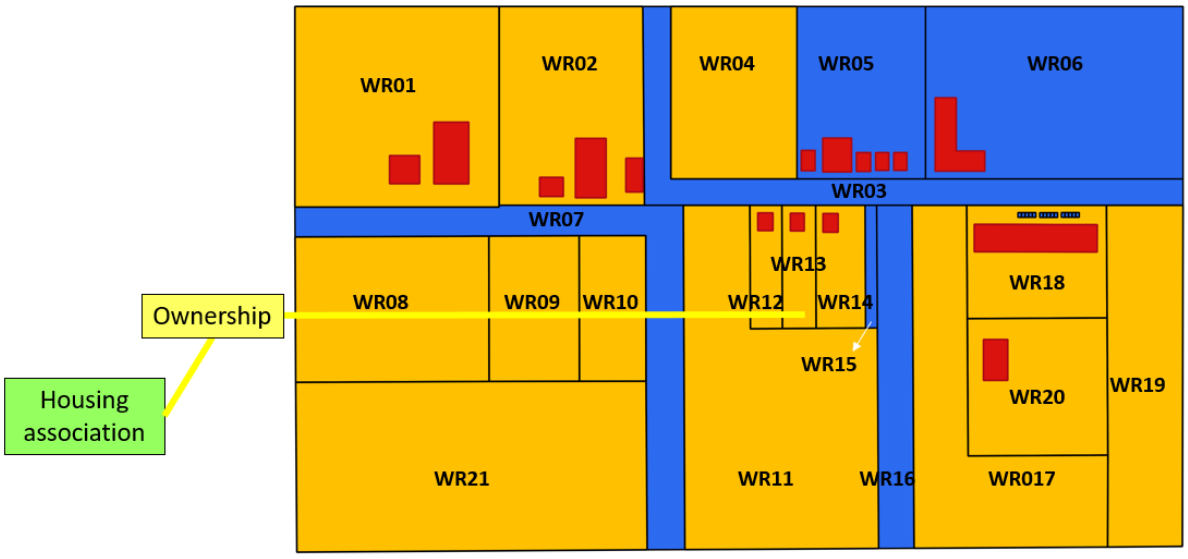


Figure 111. Social housing association owns BAU13.

Figure 112 shows the relationship between one cadastral unit (i.e., WR13) which associated with (three) valuation units in this case of multiple rented out units. WR13 is a social house and includes three apartment units (in this case all valuation units) that have different values . The value (Value13-1) of VU13-1 is calculated as €220000, while the value of VU13-2 is calculated as €230000 and the value of VU13-3 is calculated as €235000.

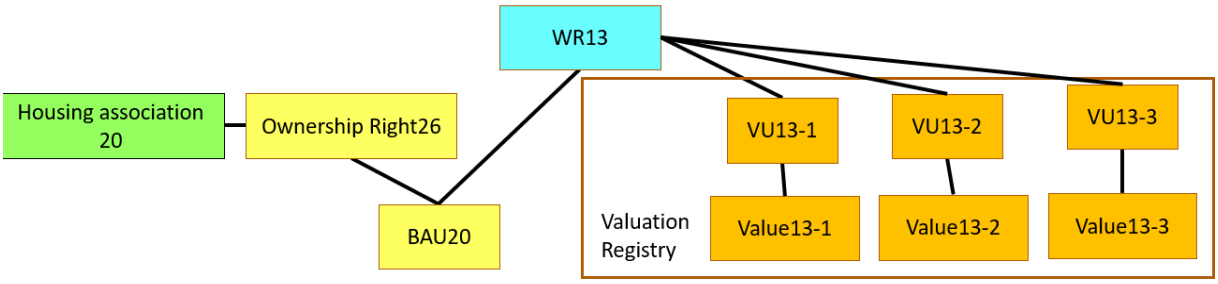


Figure 112. One cadastral unit (WR13) associated with three valuation units (VU13-1, VU13-2 and VU13-3).

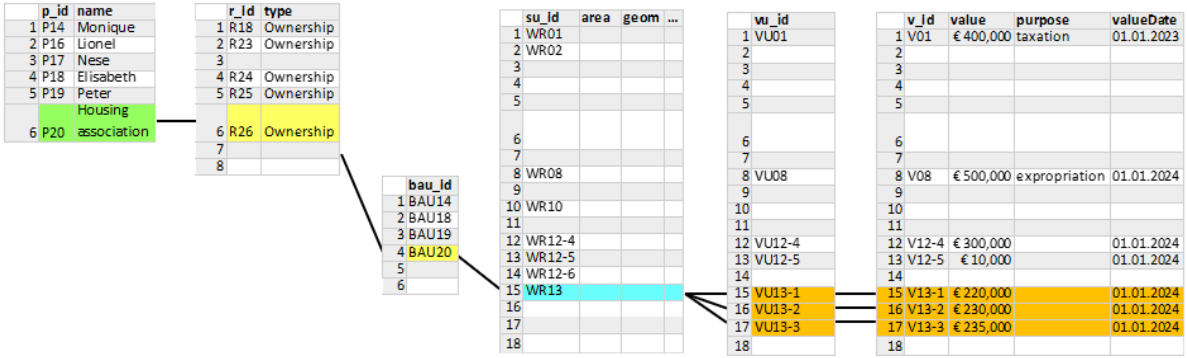


Figure 113. Three valuation units, which associated with one BAU, has three different values.

6.7 Valuation Case Six: Valuation methods

Different valuation methods (sales comparison, cost, income, etc.) are used to determine values of different property types (parcel -rural, urban-, residential, retail, industry, etc.).

The sales comparison approach compares the subject property with other similar properties that have recently been sold, known as comparable sales. It estimates the value of the subject property by adjusting the sales prices of the comparable properties for their differences from the subject property. Adjustments are usually made for date of sale, location and physical characteristics.

The cost approach provides an indication of value based on the economic principle that a buyer will pay no more for a property than it costs to obtain a property of equal utility. The cost approach requires an estimate of current construction costs, which include the direct and indirect expenses of constructing an improvement. Two types of cost can be used: reproduction cost and replacement cost. The former refers to the current cost of constructing a replica of the property, while the latter refers to the current cost of a similar property with equivalent utility.

The income approach converts the present or future stream of income derived from a property into its capital value.

Wim is the owner of BAU21 (associated with WR14) and would like to know the value of his property based on a sales comparison approach. He makes an application to a certified valuer. The valuer first identifies three properties similar to Wim's. When selecting the comparable properties that have recently been sold, the valuer takes into account the following characteristics of the properties: location, floor area, age of the building, etc. In this case, the comparable valuation units are VU15, VU16 and VU17. While VU16 has two transactions that took place on different dates, VU15 and VU17 have only one transaction price. Based on the transaction prices and characteristics of the properties, the necessary adjustments are made to the value (Value18) and the value of Wim's valuation unit (VU14) is determined, see Figure 114 and Figure 115.

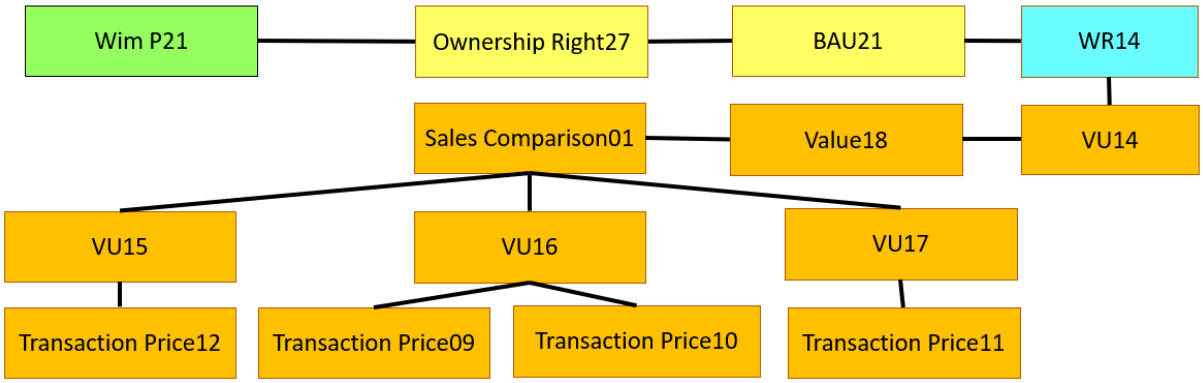


Figure 114. Valuation carried out using the sales comparison approach.

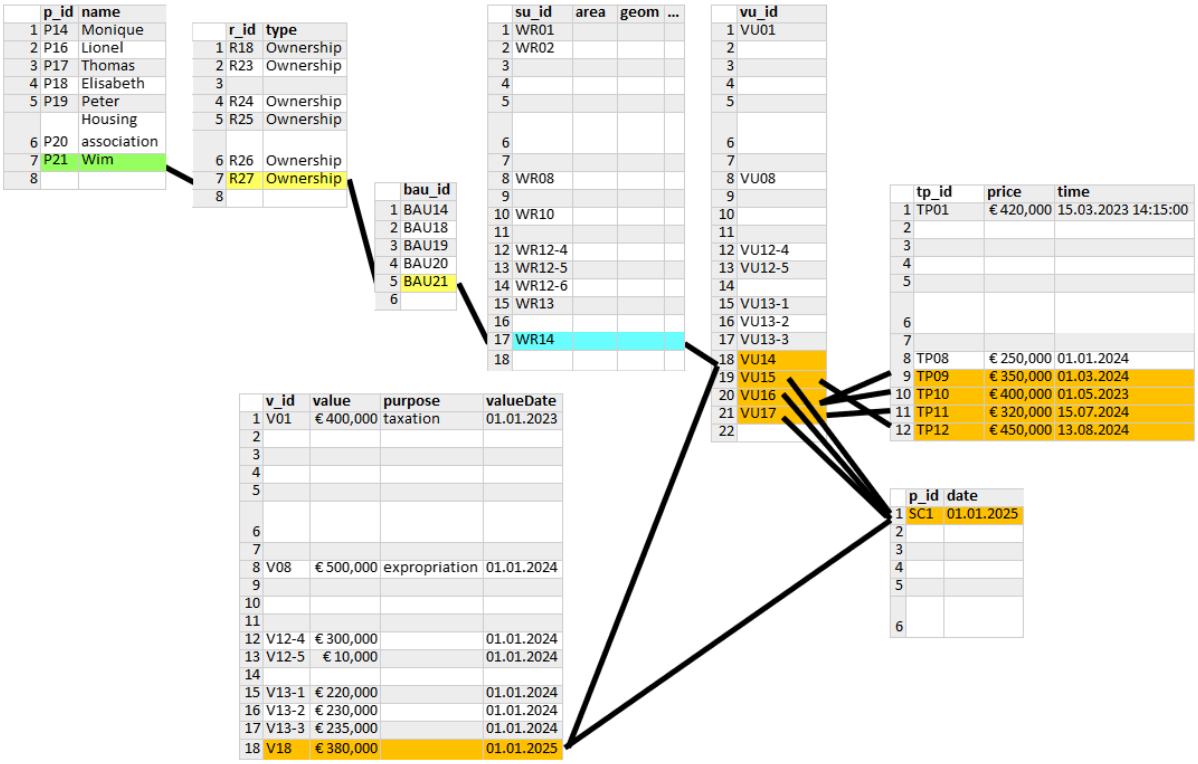


Figure 115. Database view of the valuation process based on the sales comparison approach.

Wim also wants his property to be valued using the cost approach. The reproduction cost of Wim's property is calculated on 01.01.2025. The value (Value19) of VU14 is calculated as €362850, see Figures 115 and 116.

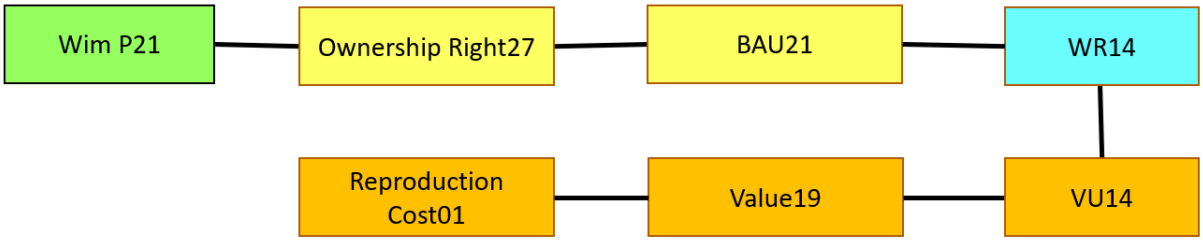


Figure 116. Valuation carried out using the cost approach.

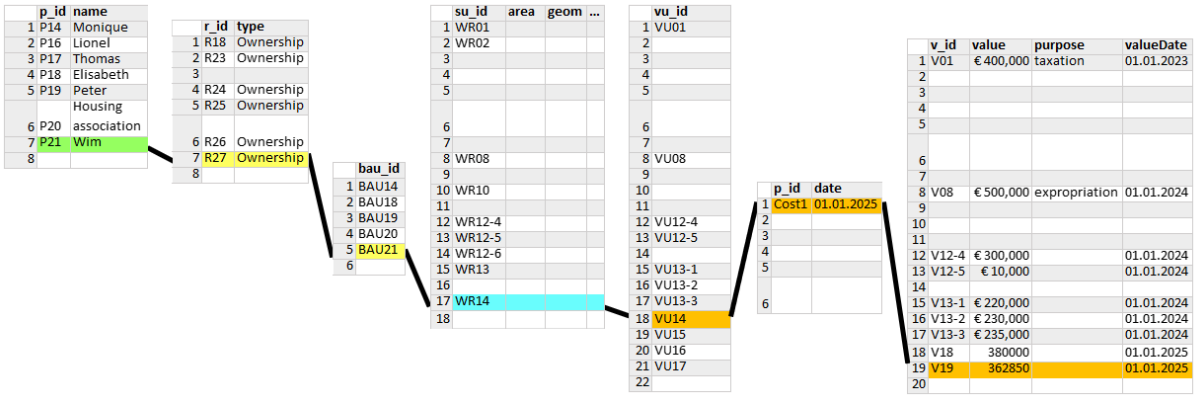


Figure 117. Database view of the valuation process based on the cost approach.

6.8 Valuation Case Seven: Mass valuation

A mass appraisal is a process that uses standard methods (e.g. multiple regression analysis), common data and statistical tests (see ratio study) to value a group of properties at a given date. By treating all properties within a group of properties in the same way, the mass appraisal process creates a consistent, uniform methodology for analysing properties that is fair to property owners. In addition, mass appraisal is used to reduce appraisal costs and increase the fairness of the process for similar types of property. An example of how LADM can be used to mass value a group of similar properties is shown in Figure 118.

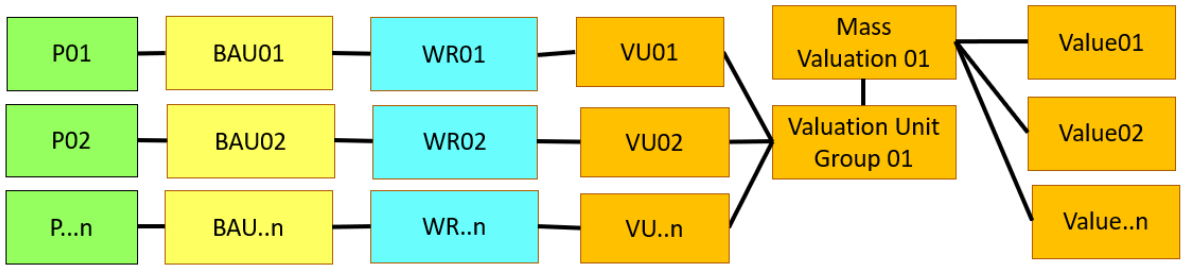


Figure 118. Mass valuation of all residential properties in the municipality of Waterriver.

7. Customary Land Tenure

7.1 The Woodygrass Basin region

Urban settings are generally regular with a simplified legal and social organization. Real Land Administration systems, however, must deal with both urban and rural as well as statutory and non-statutory tenure systems. In this chapter we illustrate further modeling possibilities of the LADM using a hypothetical customary tenure system operating in the region north-east of Waterriver. This rural region is called the Woodygrass Basin region (see map in Figure 119).

Figure 119. The Woodygrass Basin Region around Waterriver.

Woodygrass Basin is occupied by two communities. The Grassy Basin community occupies the territory adjacent to Waterriver and parts of its territory are currently experiencing urbanization. The second community, Grassy Woods, occupies the more remote territory of Woodygrass Basin including parts of the natural forest and hills bounding the Woodygrass Basin to the north, north-east, and east.

Under the newly enacted Community Land Act, communities can opt for registration of community land to protect the land they depend on, from dispossession by outside actors, by applying for a community land title. This gives communities security of tenure. Both communities of Woodygrass Basin have registered their territories under the new law.

For the registration, the land must be associated with a legal entity or group of legal entities. The communities are presented with two options. Registration can involve group parties with definite or non-definite membership. Definite membership implies that all members are identified separately and registered as parties in the register. With non-definite membership only one or more representatives must be identified - not necessarily all members. In addition,

with non-definite membership tenure security is strengthened by prohibiting the alienation of any registered community land.

Unlike the case with urban land, only the outer boundaries of a registered community's land are surveyed and boundary segments may have varying degrees of measurement precision and accuracy. For example, along the river, the water front defines the limits of community land, thus defining a dynamic boundary feature. On the other hand, boundary segments bordering the village of Waterriver are measured according to the urban land survey standard.

7.2 Customary Case One: Grassy Basin community land

Grassy Basin being nearer to the city decides to register the community with defined membership taken at a fixed point in time and *updated annually*. The community holds ownership rights to the basic administrative unit BAU18 with two spatial units WG01A and WG01B (Figure 120).

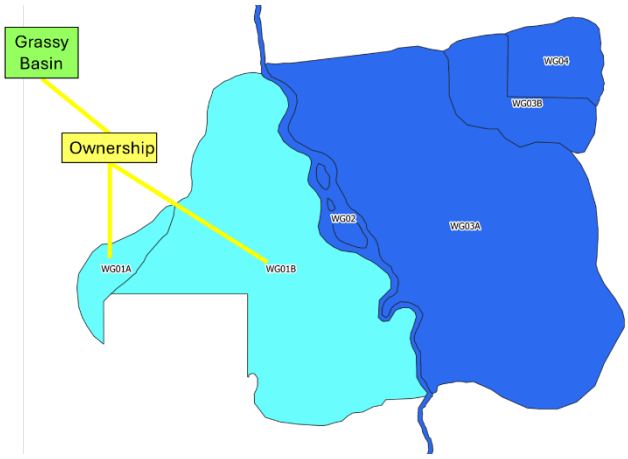


Figure 120. Spatial Units WG01A and WG01B belong to Grassy Basin community.

In the model, the community is represented by group party Grassy Basin with Party ID *GP01 which is linked to all its members*. Figure 121 shows some of the members of the Grassy Basin group party.

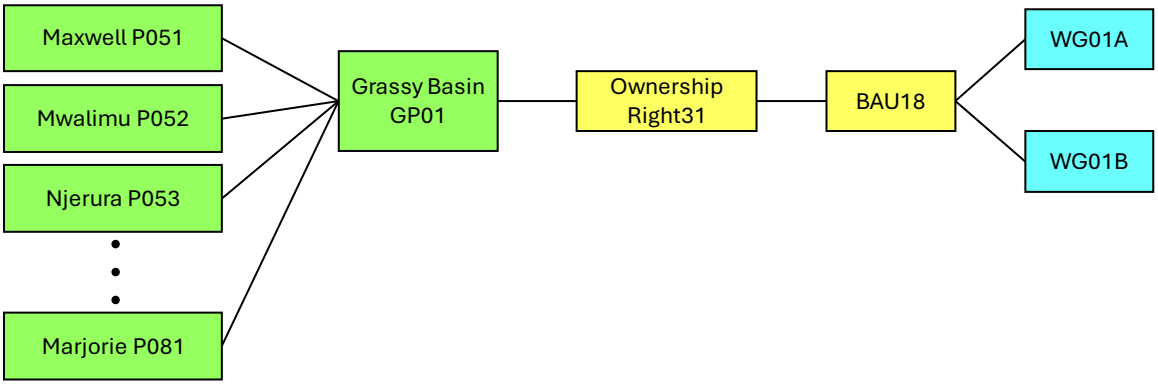
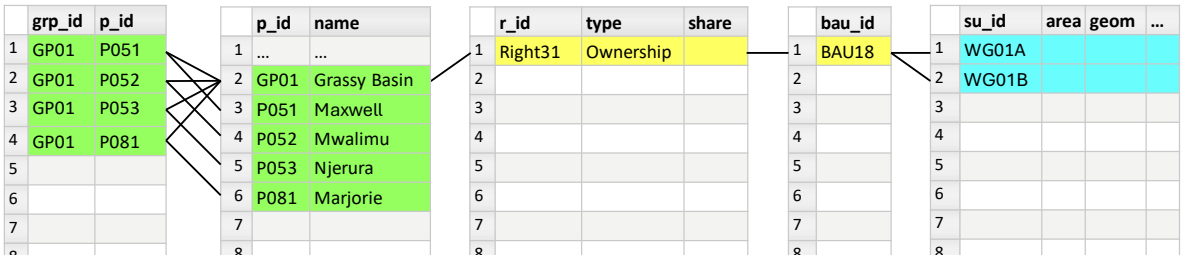


Figure 121. Grassy Basin is a group party whose membership consists of the entire adult population of the Grassy Basin territory. It is the registered owner of the two parts of the territory.

