

# New approach and tools for comparative institutional analysis of legal regimes used for integrated resources management

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## Abstract

At the moment in several parts of the world institutional reforms are taking place to deal with integrated water resources management (IWRM) issues. Increasingly intricate transboundary institutional arrangements will need to be and are established. Lessons can be learned from frontrunners, but this requires a new method to establish similarities and differences in levels of (de)centralization. In this paper an institutional law & economics perspective on the study of legal regimes for integrated management of such complex, multi-use and multi-actor ecosystems will be presented. From this perspective a new method is developed that can be used for comparative property rights analysis. The method is based on the combined insights from property rights theory, institutional legal theory (ILT) and the work of the American legal theorist Hohfeld. The paper will show how the adapted Schlager & Ostrom framework can be used to better understand the institutional arrangements used to implement IWRM. The method has been implemented in a web-based database system. The method incorporates visualization of the legal regimes and a formal model to establish similarities and differences in levels of (de)centralization for different policy fields. For the graphical visualizations of the legal regimes Graphviz is used. The formal model is transposed into SQL-scripts that can be executed through the website. At the end of the paper a first application of the method in a comparison of the legal regimes used for the IWRM of the Scheldt estuary, will be presented.

## 1 Introduction

At the moment in several parts of the world institutional reforms are taking place to deal with integrated water resources management (IWRM) issues. Current institutional arrangements are adapted and new ones are established to fulfil the need for more decentralized decision making. This in turn leads to a need for more centralized coordination, because the mechanisms and authorities for management reside with multiple actors that function on different levels of society. Multiple actors are involved due to the fact that the legal standards governing land, water and (natural) resources are not very coordinated and often address single resources rather than the ecological complex itself. The ecological complex is also very big, so it crosses several jurisdictional borders. This adds a new level of complexity to the issue of IWRM.

As a result of these observations increasingly intricate transboundary institutional arrangements will need to be and are established. These institutional arrangements must constitute a nested system of powers and authorities to accommodate for the need for decentralization and coordination. In other words, there is a need to develop ‘nested enterprises’ or ‘polycentric institutions’.

The best way forward is to observe and learn from current best practices used by frontrunners. That means that we should make systematic examination of variations in the relationships between resource management, decentralization and legal regimes and how these variations affect the integrated management of resources (Agrawal, 2001). No study like this has been done before. Our method is not capable of performing this task, but it is a good first step towards such an analysis. Through our method one can determine to which degree decision making has been (de)centralized and on which level the legal regime can be adapted to local situations. In order to do this, one needs an analysis method that is able to make systematic descriptions of legal regimes that can be used for comparative analysis and at the same time can handle huge quantities of data.

In this paper we will show in two parts a method, its tools and its theoretical basis, that is able to fulfil the task described above. First, we will show the theoretical basis (section 3) for the method. On the basis of these theories it is possible to make systematic description that can be used for comparative property rights analysis (section 5.4.1). In the second part of the paper we present the formal model (section 6) and its implementation (section 7). In a third part we will go into the future developments/evolutions of our method and its tools (section 8).

## **2 Problem statements**

When researching legal regimes, one has to look at a lot of different statutes, regulation, case law, etc., to get the full picture. This should be done in several states and/or countries, because when one wants to research legal regimes for IWRM one has to realize that he is dealing with a transboundary resource that is spread over several and different jurisdictions. During the process of gathering all the necessary information, one discovers that you then run into several scientific and practical problems.

The scientific problems have mainly to do with making comparisons of legal regimes originating in different legal systems. In our research we would like to study a legal regime originating in the (European) civil law system and one from a (American) common law system. These legal systems differ in many ways. A lot of researchers start comparing by looking with ‘glasses’ focused by their own legal system. This yields descriptions biased towards their own legal system. Furthermore, it is not enough to determine that different legal systems have components with similar names, because in reality they can have different contents.

Successful, unbiased analysis requires that you need a method that is capable of describing the components of a legal system, the logical relationships between them, and the ways in which all legal phenomena and operations in the legal system can be described in the terms of these components and relations (MacCormick and Weinberger, 1992). That means that you need frameworks that are based on some sort of common denominator that is able to describe legal regimes in term of their ‘building blocks’ (Wessel, 1999; van Wageningen, 2003). To solve this problem we have turned to the fundamental legal relations of Wesley Newcombe Hohfeld (see section 5.2).

#### Scientific requirements:

- able to compare rules originating in different legal systems
- able to describe building blocks of legal regimes
- unbiased descriptions

Table 1: Scientific requirements of a method for comparative analysis of legal regimes

One of the major practical problems is the amount of data generated. When describing a legal regime that is used for integrated water management, one is dealing with rules from several legal fields. That means one has to look at the rules related to management of water (quantity, quality and allocation of water), land (planning, zoning, spatial development, perhaps agriculture and industry), land-water interaction and property in general. That means one will be gathering data from a lot of different statutes, regulation and case law. Each one of these legal sources contains at least several (case law), but sometimes hundreds (statutes & regulation) of rules. That means that you need some sort of database system to store and handle such amounts of data.

#### Practical requirements:

- must be able to handle huge quantities of data
- must be able to implement formal approach of comparison
- must be accessible from multiple workplaces

Table 2: Practical requirements of a method for comparative analysis of legal regimes

But storing data is not enough, you also want to compare these different rules/regimes to discern differences and similarities. This can be done in two ways. One way is visualization. Visualization eases insight into complex systems, so it can help with analyzing these complex legal regimes. Visualization can be done by making graphical representations of the regimes by drawing graphs of the legal regimes. These graphs can help someone observe differences and similarities by comparing the resulting graphs. The second manner is to compare the legal actors and rules on the basis of meaningfully combined data. Differences can be established by looking at aggregated positions of entities and (the content of) their relationships with other entities. This way one can discern if differently named entities still have the same position or relations with similar entities. Or the other way around. A formal representation of our method of establishing similarities and differences can be found in section 6.

We have solved both problems by designing a web-based database system. This system is able to render legal regimes into graphs and capable of making detailed and condensed comparisons of the data stored in the database. More about the practical side of our system in section 7. But first we will present the theoretical basis<sup>1</sup> used for generating the necessary description that is the basis for our web-based database system.

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<sup>1</sup>This section is for the most part based on a paper Wim van de Griendt will be presenting at the ESNIE 2006 Summerschool from May 15th to May 20th in Corsica (France). An older version has been presented at the USGS-workshop 'Institutional Analysis for Environmental Decision-making: A Workshop', January 28 and 29, 2005, Fort Collins Science Center, Fort Collins, USA

### 3 Theoretical basis

Institutional arrangements are considered to provide the mechanisms by which individuals can resolve such social dilemmas (Steins, 1999). They are complexes composed of ‘rights’ (claims, duties, privileges and exposures), taking various forms across different types of resources and/or different institutional contexts (Cole, 2000). These arrangements define and restrict access to and control over resources, giving appropriate incentives to users and theoretically guaranteeing the sustainability of natural resources (Ostrom *et al.*, 1999). In other words, for the governance of the natural resources a legal regime is created Bromley (1991). This way a ‘tragedy of the commons’ can be averted.

Hardin (1968) already saw two solutions for restricting/controlling access and use, namely privatization and regulation. Privatization means that a decision unit must be given private ownership of its resource. One person is given absolute control over access and no one may legally exploit it without his authorization. The other option is regulation. Regulation can take the form of government-regulation or self-regulation by user groups. Both regimes will reduce or eliminate incentives to over exploitation, by (self) imposed restrictions on users and modes of use.

Almost all economic scholars discussing the alternative options of privatization and regulation fail to discern that both are property-based (Cole, 2002). Regulation cannot exist without a legal regime giving some decision units, the state or a group of (self-regulating) users, control over (some part) of a resource. The difference between the two is not the existence or non-existence of property rights, but the type of property rights regime used (Cole, 2002). This means that legal regimes and the rules they contain can be described and analyzed in terms of property rights.

To manage such (potential) resource use conflicts, one must choose the right mix of private, community and state property rights to address environmental problems. Together they can constitute successful institutional arrangements with the ability to address the problems associated with the use of CPR’s. But to really be successful, they should provide the needed flexibility to adapt to local conditions. This requires a certain degree of decentralization of natural resources management. Stakeholders, like the government and (local) user groups, must manage the natural resources together. Therefore institutional arrangements (polycentric institutions/nested enterprises)<sup>2</sup> must be established which constitute nested powers and authorities, collective action and coordinated decision-making. These institutional arrangements enable local users to adapt their local rules to their local subsystem, but at the same time they also enable coordination of rules/decisions on the (eco)system or in the case of water ecosystems, on the watershed/catchment basin level.

