Hog farmers' compliance and the role of agro-environmental institutions in the Missisquoi Bay

Alejandra Zaga Mendez,
Natural Resource Sciences
McGill University, Montreal

November 2015

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Master of Science

Table of Content

Abstract

Institutions, defined as rules, norms and strategies, play an important role in shaping socio-ecological interactions and determining human behaviour. In Québec, agro-environmental policies were introduced within the last 15 years to reduce the degrading effects of intensive agricultural production on land and water. However, the disturbance of water ecosystems remains a problem in agricultural areas in part due to producers' difficulties in complying with the present agro-environmental regulation.

This research assesses the role of institutions in encouraging the compliance of hog farmers with Quebec's *Règlement sur les exploitations agricoles* (REA) in the Missiquoi Bay. This regulation is meant to reduce the ecological impact of farming systems and to guide animal production development in the province. This study follows the methodology of Crawford and Ostrom's (1995) "Grammar of Institutions" framework which identifies the actions encouraged, the actors assigned, the boundaries of the actions as well as the punitive measures present in any given institutional setting. Furthermore, this framework makes it possible to classify institution according to their grammatical content. This case study aligns with research conducted at the intercept of institutional and ecological economics, focusing on the role of institutions in fostering collective action and environmental outcomes as well as providing alternative policy recommendations according to normative foundations.

The REA can be described by containing different types of institutions, classified by 84.5% of rules, 14.7% of norms and 0.8% of strategies. As most of the institutions in the REA exhibited complete grammar, the regulation can be considered to have a robust regulative role. However, when we analyzed rules according to the legitimacy of sanctions, we found out that the sanctions did not comply with all the conditions for their legitimacy, as the REA was not the result of collective action. The latter is a major parameter for the legitimacy and internalization of institutions. Our results show that although the REA looks rather robust from a grammatical perspective, it also offers a weak normative character. This study recommends the examination of other institutional design frameworks by focusing on the legitimacy of institutions.

Résumé

Les institutions, définies comme des règles, normes et stratégies, contribuent à façonner les interactions socio-écologiques et à déterminer le comportement humain. Au Québec, des politiques agro-environnementales ont été introduites au cours de 15 dernières années dans le but de réduire les effets environnementaux de la production agricole. Cependant, la dégradation des milieux aquatiques demeure problématique dans les zones agricoles en partie à cause des difficultés éprouvées par les producteurs agricoles à se conformer aux règlementations agro-environnementales.

Cette recherche se concentre sur le rôle des institutions dans l'encouragement de la conformité des producteurs de porc envers les politiques agro-environnementales dans la région de la Baie Missisquoi, et ce, à travers l'étude du Règlement sur les exploitations agricoles (REA). L'objectif du REA est de guider le développement durable de la production animale dans la province. La méthodologie appliquée dans cette étude est basée sur le cadre d'analyse proposé par Crawford et Ostrom (1995) et intitulé « Grammar of Institutions ». Ce cadre permet d'identifier les actions encouragées, les acteurs désignés, les limites des actions et les mesures punitives présentes dans un cadre institutionnel en plus de classifier les institutions selon leur contenu grammatical. Cette étude de cas s'inscrit dans un courant de recherches menées à l'intersection de l'économie institutionnelle et l'économie écologique, mettant l'accent sur le rôle des institutions dans la promotion de l'action collective, l'atteinte des objectifs de durabilité et la recommandation de politiques alternatives se basant sur des fondements normatifs .

Le REA peut être décrit par la présence de diverses institutions, dont des règles à 84,5 %, des normes à 14,7 % et des stratégies à 0,8 %. Possédant majoritairement une grammaire complète, le règlement peut être considéré comme ayant un rôle régulateur fort. Cependant, lorsqu'on analyse la légitimité des sanctions, nous trouvons que le règlement ne respecte pas toutes les conditions pour la légitimité et internalisation des institutions. Nos résultats montrent que même si le REA est jugé robuste grammaticalement, il montre un caractère normatif faible. Cet étude recommande d'examiner d'autres cadres décisionnels pour le design des institutions portant une attention particulière à la légitimités de ces dernières.

Acknowledgements

Firstly, I would like to express my gratitude to my advisor, Prof. Nicolas Kosoy, for his continuous support in this research, for his patience and motivation. His guidance helped me throughout the research and the writing of this thesis, sharing his knowledge and passion for ecological economics.

Besides my advisor, I would like to thank Dr. Caroline Begg for her insightful comments and encouragement.

My sincere thanks also goes to the COVABAR and Martin Mimeault of the Ministry of Sustainable Development and the Fight against Climate Change, who welcomed me and accepted to participate in exploratory interviews, providing useful and illuminating information on the agricultural and environmental history of the region and the current challenges.

I would also like to thank the Ecological Economics Lab Group, especially Diana, Vijay, Matt, Patrick, Lylia, Aaron and Grace, for their observant comments and relentless encouragement, but also for the conversations and questions which prompted me to widen my research to various perspectives.

Last but not the least, I would like to thank my family and friends, especially my mom and my brother for their continuous support throughout my studies, and with whom, one cold night, we arrived in the Saint Lawrence Lowlands.

This research was conducted with the support of the Social Sciences and Humanities Research Council of Canada.

List of Tables

List of Figures

List of Boxes

List of Appendixes

Introduction

"*Institutions are much more than constraints.*"

Vatn. 2009

The second half of the 20th century is characterized by a rapid spread and intensification of anthropogenically-driven ecological changes. Human activities during the 20th century have forever transformed the Earth's ecological history, causing irreversible environmental transformation. Environmental historian McNeill (2001) qualifies this century as peculiar due to the acceleration of many processes. He notes:

> "We have cut timber, mined ores, generated waste, grown crop for a long time. In modern times, we have generally done more of these things than ever before, and since 1945, in most cases, far more."[1]

Keatly *et al*. (2011) show that this 'Great Acceleration' in agricultural production has resulted in water quality degradation, conversion of more forest into cropland, intensification of fertilizer use and freshwater eutrophication (*Idem).* Moreover, the authors claim that the leading cause of the propagation of freshwater eutrophication finds its roots in the history of anthropogenic influence in the land, and the path of intensive agriculture could lead to a further acceleration of water degradation. It will require centuries to recover from this ecological disaster.

The above-mentioned environmental issues are the result of human economic behaviour that has trespassed ecological limits and thresholds. However, can we blame only individual behaviour for such destructive economic activities? Institutions, defined as rules, norms and strategies, are responsible for shaping socio-ecological interactions, and determining human behaviour. In order to change the use of natural resources, institutions are required to transform current practices and economies must be considered as the result of institutional changes and transformations.

[1] McNeill, J.R. 2001. *Something New Under the Sun: An Environmental History of the Twentieth- Century World*. Reprint edition. W. W. Norton & Company. Page 3.

Environmental policies and efforts are meant to constraint and to regulate behaviour, in order to change practices aimed at a sustainable use of natural resources. In the Canadian province of Quebec, agro-environmental policies have been introduced within the last 15 years to reduce the ecological effects of intensive agricultural production on water quality. However, the disturbance of water ecosystems remains problematic in agricultural areas, and it is a continuous challenge for producers' to comply with the present agro-environmental regulation.

It is necessary to analyze the institutions governing socio-ecological interactions and examining the types of outcomes and behaviours that such institutions have historically encouraged. In doing so we hope to shed light on the viability of policy in improving sustainability in agricultural practices in the province. Various studies have been conducted to retrace the biophysical portrait of Southern Quebec in terms of nutrient flow monitoring (Gangbazo and Babin 2000; Gangbazo *et al* 2003). Moreover, agronomists, environmental organizations, regional and provincial governments have promoted the introduction of best management practices among farmers in order to inform and educate on the type of practices that could reduce the effect of nutrients surplus in water quality. However, limited attention has been paid to the role of institutions in encouraging compliance with agricultural policies in the region.

This research aims to address the research gap mentioned above by answering to the following research question: What has been the role of institutions in encouraging compliance of hog farmers with the agri-environmental policy in effect in the Missisquoi Bay over the past 30 years? The main research objectives of this study are to identify the agro-environmental institutions that have influenced hog farming in the past 30 years in the Missisquoi Bay and to select and analyze a regulation or policy based on the grammar of institutions it contains.

Based on a literature review and a compilation of institutions through interviews, we selected the *Réglement des exploitations agricoles* (REA). This regulation, introduced in 2002, is considered of high agro-environmental importance as it prioritizes the control of non-point source pollution and aims to create a balance between the soil carrying capacity for phosphorous and the quantity of fertilizer and manure applied by farmers. Moreover, the REA introduces the requirement of an agro-environmental fertilization plan at the farm level. The specific research objectives for the

analysis of the REA are to identify and to classify the institutions contained in the regulation following the 'Grammar of Institutions' methodological framework, and to analyze the role of the regulation based on the requirements for the legitimacy of rules: the requirement of the 'Or Else' parameter (Ostrom 2005).

The study's first hypothesis is that the grammar of the institutions in the REA might not be complete, meaning that institutions do not have all the elements to assure a clear interpretation and application of the actions and sanctions. Moreover, our second hypothesis is that the REA is not self-contained, meaning that it does not explicitly describe all the details of the context and process for its application and sanctioning.

The results of the study are expected to shed light on the efficiency of institutions to regulate the adoption and compliance with best management practices in agricultural industries. Moreover, the results could encourage a reflection on the type of institutions needed to decrease the ecological impact of intensive farming systems in the region, emphasizing in the conditions and elements essential for institutions to play a regulative and a normative role.

This master thesis contains four chapters. The first chapter reviews the ecological problem under scrutiny and describes the history of agricultural non-point source pollution in southern Quebec, specifically in the Missisquoi Bay. Moreover, the chapter gives a portrait of the hog industry in the region and its impact on the agro-environmental landscape of Quebec. Finally, it presents a review on literature on institutional theory, focusing on the classical institutionalist school and the role of institutions in socio-economic activities.

The second chapter is dedicated to the methodological framework of the study. Firstly, we will present a methodological review on the application of Crawford and Ostrom's (1995) 'Grammar of Institutions' framework. The chapter also describes the advantages and challenges of the framework. Moreover, it announces the specific methodological guidelines used in researching the identification and classification of institutions, and the basis for the analysis of the role of institutions.

The third chapter presents the results from the historical review of institutions affecting the agro-environmental behaviour of hog farmers in the Missisquoi Bay. Furthermore, we present the regulation selected, the *Réglement des exploitations agricoles* (REA), and the results of the grammatical coding of the REA. The fourth chapter discusses the results in light of the characteristics of the grammatical elements, and the conditions for the presence of the 'Or Else' parameter, relying on the methodological framework. Finally, we discuss the implications of our results on the application and legitimacy of the institutions contained in the REA, questioning its normative and regulative role.

Chapter 1: Literature review

Agro-environmental regulations are required in the agricultural sector to reduce the effects of intensive farming systems on the environment. Animal production activities are among the main targeted industries by these regulations as livestock operations are important contributors to diffuse nutrient pollution, due to their increased animal density and manure production (Steinfeld *et al*. 2006). Additionally, intensive animal operations are responsible for producing odours that can deteriorate health and quality of life in surrounding communities (Wing *et al*. 2008).

The environmental consequences of livestock activities are a rising concern for the governments of Canada and of Quebec, as animal density has increased in the past decades, especially in the swine industry. According to the Canadian Agricultural Census, between 1996 and 2001, there was a 26.4 percent jump in the number of hogs in Canada, reaching 13.9 million in 2001. This increase has been caused by the expansion of exports between 1976 and 1981 as well as between 1996 to 2001, mainly towards finishing operations in the United Stated, and an increasing demand coming from countries such as Japan (Statistics Canada 2014a). More than half of all the hogs in Canada were found in Quebec and in Ontario in 2001 (*Idem*).