In Tenure Case Three (Chapter 4) we were first introduced to the concept of a group party. In Tenure Case Eight we have seen that both GroupParty and Party instances are stored in the Party table of our database. In Figure 122 we see how the GroupParty to PartyMember relationship is stored explicitly in the database. Every representative of the Grassy Basin community is registered as a member of the Grassy Basin group party by adding a row consisting of the group party's Party ID (GP01 in this case) and the corresponding party's Party ID (e.g. P051 for Maxwell) to a new PartyMember table (far left in Figure 122).



	grp_id	p_id
1	GP01	P051
2	GP01	P052
3	GP01	P053
4	GP01	P081
5		
6		
7		

	p_id	name
1	...	...
2	GP01	Grassy Basin
3	P051	Maxwell
4	P052	Mwalimu
5	P053	Njerura
6	P081	Marjorie
7		

	r_id	type	share
1	Right31	Ownership	
2			
3			
4			
5			
6			
7			

	bau_id
1	BAU18
2	
3	
4	
5	
6	
7	

	su_id	area	geom	...
1	WG01A			
2	WG01B			
3				
4				
5				
6				
7				

Figure 122. Party membership of Group Party must be recorded in separate table called a join table.

The PartyMember table is what is also known as a join table because it allows us to join two different rows from a chosen table in our database. In Customary Case Five we show a join table involving two distinct source tables. With a join table we are also able to record the attributes of the group-member relationship. For example, each member could be recorded with the number of generations that their family have been members of the community which could be used to weight the votes of each member when deciding important community matters. We illustrate this with the expanded PartyMember table in Figure 123. Inclusion of an attribute such as *generation* is practical only if it applies to all such group parties in the LIS.

	grp_id	p_id	generation
1	GP01	P01	3
2	GP01	P22	2
3	GP01	P33	9
4	GP01	P33	9
5			
6			
7			
8			

	p_id	name
1	...	...
2	GP01	Grassy Basin
3		Maxwell
4		Mwalimu
5		Njerura
6		Marjorie
7		
8		

Figure 123. Party Member join table with additional attributes of the relationship between the group party and the group party member.

7.3 Customary Case Two: Grassy Woods community land

Grassy Woods being farther from the city does not experience much pressure from the urbanization around Waterriver and maintains strong traditional social structures and tenure relations. They decide to register their community with non-definite membership with the Elder's Council being the custodians of the land under the new law.

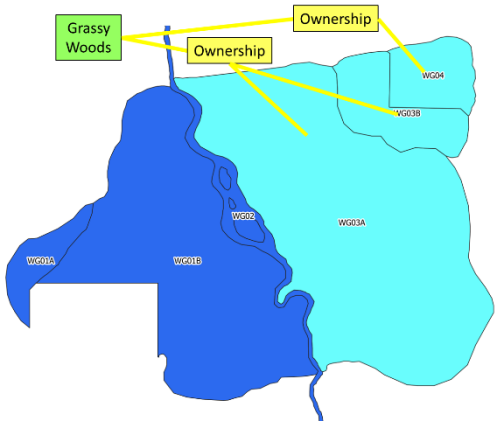


Figure 124. Spatial Units WG03A, WG03B and WG04 belong to the Grassy Woods community.

The forested piece of land referenced by Spatial Unit WG04 is registered under a separate BAUnit (Figure 124). As we shall see in Customary Case Five below, this is because there are other rights related to this spatial unit which do not apply to WG03A and WG03B. Figure 125 is the counterpart of Figure 121 for the Grassy Woods community land registration records.

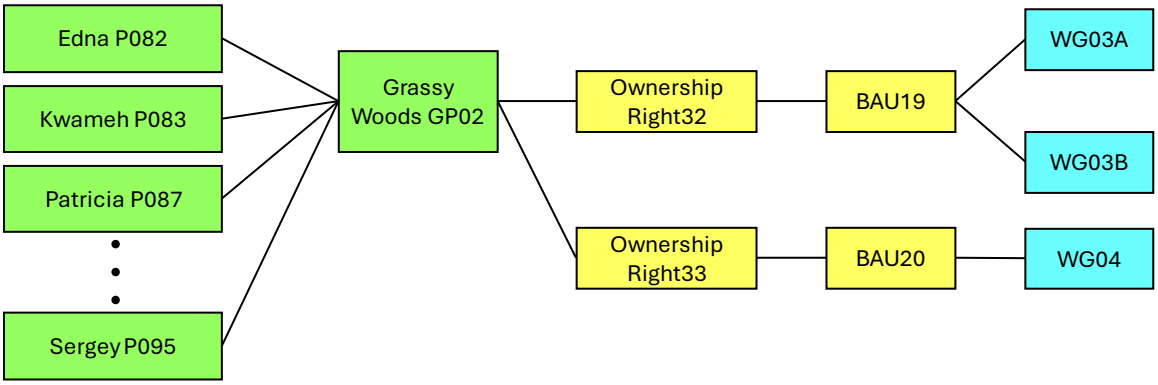
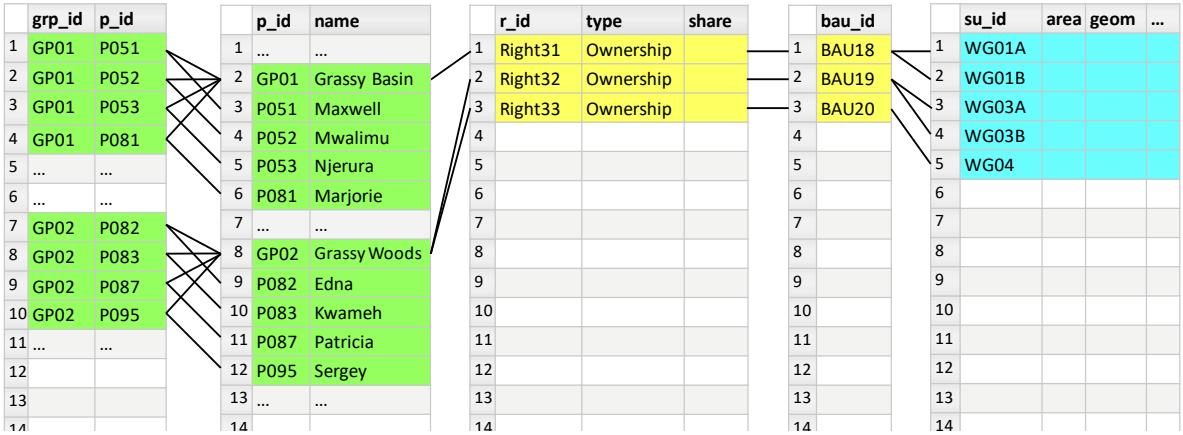


Figure 125. Grassy Woods is a group party whose membership consists of representatives of the Grassy Woods community. It is the registered owner of the two parts of the territory.

The council of elders represents the community as members of a group party. As can be seen from Figure 126, from the perspective of the database, the group parties and their membership look the almost same – there is no difference in how they are recorded. To differentiate between different types of group parties, one might introduce a separate table for group parties where additional attributes of group parties such as *membership type* could be stored.



	grp_id	p_id
1	GP01	P051
2	GP01	P052
3	GP01	P053
4	GP01	P081
5	...	...
6	...	...
7	GP02	P082
8	GP02	P083
9	GP02	P087
10	GP02	P095
11	...	...
12		
13		

	p_id	name
1	...	...
2	GP01	Grassy Basin
3	P051	Maxwell
4	P052	Mwalimu
5	P053	Njerura
6	P081	Marjorie
7	...	...
8	GP02	Grassy Woods
9	P082	Edna
10	P083	Kwameh
11	P087	Patricia
12	P095	Sergey
13	...	...

	r_id	type	share
1	Right31	Ownership	
2	Right32	Ownership	
3	Right33	Ownership	
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			

	bau_id
1	BAU18
2	BAU19
3	BAU20
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

	su_id	area	geom	...
1	WG01A			
2	WG01B			
3	WG03A			
4	WG03B			
5	WG04			
6				
7				
8				
9				
10				
11				
12				
13				

Figure 126. In the database, Grassy Woods is associated with two rights, Right32 and Right 33, but three Spatial Units.

7.4 Customary Case Three: Public roads over community land

Two roads lead out of Waterriver through Grassy Basin and Grassy Woods. The district municipality is responsible for maintaining these roads (Figure 127). In return, road access is left open to all public and private travelers. The roads are thus recorded as separate cadastral objects with easements granted to the district municipality.

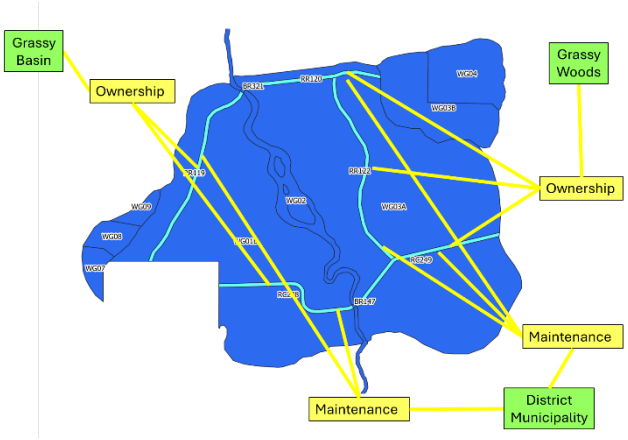


Figure 127. The district municipality has maintenance responsibilities for all public road segments over the territories of the two communities. Each community retains ownership of the corresponding road segments.

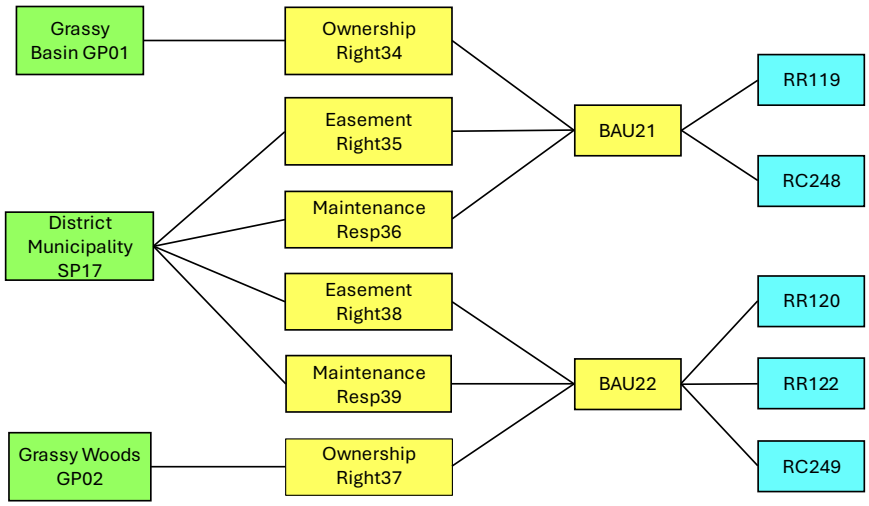
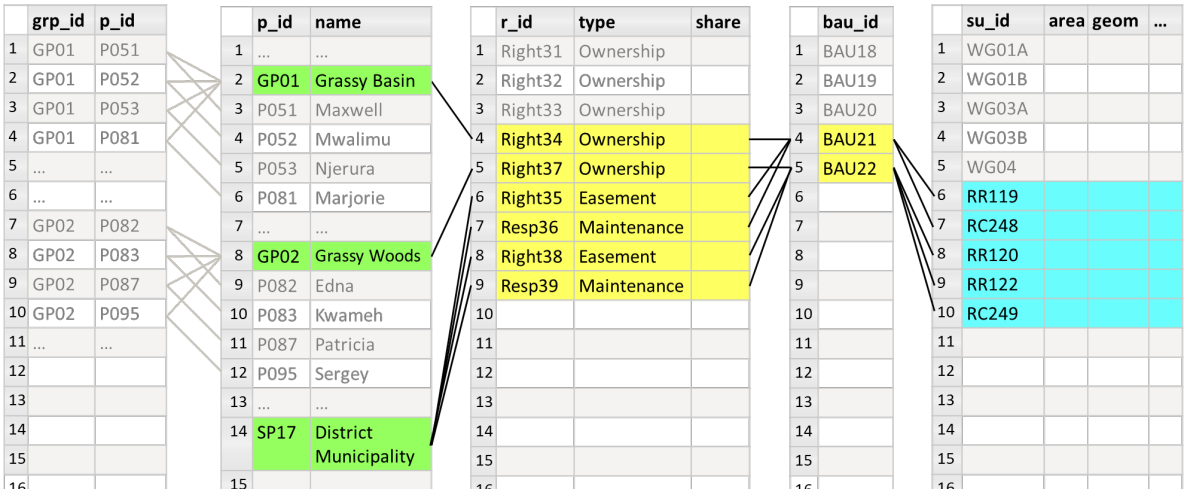


Figure 128. The Spatial Units representing to road segments are organized according to ownership.

The instance diagram of the model representing this case is shown in Figure 128. The district municipality must be recorded as party just like any other party with an interest in land. The road segments in each community's land are represented by a single BAUnit as can be seen in Figures 128 and 129. This is because there is a uniform set of rights which apply to all road segments within one community's land – Ownership Right37, Maintenance Resp39, and Easement Right38 all apply to RR120, RR122, and RC249 together. The organization of this information would likely be different in the municipality's road maintenance department whose records would likely be organized by road surface type rather than land tenure relations.



	grp_id	p_id
1	GP01	P051
2	GP01	P052
3	GP01	P053
4	GP01	P081
5	...	...
6	...	...
7	GP02	P082
8	GP02	P083
9	GP02	P087
10	GP02	P095
11	...	...
12		
13		
14		
15		

	p_id	name
1	...	...
2	GP01	Grassy Basin
3	P051	Maxwell
4	P052	Mwalimu
5	P053	Njerura
6	P081	Marjorie
7	...	...
8	GP02	Grassy Woods
9	P082	Edna
10	P083	Kwameh
11	P087	Patricia
12	P095	Sergey
13	...	...
14	SP17	District Municipality
15		

	r_id	type	share
1	Right31	Ownership	
2	Right32	Ownership	
3	Right33	Ownership	
4	Right34	Ownership	
5	Right37	Ownership	
6	Right35	Easement	
7	Resp36	Maintenance	
8	Right38	Easement	
9	Resp39	Maintenance	
10			
11			
12			
13			
14			
15			

	bau_id
1	BAU18
2	BAU19
3	BAU20
4	BAU21
5	BAU22
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

	su_id	area	geom	...
1	WG01A			
2	WG01B			
3	WG03A			
4	WG03B			
5	WG04			
6	RR119			
7	RC248			
8	RR120			
9	RR122			
10	RC249			
11				
12				
13				
14				
15				

Figure 129. Spatial Units representing to road segments as stored in the database.

7.5 Customary Case Four: Public resources and assets – the river and the bridges

The water body section covering the boundary between the Grassy Basin and Grassy Woods communities is considered a public resource with use rights claimed by the two communities. The district municipality has ownership of the river and the bridges constructed across the river on the two roads running from Waterriver village through both community land territories Figure 130.

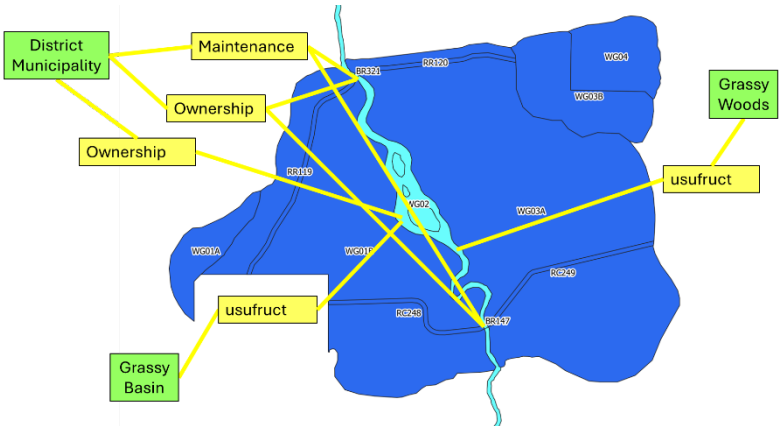


Figure 130. Maintenance responsibilities and ownership rights over bridges across the river are both held by the district municipality. The two communities have use rights on the river.

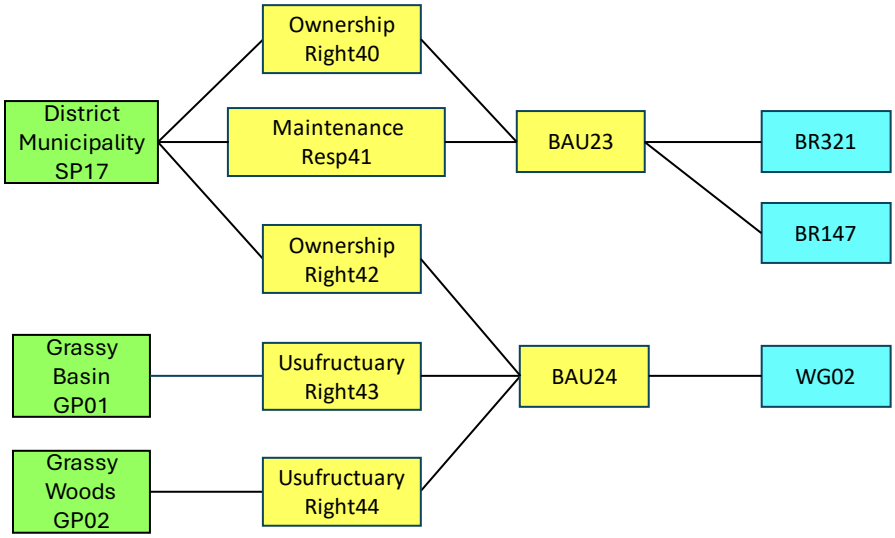
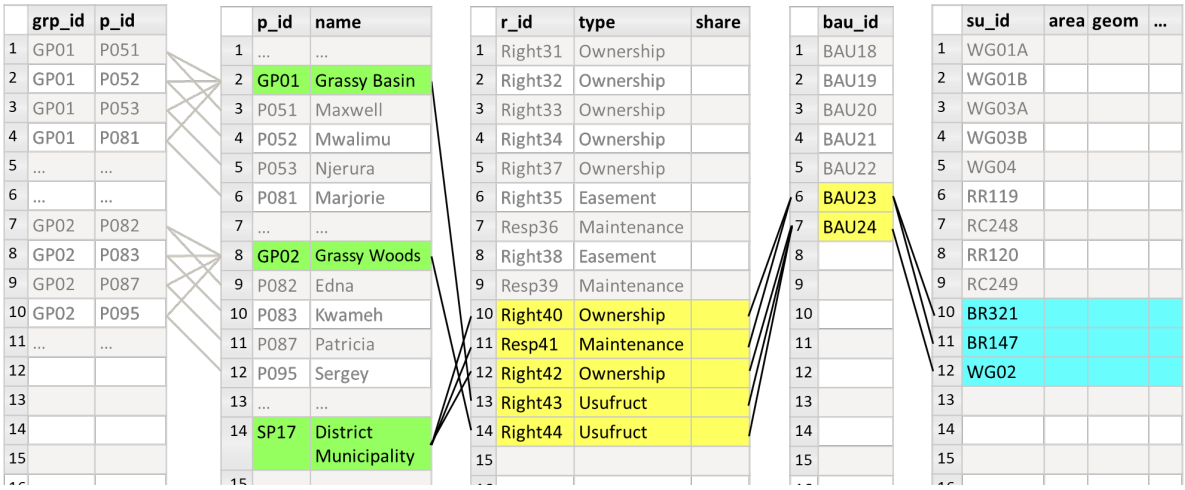


Figure 131. Instance diagram of the tenure relations involving the river and public bridges.