### 4 Institutional analysis

Therefore it is not surprising that in the current literature on natural resources management, much attention is given to the importance of institutional arrangements (see for instance Ostrom (1990); Veeman and Politylo (2003); Cortner *et al.* (1998)). Especially in cases, where

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<sup>2</sup>Ostrom’s eight design principle for successful management of common pool resources, see Ostrom (1990). With this Ostrom means that management of common pool resources must be organized in multiple layers (where one layer/organization is nested within/ is part of another (higher) layer/organization).

the responsibility for natural resources is looked at from integrated ecosystem or landscape perspectives (Söderqvist *et al.*, 2000).

In the past much research has been conducted concerning the effects of single (legal) rules. Nowadays, research concentrates on the role of (legal) rules in the wider context of, so called, ‘institutional configurations’ (Crawford and Ostrom, 1995) governing natural resources. This purpose requires institutional theories<sup>3</sup> that provide frameworks for detailed analysis which can also be used as the basis of comparative economic analysis.

The aim of this article is to show that a new combination of current institutional theories is able to provide the necessary frameworks and descriptions. In this article, a legal theoretical view of regimes for governing natural resources is taken as a starting point. This article presents the ‘underlying unities in legal doctrines and institutions’ (Posner, 2004). With the help of these ‘underlying unities’ one can determine the property rights assigned to the different actors. The type of ownership of the actors can be determined to look at the bundle of property rights they hold. This bundle determines to which degree the actor has control over access to and use of the resources and to which extent he has control over the property rights of others. By comparing the actors, their bundles of property rights and their type of ownership one can determine if there are differences in (de)centralization and who can change the rules so that the legal regime can adapt.

## 5 Legal institutions

A legal framework that can provide the necessary descriptions for comparative research must be capable of comparing legal regimes without reference to the legal systems (common, civil, etc.) in which the legal regimes are ‘located’. Successful analysis requires that the theory is capable of describing the components of a legal system, the logical relationships between them, and the ways in which all legal phenomena and operations in the legal system can be described in the terms of these components and relations (MacCormick and Weinberger, 1992). Therefore in this section we look upon the Institutional Legal Theory (ILT)<sup>4</sup> and the work of the American legal theorist Wesley Newcomb Hohfeld.

### 5.1 Institutional Legal Theory

Ruiter (1993; 1994; 2001) developed the Institutional Legal Theory, building upon the work of MacCormick and Weinberger (1986). ILT analyzes the legal order as a universe consisting of a multitude of relatively independent systems of rules (legal institutions). It opens up possibilities for analyzing legal orders as highly complex over-all systems of rules that are all reducible to a small number of basic patterns (Ruiter, 1997). For that reason, ILT can help analyze ‘institutional configurations’, where traditional legal theory only concentrates on logical and other relations between single legal norms and rules (Ruiter, 1993, 2001).

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<sup>3</sup>Diermeier and Krehbiel (2003) make a distinction between institutional theories and theories of institutions. They state that an institutional theory ‘seeks an understanding of the relations between institutions, behaviour and outcomes’ while a theory of institutions seeks ‘explanation why some institutional features come into existence, and persist, while others are either non-existent or transient’.

<sup>4</sup>Others refer to it as the Institutional Theory of Law (ITL), see MacCormick and Weinberger (1992).

The other main reasons for choosing ILT and its legal institutions lies in the fact that by describing legal regimes in terms of legal institutions, they can be compared systematically.<sup>5</sup> Many researchers comparing different laws or legal regimes compare them without the use of a common denominator. As a result their descriptions may become distorted as they compare concepts which seemingly have the same name, but in reality have different contents. In addition, they compare by looking with lenses focused by their own legal system, yielding descriptions biased towards their own legal system.

By using ILT a researcher stays clear of these problems when describing, analyzing and comparing legal regimes. This is possible, because ILT is a legal meta-language, which enables the comparison of legal regimes with the help of the common denominator(s) it presents (van Wageningen, 2003). The legal institutions of ILT are this denominator which enable a researcher to name all ‘building blocks’ (MacCormick and Weinberger, 1992; Wessel, 1999) which comprise legal regimes. All legal regimes can be rendered in the same basic forms with the same terms for their content (range of behaviour). This is the basis a researcher needs for the comparison of legal regimes which are part of other legal systems and/or several different jurisdictions.

But for our research this is not enough. The descriptions of legal regimes should be usable for determining levels of (de)centralization. This is indeed possible, by combining the detailed and systematic descriptions of legal regimes with Hohfeldian legal relations (5.2). These two elements generate the basis for a property rights analysis (5.4.1).

### **5.1.1 Legal institutions**

But what are legal institutions? To understand this, we will first take a look at the concept of institutions. Nelson and Sampat (2001) have reviewed the literature dealing with the question how institutions affect economic performance. Their survey reveals that the concept of an ‘institution’ means different things to different scholars, both within economics and across social sciences. The question they raise is whether the concept has a single coherent meaning, and their answer is in the negative.

Although such a unified content may be lacking, there appears to be general agreement on a broad conception of institutions as systems of rules that provide frameworks for social action within larger rule-governed settings. Keman (1997) surveyed a great number of definitions of institutions used in neo-institutionalists approaches. He found the following general concept of institutions: sets of rules that occur in social reality in the form of recurrent behaviour that complies with those rules. Institutions are not only effect-producing, but also distinct “realities that shape patterns of behaviour of individuals, groups and organizations” (Keman, 1997).

This definition of institutions is used as a point of reference (Ruiter, 2001) in ILT. Legal institutions are systems of legal rules governing specific social action in the context of a comprehensive social order, which purport to meet with general acceptance. General acceptance means that they are socially taken into account as a factual situation (Ruiter, 2004).

If legal institutions are socially taken to be taken into account as factual situations, their form must be such that they can actually be conceived of as particular situations. That is to say, as existent. There are three basis forms of particular situations<sup>6</sup>:

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<sup>5</sup>ILT is already applied in different fields, for instance international organizations (Wessel, 1999), universities (van Wageningen, 2003) and municipalities (Ruiter, 1995).

<sup>6</sup>See also Ruiter (1997).

1. The existence of a certain entity. (There is an Eiffeltower.)
2. A certain existing entity having a certain property. (The Eiffeltower is made of steel.)
3. Certain existing entities having a certain connection. (The Eiffeltower is near the Louvre.)

The category of entities can be further divided in two: subjects, which can perform acts, and objects, which can be acted upon. With the aid of both distinctions, a classification of particular situations and also of legal institutions can be constructed. This classification is exhaustive, as there are subjects and objects, which can only have a limited number of relations (Wessel, 2001). The different kinds of legal institutions can be characterized as follows (Ruiter, 1997, 2001, 2004):

**Legal Persons** A legal person is a valid legal régime with the form of an entity that can act. Example: the European Community.

**Legal Objects** A legal object is a valid legal régime with the form of an entity that can serve as the object of (trans)actions. Example: a conveyable right of ownership.

**Legal Qualities** A legal quality is a valid legal régime with the form of a characteristic of a subject. The legal regime regulates the behavioural relation between that *particular* subject and *all other* subjects. Example: a person's legal majority.

**Legal Status** A legal status is a valid legal régime with the form of a characteristic of an object. The legal regime regulates the behavioural relations between *particular* subjects responsible for that object and *all others* subjects. Example: a listed historical monument.

**Legal Connections** A personal legal connection is a valid legal régime with the form of a connection between subjects. The legal regime regulates the behavioural relations between those *particular* subjects. Example: a personal right.

**Legal Configurations** A legal configuration is a valid legal régime with the form of a connection between objects. The legal regime regulates the behavioural relations between *particular* subjects with certain relations towards each of the objects. Example: an easement, that is, a legal régime with the form of a connection between a servient tenement and a dominant tenement consisting in a burden (e.g. a right of way) laid on the former for the benefit of the latter. All successive owners of the servient tenement are obligated to bear the burden and all successive owners of the dominant tenement are entitled to treat the former as thus obligated.

**Objective Legal Connections** An objective legal connection is a valid legal régime with the form of connection between a subject and an object. The legal regime regulates the behavioural relations between a *particular* subject in the legal connection and *all other* subjects. Example: ownership of property.