In response to the ecological disturbance caused by intensive livestock systems, institutions were introduced with the expectation that they would decrease their socio-ecological effect. These institutions include rules, norms and strategies that influence agricultural behaviour to achieve desired sustainable outcomes. Moreover, classical institutional theory allows for the analysis of the role and effectiveness of institutions in framing actors and introducing ecological change. It is important to make the distinction between institutions and organizations, such as the state and the Church. Defining organizations as institutions is common in political science and in the colloquial use of the term, but ecological economist and classical institutionalists define organizations as agents. Institutions are responsible for shaping the behaviour of agents (Singh 2013).

This chapter will describe the socio-ecological consequences of the development of intensive farming system in Southern Quebec by looking closely at the history of ecological disturbances in the Missisquoi Bay. Moreover, it will describe how the evolution of the hog industry in the province has influenced the agro-environmental landscape of the region. Finally, the chapter will present a literature review on institutional theory and analysis, focusing on the importance of analyzing institutional context to define the role of agro-environmental regulations.

Agricultural nutrient pollution in Quebec

Water pollution in agricultural areas has been monitored by various studies showing that there is a relationship between nutrient surplus in water bodies and the intensification of agricultural systems (Gangbazo and Babin 2000; Gangbazo *et al* 2003). The main nutrients disturbing the balance of water ecosystems are nitrogen and phosphorous. For instance, agricultural activities were responsible for 70% to 90% of the nitrogen flow in the main agricultural watersheds of the province during the late 1990s (Gangbazo and Babin 2000). Gangbazo *et al*. (2003) have showed that the annual average concentration of nitrogen ammonia ($N\text{-}NH_3$) and nitrates ($N\text{-}NO_3$) in Quebec's rivers were five to seven times higher in agricultural sectors than in forestry areas during the early 2000s.

Even though the imbalance of nitrogen in watercourses remains an important environmental issue, phosphorous runoffs have caused sever biophysical disturbance in Quebec's watersheds. For instance, phosphorous levels at most Environment Canada monitoring stations along the St. Lawrence River exceeded standards for water quality by more than 50% during the 2010-2012 period (Government of Canada 2012).

The deposition of phosphorous coming from runoff and leaching from fertilized soils and livestock operations can induce severe hypoxia in water bodies, a main symptom of eutrophication (Government of Canada 2010). Eutrophication consists in a chain of biochemical and biophysical reactions leading to a change in the water's nutrient balance (*Idem*). The increase in nutrient availability sets off the proliferation of macro-algae and plankton, inducing hypoxia once the organic matter decomposes (*Idem*). Hypoxia is a consequence of high oxygen

consumption through decomposition of organic matter and low oxygen production through photosynthesis. The achieved oxygen concentration in the water body is lower than the one necessary to support aquatic animal and plant population, leading to important biodiversity loss.

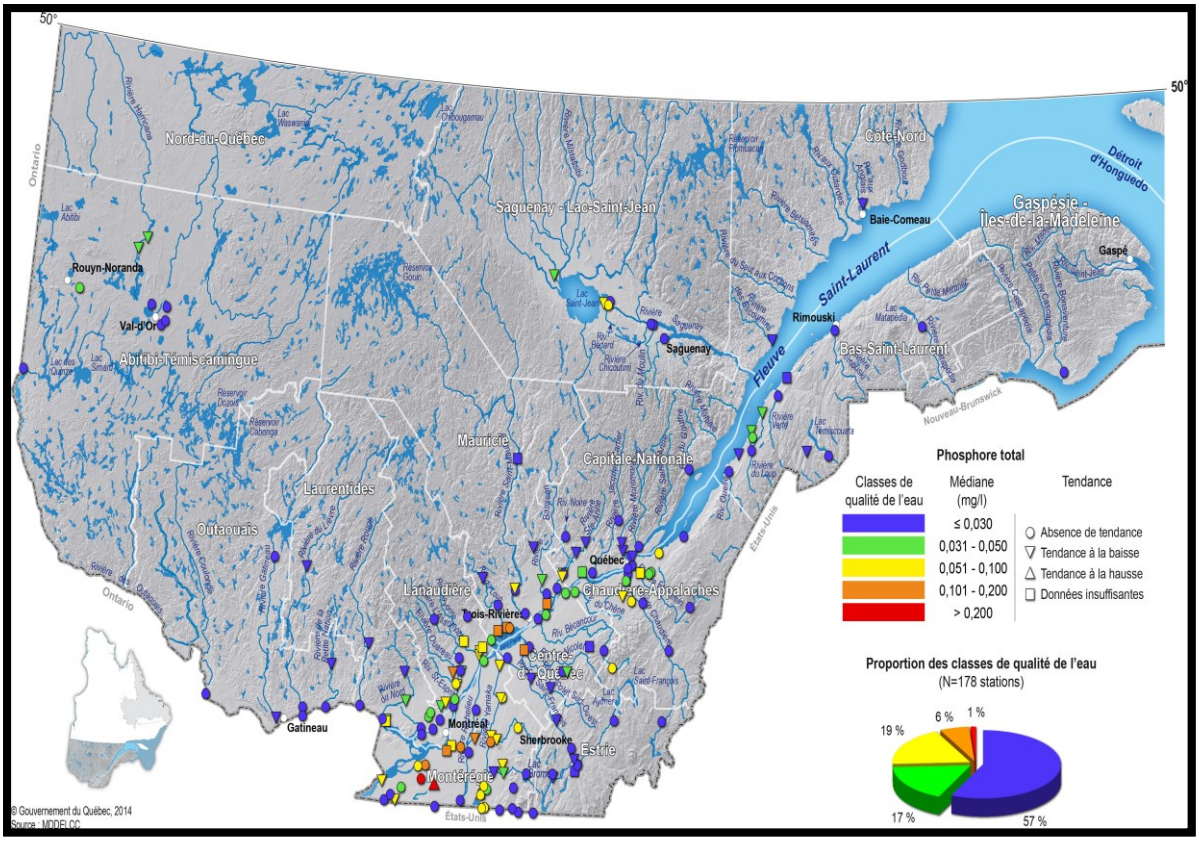

***Figure 1*:** Total phosphorous concentration in Quebec monitoring stations. Source MDDELCC 2013

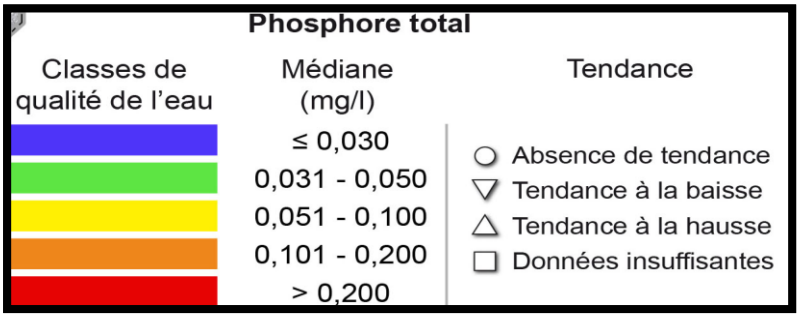

***Figure 2*:** Total phosphorous concentration ranges. Source MDDELCC 2013.

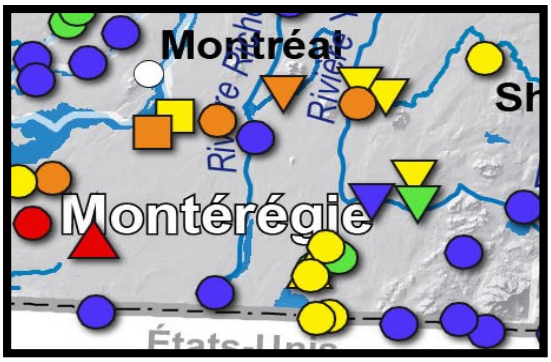

Figure 3 **:** Total phosphorous concentration in the Montérégie region. Source MDDLCC (2013)

Between 2009 and 2011, the average concentration of total phosphorous (TP) in rivers was higher than the 0.03 mg/L standard on 43% of the monitoring stations of Quebec's Ministry of Sustainable Development, Environment and the Fight against Climate Change (MDDELCC 2013). The majority of these stations are found in the Saint Lawrence Lowlands, especially in the Chaudière-Appalaches and the Montérégie regions. In the latter, average TP concentration is higher than 0.05 mg/L with a high eutrophication potential (*Idem*). Figure 1 summarizes the situation of Quebec's watersheds and shows problematic areas situated mostly in the southern agricultural region, in the vicinity of the United States border.

An instance of a problematic watercourse is the Yamaska watershed, situated at the heart of the Quebec's agricultural region (Berryman 2008). Almost half of this watershed (48%) is under agricultural production; one of the highest proportions in Quebec (*Idem*) Animal production in the region is significant. The main animal production is hog, totalling 57% of the animal industry with close to 906,000 hogs in the watershed (*Idem*). In the entire Yamaska watershed, levels of phosphorous are higher than the 0.03 mg/L criteria. For instance, the phosphorous concentration was 0.22 mg/L during the 1979-1987 period, 0.17 mg/L in the 1988-1997 period and around 0.09 mg/L during the 1998-2005 period (*Idem*).

According to Patoine *et al*. (2012), efforts to reduce phosphorous pollution introduced over the past 15 years have been all in all efficient. The author grounds his statement on the observed reduction of TP concentration in eight rivers during the last decade. According to the author these results "reinforce the idea that a decrease in feed and fertilizer mineral P used in the

watersheds was responsible for the P decrease in rivers"[2]. However, the median concentration of phosphorous is seven of the rivers studied remained two times greater than 0.03 mg/L (*Idem*). Patoine *et al*' (2012) results suggest to keep up the efforts in reducing Phosphorous pollution and to control nutrient exports coming from agricultural land and animal operations. This study also shows that the Missisquoi Bay watershed still has problems with cyanobacteria (blue-green algae) blooms and surplus of nutrients in its water bodies (*Idem*).

The Missisquoi Bay

The proliferation of cyanobacteria in the Missisquoi Bay is by far the most severe case in Quebec (Gangbanzo *et al* 2006). This ecological challenge disrupted recreational and tourist activities for several years, and brought supply problems for local drinking water treatments (*Idem*). The proliferation of cyanobacteria results from the interaction of several ecological features. Nonetheless, agricultural phosphorous runoff remains a predominant factor. A report done in 2000 by the Quebec-Vermont working group states that 79% of the phosphorous of the Missisquoi Bay originates from agricultural non-point source pollution (Mimeault 2010).

Furthermore, the Bay is a transboundary watershed shared between the province of Quebec and the State of Vermont. Quebec is responsible for 40% of the phosphorous input into the watershed and Vermont is responsible for remaining 60% (Mimeault 2010). In 2002, both governments signed an agreement to reduce the total phosphorus inputs into the Bay. The agreement states that it is crucial to reach the total target load of 97.2 metric tons of TP per year (TP/yr), setting Quebec's target at 38.9 TP/yr (*Idem*).

To illustrate the biophysical state of the Missisquoi Bay, Mimeault (2010) reviews three studies of environmental monitoring of the watershed. The first study, conducted by the *Direction du suivi de l'état de l'environnement* in 2007, shows a significant reduction in phosphorous concentration for the Pike River from 1979-2004 (*Idem*). According to the study, this decrease is

[2] Patoine, M., S. Hébert, and F. D'Auteuil-Potvin. 2012. "Water Quality Trends in the Last Decade for Ten Watersheds Dominated by Diffuse Pollution in Quebec (Canada)." *Water Science and Technology: A Journal of the International Association on Water Pollution Research* 65 (6): 1097.

largely due to the targeting and reduction of point pollution sources of urban and industrial origin. The second study, published by the Quebec-Vermont working group in June 2008, assessed the average phosphorous load from 2002-2008, and came to the conclusion that, during this period, there was a significant increase in phosphorous loads, reaching an average load of 188 TP/yr for the whole watershed (*Idem*). This rise in phosphorous flows can be partially accounted for by the 26% increase in water flow registered between 2002-2005 at the Missisquoi River, an important sub-section of the watershed (*Idem*). According to this study, if hydrological conditions remained the same to those of 1991, phosphorous load could have shown the same decreasing trend of previous years (*Idem*).