Use rights are specifically recorded for the water body but not for the bridges. This is because the bridges are already designated as public infrastructure under a different law whereas the river has usage restrictions under another law such that use rights must be explicitly granted in the register as illustrated in Figures 131 and 132.



	grp_id	p_id
1	GP01	P051
2	GP01	P052
3	GP01	P053
4	GP01	P081
5	...	...
6	...	...
7	GP02	P082
8	GP02	P083
9	GP02	P087
10	GP02	P095
11	...	...
12		
13		
14		
15		

	p_id	name
1	...	...
2	GP01	Grassy Basin
3	P051	Maxwell
4	P052	Mwalimu
5	P053	Njerura
6	P081	Marjorie
7	...	...
8	GP02	Grassy Woods
9	P082	Edna
10	P083	Kwameh
11	P087	Patricia
12	P095	Sergey
13	...	...
14	SP17	District Municipality

	r_id	type	share
1	Right31	Ownership	
2	Right32	Ownership	
3	Right33	Ownership	
4	Right34	Ownership	
5	Right37	Ownership	
6	Right35	Easement	
7	Resp36	Maintenance	
8	Right38	Easement	
9	Resp39	Maintenance	
10	Right40	Ownership	
11	Resp41	Maintenance	
12	Right42	Ownership	
13	Right43	Usufruct	
14	Right44	Usufruct	
15			

	bau_id
1	BAU18
2	BAU19
3	BAU20
4	BAU21
5	BAU22
6	BAU23
7	BAU24
8	
9	
10	
11	
12	
13	
14	
15	

	su_id	area	geom	...
1	WG01A			
2	WG01B			
3	WG03A			
4	WG03B			
5	WG04			
6	RR119			
7	RC248			
8	RR120			
9	RC249			
10	BR321			
11	BR147			
12	WG02			
13				
14				
15				

Figure 132. Database state including tenure records for the river and bridges.

7.6 Customary Case Five: Agricultural Plots in Grassy Basin

Farming plots in Grassy basin are allotted to community members for use for an indefinite period. Due to increasing parcelization of the farming parcels, the Grassy Basin community have elected to register individual farm plots and assign them to their current users. The three plots WG07, WG08, and WG09 are the first to be registered. The Party Mwalimu has also been recorded as holding Usufructuary rights on WG09. This situation is illustrated in Figure 133. The users of plots WG07 and WG08 have not yet been added to the database (Figure 134). Since users of different farm parcels will likely be different individuals, it makes sense to record such parcels under different Basic Administrative Units.

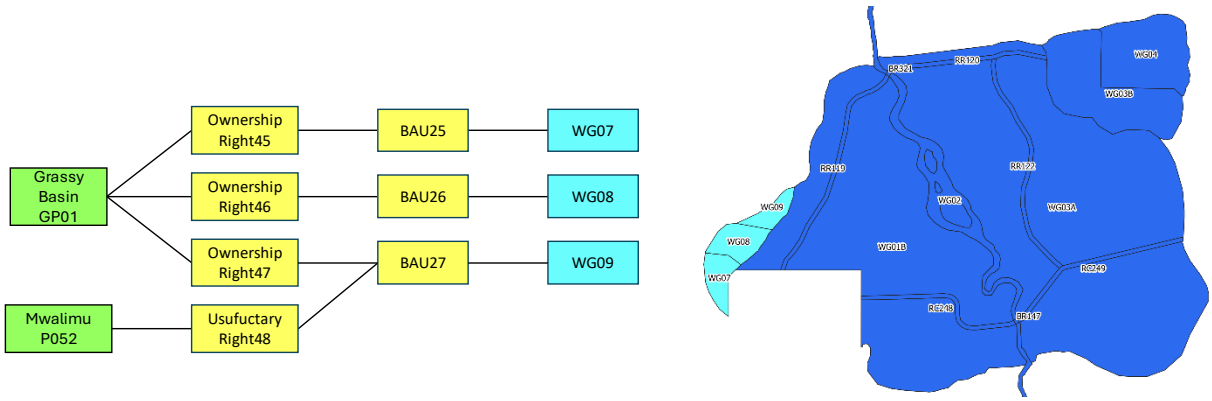


Figure 133. Farm plots registered separately by Grassy Basin community. Community members such as Mwalimu can be allotted use right on these plots.

	grp_id	p_id
1	GP01	P051
2	GP01	P052
3	GP01	P053
4	GP01	P081
5	...	...
6	...	...
7	GP02	P082
8	GP02	P083
9	GP02	P087
10	GP02	P095
11	...	...

	p_id	name
1	...	...
2	GP01	Grassy Basin
3	P051	Maxwell
4	P052	Mwalimu
5	P053	Njerura
6	P081	Marjorie
7	...	...
8	GP02	Grassy Woods
9	P082	Edna
10	P083	Kwameh
11	P087	Patricia

	r_id	type	share
...	...	...	
14	Right43	Usufruct	
15	Right45	Ownership	
16	Right46	Ownership	
17	Right47	Ownership	
18	Right48	Usufruct	
19			
20			
21			
22			
23			

	bau_id
...	...
3	BAU20
...	...
8	BAU25
9	BAU26
10	BAU27
11	
12	
13	
14	
15	

	su_id	area	geom	...
...	...			
5	WG04			
...	...			
12	WG02			
13	WG07			
14	WG08			
15	WG09			
16				
17				
18				
19				

Figure 134. Database state after addition of data corresponding to the instance diagram in Figure 133.

If the assigned user of a farm plot is unable to use the plot for one or more seasons, the user may lease out the plots for a period of one year. The party Mwalimu has leased his plot to party Edna from Grassy Woods.

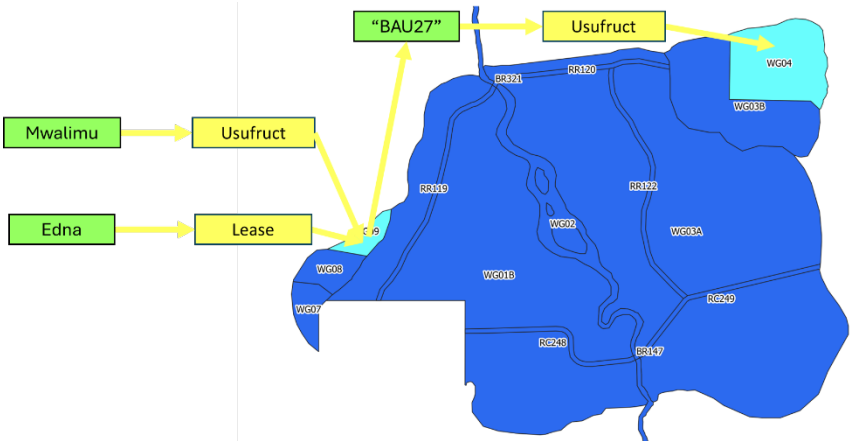


Figure 135. Edna leases WG09 and derives use rights on WG04 from the lease rights.

Apart from the right to use WG09 for farming purposes, any holder of use rights on WG09 needs to have access to the forest WG04. The rational for this is that because the main farm product in Grassy Basin is flue cured tobacco, farmers require access to wood for smoking the tobacco leaves. The communities of Grassy Basin and Woody Grass have always had the understanding that the forest WG04 would be accessible to farmers from Grassy Basin. In our example this is modelled as a right granted to the BAUnit as opposed to the person. Both Mwalimu and Edna have usufruct rights on WG04 as a result of the BAUnit BAU27 carrying the right of use of the forest (Figure 135).

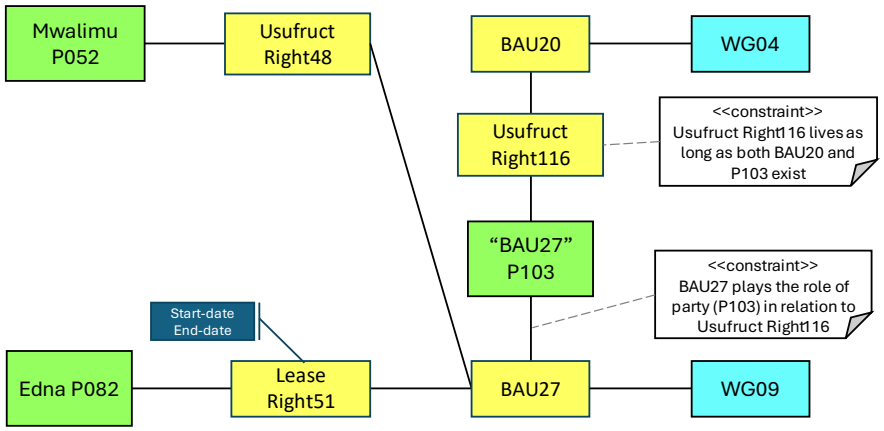


Figure 136. Party Edna obtains use rights in forest WG04 via the lease right on BAU27.

To attach rights to a BAUnit, LADM supports connecting a BAUnit to a surrogate party object, which is a virtual party that represents the BAUnit. In our example this is realized using the surrogate party with name "BAU27" and Party ID P103 (See Figures 136 and 137).

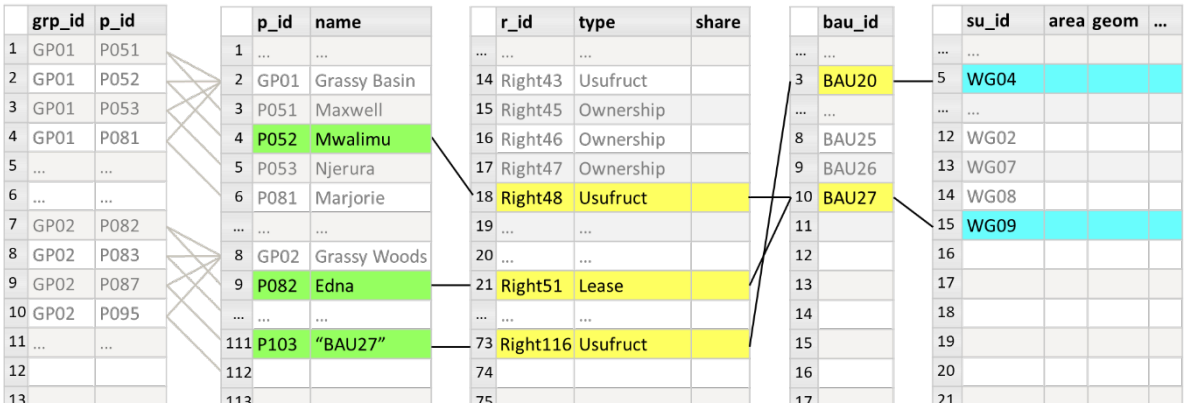


Figure 137. Database view highlighting actual recorded rights. Derived rights are realized in conjunction with the records highlighted in Figure 138.

The surrogate party P103 representing BAU27 in an RRR relationship with BAU20 can be implemented as shown in Figure 138. Here, an additional table containing a row for each BAUnit-surrogate pair is introduced (shown below the rights table in Figure 138).

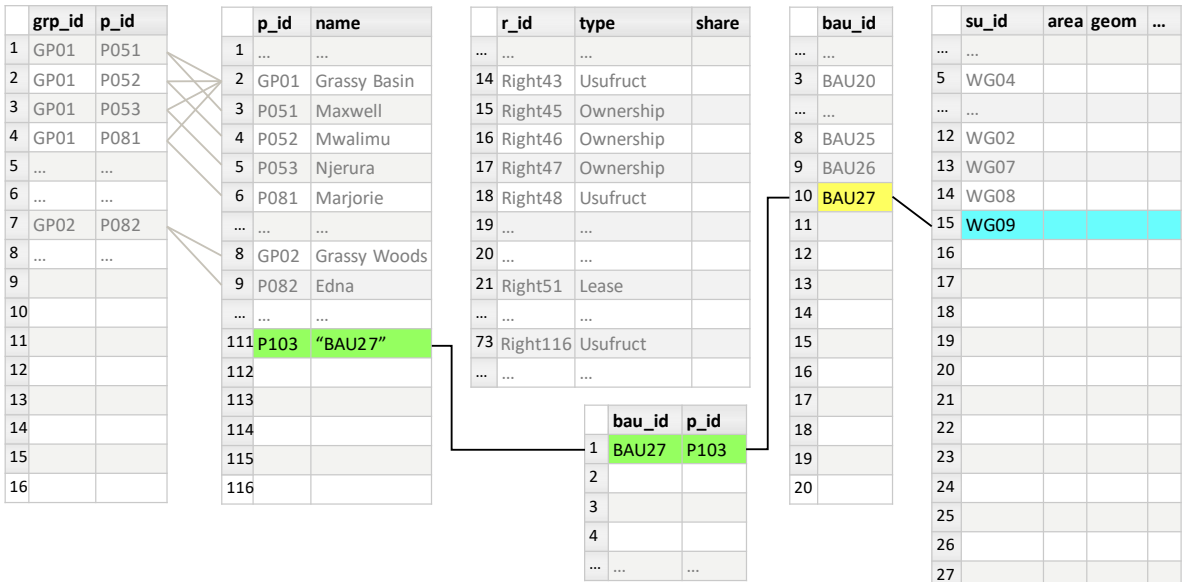


Figure 138. Surrogate party and the BAUnit it represents can be stored in a separate join table.

7.7 Customary Case Six: Internal Land Records of Grassy Woods

The Grassy Woods community maintain their own land records for internal land management purposes. Following the Social Tenure Domain Model (STDM), a derivative of the LADM, the community is recorded as collection of families. Each individual belongs to a family. The family is thus a group party.

People-to-land relationships in STDM are called Social Tenure Relationships or STRs for short. Some land rights accrue to the family and others to individuals. For example, each family has the right to a number of plots for establishing their homesteads (places of dwelling and small scale gardening). In Figure 139 we see that the Banda family have the Homestead right STR15 established on Spatial Unit WG11.

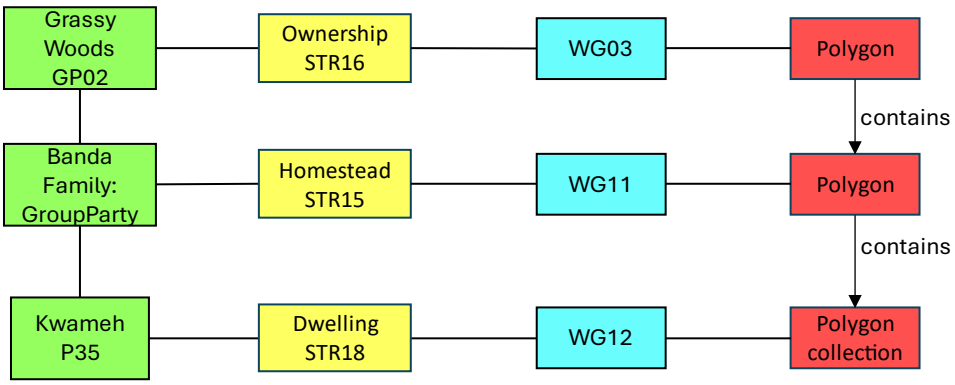


Figure 139. In STDM Parties are called Social Units. Here we visualize them as Party since they play the same role.

Instead of mapping spatial units visually in the community's land records spatial relations between spatial units and other features are recorded to give an indication of the location being described. In this case WG11 is noted to be located inside WG03. If it were to be mapped it would be mapped as a single polygon. WG12 would be mapped as a collection of polygons contained inside WG11. If we would extend the above diagram to contain all features relevant for describing the locations of objects inside Grassy Woods' land, we would show that WG03A touches the river and overlaps with the road segments RR120, RR122, and RC249.

Within STDM the community can record the valuation of forest WG03B by attaching a Social Market Value instance representing the possible market equivalent of the forest from the community's perspective. In this case, the community concludes that the forest is worth an infinite amount of any monetary medium because of its cultural significance. The forest serves as a source of medicinal trees and a place which holds the graveyard of the community.

In STDM Valuation information is attached directly to the Spatial Unit as shown in Figure 140. The community's valuation record is represented by the value instance SMV03.

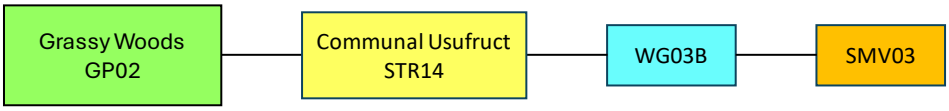


Figure 140. In STDM, land values are attached to Spatial Units.

As a final example of STR recordation Figure 141 shows that grazing rights are held on condition that one is a member of the community. Neighbours such as Njerura are allowed to pass through the pastures and let their livestock rest, graze, and drink briefly if their own homesteads and/or grazing grounds are considered to be located much further away.

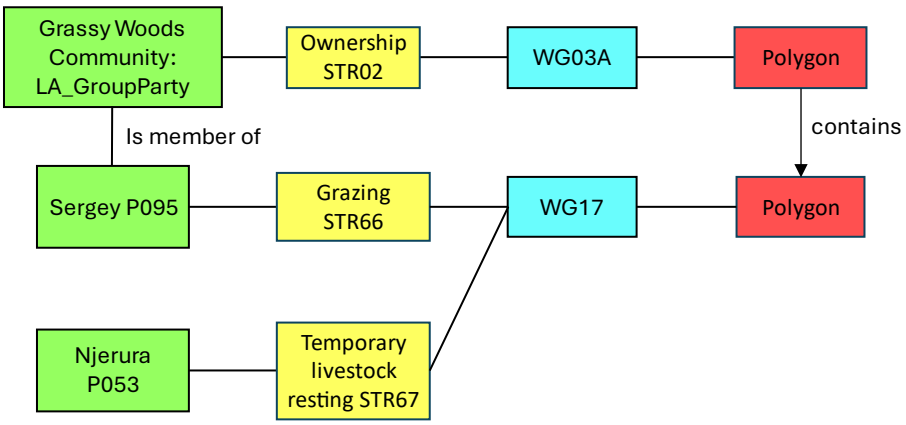
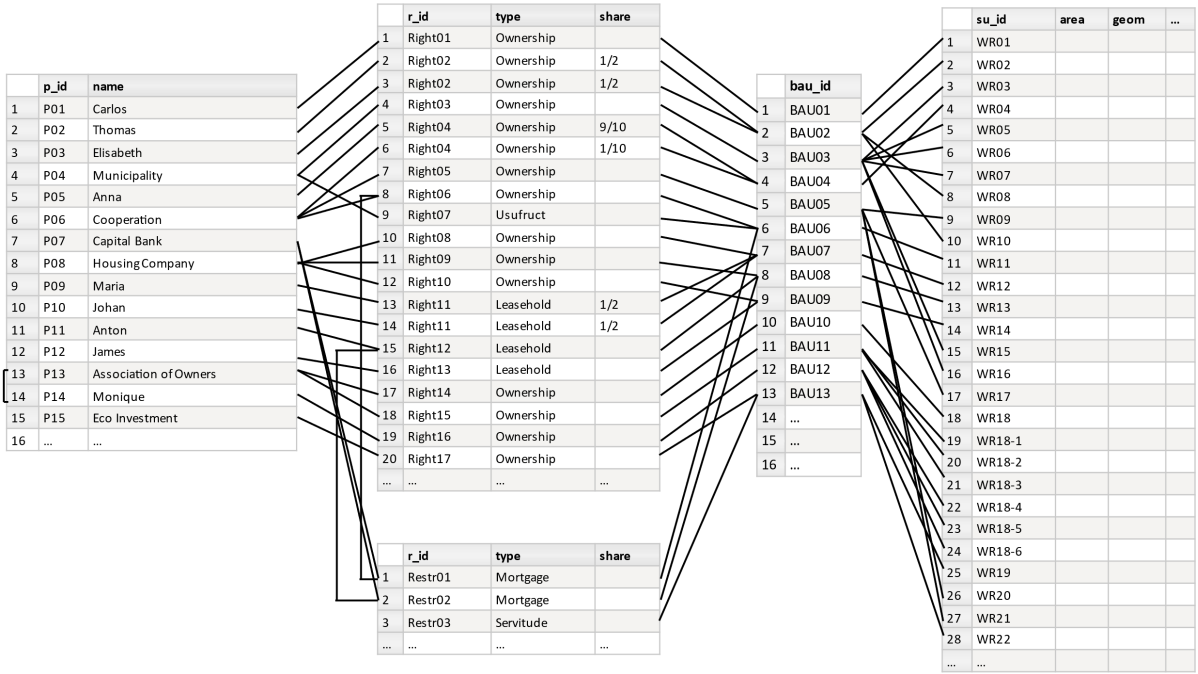


Figure 141. A wider variety of social tenure relations can be declared within the STDM model – e.g. a "Temporary Livestock Resting" right.