### 5.1.2 Content of legal institutions

The previous section discussed different forms of legal institutions as distinguished by ILT. However, in order to make an adequate and correct analysis of legal institutions possible, a theory must not only take notice of different forms, but also take their contents into account (Coleman and Kraus, 1986). ILT identifies as contents of legal institutions their ‘ranges of behaviour’. That is, the behavioural patterns regulated by them. These behavioural patterns can be captured by using the rights concepts of Hohfeld (1919). Hohfeld has succeeded in reducing the language of the law to a few essential and fundamental legal concepts answering to the standards of simplicity, precision, and universality (Hoebel, 1968). They are fundamental because they ‘express the vitally important relations of men with each other in any judicial or governmental system’ (Corbin, 1964).

## 5.2 Hohfeld

Hohfeld was driven by his dissatisfaction with the indiscriminate use of the term ‘right’ in the legal practice of his time. Judging by common legal uses of the word ‘right’, Hohfeld noticed that the idea of someone’s having a right to something is really a cluster of related ideas. This causes much unnecessary ambiguity. Contrary to the saying that for every right there is a correlative duty, he pointed out that some rights have such correlates while others do not (Perry, 1977). His analysis of fundamental legal relations was intended to show that the term ‘right’ is used in four different senses. For this purpose, Hohfeld distinguishes four legal relations, which contain his eight fundamental conceptions. These conceptions constitute the ‘lowest common denominators of the law’ (Hohfeld, 1919).

Hohfeld started his analysis by stating that ‘rights’ are used in a very broad sense, and used to denote very different concepts. Therefore he tried to limit the concept to a coherent set of concepts, or ‘relations’ as Hohfeld calls them, with definite and appropriate meanings. The first set of concepts is claim-duty. This means that someone (A) who has a duty, has a legal obligation towards the claim-holder (B) to take or refrain from taking a certain course of conduct (Co).<sup>7</sup> B’s claim that A should or shouldn’t do something is equivalent to A’s duty towards B to take that course of conduct like he is obliged to do. Hohfeld calls equivalent legal conceptions ‘jural correlatives’, which means that the existence of one necessarily implies the other. If such concepts cannot exist together in one person in respect of the same thing, he calls them ‘opposites’ (Kamba, 1974).

The second legal relation Hohfeld discerns is the one between ‘privilege’ and ‘no-claim’. A ‘privilege’ means that A may or may not do as he chooses. In equivalent terms, a privilege means that A is not under a duty to perform some action, in contrary, he is free<sup>8</sup> to choose the course of conduct he wants to take. This means that B cannot claim that A should take some course of action, therefore his position is named ‘no-claim’. Yet conversely, B may interfere with A. This is possible because A does not have a claim against B (because B has no duty not to interfere).

The first order set of Hohfeld’s legal relations discussed above, are found in table 3.

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<sup>7</sup>We use the notation of Ross (1974) of A–B (Co) instead of Hohfelds X-Y, because this fits better with our information costs analysis.

<sup>8</sup>Of course this freedom is not unlimited. Some restrictions are set, but within these restrictions, a person is free to do whatever he wants.

duty A–B (Co)	jural correlative	claim B–A (Co)
jural opposite		jural opposite
privilege A–B (Co)	jural correlative	no-claim B–A (Co)

Table 3: Hohfeld’s first order set of legal relations

‘Power’ and ‘exposure’ are the third Hohfeldian relation. ‘Power’ is the legal capacity to alter legal relations. It is one’s affirmative control over a given relation as against another. These other persons are exposed to the power of the former, and have no capability to ‘fend off’ the changes decided upon by the person having a power they are exposed to. To the degree that alterable relations are fundamental legal relations of the first order, this amounts to legal capacity of replacing existing duty-claim-relations by liberty-no-claim-relations and vice versa. However, although Hohfeld himself does not elaborate on this implication, ‘power’ may also be the legal capacity to alter legal relations of the second order. This amounts to the legal capacity of replacing existing power-exposure-relations by disability-immunity-relations and vice versa. Furthermore, it should be kept in mind that fundamental legal relations of the first and second orders need not be between the same persons. In many situations, A and B have either a duty-claim-relation or a liberty-no-claim-relation, while commonly having a power-exposure-relation or a disability-immunity-relation with C concerning their first-order legal relation. In such tripartite relations, C is legally (in)capable of changing an existing first-order legal relation between A and B (Ruiter, 2003)

The fourth and last of Hohfeld’s legal relations is the one between ‘immunity’ and ‘disability’. An immunity means that A is exempted from the effect B’s power. This means that legal relations vested in A cannot be changed by the acts of B. In other words, B is under a disability in regard to changing the relations A has with B or a third party.

The second order set of Hohfelds’ legal relations discussed above, are found in table 4.

power A–B (Co)	jural correlative	exposure B–A (Co)
jural opposite		jural opposite
disability A–B (Co)	jural correlative	immunity B–A (Co)

Table 4: Hohfeld’s second order set of legal relations

### 5.2.1 Hohfeld and Legal institutions

When looking at the descriptions of legal institutions, one can start to wonder to what extent all the Hohfeld relations can form the content of several legal institutions that are not of the basic form of a relation between one or two subjects and/or objects. This is indeed true for the legal institutions ‘legal person’ and ‘legal object’. These two forms are only basic forms to which legal relations can be attached.<sup>9</sup> that make up the other five legal institutions. The rules of the legal institutions of ‘legal connection’, ‘legal configuration’ and ‘objective legal connections’ are obviously fit to be described in terms of legal relations. The rules of these legal institutions regulate the relationship between one (group/class of) person or object and another (group/class

<sup>9</sup>They do have a content, but that content is more internally oriented. The content they have is how they can be formatted, how they can be abolished, how the internal decision-making takes place and in case of objects and legal persons not being a natural person, who may represent it.

of) person or object. But also the legal institutions ‘legal quality’ and ‘legal status’, although seemingly not of the form fit for a relation, can have legal relations attached to it. This comes through the fact that these forms contain essentially relations of the nature 1 vs. all. That means that these rules regulate the relations between the object or person against all other persons or objects. But it will not be described in this way in our database. This has to do with the fact that it is strange to add either all other entities listed in the database as either target or source entity of the relation, or to add a new entity called ”All”. There is no good solution to this, so we will only record the legal conception (one of the eight) on the part of the entity and not on the part of all other entities.

### **5.3 Comparative analysis**

By describing a legal regime in terms of legal institutions and their contents, it is possible to make unbiased descriptions based on a common denominator. But this is not enough. These descriptions should also be useful to determine the degree of (de)centralization within the different legal regimes. This can be assessed by determining the rights and capacities that are transferred to actors at lower levels of organization (Agrawal and Ostrom, 2001). For this we turn in the next section to property rights theory, and especially one of the approaches used within the natural resources management literature. The Schlager & Ostrom framework for determining types of owners by looking at their property rights, can help us examine the degree of (de)centralization.

### **5.4 Property rights analysis**

Property rights are systems of legal relations that ‘link a person to an object against all other persons’ (Bromley, 1989). Property rights comprise complex aggregates of legal relationships made up of claims, privileges, powers and immunities (Hohfeld, 1919)<sup>10</sup>, which can be seen as a ‘bundle of rights’ (Penner, 1996). Property rights are thought of as a bundle in the sense that a general description of them will allow for some kind of subdivision into ‘elementary rights’.

This leaves us two options for analysis, namely looking at what (constellation of rights) constitutes an owner or analyzing the object to which an owner is linked. Both are possible and meaningful with the descriptions made<sup>11</sup>. We have chosen for the moment to only go forward with the first option. That means we will analyze the legal relations and see which (bundle of) property rights they assign to the actors/owners in the legal regime.

There are different conceptions of the bundles of rights, because the rules of specification may vary. This leads to differing views about the concept of ownership and what constitutes an owner. We are looking for a concept of ownership that can help us assess the rights and capacities that are transferred to actors at lower levels of organization. That means it should make a distinction between levels of rights, which can connect to levels of organization or policy. The concept should also be (more) tuned to the specific needs of analysis of ownership in relation to natural resources. That means it should pay explicit attention to the rules for

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<sup>10</sup>These aggregates can differ between people. Hohfeld uses on p.30 the example of the difference between the fee simple owner and the easement owner; ‘the fee simple owner’s aggregate of legal relations is far more extensive than the aggregate of the easement owner’.