A third study, published in 2009 and produced by the Lake Champlain Basin Program (LCBP) with the participation of the Quebec's Ministry of Sustainable Development (MDDEP) focused on monitoring the evolution of phosphorous flows and concentrations for each Lake Champlain sector and for all its tributaries during the 1990-2008 period (Mimeault 2010). Results from this last study show that the TP concentrations in the Missisquoi Bay are around 50 µg/L, two times the target value in order to achieve a non-eutrophic environment. Moreover, the phosphorous load during the time period studied remained higher than the goal of 97.2 metric tons of TP/yr (*Idem*).

The Pike River is one of the main tributaries of the Missisquoi Bay. This river originates in the State of Vermont at Lake Carmi, located 8 km south of the Quebec-Vermont border (Gangbanzo *et al*. 2006). The Pike River basin drains a territory of around 630 km^2, 532 km^2 of which are located in Quebec. The 'head' of the basin is located upstream of the city of Bedford. In this area of the basin (390 km^2), around 13,265 hectares are under agricultural production. In this region, hog and dairy production accounts for more than 75% of the animal units (Gangbanzo *et al*. 2006). Additionally, the downstream region of the basin, about 232 km^2, going from Bedford to the Pike River's mouth, is located in the Saint Lawrence Lowlands. Three quarters of this fragment of the basin is under cultivation. Animal production is similar to the upstream area, and corn and soybean production accounts for respectively 30% and 20% of the area under production (*Idem*).

Furthermore, the Quebec government has established as a priority the introduction of integrated water resource management in the Pike River basin due to its annual amounts of excessive nutrient, as the TP concentration exceeds the quality criterion every month (Lehner *et al*. 2014). As mentioned previously, livestock occupies an important place in the watershed. For instance, in 2001 the average animal density in the Pike River basin was of 1.3. This high density implies that there were 1.3 times more animal units that the total crop land available in the region.

The agricultural landscape of the region is the result of agricultural changes and the intensification trend of late decades of the 20th century. During the 1950-1970 period, changes in landscape were characterized by an increase in the average farm and field sizes, leaving fewer orchids and reducing farm vegetative hedges due to the increased mechanization and implementation of subsurface drainage (Lehner *et al*. 2014). Moreover, the trends in animal production throughout the province are also reflected in the region, and are characterized by a shift from dairy to swine production and the increase in animal swine units (*Idem*). The increase in swine production induced an increase in annual crop production such as corn and soybean between 1993-2001 (*Idem*).

To sum up, the region continues to face important water quality issues due to the intensification of agricultural activities. As shown by the literature reviewed, agricultural non-point pollution has been targeted. Nonetheless, phosphorous concentrations in the watershed remain above the established standards, and continue to cause the eutrophication of water bodies, disrupting recreational activities and water quality for surrounding communities.

Hog production in Quebec

Swine production occupies an important place in the agricultural landscape of Quebec, and it has significantly increased from the end of the 20th century up to the beginning of the 2000s. In the province, sow productivity increased by 15%, from 20.1 weaned piglets per year in 1995 to 23.2 in 2003 (CAAAQ 2007). It is important to point out that swine operations have not only increased in size, they have also higher capital demands as modern and intensive operations require higher investments (*Idem*). The increase in size of swine operations and their constant

need for capital is reinforced by the demand for regular and greater supplies from food processing and distribution companies (*Idem*).

In its report on the Canadian hog industry, Statistics Canada (2014b) claims that the evolution of the industry in the past decade is characterized by a shift from a very large number of mixed farms, with a few pigs, to fewer but larger and highly specialized farms. Moreover, vertical integration and contractual arrangements are common, and contractors intervene in many sectors of the industry as some have acquired their own slaughterhouse and market the meat themselves (*Idem*).

Moreover, pork and other animal products are at the heart of Quebec's agricultural exports. They account for 43% of the total agriculture and agri-food exports of the province (CAAAQ 2007). Moreover, pork alone accounted for 33% of agricultural exports from Quebec in 2007. Pork exports from Quebec to the United States, a top importer of the province's production, rose by 58% between 2000 and 2005 (*Idem).*

The swine market has gone through various economic fluctuations in the past years. The first important economic expansion of the industry was during the 1976-1981 period (Statistics Canada 2014b). High interest rates and the Asian financial crisis pushed the industry to a stagnation period from the early 1980s to the mid-1990s (*Idem*). The industry, stimulated by new free trade agreements such as NAFTA, renewed with prosperity between 1996 and 2006. However, this period saw an important decline in prices in 1998 and decreasing demand from Asian markets deeply affected hog producers' profitability (*Idem*). From the start of the 2000s to this date hog numbers have been falling back to levels similar to those of the 1990s, and the number of hog farms is declining.

In times of economic instability, Quebec hog producers' rely on the ASRA (*Assurance stabilisation du revenu agricole*), which guarantees farmers positive and stable net revenue. This insurance compensates producers when the market price of the good is lower that the cost of

production. This program has helped producers in times of economic instability and agricultural crisis, as it was the case during the early 2000s (CAAAQ 2008).

However, the way compensations are calculated is flawed. Indeed, compensation for pork producers is unfair in so far as the flat rate does not take into account the economy of scale from which larger producers benefit. For instance, in 2003, the larger hog producers received a $16.58 compensation per animal produced. The average compensation for large producers therefore reached $558,221 in 2003. According to the CAAAQ (2008), if the costs of production used in calculating the compensation were those of the largest businesses, the compensation per animal would have dropped to $6.72. The average large farm compensation would therefore have been $331,966 instead of the $558,221. In other words, large hog exploitations benefit from the higher costs of smaller exploitations, receiving higher compensations than necessary.

Moreover, another characteristic of this industry is that in the last decades of the 20th century, hog farmers often did not own land under cultivation (CAAAQ 2007). This has led to a low ratio between the number of land under cultivation and the volume of animal waste spread in the agricultural zone, leading to important nutrient runoffs (*Idem*).

The agro-environmental effects of swine production are various. One of the consequences of intensive swine operations is the creation of malodours affecting human health and the quality of life of neighbours nearby (Wing *et al*. 2008). Studies on the effect of industrial swine operation show that neighbours can experience elevated levels of gastrointestinal and respiratory tract symptoms as well as wheezing and asthma (Wilson *et al*. 2002, Wing *et al*. 2008). Ammonia, hydrogen sulphide, volatile organic compounds, and particulates, which induce respiration problems, are among the environmental contaminants emitted into the atmosphere (Wing *et al*. 2008). A second important environmental impact of swine operations is non-point source pollution associated with the leakage from manure lagoons and runoff from sprayed fields, contaminating surface and ground water (Wing *et al*. 2008).

Moreover, agricultural organizations in Quebec agree that the hog industry might need to go through some structural changes in order to overcome the environmental and economical

challenges. According to the *Coop Fédérée*, the pork industry will have to go through a period of restructuring, at the farm level as well as within the transformation chain, because agro-environmental requirements must be met if the industry is to have a future (CAAAQ 2008).

Hog production in the Missisquoi Bay

The Missisquoi Bay hog profile is similar to that of the whole of Quebec. Animal production is fairly important in the watershed, occupying in average more than 50% of the overall agricultural production. According to the Missisquoi Bay Conservation Group (2003), the region has seen in the last three decades a decrease in dairy farms accompanied by an increase in cereal and hog production. Specialization of hog production led to increased swine unit sizes, quadrupling the number of pigs in the Bay from 1970 to 1990, and inducing non-point source pollution (Conservation Baie Missisquoi 2003).

The number of hog animal units is still very high in the region. The municipalities of Saint-Ignace-de-Stanbridge, Sainte-Sabine, Notre-Dame-de-Stanbridge and Dunham, in the Pike River basin, house the highest number of animal units within the watershed (around 4,068 and 6,561 animals). An animal unit is the equivalent of four saws (Conservation Baie Missisquoi 2003). More than half, and in some cases 64%, of the livestock is dedicated to swine production. Moreover, the municipalities of Saint-Georges-de-Clarenceville and Saint-Sebastien respectively have 1425 and 824 animal units. A third of these animal units come from hog production (OBVBM 2011). Moreover, In the case of Saint-Pierre-de-Véronne-à-Pike-River (3,658 animal units) and Frelighsburg (2,793 animal units), hog production occupies respectively 63% and 77% of the total animal production (OBVBM 2011). Table 1 presents the number of hogs and their concentration in the Brome Missisquoi municipal county, based on data extracted from the 2006 and 2011 agricultural censuses.

To remediate the increase in livestock density and non-point source pollution, agricultural institutions such as regulations, policies and laws have been introduced in Quebec, targeting livestock, and therefore, hog production

Table 1 **:** Number and density of hogs in the Brome Missisquoi municipal county

	2011			2006[3]		
	Number of animals	Number of farms	Animals per farm	Number of animals	Number of farms	Animals per farm
Number of boars on May 1st	193	11	17.5	362	19	19.1
Sows and gilts for breeding	5,947	13	457.46	31,350	23	1,363.04
Nursing and weaner pigs	16,154	20	807.7	51,766	20	2,588.3
Nursing pigs	2,550	9	283.3	-	-	-
Weaner pigs	13,604	17	800.2	-	-	-
Grower and finishing	65,478	48	1,364.12	114,428	42	2,724.4
Total number of pigs	87,772	58	1,513.3	197,906	48	4,123

Source: Statistics Canada, 2006 and 2011 agricultural censuses.

The role of institutions

The goals of the introduced institutions are to limit the effect of intensive animal farming on the environment and to ensure the sustainable development of the animal industry. According to Boutin (2006), agro-environmental regulations started to appear in the province during the late 1980s, and further developed at the beginning of the 2000s with the introduction of Quebec's water policy and the *Réglement sur les exploitations agricoles* (REA). This last is highly important for the agricultural sector as its objective has been to regulate best management practices at the farm level rendering mandatory the use of agro-environmental fertilization plans (Boutin 2006).

Despite the policy efforts, the literature shows that the environmental consequences of intensive farming system still plague the Missisquoi Bay. To understand the relationship between agricultural institutions and ecological outcomes, it appears important to analyze the role of agricultural institutions in shaping farmers' behaviour and specifically that related with compliance with the institutions. Institutions shape economic and ecological behaviour by

[3] Data on the number of nursing pigs and the number of weaner pigs were not available for the year 2006.

delimiting economic activities and determining the types of socio-ecological relationships human activities such as agriculture have with the environment (Vatn 2005a).

Different institutional theories explain the role of institutions and how they influence socio-ecological behaviour. In this thesis, I will base my analysis on classical institutional theory. I will present the particularities of this school by briefly describing the history of institutional economics theory.

History of institutional theory

Working within the classical institutional school, Vatn (2005a) links the social constructivist theory of institutions with the evolutionary role of institutions in managing socio-ecological systems. According to this author, institutions are the main force responsible for shaping human behaviour (*Idem*). The role of the institution is then to structure the relationships between people concerning their access to and use of environmental resources through the means of conventions, norms and legal rules (Vatn 2005a).

Vatn's work is influenced by early classical institutional economist such as Veblen, considered by the author as the father of institutional economics. By the turn of the 20th century, Veblen was critical of the orthodox economic assumptions regarding individual behaviour. This economist opposed the "hedonistic conception of man as that of a lightning calculator of pleasures and pain"[4]. Instead, human behaviour is explained mainly by habits and conventions, defining institutions as "settled habits of thought common to the generality of man" (Scott 2008). Moreover, Veblen introduces the notion of evolution in economics (Vatn 2009a, Veblen 1998). The author claimed that the current economic system is the result of a cumulative process of adaption of means to ends, emphasizing the role of history to describe agents' economic behaviour.