8. LADM in UMLs

8.1 Core Classes of LADM

The overview of data for Tenure Cases One till Nine from Chapter 4 as represented in the database have been presented and described in Figure 63, which is repeated here without caption.



	p_id	name
1	P01	Carlos
2	P02	Thomas
3	P03	Elisabeth
4	P04	Municipality
5	P05	Anna
6	P06	Cooperation
7	P07	Capital Bank
8	P08	Housing Company
9	P09	Maria
10	P10	Johan
11	P11	Anton
12	P12	James
13	P13	Association of Owners
14	P14	Monique
15	P15	Eco Investment
16	...	...

	r_id	type	share
1	Right01	Ownership	
2	Right02	Ownership	1/2
3	Right02	Ownership	1/2
4	Right03	Ownership	
5	Right04	Ownership	9/10
6	Right04	Ownership	1/10
7	Right05	Ownership	
8	Right06	Ownership	
9	Right07	Usufruct	
10	Right08	Ownership	
11	Right09	Ownership	
12	Right10	Ownership	
13	Right11	Leasehold	1/2
14	Right11	Leasehold	1/2
15	Right12	Leasehold	
16	Right13	Leasehold	
17	Right14	Ownership	
18	Right15	Ownership	
19	Right16	Ownership	
20	Right17	Ownership	
...	...	...	...

	r_id	type	share
1	Restr01	Mortgage	
2	Restr02	Mortgage	
3	Restr03	Servitude	
...	...	...	...

	bau_id
1	BAU01
2	BAU02
3	BAU03
4	BAU04
5	BAU05
6	BAU06
7	BAU07
8	BAU08
9	BAU09
10	BAU10
11	BAU11
12	BAU12
13	BAU13
14	...
15	...
16	...

	su_id	area	geom	...
1	WR01			
2	WR02			
3	WR03			
4	WR04			
5	WR05			
6	WR06			
7	WR07			
8	WR08			
9	WR09			
10	WR10			
11	WR11			
12	WR12			
13	WR13			
14	WR14			
15	WR15			
16	WR16			
17	WR17			
18	WR18			
19	WR18-1			
20	WR18-2			
21	WR18-3			
22	WR18-4			
23	WR18-5			
24	WR18-6			
25	WR19			
26	WR20			
27	WR21			
28	WR22			
...	...			

The LADM Core classes (or Basic Classes) are: LA_Party, LA_RRR, LA_BAUnit and LA_SpatialUnit. All classes in LADM have a prefix ”LA”. This prefix makes the class name unique in the ISO standardisation system. See Figures 142 and 143.

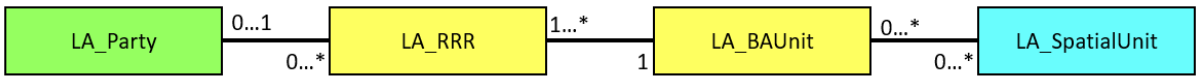


Figure 142. The LADM Core Classes – also called Basic Classes. The multiplicities between classes are represented.

A LA_Party may have zero or more rights, restrictions or responsibilities: LA_RRR’s. This means there can be LA_Party(ies) without LA_RRR’s. For example: this can be a LA_Party with a role in the transactions but without property rights.

A LA_RRR may have zero or one LA_Party. If there is no LA_Party related to a LA_RRR the LA_RRR is purely related to the land. Servitude is an example. See Restr03. If there is more then one LA_Party related to a LA_RRR the LA_RRR needs to be shared over several LA_Parties. There may be a requirement that the sum of shares in a right is equal to one.

A LA_RRR applies to exactly one LA_BAU, but a LA_BAU may be composed out of zero or more LA_SpatialUnits. A LA_BAUnit must have one or more LA_RRR's. Note: a LA_RRR must have one (and only one) BAUnit related. This allows (for example) tariffs per right type in a taxation cadaster. Different right types means different tariffs for different BAUnits – for example per municipality. See Figures 4 and 5 for an illustration of this.

A LA_BAUnit can have zero or more LA_SpatialUnits. There are zero spatial units (with geometry) if there is no cadastral map existing (there is no cadaster). In such a case there may be a land registry.

A LA_SpatialUnit may belong to zero or more LA_BAUnits. A spatial unit may be grouped in a property unit and at the same time (but in another way) in a taxation unit and in a spatial plan. This means there can be a land registry without a cadaster.

In the LADM standard the core classes are represented as in Figure 143. ISO identifies the First Edition of the LADM as ISO 19152:2012. This edition was published at 1 December 2012.

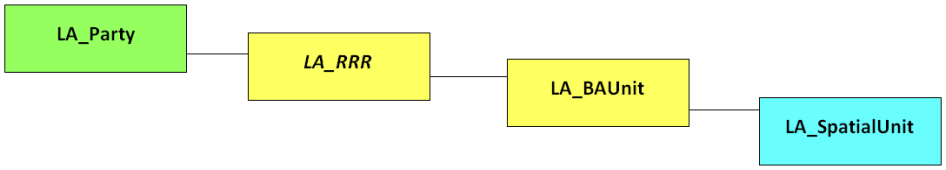


Figure 143. Core classes as represented in the ISO 19152 LADM Standard.

8.2 Special Classes

There are two special classes in the LADM: VersionedObject and LA_Source. Both VersionedObject and LA_Source are abstract classes. Their attributes are inherited by their specialisation classes.

In LADM an **object** is a right, restriction, responsibility, basic administrative unit, party, or spatial unit.

All LADM classes (except LA_Source) inherit from VersionedObject. VersionedObject contains attributes for history management: beginLifespanVersion and endLifespanVersion. Those attributes contain date and time of creation of an object and date and time of deletion respectively. Those attributes are introduced in the transactions (Transactio01 til Transaction Case Three).

Over time an object, for example a LA_Party, can have different ”versions” in the database. For example before a marriage there is no shared ownership, after marriage there is shared ownership. Note: versioning and identification are based on national or local approaches and defined in country or local LADM profiles.

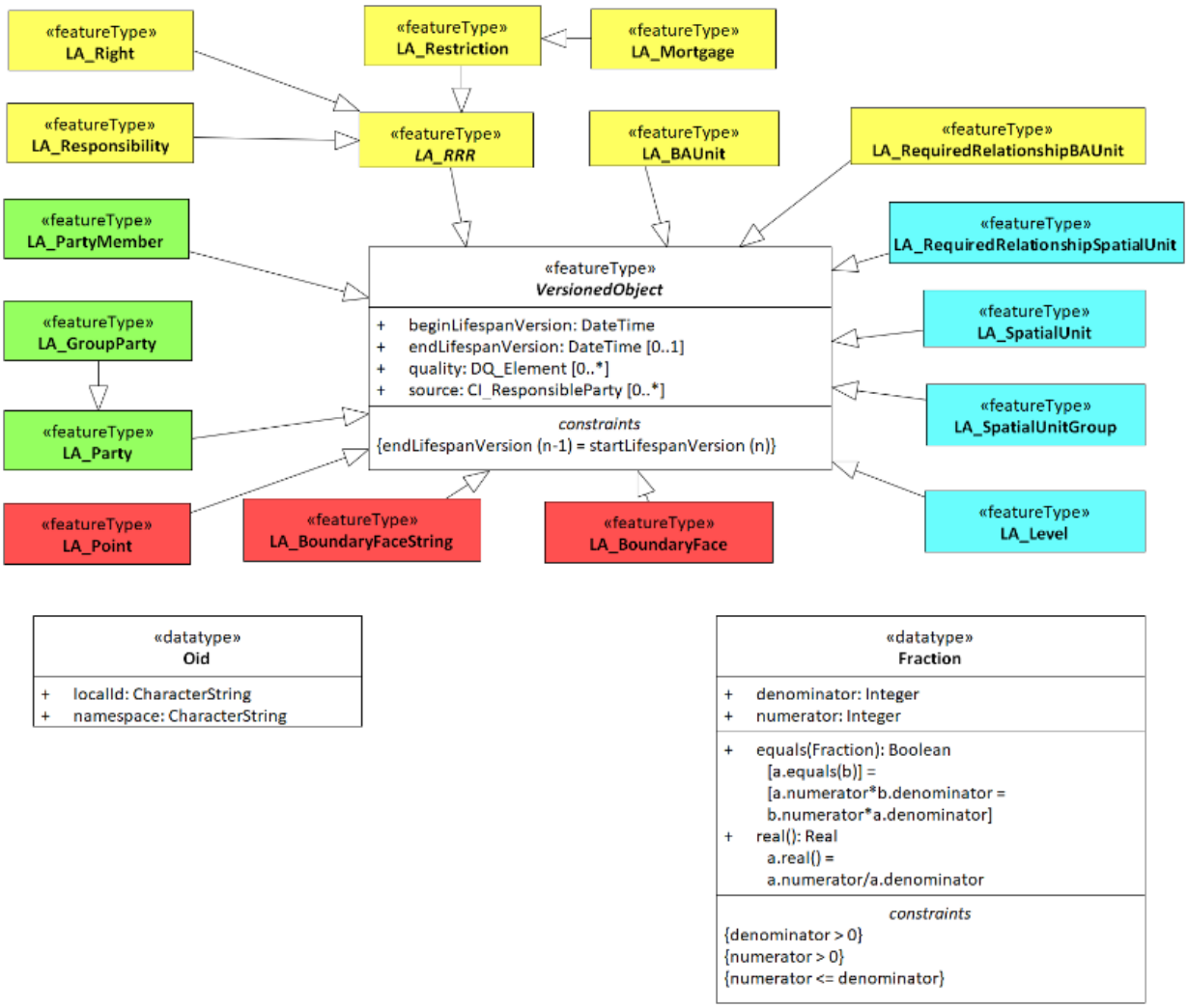


Figure 144. Class "Versioned Object" is an abstract class. Oid and Rational (fraction) are data types.

For each record there are also a quality label, that is the attribute ”quality”. And there is a reference to the responsible organisation – the ”owner” of the information on the record. This attribute is called ”source”. See Figure 144.

The generic data type Oid provides support in object identifiers. See Annex 1.

The generic data type fraction is introduced in the LADM to provide support for fractions, e.g. ½ or ¾. This is needed to represent shares in rights.

In the LADM, administrative sources and spatial sources are modelled, starting with an abstract class LA_Source. LA_Source has two subclasses: LA_AdministrativeSource, and LA_SpatialSource. Those classes inherit from LA_Source. See Figure 145.

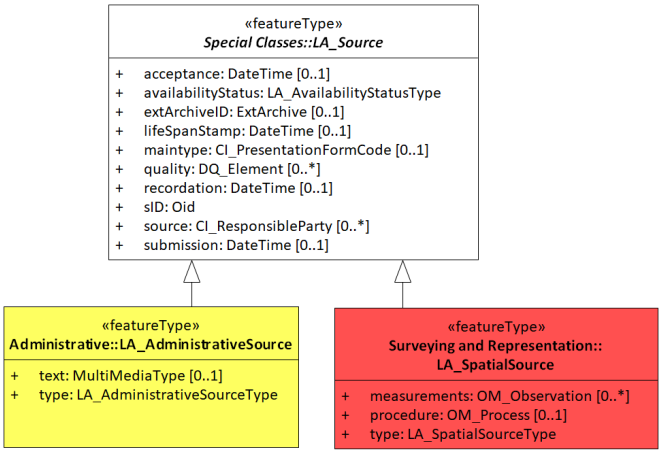


Figure 145. Class LA_Source with specialisations LA_AdministrativeSource and LA_SpatialSource.

In principle there will be no changes or updates in the database if those are not documented in a source. Each transaction in the land administration database is triggered by a source document, for example a deed.

A LA_Source is authentic and does not inherit from VersionedObject. Here below the complete set of attributes of Class LA_Source and its specialisations LA_AdministrativeSource, and LA_SpatialSource is presented.

Note: attributes are columns in database tables.

A **source** is a document providing legal and/or administrative facts on which the land administration object (that is right, restriction, responsibility, basic administrative unit, party, or spatial unit) is based.

Attributes of Class LA_Source are:

- ”lifeSpanStamp”, this is the moment that the event, represented by the instance of LA_Source, is further processed in the LA system (this is the moment of endLifespanVersion of old instances. And also the moment of beginLifespanVersion of new instances. This means the data and time of a database commit – where new objects are created with a beginLifespanVersion and old objects are placed in history with a endLifeSpanVersion in class VersionedObject and all classes inheriting from there (except LA_Source which is authentic). ”lifeSpanStamp” triggers the management of history for each transaction;
- ”extArchiveID”, the identifier of a source in an external organisation;

- ”maintype”, the type of document; and:
- ”sID”, source document identifier;

Some attributes of class LA_Source are transaction related. Those attributes concern the transaction in real time, not the database time:

- ”submission”, the date of submission of the source by a party;
- ”acceptance”, this the date of force of law of the source by an authority; and:
- ”recordation”, this is the date of registration (recordation) of the source by the registering authority. Informal rights are recorded, formal rights are registered

An **administrative source** is a source with the administrative description (where applicable) of the parties involved, the rights, restrictions and responsibilities created and the basic administrative units affected.

Attributes of Class LA_AdministrativeSource are:

- ”availabilityStatus”: ”converted”, ”destroyed”, ”incomplete”, ”unknown”, ”available”;
- ”text”, text of in the document; and:
- ”type administrative source”: deed, mortgage, title, etc;

A **spatial source** is a source with the spatial representation of one (part of) or more spatial units.

Attributes of Class LA_SpatialSource are:

- ”measurements”, survey observations (from another ISO standard);
- ”procedure”, from another ISO standard; and:
- ”type spatial source”, field sketch, GNSS survey, orthophoto, video, topMap, etc

8.3 Packages and Classes

LADM has three packages[4] and one subpackage related to:

- parties (people and organisations, classes in green)
- basic administrative units, rights, responsibilities, and restrictions (ownership rights, classes in yellow)
- spatial units (parcels, and the legal space of buildings and utility networks classes in blue), and:
- spatial sources (surveying), and spatial representations (geometry and topology, classes in red). This is a subpackage

Figure 146 shows the LADM class diagram with classes coloured by package.

[4] In LADM related classes are grouped into packages.

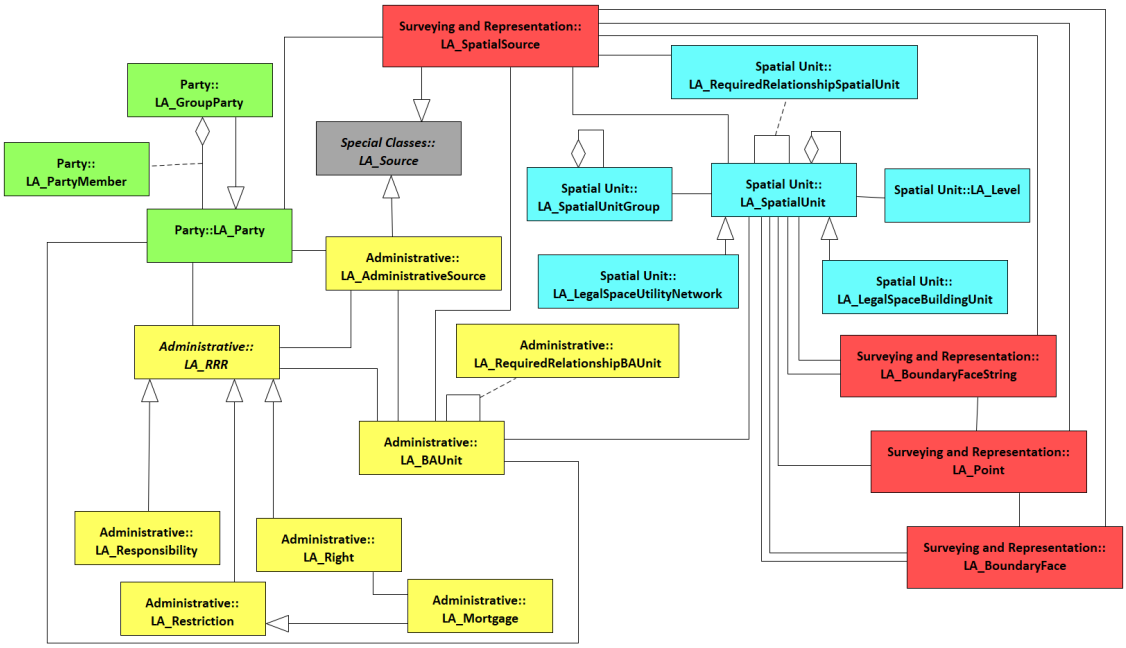


Figure 146. The Land Administration Domain Model: Class Diagram.

The main class of the party package (see Figure 147) of the LADM is class LA_Party with its specialisation LA_GroupParty. There is an optional association class LA_PartyMember.

A '**party**' is a person or organisation that plays a role in any land administration process

A '**group party**' is any number of parties, together forming a distinct entity, with each party registered

A '**party member**' is a party registered and identified as a constituent of a group party. This allows documentation of information to membership (holding shares in rights).

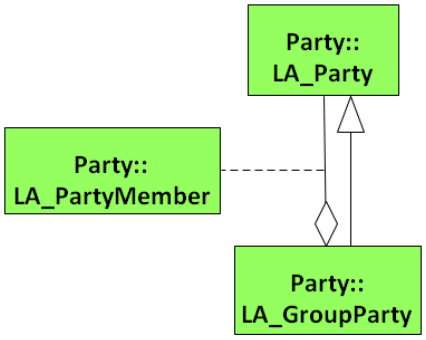


Figure 147. LADM Party Package.

The administrative package (see Figure 148) concerns the abstract class LA_RRR (with three subclasses ('specialisations'): LA_Right, LA_Restriction and LA_Responsibility), and class LA_BAUnit (Basic Administrative Unit).

A **'right'** is formal or informal entitlement to own or perform an action.

A **'restriction'** is a formal or informal obligation on the land owner to refrain from performing an action.

A **'responsibility'** is a formal or informal obligation on the land owner to allow or perform an action. Owner implies leaseholder, usufruct holder, etc.

A **'basic administrative unit'** is an administrative entity, which can be subject to registration (by law), or recordation (by informal right, or customary right, or another social tenure relationship), consisting of zero or more spatial units against which, one or more, unique and homogeneous rights, responsibilities or restrictions are associated to the whole entity, as included in a land administration system.

A 'basic administrative unit' may play the role of a 'party' because it may hold a right of easement over another, usually neighbouring, spatial unit.

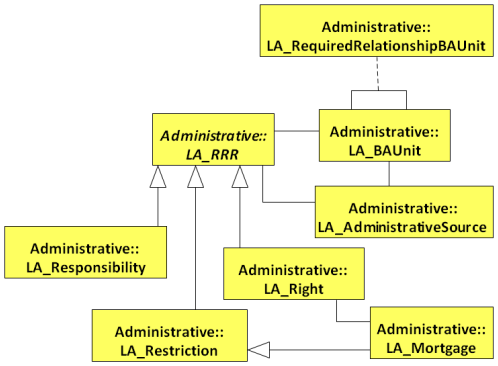


Figure 148. The LADM Administrative Package.

The spatial unit package (see Figure 149) concerns the classes LA_SpatialUnit, LA_SpatialUnitGroup, LA_Level, LA_AdministrativeSource, LA_LegalSpace Network, LA_LegalSpace-BuildingUnit and LA_Required RelationshipSpatialUnit (this class is not shown in Figure 149).

A 'Spatial unit' is feature type related to land administration with associated spatial and thematic attributes.

Single areas are the general case and multiple areas the exception. Spatial units are structured in a way to support the creation and management of basic administrative units.

A **'spatial unit group'** is a group of spatial units; e.g.: spatial units within an administrative zone (e.g. a section, a canton, a municipality, a department, a province or a country) or within a planning area.

A **'level'** is a collection of spatial units with a geometric and/or topologic and/or thematic coherence.

A **'utility network'** network describes the legal space of the topology of a utility. This is the legal space, not the physical cable or pipeline. To maintain the cable you need space.

A **'building unit'** is a component of a building, it is the legal, recorded or informal space of the physical entity.

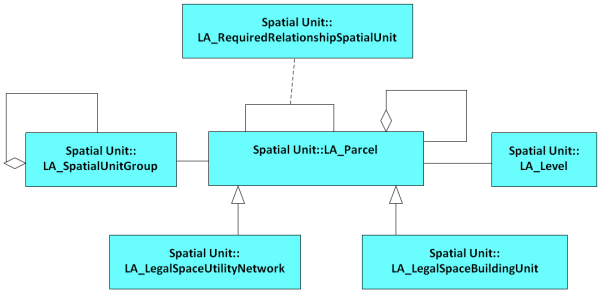


Figure 149. The LADM Spatial Unit Package.

The Spatial Unit Package has one Surveying and Representation Sub-package with classes such as LA_SpatialSource, LA_Point, LA_BoundaryFaceString and LA_BoundaryFace. See Figure 150.

A **'point'** is a 0-dimensional geometric primitive, representing a position. Points can be acquired in the field by classical surveys or with images. A survey is documented with spatial sources. A set of measurements with observations (distances, bearings, etc.) of points, is an attribute of LA_SpatialSource. LA_Point is associated to LA_SpatialSource.