<sup>11</sup>The second option will be presented as a future development in section 8.2. More detailed information can be found in van de Griendt (2005).

governing access to and use of the resource. Our choice has fallen on the concept of ownership of Schlager and Ostrom (1992; 1996) Their conceptualization fulfils all the requirements set above. It is also one of the most used conceptualizations in the natural resources literature. The concept of Schlager and Ostrom will be discussed in the next paragraphs.

#### 5.4.1 Schlager & Ostrom's ownership types

Schlager and Ostrom present 'a conceptual schema for arraying property-rights regime that distinguishes among diverse bundles of rights that may be held by the users of a resource system'. They distinguish five classes of property rights holders: owner, proprietor, authorized claimant, authorized user and authorized entrant. Each position has its own associated bundle of rights containing one or more property rights. Schlager and Ostrom discern five different property rights(p.250-251), which they define as:

**access** *The right to enter a defined physical property.*

**withdrawal** *The right to obtain the 'products' of a resource (e.g., catch fish, appropriate water, etc.).*

**management** *The right to regulate internal use patterns and to transform a resource by making improvements.*

**exclusion** *The right to determine who will have an access right, and how that right may be transferred.*

**alienation** *The right to sell or lease either or both of the above-mentioned collective-choice rights.*

You can see them as a three level scheme. Level 1 contains the rules for access to and withdrawal from the resource. Level 2 holds the rights (management and exclusion) that can set and change the rules of level 1. On Level 3 (alienation) we can find the rules that determine who may use the rights of level 3 and 2, and who may give instructions to level 2 right-holders containing the conditions under which the level 2 right-holders may use their rights.

Schlager and Ostrom are talking about rights, but Hohfeld has taught us that there are no such things as rights. So with what kind of Hohfeldian relations (see table 5) are we dealing here? A right of access gives the holder a privilege to enter the property while simultaneously giving others a no-claim towards this person. This means that they cannot claim that the privilege holder must take some course of action. On the other hand, it does not mean that the no-claim holders must/can not interfere with the latter's access. A situation of non-interference can only exist if the privilege is reinforced with claim rights, giving persons other than the privilege holder a duty not to interfere. A subject with withdrawal rights have a privilege to obtain products produced by the resource, meaning that others cannot claim that he should not take them. Here exists the same situation as with access rights: they must be reinforced with claim rights before a situation of non-interference comes into existence. A person with management rights has a power because he has the capacity to change the relations between himself and other people wanting withdrawal rights. If he has not given them 'rights', they are under a duty to not take any products. If he uses his power and gives them rights, the legal situation and legal relations changes. Then the 'manager' is in a no-claim position towards the persons

taking products. This is the same for exclusion rights: the person holding them has a power for granting other access rights. Also the right of alienation is a power, as the owner of this right may change his position to the object in relation to others, letting someone else partly or totally take over his position. For that to happen, he must change the legal relation between himself and the new ‘owner’. Because he has transferred some of his rights, he can no longer claim that the new ‘owner’ should refrain from taking a course of action in relation to the object.

Schlager & Ostrom	Hohfeld
access	privilege to enter a defined physical property
withdrawal	privilege to the products of an object
management	power to determine usage of object
exclusion	power to determine access to object
alienation	power to transfer rights

Table 5: Property rights of Schlager & Ostrom in Hohfeldian terms

Table 6 shows how these property rights enable us to make distinctions among the different categories of property right holders.

	Owner	Proprietor	Authorized Claimant	Authorized User	Authorized Entrant
Access	x	x	x	x	x
Withdrawal	x	x	x	x	
Management	x	x	x		
Exclusion	x	x			
Alienation	x				

Table 6: Bundles of rights associated with types of owners(Schlager and Ostrom, 1992; Ostrom and Schlager, 1996)

Individuals holding only access rights are called ‘Authorized Entrants’ by Schlager & Ostrom. An example is the tourist who buys a ticket to visit a national park. If individuals also hold withdrawal rights, they are called ‘authorized users’. If specified in the rules, these access and withdrawal rights could be temporarily (lease) or permanently (sale, granted or assigned) transferred to others. One example is persons holding permits or individual transferable quotas. The rights of access and withdrawal are determined by the persons holding management (for withdrawal) and exclusion (for access) rights. ‘Authorized Claimants’ have, next to their access and withdrawal rights, management rights. This means they may devise a set of withdrawal rules, with which they determine and coordinate usage of the resource, but they cannot determine who has access to the resource. One example is a group of professional fishermen together determining the fishing rules for their joint property, but not for the sporting fishermen using the same ‘piece’ of water. People with an extra exclusion right are called ‘Proprietors’. Proprietors decide who may have access to the resource and how it may be utilized, but they may not sell it. One example is a committee of stakeholders’ representatives governing the usage of a resource, but not authorized to sell the property. The right of alienation is only reserved for ‘Owners’. Owners have the complete bundle of rights.

The Schlager-Ostrom conceptualization is based on and applied to single-use and local-community level institutional arrangements, mostly local fishery or lobster communities (see

their examples in their 1992 article). For our purpose, the analysis of multi-level and multi-use CPR, the conceptualization must be adapted to accommodate for the positions of governmental (the state and its agencies) and non-governmental organizations (NGO's). Therefore we propose a new type of owner, the trustee (see table 7). A trustee is a not self-interested actor, but he is goal oriented and in a principal-agent relation towards this goal set by others. This means that he does not act on his own behalf, but on the behalf of others or certain objects. This is quite different from the 'owners' of Schlager and Ostrom who act in their own best interest. The 'trustee' is an agent of the beneficiaries<sup>12</sup> and tries acting in their best interest. A trustee is not acting on his behalf, but serving a 'higher purpose'. To do this, he needs a bundle of rights that contain management rights, exclusion rights and alienation rights. With these rights he can control the usage and access to the resource in the best interest of the beneficiaries. Such a position would be useful in cases where a large group of people is joint owner of a resource. To achieve an optimal allocation or maximized welfare, it is necessary that activities of users are coordinated/restricted. Since the people themselves cannot come to an agreement about the usage of the resource, due to high transaction costs, they partially transfer their rights to a trustee. Such a trustee would then regulate and coordinate the usage of the resource on behalf of the people.

	Owner	Trustee	Proprietor	Authorized Claimant	Authorized User	Authorized Entrant
Access	x		x	x	x	x
Withdrawal	x		x	x	x	
Management	x	x	x	x		
Exclusion	x	x	x			
Alienation	x	x				

Table 7: Adapted version of table 'Bundles of rights associated with types of owners'

With these six types of owners and the three levels of property rights one is able to determine the extent to which claims, privileges, powers and immunities are transferred to actors at lower levels of organization. By knowing at which levels the powers and/or types of owners are located, one can also get a view on the abilities of the legal regime to adapt to local situations. In the next section our formal model, representing the comparative analysis of our method, will be discussed.

## 6 Formal Model

In this section we define the mathematical basis for the comparison of two legal arrangements. Obviously we are only interested in the similarities between legal arrangements that are concerned with the same policy area, e.g. water quality management, water quantity management, spatial planning, etc. Therefore, in the remainder, the policy area is considered a parameter for the comparison and thus fixed.

<sup>12</sup>In case of the government, the 'people', this can be the current population, but it can also contain future generations.

## 6.1 Preliminaries

First we define several sets which embody the concepts as discussed in the preceding sections.

- HoF is the set of  $2 \times 4 = 8$  legal relations of Hohfeld:  
HoF = { claim\_duty, privilege\_noclam, power\_exposure, immunity\_disability, duty\_claim, noclaim\_privilege, exposure\_power, disability\_immunity }
- PR is the set of *property rights*:  
PR = { ro-access, ro-withdrawal, ro-management, ro-exclusion, ro-alienation },  
where “ro” stands for “right-of”.
- Levels is the set of *levels* on which entities are defined. Levels = { International, National, State, Province, Region, Local }.

### 6.1.1 Legal arrangement L.

A legal arrangement L can be seen as a set of legal rules. Each rule relates a set of *source* entities *es* to a set of *target* entities *et*.  $\text{Ent}_L$  is the set of all entities that appear in L. An entity is either an *object* or *subject*. In the remainder we do not make a distinction between objects and subjects. Each entity  $e \in \text{Ent}_L$  has a fixed  $\text{level}(e) \in \text{Levels}$  associated.