[4] Veblen, Thorstein. 1998. "Why Is Economics Not an Evolutionary Science?" *Cambridge Journal of Economics*. Page 411.

In addition to Veblen, other important institutional economists influenced economic theory at the beginning of the 20th century, including John Commons and Westley Mitchell (Scott 2008). Commons also challenged individual choice theory, suggesting instead as the unit of economic analysis the 'transaction', borrowing this concept from legal analysis (*Idem*). According to the author, transactions are governed by 'rules of conduct' referred to as social institutions. Institutions according to Commons are "necessary to define the limits within which individuals and firms could pursue their objectives"[5].

Mitchell, for his part, embraced a perspective of economic equilibrium, suggesting economic principles be grounded in empirical facts as opposed to abstract deductive theories (Scott 2008). For this author, institutions' role is to achieve economic equilibrium in daily economic activities. These three perspectives of institutions have in common their understanding of institutions as regulators to foster desired economic behaviours and outcomes. However, the conception of the role of institutions of classical institutional economy did not receive much echo during the 20th century, during which neoclassical economic theory dominated institutional analysis.

Neoclassical economic theory explains human behaviour as selfish individualistic choices that seek to optimize actors' utility. Institutions are seen as rules that either favour or prevent the optimization of individual utility by reducing or increasing the obstacles to the fulfilment of individual pleasure (Vatn 2009a). According to this school, individuals interact only through trading activities, and they are considered autonomous and independent from their social and historical background (Scott 2008, Vatn 2009a). The main role of institutions is then to reduce the costs related to economic activities, such as the costs of information gathering, contracting and controlling (Vatn 2009a).

Neoclassical economic theory assumes rational choice as maximization, stable preference over time and equilibrium states of markets (Vatn 2005b). This model of rational choice seeks to construct favourable institutions in order to avoid 'behavioural errors'. It is believed that the

[5] Scott, W. Richard. 2008. *Institutions and Organizations: Ideas and Interests*. Los Angeles: Sage Publications. Page 3.

right institutions will enable actors to act rationally (Vatn 2009b). For instance, markets, by imputing a cost to 'irrational' behaviour, promote and create rationality in society (Shogren 2006, Vatn 2009b). Moreover, rational choices, only described in individualistic terms, must be in accordance with what is preferred the most by the individual, and individual preferences are stable over time.

Inspired by neoclassical economics, new institutionalism does not break with the past, but brings new emphases and insights to the role of institutions (Scott 2008). For instance, most new institutional economists seek to develop an economic theory of institutions rather than to replace orthodox theory on human behaviour through the study of multiple and diverse institutional conditions (Scott 2008). Working within the school of new institutionalism, North (1990) defines institutions as the 'rules of the game' that set the constraints on human. According to North, institutions are 'external constraints,' defining individual actors as autonomous (Singh 2013). Individual behaviour plays a strategic role according to this school since individuals aim to maximize utility within the 'rules' or constraints (Singh 2013).

According to Scott (2008), there are three common threads in new institutional economics. The first is a broader conception of the economic agent, which extends the assumption of utility maximizing. The concept of bounded rationality (rationality limited to the information available) is still employed, but other concepts such as 'procedural' rationality are introduced, and behaviour is considered rational if specific procedures are followed (Scott 2008). The second theme is the focus on the study of the economic processes rather than on the study of pure equilibrium states, therefore recognizing the evolution of the economic system (Scott 2008). For instance, new institutionalists can ask how norms and rules emerge when actors interact or when dealing with conflict. The third theme recognizes that the coordination of economic activity is not simply a matter of market-mediated transactions, but involves other types of institutional structures.

Despite the introduction of these three new themes, the definition of rational choice prevails in new institutional economics. For instance, new institutionalists tend to stress the micro foundations of institutions, asking how institutions are devised to solve collective action problems through the experience of the individual (Scott 2008). In contrast, classical institutional economists, using a more historical perspective, are more likely to opt for a macro standpoint, tracking the evolution of an institution and analyzing how it affects individual preferences and behaviours.

Institutional ecological economics

Classical institutionalists and ecological economists such as Bromley (2009) and Vatn (2005a) emphasize the role of institutions in shaping behaviours, interests and values (Singh 2013). Moreover, the economic system is understood as one of *existing constructs* deriving from history and plurality and not as a 'deducted structure based on a set of axioms' (Singh 2013). They claim that individual and independent calculations are not possible since individual cognitive structures are socially constructed (Vatn 2005b). Classical institutional and ecological economics also takes into consideration the role of power dynamics when analyzing institutions. Power is structural and embedded in institutions (Vatn 2009a). According to Vatn (2009a), institutions protect interests and secure access for actors to various benefit streams. They also define rights and the specific actors who access resources (Martinez Alier and Schlüpmann1987).

Institutions are important building blocks towards structural transformation and the achievement of sustainability. According to Vatn (2009b), sustainability requires to move away from institutions that only foster individual rationality and towards institutions that promote more collaborative behaviour. Institutions should also reflect the complexity and dynamics of ecological systems. According to the author, our environmental system is one of *interlinked processes* (Vatn 2009b). Nevertheless, we currently manage our resources with an institutional system of *delinking* or separation, dividing decisions and responsibilities, and counting mostly on individual action for social transformation.

Critique to this neoclassical strategy focuses in three important issues. The first is the creation of high social and ecological costs, due to the separation and compartmentalization in space of the

economic process (Kapp 1963, Bromley 1991, Vatn 2009b). The second issue has to do with the separation of interests, as each unit tries to maximize its gains and reduce its costs. The third issue refers to the separation in time and space between the duration and place of the exploitations and the geographical and temporal appearance of the consequences. Compartmentalizing decisions encourages individual rationality. Vatn (2009b) proposes the promotion of social rationality through more integrative and interlinked institutions, leading to a reduction of social and material costs, by promoting environmental consciousness and reflecting the socio-ecological characteristics of the system they regulate.

All in all, human behaviour and motivation are complex, and the standard model of rational choice cannot adequately describe them (Vatn 2009b). Rational choice could be challenged when we consider the complexity and plurality of institutions. Studies and observations of ultimatum and dictator games, public good games and wage experiments have shown the complexity and plurality of human rationalities (Gintis 2000, Ostrom 1998, Fehr and Falk 2002, Gintis *et al*. 2003, Bowles and Gintis 2004, Vatn 2005a)

In this research, we will take into account the complexity and plurality of human behaviour as well as its evaluative aspect. As claimed by Vatn (2009a): "Human behaviour can be inspired by different kinds of motivations and that different institutional contexts, like the market or the community, appeal to different logics those of private gain versus adherence to social norms-respectively"[6]. Furthermore, actors and the environment are defined as the result of past processes, as outcomes of historical and evolutionary transformations (Vatn 2009a). Thus, the current preferences of agents are endogenous to the social and economic systems in which they have evolved (*Idem*). In other words, in order to explain socio-economical behaviour, we need to assess institutional changes and transformations, and the current framework of norms, rules and strategies that influence human behaviour.

[6] Vatn, Arild. 2009a. "Combining Post Keynesian, Ecological and Institutional Economics Perspectives." In *Post Keynesian and Ecological Economics, Cheltenham,* Edward Elgar. Page 117.

Institutions and legitimacy

Institutions define the legal, moral and cultural boundaries, setting off legitimate from illegitimate activities (Scott 2008). In order to influence behaviour, institutions require social acceptability and credibility (*Idem*). These characteristics are part of the wider notion of legitimacy. According to Schuman (1995), legitimacy can be defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions"[7]. Following this definition, legitimacy is a generalized evaluation, rather than event-specific (Scott 2008).

According to Scott (2008), there are three institutional pillars that offer a basis for legitimacy: the regulative, the normative and the cognitive. According to the author, these three pillars are all equally important. Sometimes one will dominate over the others, but in robust institutional frameworks they create a synergy (Scott 2008).

The regulative pillar involves "the capacity to establish rules, inspect others' conformity to them, and as necessary, manipulate sanctions […] in attempt to influence future behaviour[8]". The normative pillar recognizes that institutions have a prescriptive, evaluative and obligatory dimension into social life (Scott 2008). The normative system includes values and norms, which define goals or objectives, and designates appropriate ways to pursue them. The cognitive pillar, according to Scott (2008), refers to the individual and shared conceptions of social reality, creating the frames through which meaning is produced.

The analysis of institutions cannot be limited to a single pillar. For instance, one cannot assess independently the regulative and coercive functions of law. According to Scott (2008), many laws are ambiguous and do not provide clear prescription of conduct. In these cases, law is conceived as a collective interpretation, relying more on normative rather than on regulative elements.

---

[7] Suchman, Mark C. 1995. "Managing Legitimacy: Strategic and Institutional Approaches." *The Academy of Management Review* 20 (3): 574.

[8] Scott, W. Richard. 2008. *Institutions and Organizations: Ideas and Interests*. Los Angeles: Sage Publications. Page 52.

In the case of legitimacy, the regulatory aspect of institutions emphasises on the conformity to rules (Scott 2008). Legitimate actors and organizations are those that behave according to legal requirements. On the other hand, the normative aspect of institutions proposes a socially constructed base for legitimacy, built on social obligations that are governed by morality (Scott 2008) Actions are deemed legitimate if they are motivated by social rewards or sanctions. In other words, institutions can also be found to be legitimate because they are part of a common social understanding.

The pillars of an institution must not be in conflict if it is to be legitimized. For instance, actors might refuse to follow a policy or a regulation if it does not follow social norms and values. It then becomes a major challenge to combine the regulative and normative aspects of legitimacy when designing institutions. One tool to combine the pillars of institutional legitimacy is collective action. According to Carr (2015), management strategies decided upon democratic and accessible processes, including a fully representative group of participants, might be considered legitimate and fair Through the process of collective action and participation, institutions can be legitimized because it implies the participation of stakeholders, shared interests, delimiting actions and sanctions to achieve the desired institutional outcome.

Other management strategies rely on coercion for achieving legitimacy, relying solely on the regulative role of institutions. An example of such a strategy is Command and Control (C&C). This management concept, which originated in the military field, is defined as "the exercise of authority and direction by a properly designated [individual] over assigned [resources] in the accomplishment of a [common goal][9]." When extended to environmental management, C&C is a regulatory approach built on the assumption that producers and consumers would not take action to reduce environmental degradation without coercion measures (Cole and Grossman 1999). In this framework, the government "commands" pollution reductions (e.g. by setting emissions standards and regulations) and "controls" how these reductions are achieved (e.g. through sanctioning) (*Idem*). Through a positivist lens, a problem is identified. Is then developed and

[9] NATO. 1988. "Glossary of Terms and Definitions." Standarization Agreement AAP-6 (R). Brussels: NATO.

implemented a solution, which will be direct, feasible and effective over the relevant spatial and temporal scales, to control the problem (Holling and Meffe 1996).

Moreover, C&C measures assume ecological processes are linear and well defined, and follow cause-effect dynamics. However, Holling and Meffe (1996) show that applying C&C measures to complex ecosystems rarely leads to the expected outcome. Instead, there is a reduction in the range of variation of the ecological system, weakening the resilience of ecosystems (Holling and Meffe 1996). Furthermore, C&C measures might exhibit other issues such as those described by Dietz *et al*. (2003). These authors show that C&C institutions heavily rely on the government's will, and the effectiveness of the institutions depends mainly on sufficient governmental resources to monitor and enforce the institutions.

Chapter 2: Methodological review and framework

The following chapter will introduce the Grammar of Institutions framework, an analytical tool used to study the components and characteristics of institutions. As stated in the literature review, this work draws from classical institutional economics literature, and from Vatn's (2005a) definition of institutions:

> "Institutions are the conventions, norms and formally sanctioned rules of society. They provide expectations, stability and meaning essential to human existence and coordination. Institutions regularize life, support values and protect interest"[10]

An institutional analysis of the conventions, norms and rules refers to a process of decomposition of the institutional context to understand how their elements interact and affect each other shaping socio-ecological outcomes (McGinnis 2011). In this type of analysis, human beings are considered able to learn heuristics, norms and rules, as well as to develop new institutions to achieve desired outcomes (Ostrom 2008).