2D and 3D representations of spatial units use boundary face string (2D boundaries implying vertical faces forming a part of the outside of a spatial unit) and boundary faces (faces used in 3D representation of a boundary of a spatial unit).

A **'boundary face string'** is a boundary forming part of the outside of a spatial unit.

A **'boundary face'** is a face that is used in the 3-dimensional representation of a boundary of a spatial unit.

Coordinates themselves either come from points or are captured as linear geometry.

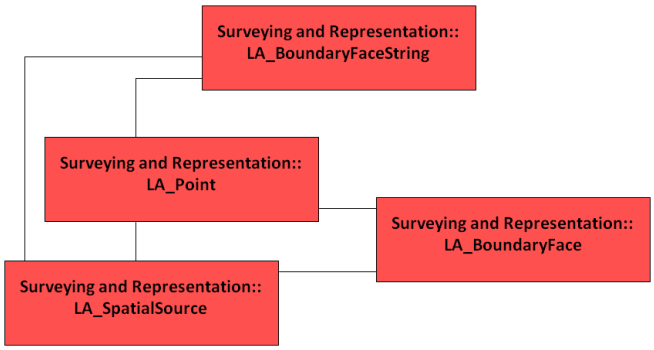


Figure 150. The Surveying and Representation Sub-Package.

8.4 Party Package

The party package is shown in Figure 151. The datatypes are behind the attribute name. This can be a character string, a boolean etc. If the attribute is of type “type” there is a code list.

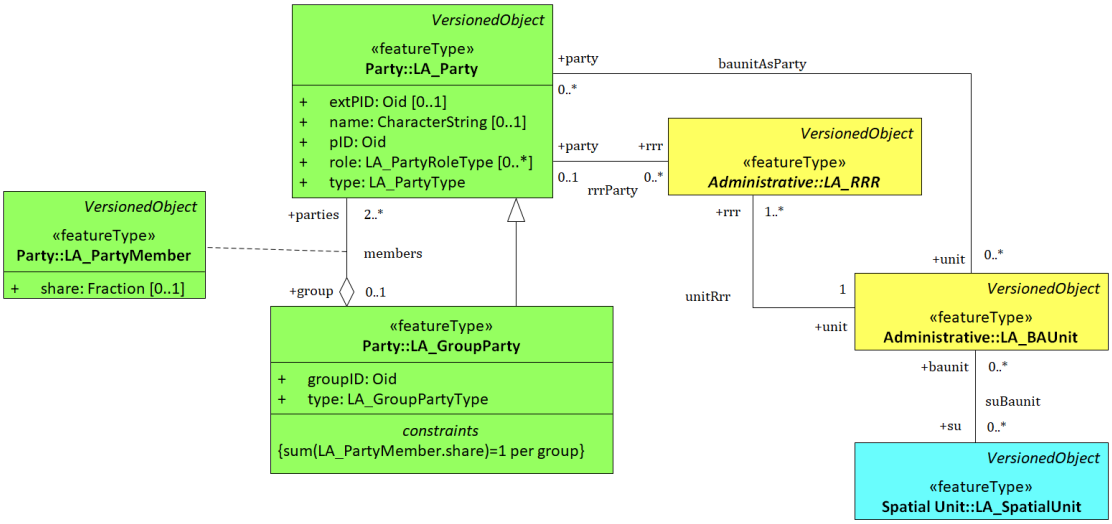


Figure 151. The PartyPackage in green, combined with the core classes LA_RRR (in yellow), LA_BAUnit (in yeloow) and LA_SpatialUnit (in blue).

Class LA_Party is a specialisation of class VersionedObject. See Figures 144 and 152.

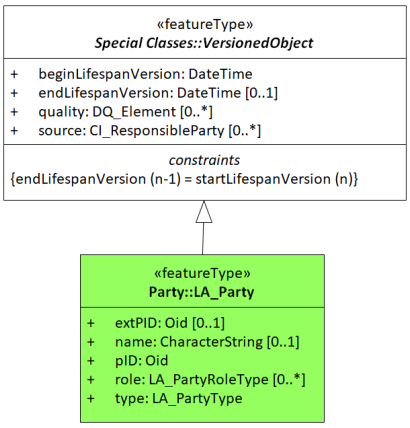


Figure 152. Class LA_Party is a specialisation of class VersionedObject.

VersionedObject is an abstract class. This means that LA_Party inherits from VersionedObject.

The attributes of VersionedObject are beginLifespanVersion, endLifespanVersion, quality and source.

Attributes of LA_Party are extPID, name, pID, role and type, see Figure 152.

The inheritance of attributes by LA_Party from VersionedObject means that all attributes from VersionedObject will be included in the Party table. See Figure 152. There can be more attributes from local or national LADM profiles.

	ext_id	name	p_id	role	type	Begin_Lifespan	End_Lifespan	quality	source
1	1	Carlos	P01	Citizen	NP				
2	2	Thomas	P02	Citizen	NP				
3	3	Elisabeth	P03	Citizen	NP				
4	4	Muni	P04	Government	NNP				
5	5	Anna	P05	Citizen	NP				
6	6	Cooper	P06	Cooperative	NNP				
7	7	Bank	P07	Money Prov	NNP				
8	...	...	...	...	...				

Figure 153. LA_Party implemented in a party table. LA_Party inherits attributes from VersionedObjects. In the database this means that the combined sets of attributes are represented in the party table.

Here below the complete set of attributes related to the classes in the party package is presented. Note: attributes are columns in database tables (See Figure 153).

Class LA_Party:

- ”extPID”, this is the identifier of the party in an external registration, for example the population register or the business register;
- ”name”, the name of the party, in accordance to local conventions for names of natural and non natural persons;
- ”pID”, this is the ID of the party;
- “role”, this is the role in which the party appears, for example citizen, conveyor, employee, farmer, surveyor, writer, bank, notary, etc. Note: a surveyor can also be a citizen as owner. Those are two roles. And:
- “type”, the type of party: group, natural person, non natural person or a governmental organisation

Class LA_GroupParty:

- ”groupID”, the identifier of a group party; and:
- ”type”, the type of a group party, for example a tribe, an association, a family. Note: those group parties are represented by a chief, a chair, a family head

Class LA_PartyMember:

- ”share”, the fraction of the whole. A LA_GroupParty can be with defined or undefined membership. Note: there can also be a share in a right on a BAUnit

The implementation of this data package results in the of tables as in Figure 154.

LA_GroupPart inherits from LA_Party, this means that a group party is a party.

Because of this inheritance the first five columns in the group party table are the same as the five columns in the party database.

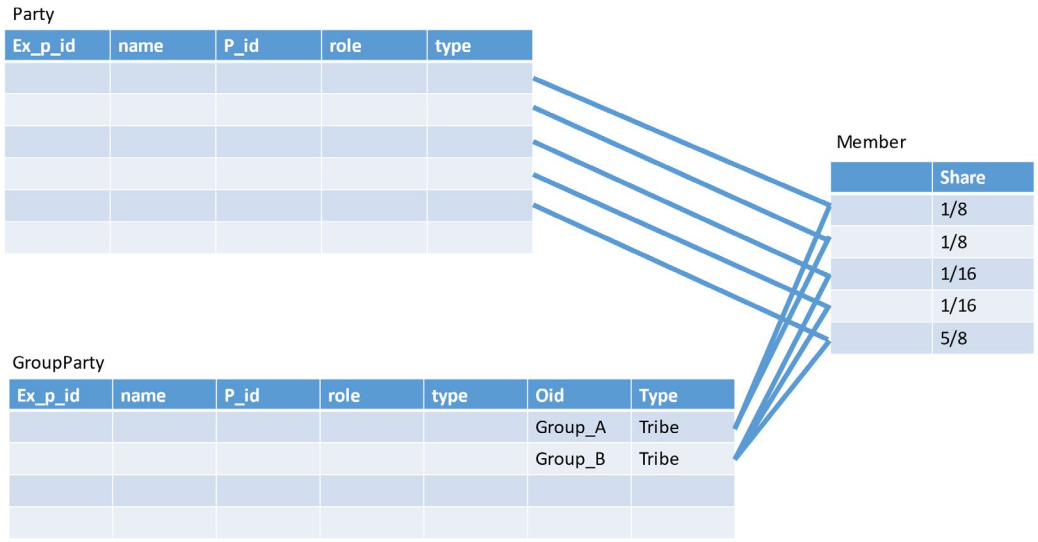


Figure 154. Implementation of the Party Package in the database.

8.5 Administrative Package

The Administrative Package with its classes, attributes and multiplicities is represented in Figure 155. All core classes are included, also the LA_Party class in green and the LA_SpatialUnit in blue.

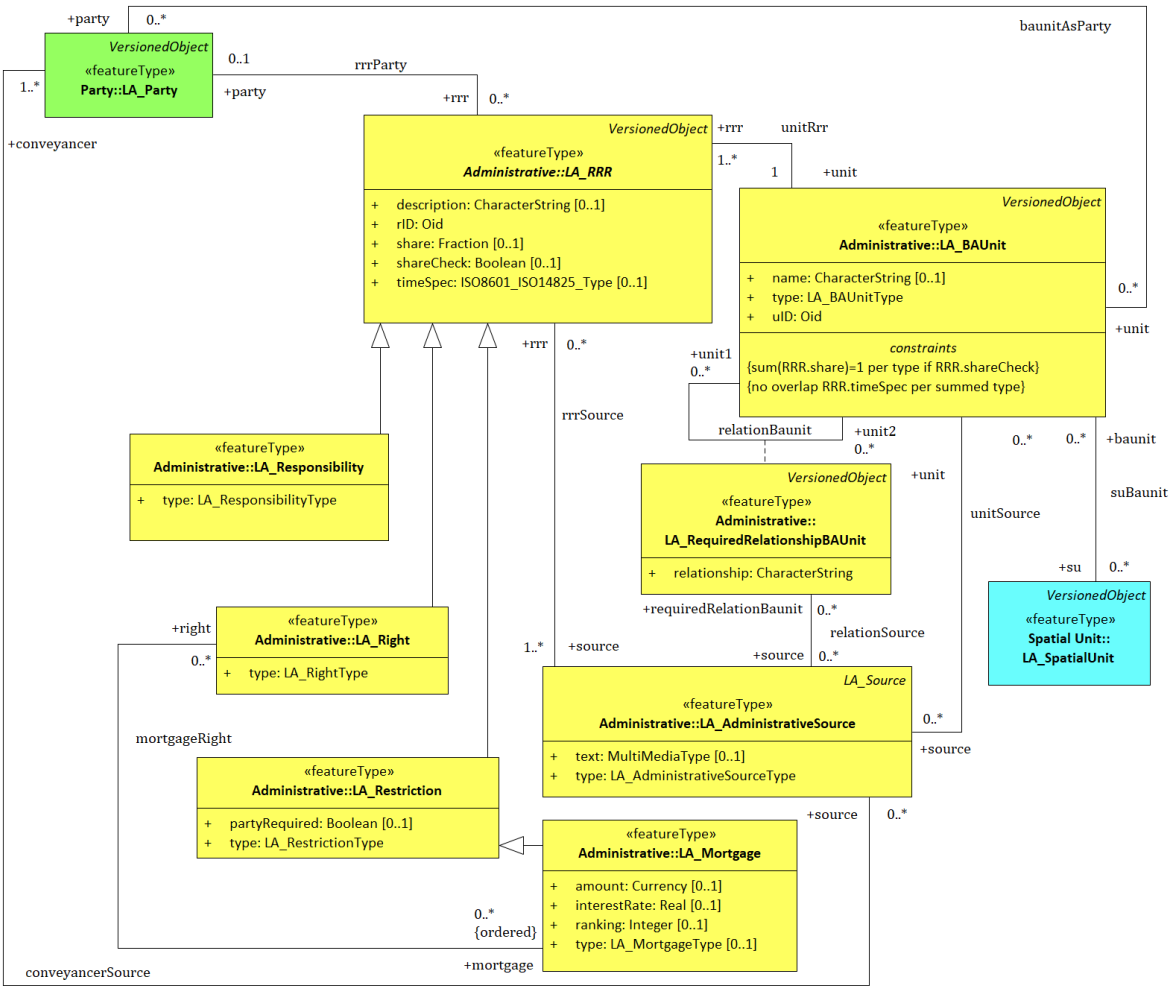


Figure 155. The LADM Administrative Package.

Here below the complete set of attributes related to the classes in the administrative package is presented. Note: attributes are columns in database tables.

Class LA_RRR:

- "description", description regarding the right, restriction or responsibility;
- "rID", the RRR identifier;
- "share", a share in an instance of a subclass of a LA_RRR;
- "shareCheck", indicates that sum of shares is equal to one, this is a constraint in class LA_BAUnit, see Figure 109; and:
- "timeSpec", operational use of a right in time sharing (for example: you're user/owner in May/June, there are other users/owners during the other months

Class LA_Right:

- "type", right type, this is country specific, can be for example: ownership, lease, occupation, usufruct, tenancy, informal occupation, fishing right, etc.

Class LA_Responsibility:

- “type”, responsibility type, this is country specific, can be for example: mandatory monument maintenance or waterway maintenance. If this maintenance is not done another organisation will do it on costs of the responsibility holder

Class LA_Restriction:

- “type”, restriction type, this is country specific, for example a restriction can be a monument where are kind of changes in the building are not allowed, servitude where

Class LA_Mortgage

- “amount”, the amount of money of the mortgage;
- “interestRate”, interest rate (percentage) of the mortgage;
- “ranking”, the ranking order of the mortgage if more than one mortgage applies; there can be a first mortgage, a second mortgage etc. as a restriction to right. In case the court decides that the money provider can sell the collateral the first mortgage prevails, then the second etc. And:
- “type”, mortgage type, this is country specific, for example: linear, micro credit

Class LA_BAUnit:

- “name”, the name of the Basic Administrative Unit, for example the farm name or the name of the locality;
- “type”, BAUnit type, this is country specific, for example basic property unit, leased unit, taxation unit (see Figure 109), right of use unit, spatial plan – reallocation;
- “uID”, the identifier of the basic administrative unit; and:

Class LA_RequiredRelationshipBAUnit:

- “relationship”, the description of the required relationship. This may be needed to connect historic versions of a BAUnit in time

An example of a set of basic administrative units for tax purposes is shown in Figure 156 below.

Party A owns two basic administrative units in different municipalities: Freetown and Waterriver. Party A leases one BAU in Waterriver. For the land tax there are different tariffs per municipality per right type.

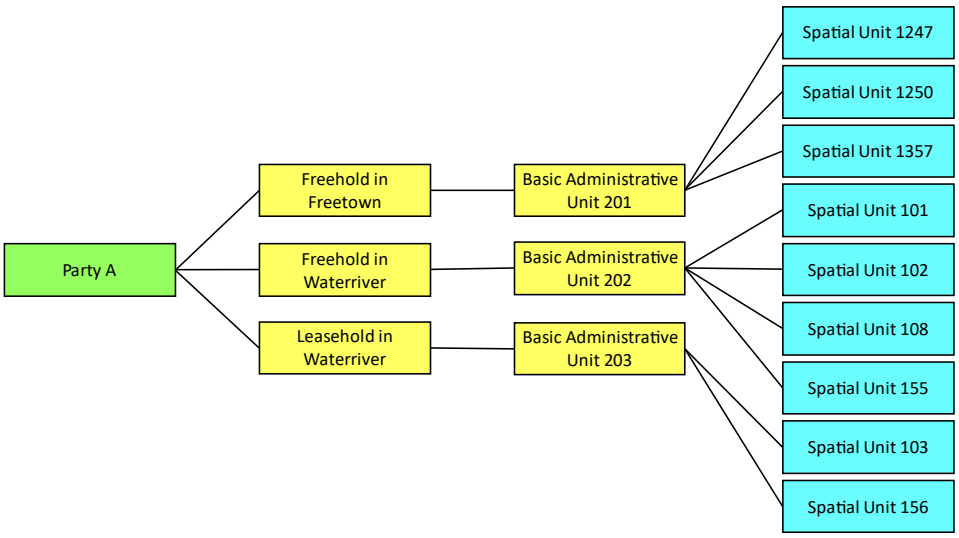


Figure 156. Three basic administrative units for taxation purposes.

8.6 Spatial Unit Package

The Administrative Package with its classes, attributes and multiplicities is represented in Figure 157. All core classes are included, also the LA_Party class in green, and LA_RRR and LA_BAUnit in yellow.

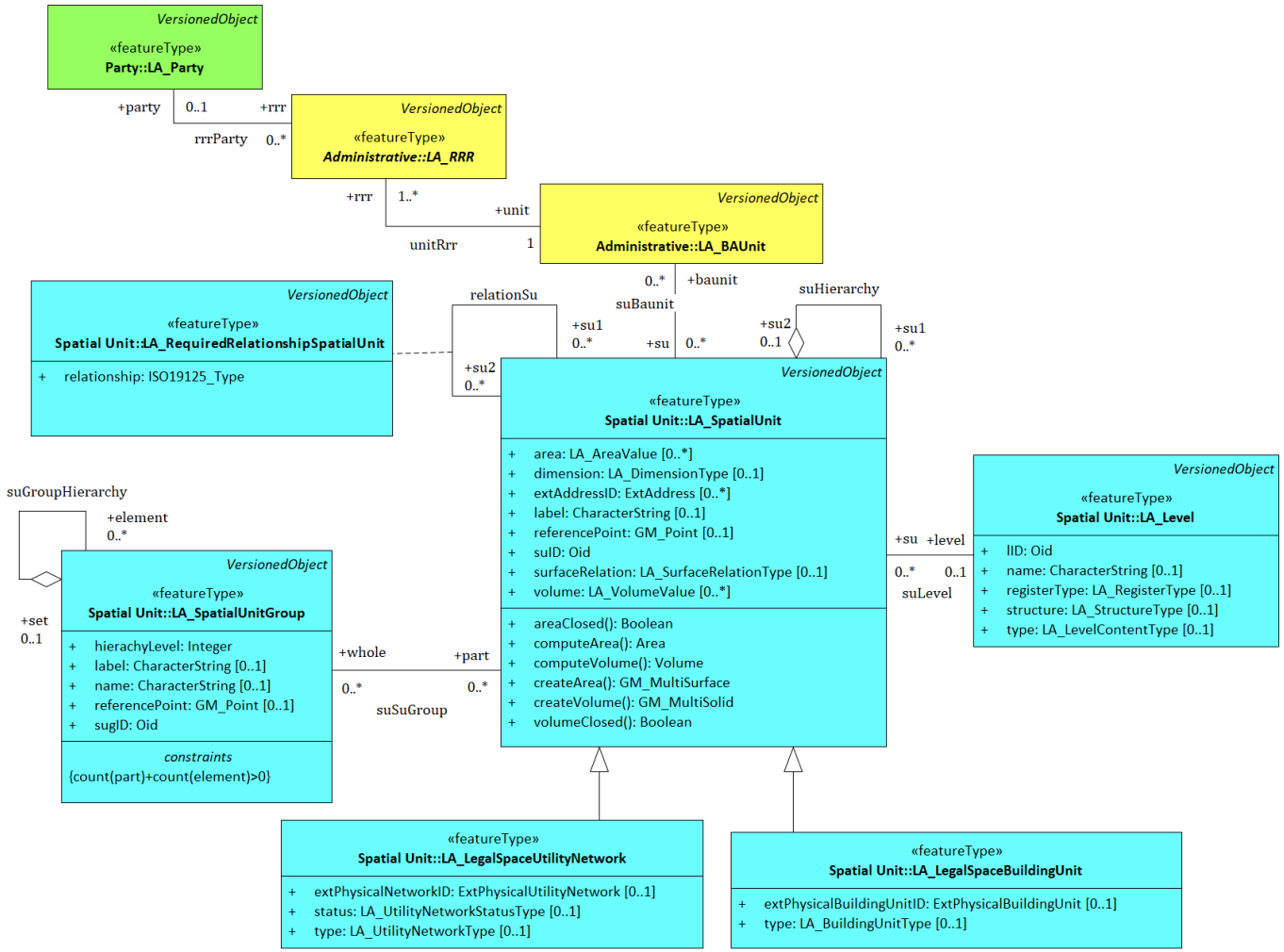


Figure 157. The LADM Spatial Unit Package.

Here below the complete set of attributes related to the classes in the spatial unit package is presented.

Note: attributes are names of columns in database tables.