### 6.1.2 Rule *r*.

Formally, a rule  $r \in L$  is a tuple  $(nr, es, et, hf, co, prox, pr_{es}, pr_{et})$ , where

- *nr* is a unique *key* (i.e. a unique number) identifying this rule within the legal arrangement L,
- $es \subseteq \text{Ent}_L$  are the *source* entities of the rule. We denote the entities of *es* by  $es_1, es_2 \dots$
- $et \subseteq \text{Ent}_L$  are the *target* entities of the rule. We denote the entities of *et* by  $et_1, et_2 \dots$
- $hf \in \text{HoF}$  is the Hohfeld relation of this rule, relating the entities in *es* to *et*,
- *co* is the range of behaviour or conduct that is regulated between the entities *es* and *et*,
- *prox* is the proxy this rule is related to,
- $pr_{es} \subseteq \text{PR}$  is the set of property rights for the entities in *es*, and
- $pr_{et} \subseteq \text{PR}$  is the set of property rights for the entities in *et*.

For convenience we use the names of the elements of the tuple to select the particular elements from a rule *r*. For example, the function  $es(r)$  returns the set of source entities of rule *r* and  $pr_{es}(r)$  returns the set of property rights for these source entities in rule *r*. You will notice that the elements *hf*, *co* and *prox* are not used in the remainder of this formal model. These three elements are already taken up in the tuple that describes the content of a rule, because they are the basis for future development of the method. These developments are discussed in section 8.

### 6.1.3 Entity.

We define the function  $ent(r)$  which returns the set of all entities appearing in rule  $r$ , i.e.

$$ent(r) = es(r) \cup et(r).$$

Consequently,  $Ent_L = \bigcup_{r \in L} ent(r)$ .

Furthermore, given a rule  $r$  and an entity  $e \in Ent_L$ , the function  $pr(r, e)$  returns the set of property rights for the entity  $e$  as defined by rule  $r$ , i.e.

$$pr(r, e) = \{ ro \mid r \leftarrow L, e \in es(r), ro \leftarrow pr_{es}(r) \} \cup \{ ro \mid r \leftarrow L, e \in et(r), ro \leftarrow pr_{et}(r) \}$$

Note that  $pr(r, e)$  might well be the empty set for a given rule  $r$  and entity  $e$ .

We use the function  $pr$  to define the function  $all\_pr(e)$  which returns the set of all property rights of the given entity  $e$ , i.e.

$$all\_pr(e) = \{ ro \mid r \leftarrow L, ro \leftarrow pr(r, e) \}$$

The function  $all\_pr(e)$  can be used to determine the *property type* of the entity  $e$  due to Schlager & Ostrom, e.g. *Owner, Trustee, Proprietor*, etc.

Given an entity  $e$ , we are also interested in all entities that are related to  $e$  by some rule. The function  $tgt(e)$  gives all the *target* entities of  $e$ , whereas  $src(e)$  gives all the *source* entities of  $e$ <sup>13</sup>, i.e.

$$\begin{aligned} tgt(e) &= \{ t \mid r \leftarrow L, e \in es(r), t \in et(r) \} \\ src(e) &= \{ s \mid r \leftarrow L, s \in es(r), e \in et(r) \} \end{aligned}$$

Now the following holds:

$$\forall e_s \in Ent_L, \forall e_t \in Ent_L \bullet e_t \in tgt(e_s) \Leftrightarrow e_s \in src(e_t)$$

## 6.2 Graph $\mathcal{G}_L$ .

A legal arrangement  $L$  can be seen as a directed graph, induced by the rules of  $L$ . The nodes of this graph are the entities of  $L$  and the *edges* are the source-target relations between the entities, due to the rules.

We formally define the graph  $\mathcal{G}_L$  as  $\mathcal{G}_L = (Ent_L, Rel_L)$ , where  $Ent_L$  are the nodes of the graph  $\mathcal{G}_L$  and  $Rel_L$  are the edges between the entities.  $Rel_L \subseteq Ent_L \times L \times Ent_L$  is defined as:

$$Rel_L = \{ (e_x, r, e_y) \mid r \leftarrow L, e_x \leftarrow es(r), e_y \leftarrow et(r) \}$$

In other words, each rule  $r$  in  $L$  defines pair-wise edges between the source entities  $es$  and the target entities  $et$  of  $r$ . So there is an edge from  $e_x$  and  $e_y$  if  $e_y \in tgt(e_x)$ . The edge between  $e_x$  and  $e_y$  is labelled by the rule  $r$  which relates the two entities. There may very well be several edges between two entities, each labelled by different rules.

<sup>13</sup> The notation  $tgt$  stands for *target* and  $src$  stands for *source*.

### 6.3 Comparison.

We are interested in comparing two legal arrangements  $L_A$  and  $L_B$ , more specifically the entities of both arrangements. As said before, the policy areas of the two arrangements under comparison is the same and fixed. We now define several equivalence relations  $\sim_i$ , which relate entities  $e_a$  from  $L_A$  and  $e_b$  from  $L_B$ .

**0. Property rights.** Two entities are related via the (weakest) relation  $\sim_0$  if the property rights of both entities are the same.

$$e_a \sim_0 e_b \Leftrightarrow all\_pr(e_a) = all\_pr(e_b)$$

**1. Level.** For  $\sim_1$ , apart from the property rights, the entities should have the same level of authority.

$$e_a \sim_1 e_b \Leftrightarrow e_a \sim_0 e_b \wedge level(e_a) = level(e_b)$$

**Comparable number of related entities.** Two entities are related via  $\sim_c$  if the entities have comparable number of related entities, i.e. the number of target- and source entities should be more or less equal.

$$e_a \sim_c e_b \Leftrightarrow abs(|tgt(e_a)| - |tgt(e_b)|) \leq n \wedge abs(|src(e_a)| - |src(e_b)|) \leq n$$

Here,  $n$  is either a constant (e.g. 1) or a function which depends on the functions  $tgt$  and/or  $src$  of both entities, e.g.  $n = 0.25 \times max(tgt(e_a), src(e_b))$ . This relation  $\sim_c$  is used in the following two relations.

**2a. Same level of jurisdiction.** Here we are interested in similar entities on the same level of jurisdiction, i.e.

$$e_a \sim_{2a} e_b \Leftrightarrow e_a \sim_1 e_b \wedge e_a \sim_c e_b$$

**2b. (De)centralized jurisdiction.** We are also interested in entities that are similar but are not on the same level. This relation shows related entities which differ in centralized and decentralized jurisdiction. So,

$$e_a \sim_{2b} e_b \Leftrightarrow e_a \sim_0 e_b \wedge level(e_a) \neq level(e_b) \wedge e_a \sim_c e_b$$

**3. Every target entity has a comparable peer.** For the strongest relation  $\sim_3$ , we require that the target entities of both  $e_a$  and  $e_b$  are themselves related via  $\sim_0$ , i.e. have the same property rights.

$$e_a \sim_3 e_b \Leftrightarrow e_a \sim_{2i} e_b \wedge \forall e_i \in tgt(e_a) \exists e_j \in tgt(e_b) : e_i \sim_0 e_j \wedge \forall e_i \in tgt(e_b) \exists e_j \in tgt(e_a) : e_i \sim_0 e_j$$

where  $\sim_{2i}$  is either  $\sim_{2a}$  or  $\sim_{2b}$ .

These are the equivalence relations that form the basis of our comparative analysis. Since we are dealing with legal regimes that are made up out of many rules, we need a tool to automate the comparative analysis. It is too much to do it by hand. For that reason we have developed a web-based database system.

## 7 Implementation

The website is the heart of our tools. Everything happens through this website, namely adding data, generating new (secondary) data based on the primary input, analyzing data and reporting results. In the next subsections we will discuss the website and the tool we have used to generate the graphical visualizations of our legal regimes.

### 7.1 Basis: Website & PHP & MySQL

The website is made up from two components, namely the database and the forms that are used to add and extract information from the database.