The differences among institutions, such as conventions, referred to as 'strategies' by Crawford and Ostrom (1995), norms and rules are replicated in the language used, since language is a key, if not the main medium, for formulating institutions (Vatn 2005a). This concept is reflected in the grammar of institutions framework (GoI) introduced by Crawford and Ostrom (1995). The following chapter will first outline the characteristics of this framework as well as challenges in its application. Moreover, this chapter will detail the specific guidelines used in this case study.

The Grammar of Institutions

To determine the role of institutions that have affected hog farmers' behaviour in the Missisquoi Bay, we will use the Grammar of Institutions (GoI) framework that allows identifying, categorizing, and organizing institutions. This framework helps to identify key institutional

[10] Vatn, Arild. 2005a. *Institutions and the Environment*. Edward Elgar. Page 60.

components and to classify institutions according to their inherent institutional statements (Crawford and Ostrom 1995). The analysis of these statements allows categorizing institutions in terms of rules, norms and strategies. Institutional statements are considered to be constituted and reconstituted by socio-ecological and human interactions, having an evolutionary character (*Idem*). Thus, the grammar creates a structural description of institutional statements by identifying common components and establishing the constituents of institutions (Basurto *et al*. 2009).

Crawford and Ostrom (1995) define an institutional statement as a *"shared linguistic constraint or opportunity that prescribes, permits or advises actions or outcomes for actors*[11]" These statements can be either "*spoken, written or tacitly understood in a form intelligible to actors*[12]". Moreover, the proposed framework integrates different theories on institutions into their definition; such as: institutions as equilibrium, institutions from a normative perspective (focusing on behaviour) and institutions as rules (Frantz *et al*. 2013). The grammar helps as well to identify policy elements such as target audiences, expected patterns of behaviour, and modes of sanctioning (Sidikki *et al*. 2011).

The GoI has been used in other institutional economics research and case studies. For instance, in the area of multi-agent simulation, Smajgl *et al.* (2010) applied the framework to model changes of rule statements in the context of water usage. Furthermore, Ghorbani *et al.* (2012) have contribute to the use of the grammar developing an MAIA framework, a translation of Ostrom's Institutional Analysis and Development (IAD) framework into an agent-based model (Frantz *et al*. 2013). Other studies have concentrated on the challenges and the development of guidelines for the application of the GoI, especially in the characterization and analysis of institutions (Sidikki *et al*. 2011, Schluter and Theesfeld 2010, Basurto *et al*. 2009). These studies will be further discussed, as they describe the application challenges of the GoI when characterizing institutions, focusing on legal contexts.

---

[11] Crawford, Sue E. S., and Elinor Ostrom. 1995. "A Grammar of Institutions." *American Political Science Review* 89 (03): 583.

[12] *Idem*.

Furthermore, the GoI draws from Ostrom's IAD framework that considers three levels of institutional analysis: the constitutional level, the collective-choice level and the operational level (Sidikki *et al*. 2011). The operational level refers to day-to-day interactions among agents. The collective choice level groups the common interaction and prescriptions that will affect operational activities. Last, the constitutional level focuses on prescriptions that affect common strategies, norms and rules (Ostrom 2005). The GoI allows for studying institutions that act at these three levels, by categorizing them according to their grammatical content, outlining the types of institutions dominant at each level, the socio-ecological outcomes they enhance, as well as possible mismatches (Sidikki *et al*. 2011, Ostrom 2005).

The relevance of the grammar of institutions framework is well expressed by Sidikki *et al.* (2011); its importance relies on its clear categorization of the main policy elements for sound policy analysis. According to the authors, this framework can aid scholars and policy analysts to study:

i. the actions that are required, permitted, and forbidden;
ii. the actors assigned to particular activities;
iii. the temporal and spatial boundaries in which these activities take place, and, in some cases;
iv. the punitive measures associated with noncompliance.

By following a grammatical categorization, institutions are classified by strategies, norms and rules. Strategies or conventions refer to the action of "*combining certain situations with a certain act or solution*[13]*"* (Vatn 2005a). Examples of different areas of society where we can find these conventions are language, syntax and semantics, measurement scales, acts in certain situations, greetings and how to behave in traffic, among others (Vatn 2005a, Crawford and Ostrom 1995). The main characteristic of strategies is that they solve coordination problems in society.

[13] Vatn, Arild. 2005a. *Institutions and the Environment*. Edward Elgar. Page 62.

Norms differ from conventions as they reflect the required and expected behaviour to adapt in a particular situation (Coleman 1987, Vatn 2005a). They can influence changes in preferences, as they evolve from the internalizaBtion of social lessons, from experience or training provided by peers or others (Ostrom 2008). Norms are thus the archetype of institutions in civil society (Vatn 2005a). They can be totally internalized and they can create a feeling of guilt, not requiring any external sanctions (*Idem*). Rules, on the contrary, are artefacts, created in either private association or in public institutions, carrying an additional legal weight. Formally sanctioned rules require a third party sanctioning, in many cases the law (*Idem*). As stated by Bromley (2009), these institutions are fundamental in the creation of order in society, as well as economic relations. Based on these characteristics and notions of rules, norms and strategies, Crawford and Ostrom (1995) developed the ADICO framework.

The GoI framework contains five components: Attribute, Deontic, Aim, Conditions and Or else, also known as the ADICO formula (Crawford and Ostrom 1995). The Attribute refers to the actor and/or holder to whom the institutional statement applies. The Deontic refers to the action included in the statements, represented by the verbal mode used in the statement. According to the authors, a Deontic can permit, oblige or forbid an action (*Idem*). The Aim refers to the actions and/or outcomes to which the Deontic is assigned. The Conditions element of the grammar denotes the variables determining the where, when and how of the permitted (or forbidden) action. The last element, Or else, defines the sanctions imposed by the statement (Crawford Ostrom 1995).

According to the presence or absence of the ADICO elements, institutions are classified into strategies, norms and rules. Strategies derive from institutional statements that contain an Attribute, an Aim and a Condition (AIC). Norms differentiate from strategies as they contain a Deontic (ADIC). Rules are more complex and complete institutions containing the five elements of the grammar (ADICO). The relation between institutions are then presented as being grammatically cumulative (Crawford and Ostrom 1995)

Institutional statements and their components

The first step in applying the GoI framework is the identification of institutional statements, present in legislation, policies, oral traditions, or in common social understanding. As defined by Crawford and Ostrom (1995), institutional statements prescribe or prohibit an action, and contain at least an Attribute, an Aim and a Condition. The original grammar suggests studying institutional statements as only single units of observation (*Idem*). However, Basurto *et al.* (2009) complement this original framework suggesting that institutional statements be analyzed as units of observation, as either stand-alone statements or as aggregated units of observation that derive from more complex statements. This last aggregation of statements should be considered the unit of analysis (Basurto *et al*. 2009). For instance, the 'Or else' parameter could be found in another statement, and the aggregation of these statements gives the complete grammar of the institution, taking into consideration the nested characteristic and the complexity of institutions (*Idem*).

However, Basurto *et al.* (2009) propose to apply the original 'fine-grained approach' treating the institutional statements, coming from a stand-alone statement or from an aggregation of statements, as single units of observation; the authors suggest that the writer avoid referring to the institutional context or any other exogenous information not contained in the statement. It is important to mention that Basurto *et al.*' (2009) study was done only on legislative bodies, where statements are easier to identify within a document. The authors emphasize that even if their study refers only to legislation, the discussion on the tools of analysis could be used for formal or informal institutions (Idem).

Attribute

The Attribute refers to the actor conducting the Aim and Deontic. The Attribute could be explicit or implicit on the statement, as it is possible for this element to designate an actor present in another statement, or refer to all of the actors (Basurto *et al*. 2009). Basurto *et al.* (2009) suggest that to identify the Attribute, we must look for an organization or actor to which the stated

Deontic or Aim applies. The attribute is easier to be identified once the Aim of the statement is known. The Aim is thus suggested as the first element that a coder needs to identify, to ensure a logical relationship between the agent and the action described (Sidikki *et al*. 2011)

Furthermore, if the Attribute is implicit, the researcher must understand the context of the institutional statement within the document to assure a proper implication. For instance, the agent might be nested into a larger organization or group, also called secondary agent. This situation is common when the Attribute refers to a representative of a governmental organization, who carries out an action on behalf of the organization (Sidikki *et al*. 2011). Sidikki *et al.* (2011) recommend identifying this secondary agent, to place the Attribute in its institutional context. It is unclear where the analytical boundary of the institutional context can be drawn, as elements might not always be contained in legislative documents and could arise from social interactions. In this sense, Sidikki *et al.* (2011) question the original grammar and Basurto *et al*.' work, suggesting expansion of the research scope to institutional information contained outside the boundaries of formal sanctioned institutions.

Deontic

The Deontic specifies the actions that are allowed, required or prohibited by the relevant actor(s). This element is usually explicit in the statement, however it could also be implicit (Crawford and Ostrom 2005). This type of case often occurs when a statement describes a command or an order without using a usual grammatical mode, such as 'must', 'may' or 'must not', or when the Deontic is present in another institutional statement (Basurto *et al*. 2009). The consideration of implicit Deontics in the coding is not part of the guidelines of the original framework, where the Deontic must always be present in the institutional statements to classify the institution (Crawford and Ostrom 1995). Basurto *et al.*' (2009) results showed that implicit Deontics were common in their coding of institutions. Moreover, in their coding framework they assume that some Deontics could have the same intensity, for instance 'should' and 'must' represent an equal prescriptive force.

The prescriptive operator presents itself in different forms; actions can be "permitted", "obligated", or "forbidden", and actors "may", "may not", "must", "should", "must not", or "should not"(Basurto *et al*. 2009). Sidikki *et al.* (2011) followed Basurto *et al.*' modifications, accepting tacit Deontics, especially when statements express a command without using a classic grammatical mode. Other examples of Deontic are found where the verb "required" is used, implying a 'must' type of Deontic (Sidikki *et al*. 2011). Moreover, Deontic operators vary according to their prescriptive force; 'must' for instance represent a stronger force than 'should' (Crawford and Ostrom 1995). The Deontic is suggested to be one of the first elements to be identified. A suggested order of identification, according to Sidikki *et al.* 2011, is: (Deontic)(aIm)(Condition) (OrElse)(Atribute).

Aim

The Aim describes the goal of the action, the outcomes and the process (Crawford and Ostrom 1995). This element provides answers to the questions: what action is conducted and how is this action conducted? The outcome does not include the description of where and when the actions are followed, as this information is found in the Conditions component. The Aim is the element that helps in defining the Attribute. Moreover, the Aim can modify the Deontic, especially when there is a vague definition of the Aim, or when the latter has multiple definitions, creating an ambiguity.