Class LA_SpatialUnit:

- “extAddressID”, this is the link to external address(es) of the spatial unit. Spatial units can be used as references in many applications also applications in other organisations
- “area”, the area of the 2D spatial unit. There can be more then one area, for example legal area and calculated area or calculated area after conversion
- “dimension”, the type of dimension is 0D (point), 1D (line), 2D, 3D, liminal (this is a spatial unit on the threshold between 2D and 3D representations)
- “label”, short textual description of the spatial unit
- “referencePoint”,
- “suID”, the identifier of the spatial unit,
- “surfaceRelation”, this attribute indicates whether a spatial unit is above or below surface, and:
- “volume”, the volume of the 3D spatial unit

Methods in Class LA_SpatialUnit are:

- “areaClosed” checks if associated spatial representation is closed (2D),
- “volumeClosed” checks if associated spatial representation is closed (3D),
- “computeArea” computes area of associated spatial representation (2D),
- “computeVolume” computeVolume( )’ computes volume of associated spatial representation (3D),
- “createArea” constructs geometric primitive of type GM_MultiSurface based on associated spatial representation (2D), and
- “createVolume” constructs geometric primitives of type GM_MultiSolid based on associated spatial representation (3D).

Class LA_SpatialUnitGroup:

- “hierarchyLevel”, the level in the hierarchy of an administrative or zoning subdivision. The can be a group of spatial units (for example a section) or a group of groups of spatial units (for example a municipality) or a group of groups of groups of spatial units (for example a province). Three levels is hierarchy,
- ”label” is a short textual description of the spatial unit group,
- ”name” is the name of the spatial unit group, a spatial unit can be related to more then one spatial group,
- ”referencePoint” the coordinates of a point within the spatial unit group, this is for example for GIS applications, and:
- ”sugID” is the identifier of the spatial unit group.

Class LA_LegalSpaceBuildingUnit:

- ”extPhysicalBuildingUnitID”, this is the identifier of the building unit in an external database, and:

- ”type”, the type of the building unit. This type can be ”shared” or ”individual”. Common ownership or individual ownership in an apartment building

Class LA_LegalSpaceUtilityNetwork:

- ”extPhysicalUtilityNetworkID”: A reference to the physical (technical) description of the utility network;
- ”status”: the status of the utility network, this can be ”in use”, ”out of use”, ”planned”, and:
- ”type”: the type of the utility network, can be for example: chemicals, electricity, gas, heating, oil, telecom, water, etc,

Class LA_Level:

- “lID”: the identifier of the level,
- “name”: the name of the level,
- “registerType” – for example: “urban”, “rural”, “mining”, “public space”, “forest”, “all”. Different types of cadaster’s all structured in LADM can be interoperable
- “structure” is the structure of the level geometry – this can be point, polygon, text, topological, unstructured lines, and sketch. Different types of geometry per level, there can be a development path to well structured topology,
- “type” is the type of content of the level, for example: buildings, customary, mixed, network, primaryRight, responsibility, restriction, informal, etc,

Class LA_RequiredRelationshipSpatialUnit:

- “relationship” is the description of the required relation

8.7 Surveying and Representation Subpackage

The Surveying and Representation Sub package with its classes, attributes and multiplicities is represented in Figure 158. All core classes are included, also the LA_Party class in green, and LA_RRR and LA_BAUnit in yellow.

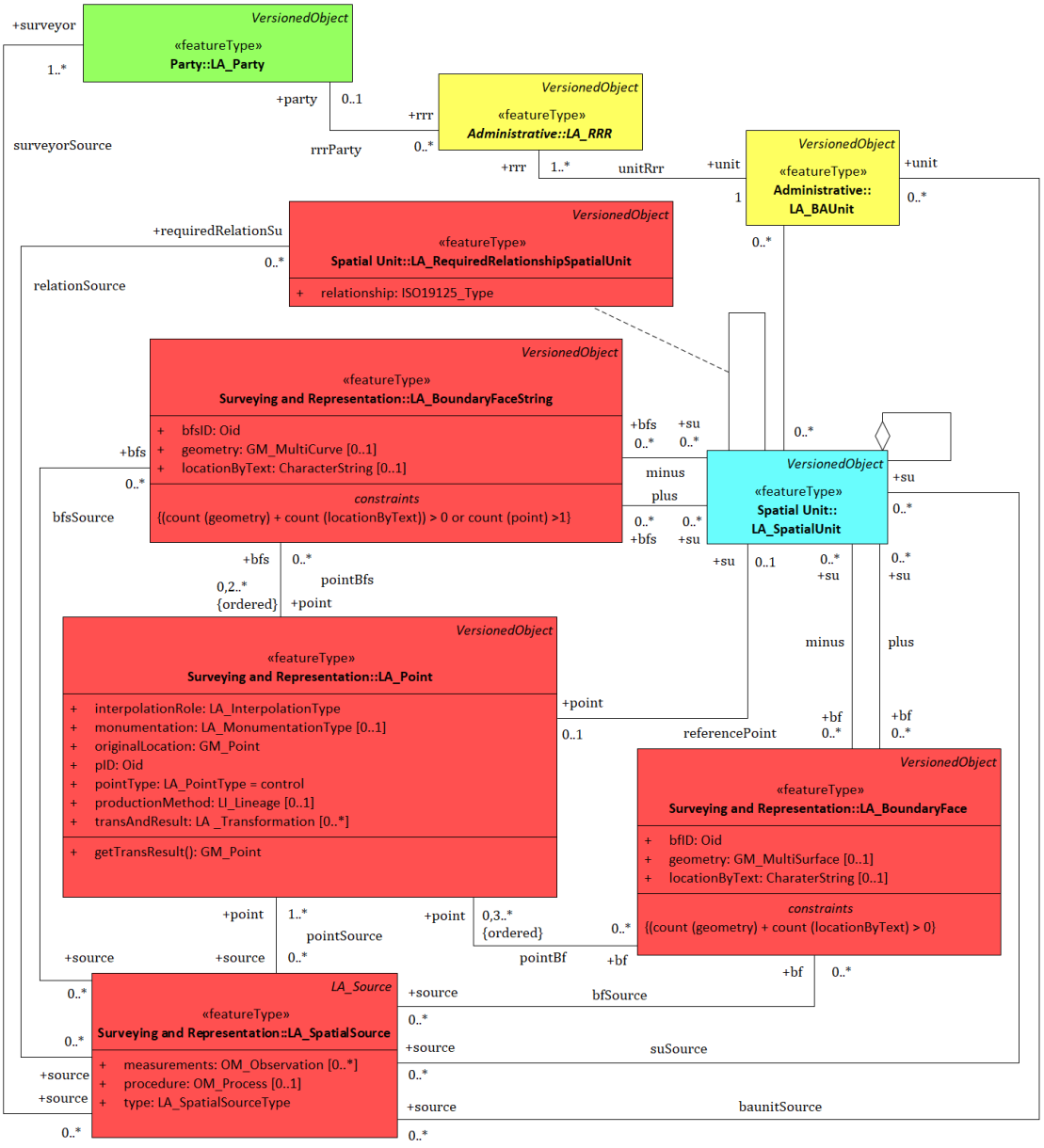


Figure 158. LADM Surveying and Representation Subpackage combined with LADM Core Classes.

Here below the complete set of attributes related to the classes in the surveying and representation subpackage is presented. Note: attributes are columns in database tables.

Class LA_Point:

- ” estimatedAccuracy” is the estimated accuracy of the point;
- ” interpolationRole” the role of the point in the structure of a straight line or curve, this can be for example ”end”, ”isolated”, ”mid”, ”midArc”, ”start”;
- ” monumentation”, this is the type of monument of a boundary point placed in the field by the surveyor, for example: ”beacon”, ”cornerstone”, ”marker”, ”not marked”, ”chip”;

- ”originalLocation”, those are the calculated coordinates, based on measurements and observations in the field;
- ” transAndResult”: this is the transformed and adjusted version of the coordinates based on the original field observations;
- ” ID”, this is the point identifier;
- ”pointType: the type of point, e.g. control point, no source, source; and:
- ” productionMethod” Lineage – derived from another standard,

Class: LA_BoundaryFaceString:

- ” bfsID” this is the boundary face string identifier;
- ”geometry: the boundary represented via a curve at ground level; and:
- ”locationByText” this is the boundary represented in text: from the path north to the church walk twenty five steps to the oak tree,....”

Class: LA_BoundaryFace:

- ”bfID” is the boundary face identifier;
- “geometry” is the boundary represented via a surface in 3D; and:
- ”locationByText: the boundary represented in text;

8.8 Code lists

If an attribute is of a certain “type” it means there are different values possible. Those values are represented in code lists. If one value is valid for an object the other values in the code lists are not valid.

For code lists in LADM see Figures 159, 160, 161 and 162.

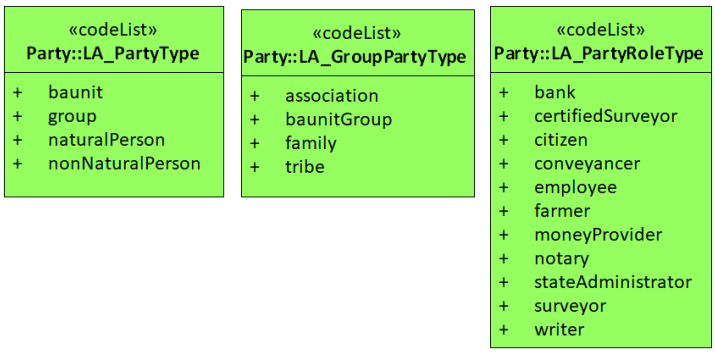


Figure 159. Code lists for Party Package.

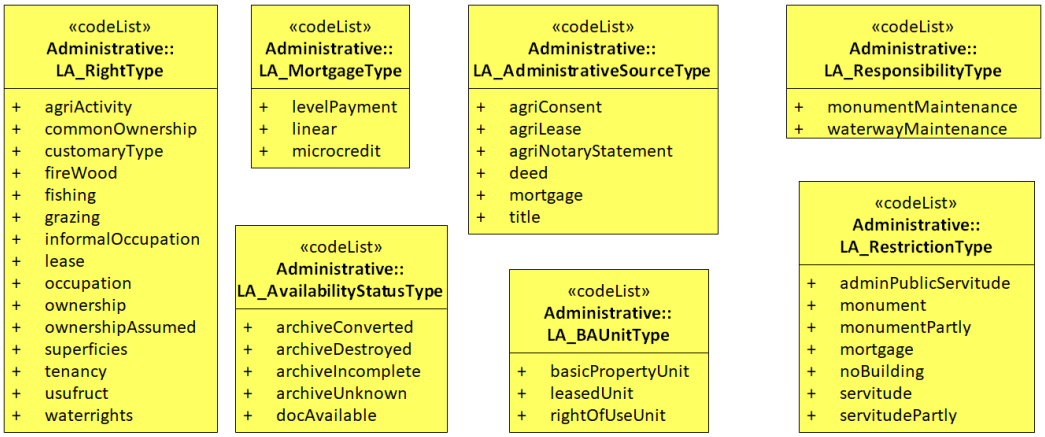


Figure 160. Code lists for Administrative Package.

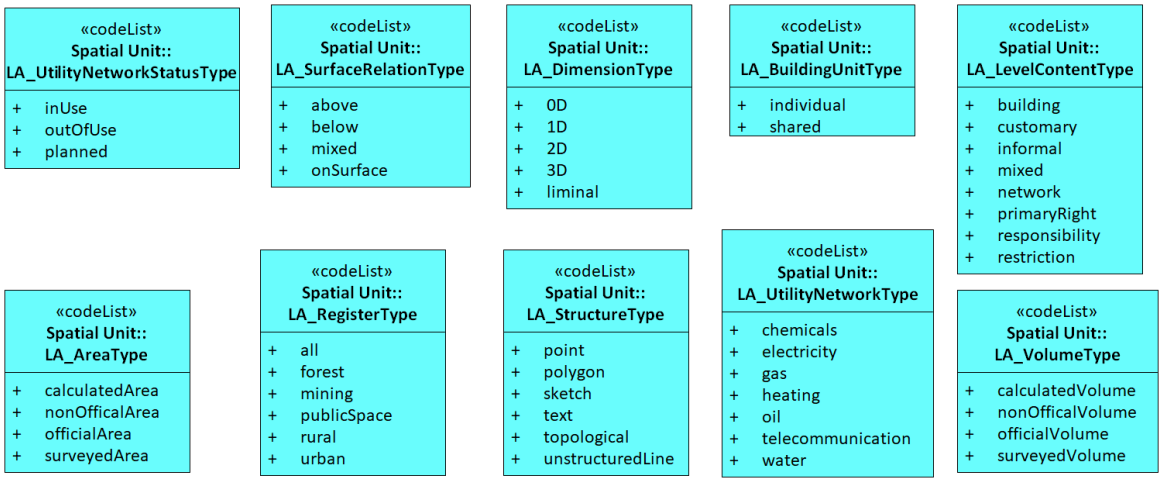


Figure 161. Code lists for Spatial Unit Package.

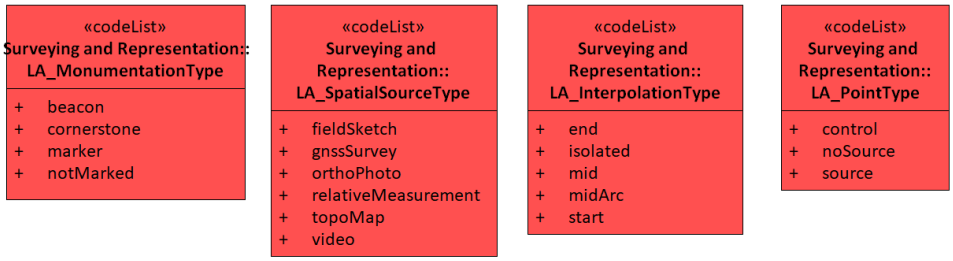


Figure 162. Code lists for Surveying and Representation Subpackage.

8.9 External links (databases)

The construction of external databases with party data, address data, taxation data, land use data, land cover data, valuation data, physical utility network data, and archive data, is outside the scope of the LADM.

However, the LADM provides placeholder classes for these data sets, which indicate what data set elements the LADM expects from these external sources, if available.

See Figure 163. External classes may be included in other ISO standards available or under development. Valuation and land use information are under LADM Edition II which is under development.

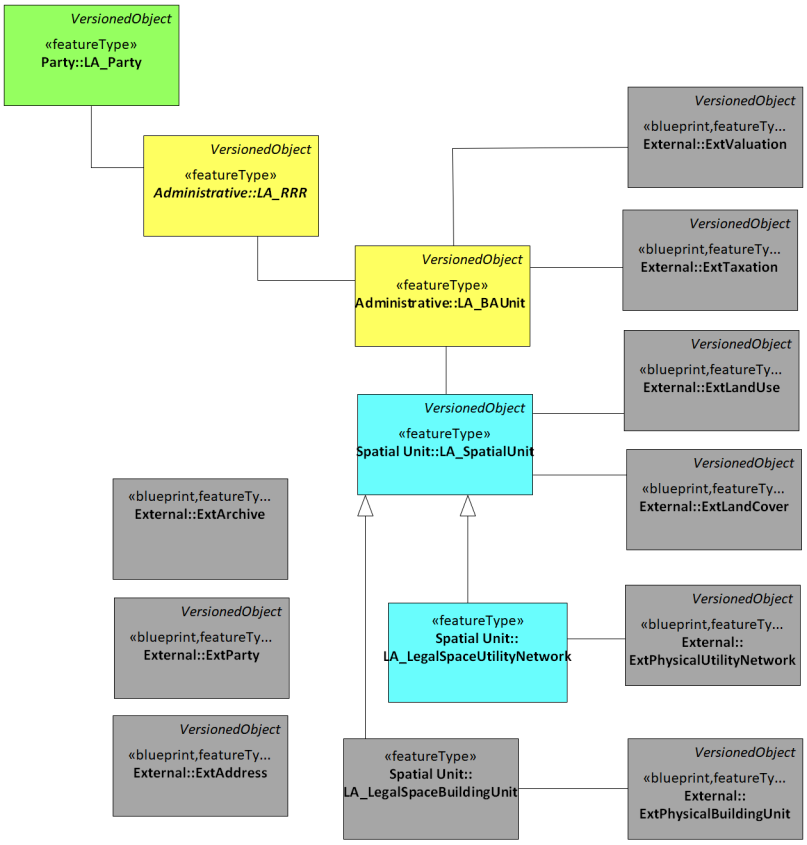


Figure 163. External links.

8.10 Multiplicities

Table 1 below provides an overview of multiplicities related to associations in LADM.

Table 1. Associations and multiplicities between LADM classes.

Class 1[a]	Class 2[a]	Association name	Role name End 1	Multi-plicity	Role name End 2	Multi-plicity
AdministrativeSource	BAUnit	unitSource	source	0..*	unit	0..*
AdministrativeSource	Party	conveyancerSource	source	0..*	conveyancer	1..*
AdministrativeSource	RRR	rrrSource	source	1..*	rrr	0..*
AdministrativeSource	RequiredRelationship-BAUnit	relationSource	source	0..*	required RelationBaunit	0..*
BAUnit	BAUnit	relationBaunit	unit1	0..*	unit2	0..*
BAUnit	RRR	baunitRrr	unit	1	rrr	1..*
BoundaryFace	SpatialSource	bfSource	bf	0..*	source	0..*
BoundaryFace	SpatialUnit	minus	bf	0..*	su	0..*
BoundaryFace	SpatialUnit	plus	bf	0..*	su	0..*
BoundaryFaceString	SpatialSource	bfsSource	bfs	0..*	source	0..*
BoundaryFaceString	SpatialUnit	minus	bfs	0..*	su	0..*
BoundaryFaceString	SpatialUnit	plus	bfs	0..*	su	0..*
Mortgage	Right	mortgageRight	mortgage	0..*	right	0..*
Party	BAUnit	baunitAsParty	party	0..*	unit	0..*
Party	GroupParty	members	parties	2..*	group	0..1
Point	BoundaryFace	pointBf	point	0,3..*	bf	0..*
Point	BoundaryFaceString	pointBfs	point	0,2..*	bfs	0..*
RRR	Party	rrrParty	rrr	0..*	party	0..1
SpatialSource	BAUnit	baunitSource	source	0..*	unit	0..*
SpatialSource	Party	surveyorSource	source	0..*	surveyor	1..*
SpatialSource	RequiredRelationship-SpatialUnit	relationSource	source	0..*	required RelationshipSu	0..*
SpatialSource	Point	pointSource	source	0..*	point	1..*
SpatialUnit	BAUnit	suBaunit	su	0..*	baunit	0..*
SpatialUnit	Level	suLevel	su	0..*	level	0..1
SpatialUnit	Point	referencePoint	su	0..1	point	0..1
SpatialUnit	SpatialSource	suSource	su	0..*	source	0..*
SpatialUnit	SpatialUnit	relationSu	su1	0..*	su2	0..*
SpatialUnit	SpatialUnit	suHierarchy	su1	0..*	su2	0..1
SpatialUnit	SpatialUnitGroup	suSuGroup	part	0..*	whole	0..*
SpatialUnitGroup	SpatialUnitGroup	suGroupHierarchy	element	0..*	set	0..1

[a] The LA prefix of class names has been omitted due to space reasons.

9. LADM Editions

LADM Edition I was published in 2012 (ISO, 2012).

ISO TC211 on Geographic information/Geomatics has decided to revise the LADM. This is an opportunity to further develop LADM with new, additional functionalities, such as: a refined (3D) survey and legal model, semantically rich code lists, marine space geo-regulations, valuation information, spatial plan information. Combined with land registration this forms the backbone of a nations land information infrastructure.

In Edition II there will be attention to LADM implementation aspects, which can be done in various ways, and various platforms and encodings can be used.

The TC 211 is developing this new edition of the LADM as multipart. This was agreed in a Stage 0 document. The general title of the new edition will be 'Geographic information — Land Administration Domain Model (LADM)', consisting of the following six parts:

- Part 1 – Generic Conceptual Model. This part provides the scope and definitions, a general overview of the model, its core classes and its individual packages and a more detailed overview of the LA_Source and VersionedObject classes,

- Part 2 – Land Registration. This part introduces the Land Registration Standard including a refined Survey and Representation package with a range of measurement techniques. It further includes updates around the functionality published in Edition 1 of the LADM,

- Part 3 – Marine Space Georegulation. This part is based on IHO's S121 standard: Maritime Limits and Boundaries,

- Part 4 – Valuation Information. This part specifies the characteristics and semantics of data in valuation registries maintained by public authorities,

- Part 5 – Spatial Plan Information. This includes planned land use (zoning) to be converted into rights, restrictions and responsibilities (RRR), and:

- Part 6 – Implementations. This part will address a range of topics needed for implementations of LADM: developing a country profile, modelling processes/ workflows, and encodings.