The database is a MySQL-database (version 4.1.18-nt)/<sup>footnote</sup>Software, manuals, training, support, etc. can be found at <http://www.mysql.com><sup>14</sup>. MySQL is the world's most popular open source database and it has become the database of choice for a new generation of applications built on the LAMP (Linux, Apache, MySQL, PHP/Perl/Python) or WAMP (Windows, Apache, MySQL, PHP/Perl/Python) stack. These combinations enable one to build dynamic websites. In other words, websites that present information that is (partly) stored in and extracted from a database. This is very helpful if one wants to analyze legal regimes, because this means storing information about thousands of rules, subjects and objects. The dynamic website is build with the help of PHP (version 4.4.1)<sup>15</sup>. PHP is a widely-used general-purpose scripting language that is especially suited for Web development and can be embedded into HTML. PHP gives one the opportunity to special commands to communicate with a (My)SQL-database. Therefore it is possible to make forms that can add information to the database. But it is also possible that some of the information that is used to make up these forms is extracted from the database. For instance, if one is analyzing a legal rule and one wants to store in the database which entities have a legal relationship, it is possible to select these entities from a list of entities already added to the database.

### 7.2 Visualization: Graphviz

The graphic visualizations of the legal system are made with the help of the program Graphviz(version 2.8)<sup>16</sup>. We were looking for a program that was able to visualize the legal relations between

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<sup>14</sup>The database was managed with the help of phpMyadmin (version 2.6.1.). Currently it can create and drop databases, create/drop/alter tables, delete/edit/add fields, execute any SQL statement, manage keys on fields, manage privileges, export data into various formats and is available in 50 languages. The software can be downloaded from <http://www.phpmyadmin.net>

<sup>15</sup>PHP can be found at <http://www.php.net>. This site contains the software, manuals, tutorials and support software.

<sup>16</sup>The Graphviz software is available at <http://www.graphviz.org> and at <http://www.research.att.com/sw/tools/graphviz>. The Graphviz software is freely available under an open

entities in a legal regime. Essentially we were looking for a program that can draw graphs, which are made up out of nodes (entities) and edges (relations). The choice has fallen upon Graphviz. Graphviz is a collection of software for viewing and drawing attributed graphs. It consists of implementations of various common types of graphs and it supports a wide assortment of graphical features and output formats. The program started with the article of Gansner *et al.* (1993). In this article they presented a collection of software that was designed to draw graphs based on the following aesthetic principles:

- A1. Expose hierarchical structure in the graph. In particular, aim edges in the same general direction if possible. This aids finding directed paths and highlights source and sink nodes.
- A2. Avoid visual anomalies that do not convey information about the underlying graph. For example, avoid edge crossings and sharp bends.
- A3. Keep edges short. This makes it easier to find related nodes and contributes to A2.
- A4. Favor symmetry and balance. This aesthetic has a secondary role in a few places in our algorithm. [p.214]

Graphviz has been used in several applications (e.g. displaying metabolic pathways, producing class hierarchies and other diagrams directly from source code, displaying co-author networks, to visualize clickpaths taken by users on websites, etc.<sup>17</sup>) to assist users to better understand domain-specific information or to perform some tasks visually (Gansner, 2004; Gansner and North, 2000). It has proven to draw very large graphs based on a lot of data.

Graphviz can give nodes and edges different shapes and colours on the basis of the input-code. It can also generate and link subgraphs into a big graph. Also important is the fact that nodes can be vertically ordered by given them ranks. This means that some nodes can be set at a higher level in the graph than others. These elements are all very helpful for our analysis. We can select different shapes of nodes for different types of owners and give edges different colours that relate to different types of Hohfeld-relationships. The ability of the software to draw subgraphs enable us to visualize the legal regime with subgraphs per policy area. With the help of the ranking of nodes, we can recreate the different levels (international -; local) of the legal regimes. These are all useful elements for our analysis.

This is all possible with the data in our database. With the help of PHP- and MySQL scripts the relevant information for visualizing the legal system (entities = nodes, legal relations = edges)<sup>18</sup>, is translated into a language that can be interpreted by Graphviz. This language is called the DOT-language<sup>19</sup>. For a simple example generated by our tools, see below. It represents the legal regime of the Scheldt-regulation, regulating the navigation and pilot-services in the Scheldt estuary.

```
digraph L0 {
  size = "12,12";
  ordering=out;
  node [shape = record];
```

---

source license. The website of AT&T also contains several supporting documents and working papers, sample layouts and links to various sites that describe and support software that incorporates or extends the different uses of Graphviz.

<sup>17</sup>For an overview of tools and their application, look at <http://www.graphviz.org/Resources.php>.

<sup>18</sup>The formal model for this information can be found in section (6.2)

<sup>19</sup>See for more information about this language Gansner *et al.* (2002)

```

{rank = same; "n0006"; "n0005";"n0001";"n0020";}
{rank = same; "n0008"; "n0016";"n0009";"n0018";}
{rank = same; "n0010";"n0013";"n0017";"n0019";"n0004";"n0011"; "n0012";}

n0006 [label="Belgium\nfederal\ngovernment"];
n0012 [label="pilotage performance"];
n0010 [label="Scheldefahrer"];
n0007 [label="Dutch\npilotage\nservice"];
n0017 [label="Harborcompany"];
n0013 [label="Pilot\nvessel"];
n0005 [label="Dutch\ngovernment"];
n0019 [label="Flemmish\npilot"];
n0001 [label="Dutch\nminister\nof\nTransport,\nPublic\nWorks\nand\nWater\nManagement"];
n0020 [label="Flemmish\nminister\nof\nMobility,\nPublic\nworks\nand\nEnergy"];
n0008 [label="Flemmish\npilotage\nservice"];
n0004 [label="Dutch\npilot"];
n0011 [label="Caption\nship/scheldefahrer"];
n0016 [label="Dutch\ncommissionars"];
n0018 [label="Flemish\nregional\ngovernment"];
n0021 [label="Flemmish\ncommissionars"];
n0009 [label="Commissionars"];

n0005 -> n0006 [color=coral, arrowhead=back]
n0007 -> n0005 [color=coral, arrowhead=back]
n0009 -> n0012 [color=lawngreen ]
n0008 -> n0005 [color=coral, arrowhead=back]
n0009 -> n0010 [color=lawngreen , style="setlinewidth(2)", arrowsize=2]
n0008 -> n0007 [color=aliceblue ]
n0008 -> n0011 [color=coral, arrowhead=back]
n0007 -> n0008 [color=aliceblue ]
n0009 -> n0007 [color=lawngreen , style="setlinewidth(2)", arrowsize=2]
n0009 -> n0008 [color=lawngreen ]
n0013 -> n0017 [color=yellow ]
n0013 -> n0005 [color=yellow , style="setlinewidth(2)", arrowsize=2]
n0013 -> n0018 [color=yellow ]
n0011 -> n0004 [color=coral ]
n0011 -> n0019 [color=coral ]
n0011 -> n0001 [color=lawngreen ]
n0011 -> n0020 [color=lawngreen ]
n0011 -> n0007 [color=coral, arrowhead=back, style="setlinewidth(2)", arrowsize=2]
n0011 -> n0008 [color=coral, arrowhead=back, style="setlinewidth(2)", arrowsize=2]
n0009 -> n0011 [color=lawngreen , style="setlinewidth(5)", arrowsize=2]
n0009 -> n0019 [color=lawngreen , style="setlinewidth(2)", arrowsize=2]
n0009 -> n0004 [color=lawngreen , style="setlinewidth(2)", arrowsize=2]
n0011 -> n0007 [color=coral ]
n0005 -> n0016 [color=lawngreen ]
n0018 -> n0021 [color=lawngreen ]
n0007 -> n0009 [color=coral ]
n0008 -> n0009 [color=coral ]

```

```
n0009 -> n0009 [color=coral ]
}
```

The website is generating the code given above. This code should then be copy-pasted into a text file (with extension .dot). This dot-file is subsequently selected as input for the program Graphviz. With the help of one of its tools (also called dot), Graphviz can draw a graph visualizing the legal regime (see figure 7.2). Several types of output can be selected, ranging from jpeg and gif to ps and cmap.