Sidikki *et al.* (2011) give the following example to show this type of ambiguity, and to show how the identification of the Aim can change the classification of other grammatical components. The authors propose as an example the following institutional statement included in the Colorado Wildlife legislation: *"The Director is granted authority to exempt applicants from specific pathogen testing"*. In this example, if we code 'is granted' as an implicit Deontic, 'the Director' would be coded as the Attribute. However, if 'is granted' is coded as the Aim, then the Attribute becomes implicit, and refers to the 'Colorado Division of Wildlife' as it is the actor in

charge of granting the director an authority (Sidikki *et al*. 2011)

Conditions

The Conditions reveal when and where a particular Deontic is said to be appropriate or relevant for application (McGinnis 2001). The 'when' generally refers to temporal characteristics; however, it can also refer to a process. The 'where' refers to a geographical or jurisdictional component. Basurto *et al.* (2009) include, among the Condition elements, the "if" and "unless" operators. For instance, the Aim of the statement can be only allowed *if* another action occurs. Basurto *et al.* (2009) also suggest that 'when', 'where', 'if' and 'unless' should be used as *operational guidelines;* and the Conditions, derived from these operators, are the parameters that set the restrictions or prerequisites for the Aim. The Conditions element can be either explicit or implicit (Crawford and Ostrom 1995). When there are no references to the Conditions in the statement, the default value is 'everywhere and in all times' (Crawford & Ostrom 1995)

Or Else

This last parameter specifies the consequences and the sanctions of not complying with the statement. In the original GoI framework, it is assumed that all legislative prescriptions should clearly state the 'Or else' element (Crawford and Ostrom 1995). On the contrary, Sidikki *et al.* (2011) recognize the importance of reaching out to other legal frameworks and legislation to identify the sanctions when they are not explicit in the institutional statement. However, this expansion could increase the complexity of the grammatical analysis. In their study, Sidikki *et al.* (2011) chose not to incorporate contextual variables in their analysis, avoiding coding policies outside of their legal context and increasing the analytical challenge.

Moreover, there are three conditions that must be met in order for the 'Or else' parameter to exist. The first imperative of an 'Or else' parameter is the presence of another rule or norm that changes the assigned Deontic to an Aim under the conditions in which an actor fails to follow the

rule (Ostrom 2005). The sanctions and consequences presented in the 'Or Else' parameter are often forbidden in most of the conditions. For instance, incarcerating a citizen or imposing a fine is not usually allowed. Thus, there should exist a prescription, such as a norm or a rule, which backs the sanctions, making the sanctions, permitted or required under the conditions that someone does not comply with the rule (Ostrom 2005, Crawford and Ostrom 1995).

The second imperative of the 'Or Else' parameter is that institutional statements must exist that affect the constraints and opportunities facing actors who monitor conformance with the prescription (Ostrom 2005). This implies that actors should only report non-conformance to someone responsible for sanctioning (Ostrom 2005, Crawford and Ostrom 1995). The third condition for the effectiveness of the 'Or Else' parameter is that it must be collectively designed so as to be useful for discussing, prescribing, and arranging the enforcement of rules. Thus, the consequences that are stated in the 'Or Else' should be the result of collective action (Ostrom 2005). According to the author, a collective decision must be taken in a 'relevant collective-choice arena' to define the sanctions for or consequences of not complying with a rule (Ostrom 2005).

To simplify the classification of institutions based on the 'Or else' element, Basurto *et al*. (2009) suggest diminishing the requirements for the 'Or else' parameter. The author's framework did not require the 'Or else' parameter to be supported or backed by another institutional statement, or a statement outlining the roles of the monitoring agency. By coding each statement as an individual unit of observation, their framework requires only the explicitness of the Or Else parameter, whether in the same institutional statement or elsewhere in the legislative document. Table 2 summarizes the characteristics and identification questions of the GoI elements presented.

Table 2 **:** Characteristics of institutional statement components

Grammatical Element	Characteristics	Identification questions
Attribute (A)	Organization or Actor to whom the institutional statement applies. Explicit or Implicit element	Who *deontic + aim?* *i.e: Who must not apply manure?*
Deontic (D)	Verbal mode used *i.e*: Should, must or must not Explicit or implicit element	Is the action forbidden, permitted required?
Aim (I)	Action, the goal of the action and the process of the action	What action *Deontic* is/is not to be conducted by *Attribute*? How this action *Deontic* is/is not to be conducted by *Attribute*?
Conditions (C)	Restrictions on and prerequisites for the action. Operators: 'when', 'where', 'if', 'unless'. When: temporal or in relation to a process Where: geographical and jurisdictional	When is the action *Deontic* to be/not to be conducted? Where is the action *Deontic* to be/not to be conducted?
Or Else (O)	Sanction for not complying with the institutional statement Must be explicit.	What are the consequences of not complying with the statement?

Guidelines for identifying institutional statements

Different guidelines exist to identify institutional statements and their components. Crawford and Ostrom (1995) offer the basic parameters to identify institutional statements in formal or informal institutional discourses. Crawford and Ostrom (1995) do not determine detailed guidelines for practitioners. The core of the authors' guideline is summarized by the definitions and characteristics of the ADICO elements, as described in the preceding section. Moreover, they consider an institutional statement a single unit of analysis that can present explicit or implicit grammatical elements.

Moreover, Basurto *et al.* (2009) propose more specific guidelines when working with legislation. In these cases, institutional statements are expressed within a law, making it difficult to isolate the units of observation. The unit of observation (or institutional statement) can constitute more than one sentence, and in some cases, a legal sentence can include two different institutional statements. Moreover, the authors suggest not to include coding of the totality of the legislative text, but to discard elements of the item of legislation such as definitions, titles, preambles and headings, as they do not constitute institutional statements.

Following Basurto *et al*. (2009), Sidikki *et al.* (2011) propose a revised guideline for applying the Grammar to the study of policy design. Sidikki *et al.* (2011) criticize the initial work of Crawford and Ostrom (1995), as it did not offer researchers clear guidelines for its empirical application. They recall as well the importance of Basurto *et al.*' (2009) comparative analysis of transportation and abortion policy by using the ADICO framework. Sidikki *et al.* (2011) aim to respond to the challenges identified by Basurto *et al.*' work by proposing a new synthetic component – the oBject- that aims to reduce the ambiguities and increase inter-coder reliability. The authors apply a new formula (ADICBO) to four Aquaculture policies in the State of Colorado, demonstrating the importance, effectiveness and utility of the analytical tool. They also revised Basurto *et al.*' guidelines for coding. The coding of Sidikki *et al.*' (2011) aquaculture policies illustrates new possibilities for studying cross-level linkages.

To test the reliability of their coding lines, Sidikki *et al.*'s (2011) study conducted a test of inter-coder reliability on three different policies. In their study of the Colorado Aquaculture Act Administration and Enforcement Rules, the results showed that at least 80 percent agreement was found between coders for all components. Moreover, among the 10% of statements coded from the three policies, there was only one institutional statement containing all grammar components. This finding is similar to Basurto *et al.*' result. However, it is important to keep in mind that the absence of an 'Or Else' parameter does not necessarily imply the absence of a punitive measure in practice. We need to consider the nesting characteristics of institutional statements, and the implication of other levels of governance as well as the role of other agencies

that might play a role in the sanctioning and monitoring of policies. Table 4 summarizes the guidelines used by Crawford and Ostrom (1995), Basuto *et al.* (2009) and Sidikki *et al.* (2011)

The role of 'Or Else' and delta parameters

There are difficulties when classifying institutions into strategies, norms and rules according to the ADICO syntax. Schluter and Theesfeld (2010) summarize these challenges. The authors discuss the syntactical clearness of institutional statements, and emphasize the presence of delta parameters as key elements to understanding institutions. The authors acknowledge that the initial framework does provide a clear and common language for analyzing and studying institutions, based on the building blocks of institutional statements (Schuler and Theesfeld 2010).

Moreover, the ADICO syntax also suggests parameters to explain why actors comply or do not comply with institutions. Scluter and Theesfeld (2010) explain three main parameters. The first parameter is the '*Or else'* element: the presence of a material or penal sanction for not following the Deontic of an institutional statement. A second parameter is the presence of 'internal deltas' that refer to the individual internalized moral values. The third parameter discussed is a mechanism of enforcement, called 'external deltas'. These last two parameters are more emotional factors than material ones and are not stated in the GoI elements (Schluterand Theesfeld 2010).

The presence and consideration of these three parameters emphasize the fact that to explain human behaviour we cannot reduce actors to their material self-interests; instead we should refer to the social context and socialization process in which they have evolved (Schulter and Theesfeld 2010; Vatn 2005a) Thus, the authors suggest that intrinsic and extrinsic motivations can explain the complexity of human behaviour. It is then important to identify and differentiate between non-material sanctions translated by delta parameters (Schluter and Theesfeld 2010) and material sanctions explicit or implicit in the "Or else" parameter (Crawford and Ostrom 1995).

Table 3 **:** Comparison of coding guidelines

	Crawford and Ostrom 1995	Basurto *et al.* 2009	Sidikki *et al.* 2011
Main Guidelines	• Institutional statements as single units of observation • Code the units of observation following the ADICO syntax • Indicate if elements are tacit or explicit	• Disregard definitions, titles, preambles, and headings in coding • Institutional statements as units of observation that can be either stand-alone statements or aggregated units of observation • Do not refer to the institutional context or any other exogenous information not contained in the statements. • Code the units of observation following the ADICO syntax. • Indicate if elements are tacit or explicit • Subdivide all sentence-based units of observation that have more than one rule, norm or strategy into separate units and recode following the ADICO syntax as rules, norms or strategies	• Disregard definitions, titles, preambles and headings from coding • Identify sections and subsections of the bill as initial units of observation. • Subdivide all initial sections or subsections that have multiple sentences into sentence-based units of observation. • Code the units of observation following the ABDICO syntax. • Code statements according to components present, separating statements into AIC/ABIC, ADIC/ABDIC and ADICO/ABDICO categories. • When applicable, indicate implicit components when they are not explicitly provided in the statement. • Use multiple coders for inter-coder reliability, according to the type(s) of document(s) being coded.

A delta parameter influences an actor to obey or disobey a norm. These parameters are directly associated with the Deontic element, as the ‘Or else’ element does not exist in a norm. This non-material sanction depends on the context of the action, as well as on the individual internal beliefs, past experiences and socialization (Schluter and Theesfeld 2010). The individual aspects of the sanction are called 'internal deltas' and are formed by individual norms, values and preferences. The contextual delta parameters, also known as 'external deltas', refer to social norms, values and preferences (*Idem*). On the contrary, the ‘Or else’ parameters are more tangible, and consist of material sanctions, always negative. Examples of material sanctions are a punishment, a sanction or a fine.

By following the original GoI framework, institutions are classified according to the building blocks of the ADICO formula they contain; however, institutions can further be classified according to the type of sanctioning they involve. Among institutions, strategies are the only institutions that have no sanctions associated with them. On the contrary, rules always have a material sanction presented in the ‘Or Else’ parameter. In between these two, norms have no material sanctions that rely on either social or individual pressure emerging from a moral common understanding, referred to as the delta parameters (Schluter and Theesfeld 2010).

Another important element to consider during institutional classification is that the distinction between a norm and a rule does not refer to the distinction between a formal and an informal institution. For instance, a statement within a formal law can be classified as a norm in the absence of an ‘Or else’ parameter (Schluter and Theesfeld 2010). Furthermore, rules can be unwritten and informal, as long as the ‘Or else’ parameter follows the conditions suggested by Crawford and Ostrom (1995). Thus, an institution is defined as a rule, beyond its formal or informal character, if it follows the ‘Or else’ parameters requirements.

In other words, by following the GoI characterization, both informal and formal institutions could be classified by either strategies, norms or rules, depending only on the elements they present, and independently of their providence (Schluter and Theesfeld 2010). This characteristic

of the framework allows incorporating other sources of institutions, beyond the scope of legal boundaries, and challenges classical conceptions of the sources of normative statement.

Drawing lines between institutions

Even if the framework defines clear differences between institutions based on the elements statements contain, there are still some similarities between the categories suggested by Crawford and Ostrom (1995). For instance, it can be difficult to distinguish between norms and strategies due to the roles that delta parameters play in these institutions (Schluter and Theesfeld 2010). Strategies are institutions that help explain the behaviour of an actor or a player in a game. Strategies do not have constraints and may change from one day to another (Schluter and Theesfeld 2010). Strategies are followed because there is an advantage to following them from an individual point of view, and there does not exist any rule or norms to prevent actors from following these strategies. When everyone shares this strategy, it becomes a type of convention (Schluter and Theesfeld 2010).