References

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UN ECE (2004) Real Property Units and Identifiers. United Nations, Economic Commission for Europe https://unece.org/fileadmin/DAM/env/documents/2005/wpla/Guidelines_On_Real_Property_Identifiers.pdf

Zevenbergen, Jaap and Erik Stubkjær TS11.4 Real Property Transactions: Challenges of Modeling and Comparing From Pharaohs to Geoinformatics FIG Working Week 2005 and GSDI-8 Cairo, Egypt April 16-21, 2005

Annex 1: Identifiers

In LADM all information is versioned and identified by a unique identifier. The generic data type Oid provides support in object identifiers. Note: this is not about internal database identifiers. The following attributes are data types with value Oid:

- sID: the identifier of the source
- pID: the identifier of the party
- groupID: the identifier of the group party
- uID: the identifier of the basic administrative unit
- rID: the RRR identifier
- suID: the spatial unit identifier
- lID: the identifier of the level
- pID: the point identifier
- bfsID: the boundary face string identifier
- bfID: the boundary face identifier

In the country profile there needs to be attention for identification. In most cases the identifiers can be generated automatically.

For parties a national identification number or national identity numbers can be used. There are many options.

Every basic administrative unit and spatial unit (parcel) recorded within a cadastre or land registry must have an identifier.

The establishment of nationwide unique identifiers for basic administrative units and spatial units is an effort and is usually based on the advice of a national committee of experts.

UNECE (2004) provides a comprehensive set of guidelines. Note: this Annex is based on (UNECE, 2004). See also (IAAO, 2015). See Figure 164.

Parcel identifiers need to be (UNECE, 2004):

- unique so that no two properties or parcels have the same reference. There must be a one-to-one correspondence between what is on the ground and what is on the registers and vice versa
- easy to understand so that there is little confusion and little likelihood of making mistakes. It is, for example, easy to misread numbers that are otherwise meaningless
- easy to remember so that landowners can correctly recall the identity of their properties
- easy to use both by the general public and by the cadastral and land book administration. They should also be easy to use by computer although how the computer handles any digital records internally is of no concern to the landowner and will depend on the database structure that has been adopted
- permanent so that the reference does not change unless the real property is to be subdivided
- capable of being updated when subdivision arises or when adjoining properties are amalgamated
- suitable for referencing plots within parcels
- flexible so that they can be used for a variety of purposes within and outside land administration, for example within local government
- economic to introduce and cheap and easy to maintain.
- able to support archiving and permit historical review so that it is possible to determine who was the owner of a certain real property on a certain date in the past.
- maintained by one responsible legal authority
- independent of parcel attributes that can be changed by other responsible authorities (such as postcodes)

Figure 164. Guidelines for the development of identifiers for BAUnit's and Spatial Units (UNECE, 2004).

In many cases the parcel identification is related to the administrative subdivision of a country with nationwide unique codes for states, provinces, departments, municipalities. This is followed by codes for cadastral units as sections, cantons or blocks and then a sequential number inside. See examples in Figure 165. This concerns country examples for identification of BAUnits and spatial units (UNECE, 2004).

Note: if the numbering is organised per project or per municipality then a unique project code or municipality code should be included. It is also possible to use a generated meaningless code that is nationally unique.

AUSTRIA (and similarly in CROATIA)

Parcel ID: 20018-123/23 (Cadastral unit identifier plus the number of the parcel. The Cadastral unit identifier consists of five digits: provincial code (first digit); competent district court (second and third digit); and cadastral unit (last 2 digits). The codes remain unique keys in the sense of a database system even when mergers of administrative offices occur.)

DENMARK

The Danish cadastral identifier is a compound of a number and small letters, like 2df. Each parcel has a unique number within a specific defined area. Prior to April 2001, the same number could be attached to several parcels within the same area, but now each parcel must have a unique number within a specific defined area. The numbering system does not apply to all parts of Denmark for historical reasons.

FINLAND

BAUnit ID: 123-223-3-44 (Municipal code, location code, group code (block or house), unit code (lot or register unit.)

GREECE

Parcel ID: 22-333-22-22-333 (Prefecture (2 digits)-municipality (3)-cadastral sector (2)-cadastral section (2)- parcel (3).)

LATVIA

Parcel ID: 01000030002 (0100 = code of cadastral territory; 003 = code of cadastral group; 0002 = unique number in cadastral group (from 0001 - 9999).)

LITHUANIA

Parcel ID: 4400-0004-4230 (the unique code) (Each land parcel has a unique number consisting of 12 digits including 1 control number. The digits have no special significance.) Cadastral address: 5203/0003:4 (5203 = code of cadastral unit; 0003 = code of block; 4 = parcel number in the block (unique within the block).)

RUSSIAN FEDERATION

Parcel ID: 50:13:03:001 is the first parcel in cadastre block 3 in Chimki rayon (13 = the number of the cadastre rayon) in Moscow region (50 = number of cadastre okrug).

SWEDEN

Parcel ID: Haninge Svartsö 3:49 where the municipality, township or village is named, followed by the block number and BAUnit number

Figure 165.. Country examples for identification of BAUnits and spatial units (UNECE, 2004).

Identifiers can be numbered sequentially per cadastral unit as a section, canton or block. See Figure 166 to the left. Another approach is to use the X,Y of the centroid, see Figure 166 to the right.

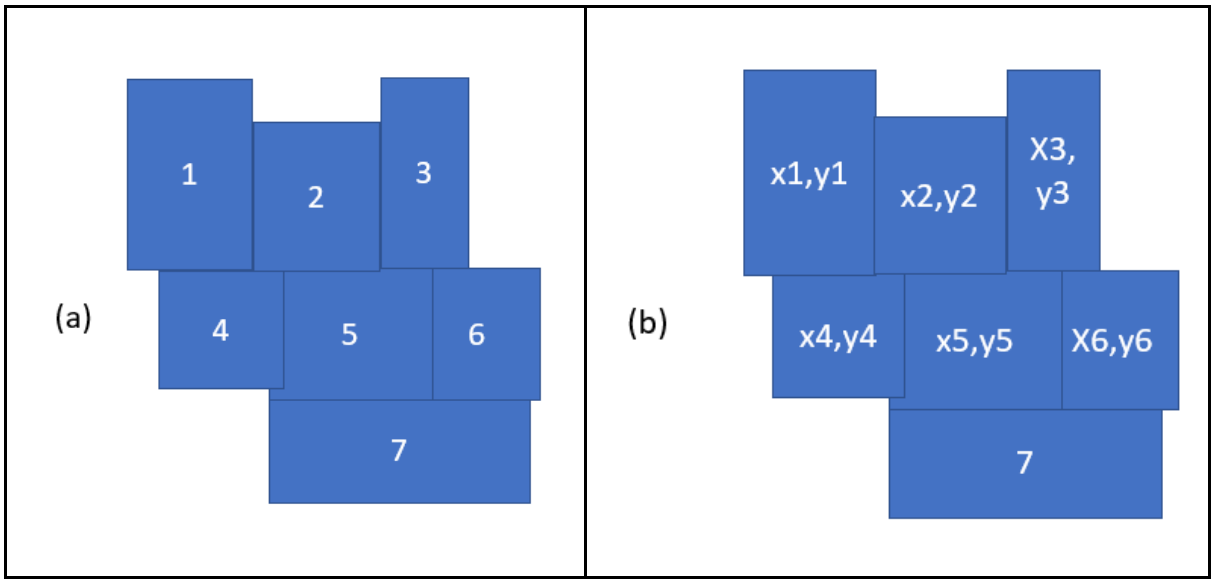

Figure 166. Different ways of parcel (spatial unit) identification: (a) numbering per cadastral unit, for example a section, canton or block. (b) Use of geographic coordinates of the centroid as a unique identifier.

It is possible to use meaningless IDs with (for example) 12 digits including a control digit.

And, another approach, unique numbers can be related to a geographic name.

It is very well possible to use postal addresses There may be complications because addresses are street based and not area based. And not all streets have names or zip codes.

Subdivision of spatial units requires special attention in relation to spatial unit identifiers. Three examples are given in Figure 167. Under (a) new parcels get a sub-index to the mother parcel 1234: 1234/1 and 1234/2. Similar in (b) where 1011 and 1012 are created out of 101. In (c) the part that remains to the seller remains the same identifier 101. That means that 101 is related to different parcels over time.

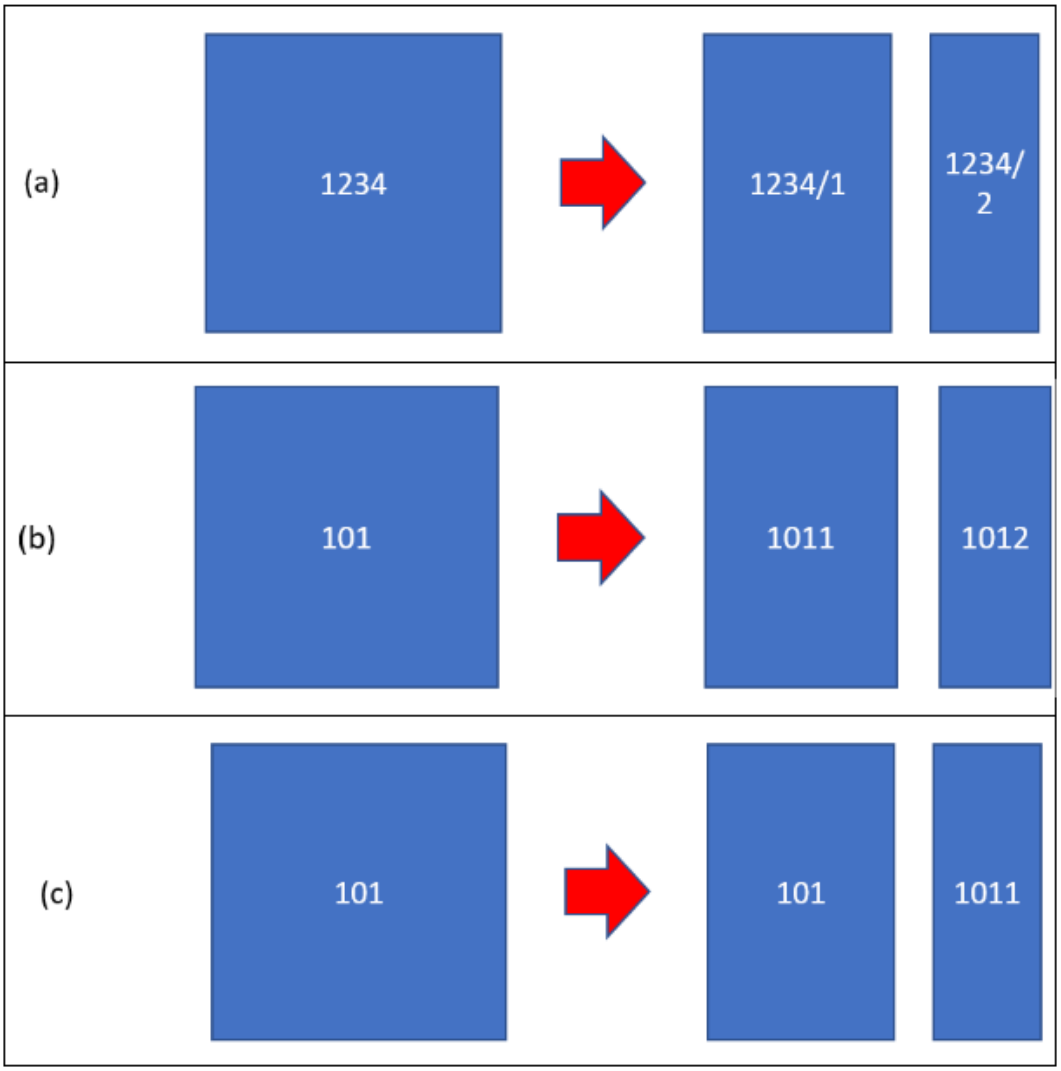

Figure 167. . Under (a) new parcels get a sub index to the mother parcel 1234: 1234/1 and 1234/2. Similar in (b) where 1011 and 1012 are created out of 101. In (c) the part that remains to the seller remains the same identifier 101. That means that 101 is related to different parcels over time.

Annex 2: Spatial Units

In LADM spatial units can be text based, point based, line based, line based (with or without topology), polygon based or volume based. Text based means a description in words, not in coordinates:

Text based spatial units don't have coordinates, the geo referencing is done by using names of areas and regions. For example: *'beginning with a corner at the intersection of two stone walls near an apple tree on the north side of Muddy Creek road one mile above the junction of Muddy and Indian Creeks, north for 150 rods to the end of the stone wall bordering the road, then northwest along a line to a large standing rock on the corner of John Smith's place, thence west 150 rods to the corner of a barn near a large oak tree, thence south to Muddy Creek road, thence down the side of the creek road to the starting point.' (quoted from: http://en.wikipedia.org/wiki/Metes_and_bounds).*

Point based

Point based spatial units identify a spatial unit, usually the centroid. There is no delineation, there are no boundaries represented in the land administration system. The centroids can be on top of an image as in Figure 168.

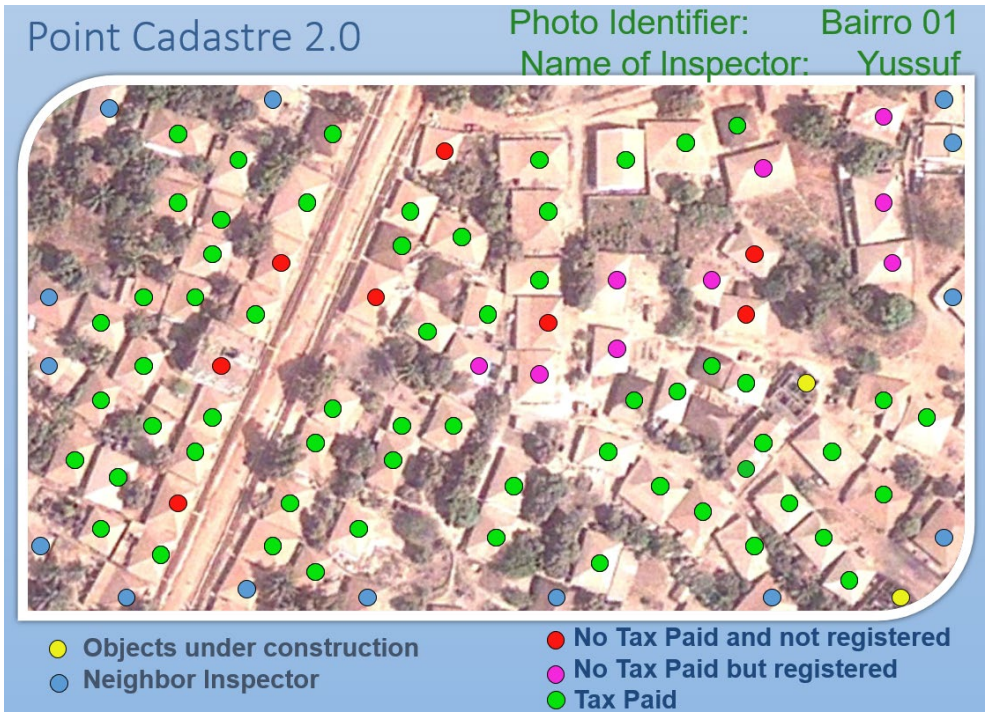

Figure 168. Example of a point cadastre.

It is assumed that a single coordinate of the centre of the dwelling unit could positively identify that unit, and this may be sufficient for basic recording purposes where the limits of the landholding are for the time being unimportant. This can be applied at an early stage in a system of progressive title improvement, ending in a standard freehold system. Note: this approach provides an address reference point.

Line based (no topology)

Line based spatial units can, likewise as point based spatial units, be used at an early stage in development. There is no topology, the boundaries are represented as lines and are not linked. Boundaries of one spatial unit may be collected from different sources, as existing cadastral maps and imagery. Overshoots are allowed, and then it still provides a useable "cadastral map" base, see Figure 169.

Subdivision is difficult, this should also be line based. Area calculation can be done manually.

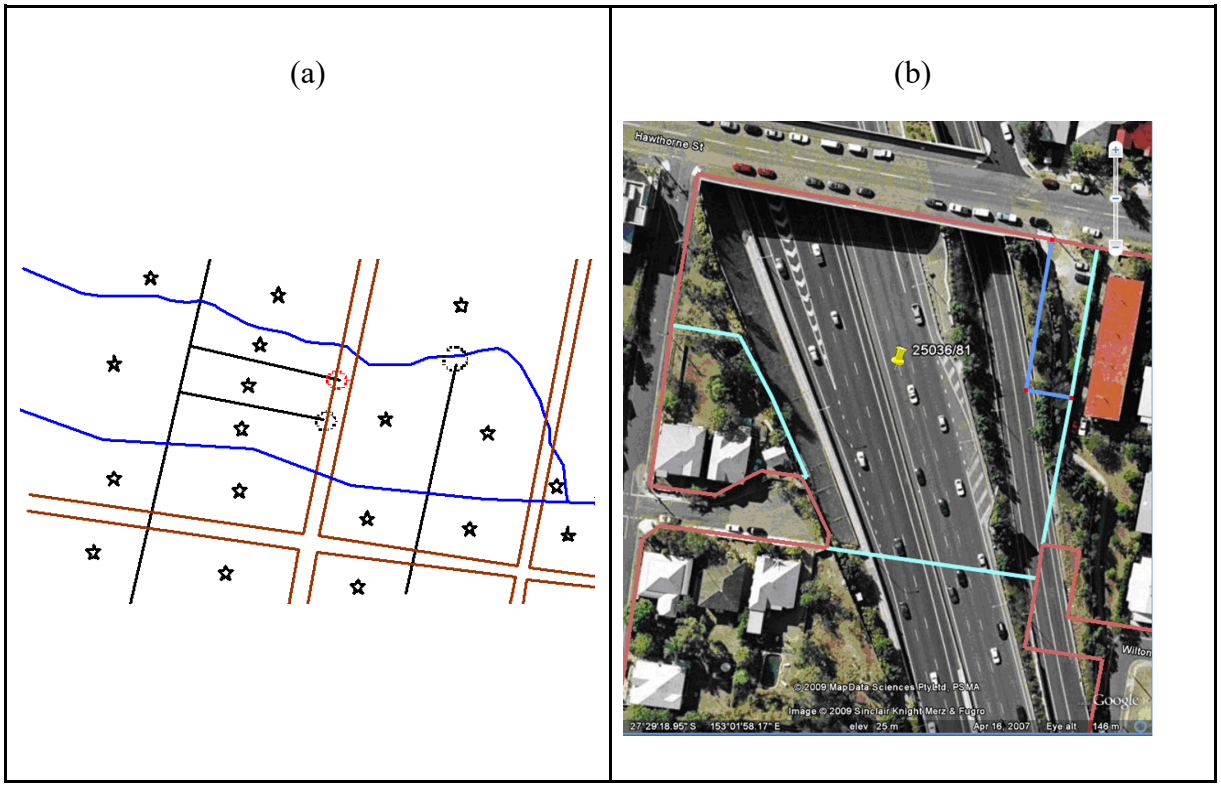

Figure 169. Line based spatial units: (a) over and undershoots are allowed in this approach. (b) Original boundaries from different sources are used. Attributes, as the name of the surveyor, can be linked to individual boundaries.

Line based (with topology)

Now the lines are linked and form the boundaries of a spatial units. Lines are stored once only and are broken at points. Topology is built into the database. Attributes can be linked to individual lines (boundaries), see Figure 170.

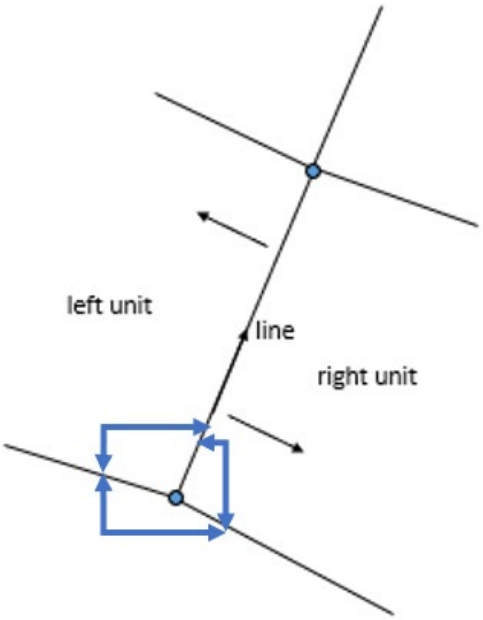

Figure 170. . Line based spatial units with topology: there may be attributes per line (boundaries) and there are links between lines based on the boundary face string identifier or the bfID: the boundary face identifier. An example of linking is given in blue.

Polygon based

In case of polygon based spatial units aach spatial unit is recorded as a separate entity (a polygon in 2D). There is no topological connection between neighbouring spatial units (and no boundaries shared), All lines are represented twice (at least). See Figure 171.