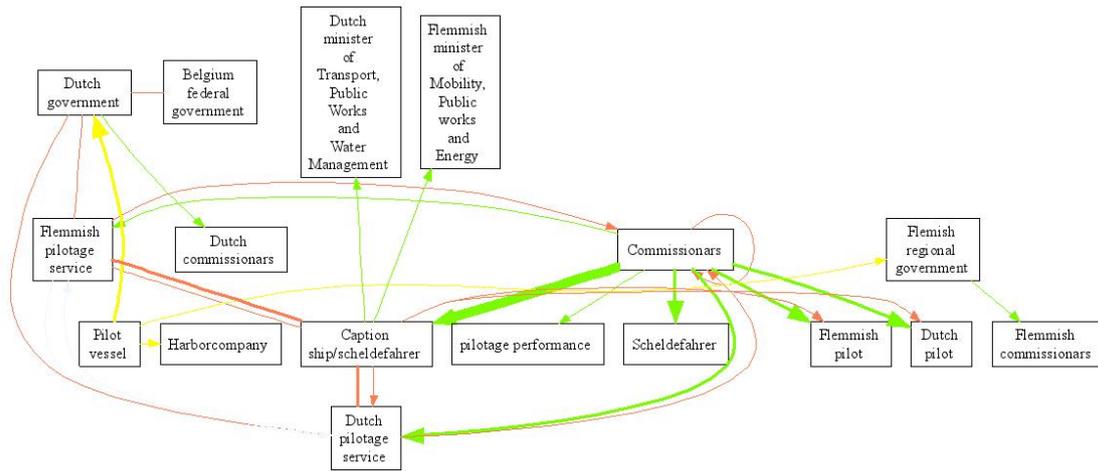


Figure 1: Resulting graph from the dot-file

We have shown that it is possible to visualize the legal system per policy area with the help of the MySQL and PHP scripts. But one can also limit the visualization to all the entities that have a legal relation with a specific (selected) entity. This can be very helpful in determining similarities and differences between or within legal systems.

### 7.3 Comparison

The comparison is made with the help of a few MySQL&PHP-scripts. Each new step in the formal approach is reformulated in SQL-language. These SQL-scripts are then incorporated in PHP-scripts in order to generate the necessary forms. With the help of these forms the SQL-scripts can be executed, but also tuned (e.g. entities must be on the same level (or not)) to specific needs. That way one is able to perform the required analysis with an minimum amount of effort.

## 8 Future developments

The method we present in this paper is still under development and has not yet reached its full potential. We are still learning and adapting the method and its tools to fulfil its task (more) efficiently and effectively. In this section we will be discussing some elements that we will be adding in the near future.

## 8.1 Webdot

WebDot<sup>20</sup> is a CGI program that converts a graph description from a .dot file into an image that can be included on a web page. The idea is that our SQL and PHP scripts generating the dot-language put this code directly in a file on our webserver. Filename and output format can be selected by the user and WebDot can directly generate the image and render it at the website.

WebDot is also capable of generating images that can contain URLs. Both nodes and edges can be made clickable. Our idea is to use this element of the tool to enhance the information generating capabilities of the image. We would like to make the graphs so that users can click on a node/entity. By clicking a new webpage will popup, which gives information about the entity (attributes, in which policy areas the entity is active, its bundle of property rights, etc.) and with which other entities this entity has a relation. By clicking at the edges one should be linked to a webpage containing the content of the legal relations, which the edge represents. This should greatly enhance the usability and function of the graphs.

## 8.2 Information cost analysis

As we have reported above, one has two options when analyzing property rights. One can look at what (constellation of rights) constitutes an owner or analyze the object to which an owner is linked. In another paper of Van de Griendt van de Griendt (2005) we have presented a method to make estimates about the relative order of magnitude of information costs that the legal regime is generating. The same descriptions generated by ILT and Hohfeld hold also the key for an information costs analysis with the help of Information Cost Theory of Smith (2002, 2004a,b). This theory is based on the idea that one can make estimates on the levels of information costs by looking to the objects and the legal relations that extend over it.

For determining the level of information costs, Smith argues that it is important to answer two questions. The first is: What collection of attributes is treated as a unit for describing permitted or forbidden activities? It is costly to define, monitor and enforce property rights, because objects can be seen as a bundle of valuable attributes, which are individually costly to measure. However, not all measurement methods are as costly. Due to these issues, people setting up a system of property rights will try to economize on measurement/information costs. They do this by using a more or less rough ‘proxy’<sup>21</sup> for describing the property and the legal relations among the legal actors. Detailed proxies have the benefit of being better able to capture the (true) value of the property. But the more specified the rules, the more effort it will take to communicate these rules to all users and for them to remember them and act accordingly. Therefore more specific rules lead to higher costs of protecting the property. This way a trade-off can be made between the costs and benefits of a more specific<sup>22</sup> ‘proxy’.

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<sup>20</sup>WebDot was written by John Ellson and is released under a BSD-style license. More information can be found at <http://www.site.uottawa.ca:4333/webdot/>.

<sup>21</sup>The proxy functions as a referent for complex legal relationships. That way it reduces information costs (Long, 2004).

<sup>22</sup>Sjaastad and Bromley (2000) describe in their article several processes for making rights more specific. Therefore we like to say that specific means here “more fragmented”.

Thus, rights that distinguish between access to different tree species are more detailed than rights that do not, and rights that define access to grazing land in terms of different seasons are more detailed than rights that do not. Detail is of relevance when rights are assigned in some manner other than location (Sjaastad and Bromley, 2000, p.369).

This leads us to the second question, namely which range of behaviour is allowed in relation to this ‘proxy’. In other words, what are the legal relations between legal actors in relation to the object to which the relations apply (Long, 2004)? When rough ‘proxies’ like borders are used, a large class of activities, in an all-or-nothing way (Smith, 2004b), will be bundled and not defined separately, because of the very crude methods of measurement. That way a set of attributes becomes difficult to use without the right holder’s permission. Such proxies are called exclusion rules. If an owner wants to protect his resource, he must make ‘exclusion costs’. These are the costs of drawing and enforcing boundaries to restrict access to and use of the resource to the owner(s) of the property (Cole, 2002) and the cost of monitoring.

Alternatively, the people setting up a property regime can also use governance rules. Governance rules are rules which pick out uses and users in more detail and directly describe proper use. These rules come with governance costs, namely the costs of negotiating arrangements, coordinating decisions and monitoring and enforcing the rules set by the arrangement governing the usage of ((part of) one of the attributes of) the property. These costs are initially higher than exclusion costs, because it is difficult to separate the effects of the different uses and coordinate the activities of the different users.

Exclusion and governance are opposites differing in the proxies selected. That does not mean that when setting up a property regime one must choose for either one. They are poles of a continuum, with hybrid solutions in between. To estimate the level of costs associated with the legal regime it is not necessary to make an accurate calculation. We can make these estimates by determining the level of specification of the proxy. This level will be somewhere between the level of total specification and total absence of specification. Total specification means that for every use of every attribute every potential Hohfeldian relation<sup>23</sup> is specified between every pair of members of the society. Total absence of specification is a situation where no rules are set and no property rights are assigned. By comparing the levels of specification of the proxies defined by the legal regimes, one can observe if one legal regime has a higher level of information costs associated with it than the other(s).

The level of specification can be determined with the information stored in the database. For every rule it is already stored to which proxy (*prox*), this rule is related. Combined with the content of the rule (*co*) and the Hohfeld relation (*hf*) one can determine the number of Hohfeld relations and the attributes discerned. The idea is that in the future all this information can be gathered with a click at one of the buttons at our website.

### 8.3 Extension of formal model

The last development of our method is an extension of the formal model to establish equivalences between legal rules. We propose to add a level 4 analysis. This level should build upon the analysis of levels 2 and 3 and look if there legal relations between the target entity and its peer that have the same type of Hohfeld relation which regulates the same content. This is the strongest test one can use to determine if there two legal regimes are equal or not.

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<sup>23</sup>Paragraph 5.2 is dedicated to Hohfeld and his legal relations.

## 9 Conclusion

In this paper we have shown a method and its tools to analyze and compare legal regimes for integrated management of multi-use and multi-user common pool resources in order to determine their level of (de)centralization and its ability to adapt. The method is based on the idea that legal regimes can be described by looking at the legal institutions they contain. Institutional Legal Theory and Hohfeld give one a useful typology for describing respectively the form and content of these legal institutions in terms of their ‘underlying unities’. This enables a researcher to make unbiased comparisons. The descriptions of legal regimes can also be used for assessing the level of (de)centralization of the legal regimes, by looking at the property rights they assign to different actors. By examining the bundle of property rights hold by the different actors, one can determine their type of ownership and assess at which level of organization the legal regime can be adapted to local situations.

With the help of the combination of legal and economic institutional theories and the web-based database system and the tools we have developed that implement the method in order to perform (semi)automatic analysis, we think that we have made a first step towards the development of a method that can help us draw conclusions about the way in which structural differences can explain differences in performance of legal regimes governing aquatic resources. Reaching this goal becomes easier if the future developments are no longer on the ‘to do’ list, but an integral part of our system and tools.