Furthermore, norms are standard behaviours shared by actors and members of a social group. These institutions can be internalized, incorporated within the individual, and followed without any external sanctions or rewards (Schluter and Theesfeld 2010). Additionally, we should distinguish between individual and community norms. Individual norms rely on internal deltas, meaning that the individual performs a type of self-monitoring (*Idem*). Individual norms can also be considered as being derived from internalized social norms, through the process of socialization (*Idem*). In the case of social norms, actors rely on external deltas for compliance with them (*Idem*).

Even if individuals follow strategies without any material sanction or enforcement, strategies depend on many internal deltas such as internalized normative statements, as well as on past positive or negative individual or social experience (Schluter and Theefeld 2010). Thus, there are situations where even if a grammatical classification of an institutional statement is carried out,

norms and strategies can be confused when considering the role of internal deltas. This is one of the challenges that obtains when applying the grammar of institutions framework, especially when the institutional context as well as individual experience is ignored.

Similar limitations are found in examining the differences between norms and rules. In the GoI, rules these are institutions that possess an 'Or Else' component. Crawford and Ostrom (1995) also bring attention to rules in use, those that are truly lived by actors, not only to the rules in form, which may exist only in discourse and legislation (Schluter and Theesfeld 2010). The relation between norms and the 'Or else' parameter can enlighten some of these limitations. When analyzing informal institutions, the 'Or else' component of norms is not well understood, as it is not expressed in juridical terms. Schluter and Theesfeld (2010) suggest that if we reformulate many informal institutions to fit juridical terms, translating the social or individual sanction into legal punishment, many norms, either social or internal, could have an 'Or else' parameter associated with them.

To better integrate the role of the delta parameter and 'Or else', Schluter and Theesfeld (2010) suggest classifying institutional statements according to the type and nature of the sanctions attached. A strategy has automatic sanctions to the actor. A personal norm has internal, emotional sanctions, and a community norm will have external emotional sanctions. Rules are the only institutions that involve more tangible, mostly material sanctions, such as fines or other legal penalties. Other authors have argued the need for a more continuous perspective of institutions, as well as the need for more flexibility, especially when defining norms. This flexibility is needed to take into consideration the continuous adaptation of norms that emerge, evolve, and might replace existing rules. (Frantz *et al*. 2013).

Moreover, if institutions are classified based on the 'Or else' parameters, Schluter and Theesfeld (2010) propose to further analyze the characteristics of this last parameter. Recall the three qualifications linked to this element introduced by Crawford and Ostrom (1995):

- a monitor must exist;
- a norm or a rule about the monitor's right and duties must exist;
- the sanction should emerge from a collective action process.

When considering these requirements, classifying institutions according to the characteristics of the 'Or Else' parameter presents some difficulties. First, the presence and the nature of a monitor may be unclear, or not mentioned in the statement or elsewhere in the institution document (Schluter and Theesfeld 2010). Some questions remain unanswered as to how to distinguish between a proper monitoring agency in the case of rules and an improper monitoring agency as present in norms. Moreover, it has been shown that internal monitoring might function more effectively when enforcing some institutions, while others might be better enforced either with social monitoring or with informal assigned monitors (Schluter and Theesfeld 2010). Thus, an officially assigned monitor might be unclear or become irrelevant, as it mismatches the nature of the institutional statement.

Institutional statements can also be largely influenced by who plays the monitor role. Schluter and Theesfeld (2010) classify the types of monitors into internal, social, informally assigned, formally assigned (private) and formally assigned (governments). The authors suggest adding a description to the type of monitoring in place to better characterize the type of institutional statement. This is based on the institutional context from which the institutional statement derives. As well, the analysis of the internal deltas, external delta and the 'Or Else' parameters provides characteristics on the type of monitoring, the responsibilities and duties of the monitor, without expanding the analysis too much to the institutional context (Schluter and Theesfeld 2010)

Frantz *et al.* (2013) introduce the concept of nested institutional statements, to provide a more detailed description of the complexity of institutional statements, specifically of the 'Or else' component and the consequences of actions. The authors consider the first part of the statement

(ADIC) a monitored statement, relating to a second nested fragment, (the Or else element) – what the authors label the 'consequential statement'. By using vertical nesting, the authors suggest that the 'Or else' element can be classified using the same structural components as the monitored statement. They also allow for the presence of a second-order monitored statement as well as a second-order consequential statement, present in the 'Or Else' element. The authors claim that this vertical nesting shows the interrelation and interdependence among different institutions, as well as showing which other institutions are involved in the shaping of behaviour.

Additionally, Frantz *et al.* (2013) suggest 'horizontal nesting' to analyze the multiple consequences involved when transgressing a rule or the types of reactions involved when not complying with a norm. This introduction complicates the distinction between norms and rules based only on the existence of the 'Or Else' parameter. The authors suggest referring to characteristics that might not be reflected in the original grammar. For instance, they agree with Schluter and Theesfeld (2010) to include and investigate the nature of the monitoring agency. The authors suggest that having a more inclusive perspective on monitors should not be ignored, and that these should be identified and characterized for normative statements (Frantz *et al*. 2013).

However, there are still some difficulties when it comes to the distinction between an institution monitor and an enforcer or sanction. Crawford and Ostrom (1995) presume that the monitor of an institution is always the enforcer. Nevertheless, there may be a differentiation between the monitoring agent and the enforcement agent, and this distinction seems to be more common for rules, where the enforcement may be carried out by a different governmental regulatory body such as the police. In the case of norms, effectiveness depends on the fact that the monitor is not clearly stated or specified. Thus, the enforcer and the monitor are considered a unified entity that is indirectly affected by the transgression of the norm, and might feel the necessity to act as the enforcer.

Furthermore, the third condition of the 'Or Else' parameter states that "sanctions need to be the result of collective actions". One would need to differentiate what kinds of collective action processes should be involved in crafting institutional statements to obtain a more nuanced grammar and to differentiate a rule from a norm. Collective action can be defined by 'the action taken by a group in pursuit of member s' shared interests (Marshal 1998, Ostrom 2000). There are various definitions of what constitutes collective action; the main three features of these definitions are: (1) the involvement of a group of people, (2) shared interests, and (3) common and voluntary actions to pursue shared interests (Vanni 2014, Ostrom 2000).

However, the collective action process may be difficult to define and to analyze. Schluter and Theesfeld (2010) bring up the example of an institution in a workplace, where employees are asked to put the used dishes in the dishwasher. The sanction for not complying with the action is a written notice by the secretary. The author asks what makes this action a rule. Is it because the rule was discussed in staff meetings, or is it a rule because the boss has instituted it and supports the sanctioning by the secretary? Do these processes adequately qualify as a collective action process? Here the authors put forward the question of what makes an adequate collective action process to institutionalize the rules in form and respect for its sanctions, and suggest that this question could provide for a useful extension of the grammar in the classification of statements.

Methodological framework

In this study, we suggest that institutions play a major role in framing the ecological and economic behaviour of hog farmers in the Missisquoi Bay. As described, institutions exist in different forms, such as strategies, norms and rules. They can be formal, as contained in legislation and regulations, or informal as part of the discourse of day-to-day understandings. In order to answer the research question - *What is the role of agricultural institutions in promoting compliance of hog farmers with the agro-environmental policy in the Missisquoi Bay*? - We limited the scope of the research to a specific institutional body. The following section will present the methods and guidelines applied in this research for the selection and analysis of the studied regulation.

Identification of institutions

The first research objective of this study is to identify the agro-environmental institutions that influenced hog production in the Missisquoi Bay over the last 30 years, based on secondary sources and exploratory meetings with key informants. The information gathered in the exploratory meetings was not used in this research as primary data. However, these exchanges allowed the researcher to explore and inquire as to the type of formal institutions present in hog farming and water protection in the region, as well as current agro-environmental challenges.

The interviews were conducted following the ethics approved interview guideline found in Annex 1. The questions focused on the identification of relevant institutions that according to the actors influenced hog production in their region, on the application of current regulation and the challenges associated with complying with agro-environmental institutions. Three key informants from watershed management organizations and the Ministry of Sustainable Development, Environment and the Fight against Climate Change accepted to participate in the interviews.

For the purpose of this research, the review of institutions was limited to formal institutions such as policies, legislation and regulations. This limitation is imposed by time constraints. Moreover, we recognize the difficulty in identifying informal institutions involved in a farmer's behaviour, as this type of data collection requires a complex and different methodology.

The Grammar of Institutions framework was used to identify and classify the institutions found in the selected regulation: *Règlement sur les Exploitations Agricoles* (REA) In order to analyze the role of institutions included in the REA, this study focused in two specific research objectives:

1. to identify and classify the institutions contained in the *Réglément sur les Exploitations Agricoles* (REA), following the ADICO methodological framework;
2. to analyze the role of these institutions based on the requirements of the 'Or else' parameter.

It is worth mentioning that the REA is not the only formal institution that influences hog producers' behaviours in the studied region. Based on the exchanges with key informants and on the literature reviewed, the REA is shown to be of high importance for the reduction of agricultural pollution and the development of hog production in Quebec.

The institutions contained in the REA were identified and classified following the ADICO formula. The regulation contains five chapters with 57 articles. The first step in identifying the institutions was to divide the articles of the regulation into institutional statements. The institutional statement was used as the basis for the analysis, and these were classified according to their Atribute, Deontic, Aim, Conditions and Or-Else

ADICO coding

Once the institutional statements were identified, we applied the ADICO syntax. In this work, we assumed that the smallest unit of observation was the strategy (AIC), followed by the norm (ADIC) and finally by the rule (ADICO) (Crawford and Ostrom 1995; Basurto *et al*. 2009). The title, headings, preambles and definitions of the regulation were not coded, as they were not written as institutional statements. However, we recognize that definitions in legislation can have a prescriptive character, and may offer complementary and contextual information. The guidelines for coding institutional statements were developed based on the work of Crawford and Ostrom (1995), Basurto *et al.* (2009) and Sidikki *et al.* (2010). Box 1 contains the guidelines applied in this research.

We followed the core of Basurto *et al.* (2009) guidelines, considering institutional statements as units of observation that can be either stand-alone statements or aggregated units of observation that derive from more complex statements. This instruction was relevant in our case study as all the 'Or Else' parameters were contained in a separate section of the regulation.

Guidelines for coding institutional statements

- Institutional statements as units of observations can be either stand-alone statements or aggregated units of observation (Basurto et al 2009);
- Subdivide all sentence-based units of observation that have more than one rule, norm, or strategy into separate units and recode following the ADICO syntax as rules, norms, or strategies (Basurto et al 2009);
- Code the units of observation following the ADICO syntax (Crawford and Ostrom, 1995);
- Indicate if elements are implicit or explicit (Crawford and Ostrom 1995);
- Disregard definitions, titles, preambles, and headings from coding (Basurto et al 2009);
- When applicable, explicitly identify components where they are not explicitly provided in the statement but are present elsewhere in the legislation. (Sidikki et al 2010).

Box 1: Guidelines for coding institutional statements

Moreover, we opted to follow Sidikki *et al.* (2010) methodological guideline when referring to exogenous information. Basurto *et al.* (2009) suggest that coders should not refer to the institutional context or any other exogenous information not contained in the statement for the classification. We did consider information not contained in the statements; however, this information came from preceding articles or statements within the same regulation. For instance, this was done when the Attribute was implicit, but mentioned in another sentence in the same article. The first element identified was the Deontic, followed by the Attribute, the Aim and the Conditions. The 'Or Else' was the last element identified as it was found at the end of the regulation, in the 'Sanctions' sections. The researcher had then to match each sanction to its referenced article and paragraph. Only one researcher did the coding; therefore this study did not measure inter-coder reliability as suggested by Sidikki *et al.* (2010).