Note this approach can be used where grassroot surveyors collect the boundary data together with citizens under supervision of professional surveyors, see Morales et al. (2021): '*the process starts from the field data collection stage up-to the post-processing to identify and properly position the property boundaries. Perimeters of spatial units are walked in the field and observed as polygons, this means that each boundary is observed from two sides. Topology is calculated during post processing of the observations. A field survey module is developed, in collaboration with Esri, to adhere to the stated requirements. The field survey module is based on the ArcGIS Collector app (Morgenthaler, 2020) and, consequently, the module takes advantage of the cloud infrastructure on which Collector operates. It is important to note that the fit-for-purpose approach that is proposed has been tested through several case studies in regions of Colombia with different land rights structures, ranging from formal to indigenous or social. See Morales (2021)*'.

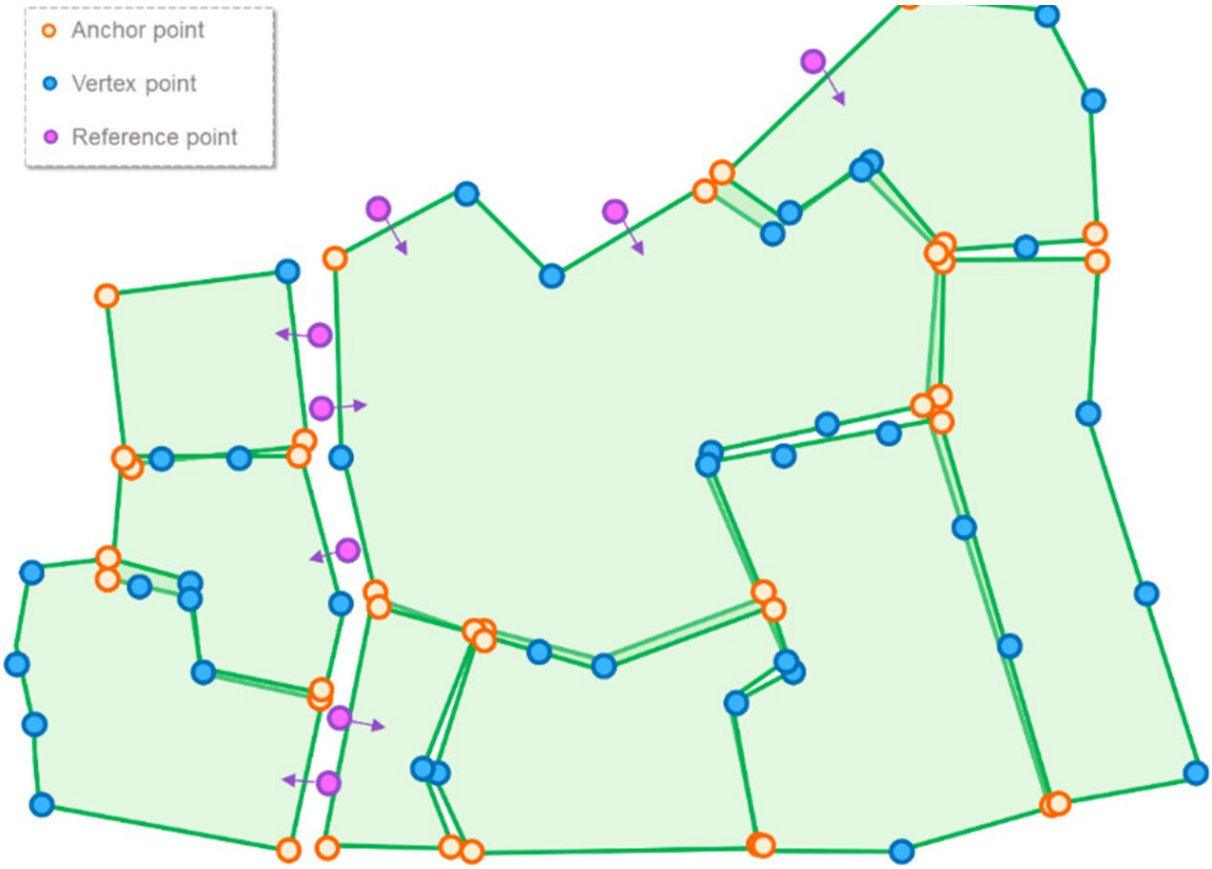

Figure 171. Polygon based approach. Example from Colombia where grassroot surveyors walked perimeters of spatial units with presumed owners Anchor points are points where several boundaries come together. Vertex points are intermediate points. Reference points refer to roads and water courses. Source: Morales et al.(2021).

3D spatial units

In lADM 3D representations are possible. Facestrings are 3D linestrings. Facestrings can be seen as invisible curtains on top of line strings representing boundaries. See Figure 172 (a).

2d and 3d integration between 2D and 3D spatial units is possible via liminal spatial units. Liminal spatial units are 2D parcels, but are stored as 3D parcels. Liminal spatial units are delimited by a combination of LA_BoundaryFace and LA_BoundaryFaceString objects. See Figure 172 (b).

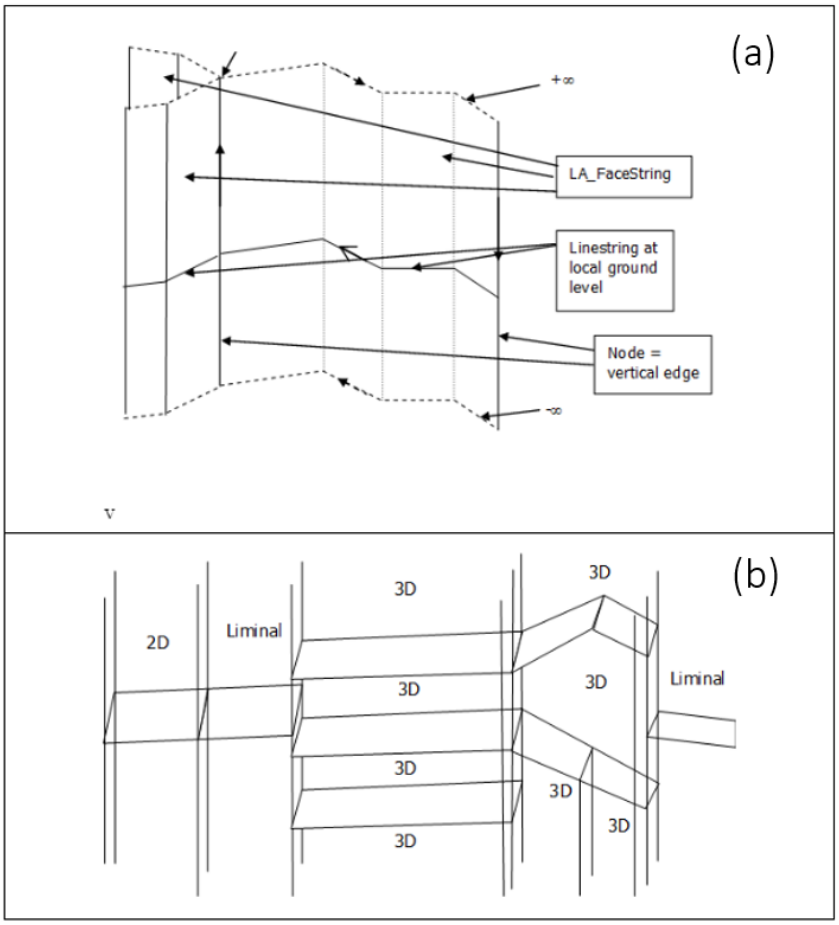

Figure 172. (a) 3D representations can use facestrings (b) 2d and 3d integration between 2D and 3D spatial units.

Annex 3: Country Profiles

The growing recognition and influence of the standard is revealed by the multiple LADM country profiles that have been developed and several LADM implementations from industry and academia. A country profile may describe the existing situation in the LA domain and adjust the current LAS into the LADM concepts or it may describe the vision/need for a future situation (Kalogianni et al., 2021).

The country profiles integrate the legal and institutional context governing the RRRs with the selected Land Administration Systems' advancements. Experiences from these developments are in the direction of integrated land administration with vision for the future and can serve as good practices for the countries. Table 2 shows an overview of documented LADM country profiles. Please refer to Kalogianni et al. (2021) for the references detailing each country profile.

Table 2. Enriched version of the overview of LADM country profiles presented by Kalogianni et al. (2021).

#	Country/ Jurisdiction	References	#	Country/ Jurisdiction	References
1	Albania	https://documents1.worldbank.org/curated/pt/481771562052486554/pdf/Albania-Status-Review-of-the-Immovable-Property-Registration-Office-IPRO-Services-and-Data-Quality.pdf *(ALBSREP claims to be LADM compliant)*	**24**	Montenegro	Radulović et al., 2015; Govedarica et al., 2018
2	Bénin	Mekking et al., 2020; Nyalewo et al., 2023	**25**	Morocco	Adad et al., 2020
3	Brazil	Paixao, 2015; Dos Santos et al., 2013; Purificação et al.,2019	**26**	Mozambique	Balas et al., 2017
4	Cape Verde	Andrade et al., 2013	**27**	Nicaragua	FAO, 2020
5	China	Guo et al., 2011; Xu et al., 2019	**28**	Nigeria	Abidoye et al., 2017; Oyetayo et al., 2015
6	Colombia	Jenni et al., 2017	**29**	Poland	Góźdź and Pachelski, 2014; Góźdź and Van Oosterom, 2016, Bydłosz, 2015
7	Croatia	Vučić et al., 2013; Vučić 2015; Mađer et al., 2013; Mađer et al., 2015; Vučić et al., 2017; Mađer et al., 2018	**30**	Portugal	ISO 19152, 2012
8	Cyprus	Elia et al., 2013	**31**	Queensland, Australia	ISO 19152, 2012; Karki, 2013
9	Czech Republic	Janečka and Souček, 2016; Janečka and Souček, 2017	**32**	Republic of Srpska	Govedarica et al., 2011; Govedarica et al., 2018
10	Ecuador	Martínez et al., 2020	**33**	Russian Federation	Elizarova et al., 2012; ISO 19152, 2012
11	Ethiopia	Kebede et al., 2018	**34**	Saudi Arabia	Alattas et al., 2019

Table 2 (cont.).

12	Finland		**35**	Scotland	Reid, 2019
13	Germany		**36**	Serbia	Radulovic et al., 2017a; Radulovic et al., 2017b; Govedarica et al., 2018; Radulović et al., 2019
14	Greece	Psomadaki et al., 2016; Kalogianni et al., 2017;	**37**	Singapore	Soon et al., 2016; Soon et al., 2019
15	Honduras	Koers et al., 2013	**38**	South Africa	Coetzee et al., 2013; Tjia, 2014
16	Hungary	ISO 19152, 2012	**39**	South Korea	Jeong et al., 2012; Lee et al., 2015; Kim et al., 2017
17	Indonesia	ISO 19152, 2012; Budisusanto et al., 2013	**40**	The Netherlands	ISO 19152, 2012
18	Israel	Felus et al, 2014	**41**	Trinidad and Tobago	Griffith-Charles and Edwards, 2014
19	Japan	ISO 19152, 2012	**42**	Turkey	Alkan and Polat, 2019
20	Kenya	Karamesouti et al., 2018; Kuria et al., 2016	**43**	Uganda	Sanjines et al., 2018
21	Korea	ISO 19152, 2012; Kim et al., 2013; Lee et al., 2015	**44**	Victoria, Australia	Aien et al., 2012; Kalantari and Kalogianni, 2018
22	Malaysia	Zulkifli et al., 2013, Zulkifli et al, 2014b; Zulkifli et al, 2014c; Zulkifli et al., 2015; Rajabifard et al., 2018	**45**	Vietnam	Le at al., 2012
23	Mongolia	Buuveibaatar et al., 2022			

Annex 4: Accessing and using the accompanying datasets

The datasets can be downloaded from https://ladm.itc.utwente.nl/ladm_classroom The link will take you to a GitHub repository where you can download the latest release (Figures *173* and *174*).

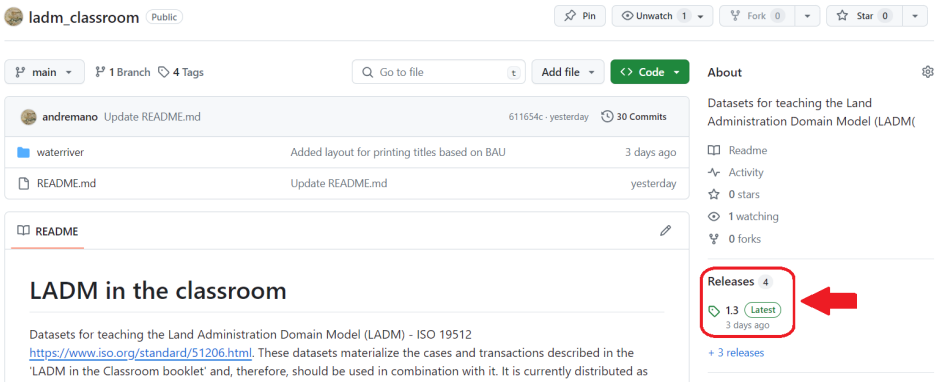

Figure 173. The Githuib repository: accessing the Releases.

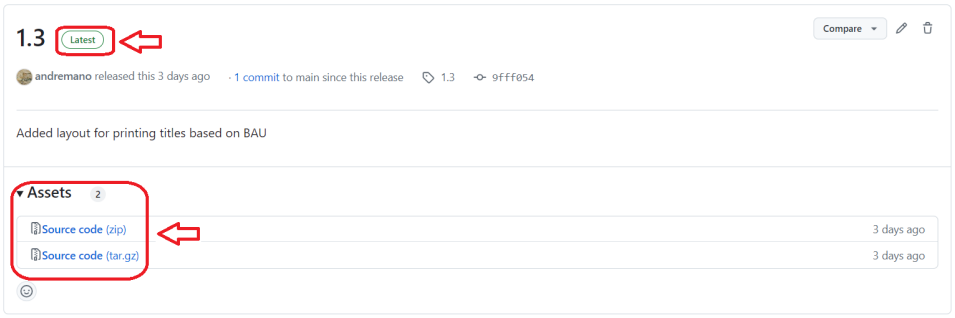

Figure 174. Downloading the latest releases.

Once you download the .zip or .tar file, you must extract its contents to any suitable folder on your computer. You should get the folder structure shown in figure Figure *175*. Note that future releases may alter slightly the folder structure you get.

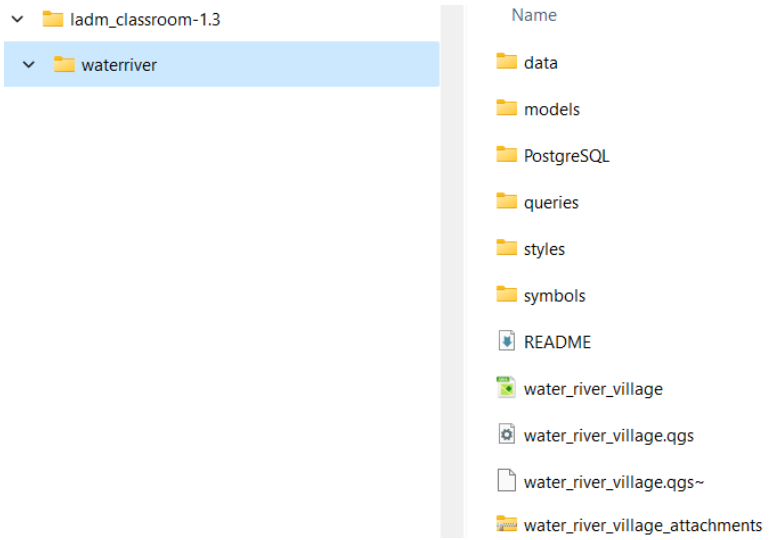

Figure 175. The folder structure.

data folder: the datasets used in the QGIS project as a Geopackage (.gpkg) portable database.

models folder: contains QGIS Processing models for extracting vertices and boundaries.

PostgreSQL folder contains the necessary elements if you want to have a server-client approach when exploring the datasets. (Please note that this approach incurs other subtleties like user account and user permission creation):

- a script to implement the database on a PostgreSQL database server, including trigger and history registration functions;
- a script consisting of INSER statements to populate the tables created by the implementation script;
- a QGIS pre-configured and pre-styled - if the PostgreSQL exists, the user only has to specify the database as the source of the datasets the QGIS project is expecting to find.

queries folder: contains the SQL queries that generate the views and the history registration used in the Geopackage portable database.

styles folder: contains QGIS .qml files with styles that can be used to change or restore the original appearance of the layers.

symbols folder: contains images used in the print layouts

Assuming you have QGIS 3.32 or higher installed on your computer, you can simply open the ***water_river_village.qgis*** file, and the the datasets will load, already with the styles applied to them, along with all the functionality like history registration, tools for geometry extraction and title issuing capabilities (Figure 176)

Figure 176. The Waterriver database in QGIS.

Please note that the folder structure has to be kept at all times for the QGIS-based environment to work properly - elements such as the datasets are expected to be located in specific folders - moving folders (or the QGIS project) will break the environment.

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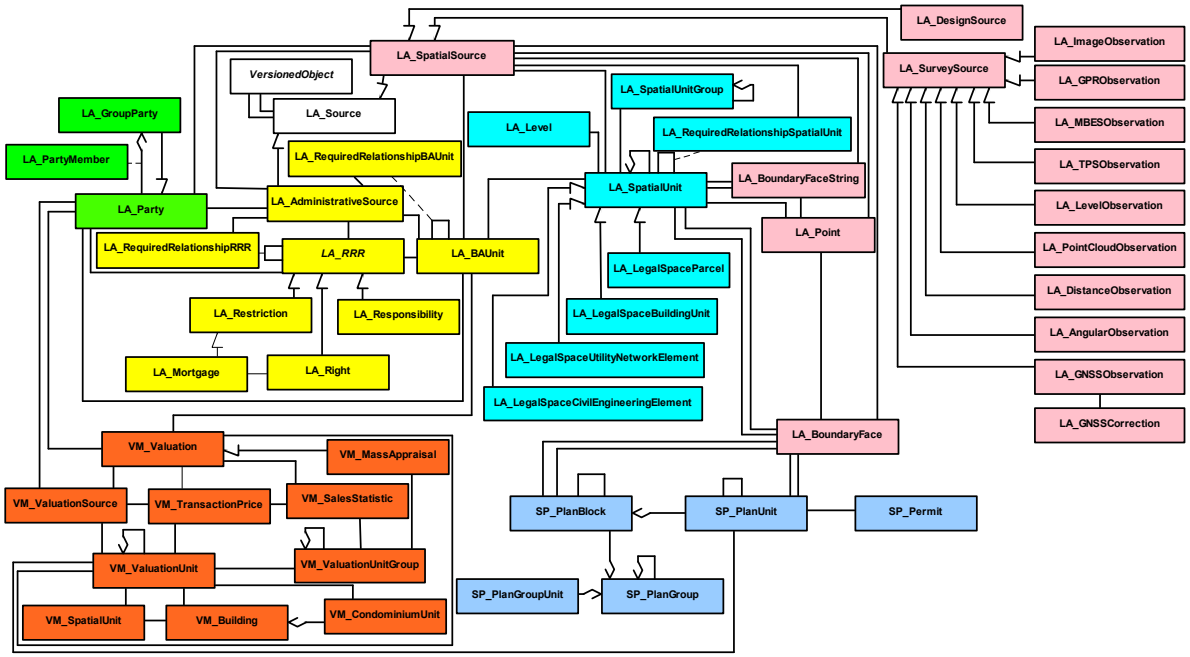

In 2012, the Land Administration Domain Model (LADM) was approved as an official ISO standard. The LADM is a conceptual information model. It describes and structures the core of a land administration: information about people, about land and about people to land relationships.

LADM supports the establishment of a common view on land administration across stakeholders involved. It stimulates the development of software applications and accelerates the implementation of proper land administration systems in support of sustainable development. It supports interoperability in land administration. This is a real need because land administration is mostly implemented under distributed mandates with many stakeholders. The LADM provides an internationally recognised model and vocabulary, which provide a solid foundation for the development process. It covers the 'information-related' components of land administration, including those over water and land, and elements above and below the surface of the earth. This means in practice that the representation of all tenure types is being supported – even when overlapping – and that 3D land administration can be developed. There are now implementations of LADM all over the world.

This book introduces the reader to the Land Administration Domain Model (LADM) through examples. It starts by giving the reader an overview of core LADM concepts then proceeds to illustrate how data about different people-to-land relationships can be organized using LADM. Each example represents a scenario that can be encountered in a Land Administration System. The scenarios used in examples are derived from the Land Administration System of the hypothetical town of Watteriver together with its surrounding rural areas. Each case, representing a particular scenario, is presented both conceptually and using a simplified representation of a database in which data are stored concretely. A demonstration dataset, accompanying GIS project, and reusable slides are available online - details in the book.

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