The next step to reach the research goal set by Agrawal (2001) would then be to develop a method that looks at the performance of the legal regimes in a way that its results can be related to the structural differences as determined by the method presented in this paper.<sup>24</sup>

## References

- Agrawal, A. (2001). Common property institutions and sustainable governance of resources. *World Development*, **29**(10), 1649–1672.
- Agrawal, A. and Ostrom, E. (2001). Collective action, property rights, and decentralization in resource use in india and nepal. *Politics & Society*, **29**(4), 485–514.
- Bromley, D. W. (1989). *Economic interests and institutions, the conceptual foundations of public policy*. Basil Blackwell.
- Bromley, D. W. (1991). *Environment and Economy, property rights and public policy*. Basil Blackwell.
- Cole, D. H. (2000). New forms of property rights: Property rights in environmental goods. In B. Bouckaert and G. D. Geest, editors, *Encyclopedia of Law and Economics*, volume 2, pages 274–314. Edward Elgar.
- Cole, D. H. (2002). *Pollution & Property, comparing ownership institutions for environmental protection*. Cambridge University Press.

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<sup>24</sup>Maybe the 2005 Water Studies Fellowship project called “Development and Testing of Pilot Indicators to Measure the Effectiveness of River Basin Management” can be this second step. For more information, please contact Dr Bruce P. Hooper, Associate Professor at the Department of Geography and Environmental Resources of Southern Illinois University. Carbondale. IL 62901-4514. bhooper@siu.edu

- Coleman, J. L. and Kraus, J. (1986). Rethinking the theory of legal rights. *Yale law journal*, **95**(7), 1335–1371.
- Corbin, A. L. (1964). Foreword. In *Fundamental legal concepts as applied in legal reasoning*, pages vii–xv. Greenwood press.
- Cortner, H. J., Wallace, M. G., Burke, S., and Moote, M. A. (1998). Institutions matter: the need to address the institutional challenges of ecosystem management. *Landscape and Urban Planning*, **40**(1-3), 159–166.
- Crawford, S. E. S. and Ostrom, E. (1995). A grammar of institutions. *American Political Science Review*, **89**(3), 582–600.
- Diermeier, D. and Krehbiel, K. (2003). Institutionalism as a methodology. *Journal of Theoretical Politics*, **15**(2), 123–144.
- Gansner, E., Koutsofios, E., and North, S. (2002). Drawing graphs with dot. Technical report, AT&T Labs-Research.
- Gansner, E. R. (2004). Drawing graphs with graphviz. Technical report, AT&T Labs-Research.
- Gansner, E. R. and North, S. C. (2000). An open graph visualization system and its applications to software engineering. *Software: Practice and Experience*, **30**(11), 1203–1233.
- Gansner, E. R., Koutsofios, E., North, S. C., and Vo, K.-P. (1993). A technique for drawing directed graphs. *Software Engineering*, **19**(3), 214–230.
- Hardin (1968). Tragedy of the commons. *Science*, **162**(3859), 1243–1248.
- Hoebel, E. A. (1968). *The law of primitive man : a study in comparative legal dynamics*. Atheneum.
- Hohfeld, W. N. (1919). *Fundamental legal conceptions as applied in judicial reasoning*. Yale University Press.
- Kamba, W. J. (1974). Legal theory and hohfeld’s analysis of a legal right. *The juridical review*, **19**, 249–262.
- Keman, H. (1997). Approaches to the analysis of institutions. In B. Steunenberg and F. van Vught, editors, *Political Institutions and Public Policy*, pages 1–27. Kluwer Academic Publishers.
- Long, C. (2004). Information costs in patent and copyright. *Virginia Law Review*, **90**(2), 465–549.
- MacCormick, N. and Weinberger, O. (1986). *An institutional theory of law, new approaches to legal positivism*. D. Reidel Publishing Company.
- MacCormick, N. and Weinberger, O. (1992). *An institutional theory of law, new approaches to legal positivism*. Kluwer Academic Publishers.

- Nelson, R. R. and Sampat, B. N. (2001). Making sense of institutions as a factor shaping economic performance. *Journal of Economic Behavior & Organization*, **44**, 31–54.
- Ostrom, E. (1990). *Governing the Commons, the evolution of institutions for collective action*. Cambridge University Press.
- Ostrom, E. and Schlager, E. (1996). The formation of property rights. In *Rights to nature, ecological, economic, cultural, and political principles of institutions for the environment*, pages 127–156. Island Press.
- Ostrom, E., Burger, J., Field, C. B., Norgaard, R. B., and Policansky, D. (1999). Revisiting the Commons: Local Lessons, Global Challenges. *Science*, **284**(5412), 278–282.
- Penner, J. (1996). The bundle of rights picture of property. *U.C.L.A. law review*, **43**(3), 711–820.
- Perry, T. D. (1977). A paradigm of philosophy:hohfeld on legal rights. *American Philosophy Quarterly*, **14**(1), 41–50.
- Posner, R. A. (2004). Law and economics in common-law, civil-law, and developing nations. *Ratio Juris*, **17**(1), 66–79.
- Ross, A. N. C. (1974). *On law and justice*. California library reprint series. University of California Press, Berkeley.
- Ruiter, D. (1994). Economic and legal institutionalism: What can they learn from eachother? *Constitutional political economy*, **5**(1), 99–115.
- Ruiter, D. (2003). Rights and individual opportunity sets. working paper.
- Ruiter, D. W. (1993). *Institutional legal facts, legal powers and their effects*, volume 18 of *Law and Philosophy Library*. Kluwer Academic Publishers.
- Ruiter, D. W. (1995). De inrichting van gemeenten in rechtsvergelijkend perspectief. In *Lokale democratie vergeleken*, pages 35–58. Tjeenk Willink.
- Ruiter, D. W. (1997). A basic classification of legal institutions. *Ratio Juris*, **10**, 357–371.
- Ruiter, D. W. (2001). *Legal Institutions*, volume 55 of *Law and Philosophy Library*. Kluwer Academic Publishers.
- Ruiter, D. W. (2004). Types of institutions as patterns of regulated behavior. *Res Publica*. forthcoming.
- Schlager, E. and Ostrom, E. (1992). Property-rights regimes and natural resources: A conceptual analysis. *Land Economics*, **68**(3), 249–262.
- Sjaastad, E. and Bromley, D. W. (2000). The prejudices of property rights: On individualism, specificity, and security in property regimes. *Development Policy Review*, **18**, 365–389.
- Smith, H. E. (2002). Exclusion versus governance: Two strategies for delineating property rights. *Journal of Legal Studies*, **31**(2), S453–S487.

- Smith, H. E. (2004a). Exclusion and property rules in the law of nuisance. *Virginia Law Review*, **90**(4), 965–1049.
- Smith, H. E. (2004b). Property and property rules. *New York University Law Review*, **79**, 1719–1798.
- Söderqvist, T., Mitsch, W. J., and Turner, R. K. (2000). Valuation of wetlands in a landscape and institutional perspective. *Ecological Economics*, **35**(1), 1–6.
- Steins, N. A. (1999). *All hands on deck, an interactive perspective on complex common-pool resources management based on case studies in the coastal waters of the Isle of Wight (UK), Connemara (Ireland) and the Dutch Wadden Sea*. Ph.D. thesis, Wageningen Universiteit.
- van de Griendt, W. E. (2005). A law & economics approach to the study of integrated management of estuaries. Paper presented at USGS-workshop ‘Institutional Analysis for Environmental Decision-making: A Workshop’, January 28 and 29, 2005, Fort Collins Science Center, Fort Collins, Colorado USA.
- van Wageningen, A. C. (2003). *De staat van de universiteit; een rechtsvergelijkende studie naar de institutionalisering van de universiteit in Nederland, Frankrijk en Nordrhein-Westfalen*. Ph.D. thesis, University of Twente.
- Veeman, T. and Politylo, J. (2003). The role of institutions and policy in enhancing sustainable development and conserving natural capital. *Environment, Development and Sustainability*, **5**, 317–332.
- Wessel, R. (2001). De Europese unie in de internationale rechtsorde. In *De plaats van de Europese Unie in het veranderende bestel van de volkenrechtelijke organisatie*, volume 123 of *Preadviezen, Mededelingen van de Nederlandse Vereniging voor Internationaal Recht*, pages 1–78. T.M.C. Asser Press.
- Wessel, R. A. (1999). *The European Union’s foreign and security policy, a legal institutional perspective*. Kluwer Law International.