Once the elements of the institutional statement were coded, we categorized each element according to its characteristics. The Attributes were coded as explicit or implicit. When the Attribute was shown to be implicit, it was coded as either subject-implicit or object-implicit. The object-implicit Attribute category was added in this study when the obligation or prohibition of the Deontic referred to an inanimate object rather than an actor. Furthermore, the Deontic was classified according to the nature of the verbal mode, referring to an action that was obliged, permitted or forbidden. Several formulations of the Deontic were accepted as long as the formulation clearly stated the nature of the action. The Aim was a determining element. Only statements containing an Aim were considered institutional statements, as suggested in the literature. The Aim was then coded as including the action and/or the process.

The Conditions were classified according to presence of the 'when', 'where', 'if' or 'unless' operator. Moreover, if the conditions were not present, it was assumed that the actions applied every time and everywhere (Crawford and Ostrom 1995). The 'Or Else' parameter was classified as being absent or stated in the regulation so as to differentiate between norms and rules. Moreover, the coding also included details of the type of sanction prescribed, being either pecuniary, penal or both.

One of the challenges encountered was to apply the GoI to an institution written in French. The original grammar was conceived for English written institutions, where the grammatical structure is closer to the 'grammar' suggested by Crawford and Ostrom (1995). It was then challenging to identify elements that were not presented in the suggested ADICO syntax. Another challenge was the high presence of implicit elements. When elements were not mentioned in the statement, the coder referred to previous information to confirm the implicit aspect. Even though the study focused only on statements and information contained in the REA, we recognize the possibility that exogenous institutional information could change the coding results.

Analysing the role of institutions

The ADICO coding provided the main characteristics of the institutions presented in the REA. Based on these results and classification, we analyzed institutions to assess their role on hog farmers' behaviour. We assumed that the presence of a complete grammar emphasises the regulative character of the institutions and their effectiveness. Based on the presence and requirements of the 'Or Else' parameter the role of the REA was then discussed.

Moreover, in the discussion chapter we questioned whether the presence of complete grammar is a sufficient condition for actors to comply with the institutions. To do so, we looked into the requirements of the 'Or Else' parameter according to Ostrom (2005). We emphasized the third condition of Ostrom (2005) - the requirement for sanctions to be the result of collective action. By exploring the participation process for the crafting of the REA, we questioned the regulatory and normative role contained by the institutions and their legitimacy. This analysis examines the farmers' relationship towards the REA as well as the type of compliance the grammar of the regulation encourages.

***Table 4*:** Logical framework of the research

Aim	Objectives	Specific objectives	Methods	Expected Results	Policy Implications
Study the role of agricultural institutions influencing farmers' environmental compliance	• Identify the agro-environmental institutions influencing hog farmers in the past 30 years in the Missisquoi Bay • Analyze the role of the identified agricultural institutions	• Identify and classify the institutions of the REA following the grammar of institutions framework • Analyze the role of the REA institutions based on the requirements of the 'Or else' parameter.	• Literature review and secondary sources • Grammar of Institutions framework • Institutional analysis of the adoption process of the REA	• The grammar of the REA might not be complete. • The institutional grammar is not self-contained • The REA does not comply with the three requirements of the 'Or Else' parameter	• Review the current agro-environmental legislation and its efficiency in the adoption of best management practices • A reflection on the types of institutions needed to decrease the ecological impact of hog farming in the region

Chapter 3: Results

The following chapter presents the results of the identification and classification of the institutions influencing hog farmers' environmental compliance in the Missisquoi Bay in the past 30 years. The first part of the chapter will present the main regulations that, according to the literature, played a role in shaping agro-environmental behaviour in hog farming and introducing best management practices in the Missisquoi Bay in the past 30 years. The results of this review go beyond the content of the "*Réglément sur les Exploitation Agricoles" (REA)*; however, only this last regulation was categorized using the GoI framework. The second part of this chapter will present the results of the categorization and the characterization of the REA content according to their Attribute, Deontic, Aim, Conditions and Or Else elements.

History of agro-environmental institutions

The identification of formal institutions influencing hog farmers' environmental compliance and practices in the past 30 years was based on the literature review, secondary sources and exploratory interviews. Within the literature, Boutin (2004) offered an extensive review of agro-environmental policies aiming at reconciling water and agricultural policies in Quebec. Other policies and legislation were identified through a review of the history of agricultural production and water management in the region (Mimeault 2002, Gilson 1990). Table 5 summarizes the identified legislation and policies influencing hog production and agricultural pollution management in the Missisquoi Bay.

It is important to consider that in terms of jurisdiction, agricultural production and fresh water management are provincial responsibilities in Canada, making the government of Quebec a main actor in the production of legislation (Boutin 2004). Moreover, the Missisquoi Bay is part of the Lake Champlain watershed, a shared basin between the province of Quebec, and the American states of Vermont and New York. Thus we found trans-boundary legislation and policies,

describing efforts among these jurisdictions to decrease the negative impact of farming on the Lake Champlain Basin (Mimeault 2002).

The regulations, laws and policies listed in Table 5 set out the basis of understandings of agricultural land occupation and protection introducing best-management practices in order to decrease the impact of intensive farming systems. The grammar of all the regulations listed was not analyzed in this study. However, the history and impact of some policies are worth mention as they played a specific role in framing current farming behaviours.

The hog industry of Quebec went through important development and expansion around the 1970s. For instance, Quebec changed its status as a 'pork deficit' province, moving from a deficit of 104,700,000 pounds in 1970 to a surplus of 68,296,000 pounds in 1978 (Karantinis *et al*. 1995). This change in production occurred without direct support from the government in the form of subsidies, but as a response to market factors affecting the rest of the meat sector. This expansion is in part attributed to changes in federal and provincial policies during this time period, altering the previous trade pattern in Canada and Quebec (Karantininis *et al*. 1995).

The Canadian supply management system is one of the policies that influenced the animal production portrait of Québec. The introduction of supply management in competing livestock commodities such as poultry, dairy, turkey and eggs influenced the described increase in hog production. As the increased production in other livestock industries was regulated by the acquisition of quota, hog production offered the opportunity to increase production at a lower cost (Gillespie *et al*. 1997). Moreover, this structural change forced feed dealers to seek other markets, to assure economic expansion. Feed mill businesses created new markets by offering contracts to hog farmers, encouraging additional producers to enter the hog market (Gillespie *et al*. 1997). Supply management is then one of the policies that induced the increase and intensification of hog production in Quebec in the 1970s, leading to the current agricultural landscape.

Table 5: Summary of agro-environnemental institutions

Date	Institution	Objectives	Source(s)
1967-1970	Implementation of Supply Management in Canada	• National agricultural policy • Protection of national market	Gilson, 1990
1978	Act protecting agricultural land	• Arable land protection	Boutin, 2004
1981	Règlement sur la prévention de la pollution des eaux par les établissements de production animale (RPPEPA)	• Water protection • Animal production	Boutin, 2004
1986	National agricultural strategy (Canada)	• Soil conservation	Boutin, 2004
1987	Agreement: Canada-Quebec on soil and water conservation	• Inventory of soil degradation issues	Boutin, 2004
1988	Support Program for the Improvement of Manure Management (*PAAGF*)	• Financial assistance for manure storage facility construction	Boutin, 2004
	Cooperation agreement between Quebec, Vermont and New York on Lake Champlain's water management	• Trans-boundary water protection	Mimeault, 2002
1989	Federal and provincial committee on sustainable agriculture	• Introducing the notion of sustainable agriculture	Boutin, 2004
1993	Agriculture component of the St. Lawrence Vision 2000 Action Plan	• Raising awareness of agro-environmental problems in various agricultural watersheds	Boutin, 2004
	Canada-Québec Subsidiary Agreement on Environmental Sustainability in Agriculture	• Canada-Québec Subsidiary Agreement on Environmental Sustainability in Agriculture	Boutin, 2004
1994	Forum on sustainable agriculture	• Bulding consensus on sustainable development	Boutin 2004
1996	Renewal of the Lac Champlain cooperation agreement	• Implementation of an action plan	Mimeault, 2002
	Introduction of the concept of "municipalities with manure surplus" in *RPPEEPA*	• Territorial management approach	Boutin, 2004
1997	Bill 23: Act respecting the preservation of agricultural land and agricultural activities	• Priorization of agricultural land use in agricultural zones • Introduction of a minimum distances for odour mitigation and management	Boutin, 2004
	Regulation respecting the reduction of pollution from agricultural sources (*RRPOA*)	• Agro-environmental fertilization plan •	Boutin, 2004

Date	Institution	• Objectives	Source(s)
1997	Agro-environmental plan for hog production	• Sectoral agro-environmental portrait • Technical support for agro-environmental clubs • Development of an environmental certification scheme	Boutin, 2004
1999	Creation of the Corporation Bassin Versant Baie Missisquoi (CBVBM)	• Integrated water management	Mimeault 2002
2000	Prime Vert – Program	• Financial assistance for manure storage facility construction • Support for agro-environmental advisory clubs	Boutin, 2004
	Report : "Partage des responsabilités entre le gouvernement du Québec et l'État du Vermont pour la réduction des charges de phosphore dans la baie Missisquoi" (Groupe de travail Québec-Vermont, 2000).	• Review of the roles of the governments involved in the management of Lake Champlain	Mimeault, 2002
2001	Act 184	• Adoption of cross-compliance principle • Adjustments to land-use planning orientations	Boutin, 2004
2002	Quebec Water Policy	• Integrated water management	Baril *et al*. 2005
2003	Règlement sur les exploitations Agricoles	• Farm-by-farm approach • Phosphorous balance Reinforcement of controls	Boutin, 2004
	Commission on sustainable development of hog production	• Drafting of a framework on sustainable development	Boutin, 2004
	Administrative requirements for hog production and moratorium	• Restrictions on pig farm development	Boutin, 2004
2008	Report of the Pronovost Comission: "Comission sur l'avenir de l'agriculture et l'agro-alimentaire Québécois"	• Diagnosis and recommendations for agricultural production and policies at the provincial level	CAAAQ,2008

As described in the first chapter, the increase in animal density in the agricultural regions of Quebec led to serious environmental impact affecting the quality of rivers and lakes. As described in Table 5, the period between 1981 and 2002 saw the introduction of legislation and programs to reduce the impact of intensive farming systems. In the late '90s, the government of Quebec began developing water policies to reflect the principles of sustainable development in water management. This process led to the Quebec water policy adopted in 2002, stressing the importance of adopting an integrated water management approach at the watershed level, notably for the St. Lawrence River and its tributaries (Boutin 2006). This policy made possible the creation of 33 watershed management committees, including municipal and provincial government representatives, members of the industrial and agricultural community as well as citizens from the region (CAAAQ 2008).

These committees are responsible for producing a 'water management plan" (*plan directeur de l'eau*). According to the policy, the farming sector is expected to play an important role in achieving water standards and participating in the conception and application of the water management plan. Moreover, as a priority item the water policy aimed to reduce the impact of the farming sector on water sources. In this policy, the government of Quebec committed to achieving a balanced phosphorous level in soils by 2010 (Government of Quebec 2002). The government also committed to supporting the establishment of riparian corridors on agricultural land and to introducing eco-conditionality within a range of financial assistance programs (Government of Quebec 2002).

Among the environmental support programs introduced, the "Prime-vert" is considered to be of high importance for the implementation of management practices and the adoption of new technology. Since 1999, this program aims to support agricultural producers in the protection of the environment by promoting individual and collective initiatives to remediate the impact of intensive crop and animal production (MAPAQ 2014b). Key informants during the interviews emphasised the importance of the Prime-vert to cover the cost of adoption of best-management practices, judged to be beyond the farmer's operational budget. For instance, to help livestock producers achieve regulatory compliance; Prime-vert subsidies can cover between 70% and 90% of the cost of building manure storage structures (Boutin 2004).

Another policy adopted to promote the adoption of environmentally conscious behaviour is the cross-compliance or eco-conditionality principle. This principle links agricultural support programs to the achievement of minimal environmental standards (MAPAQ 2014a; Boutin 2004). Producers must respect current agro-environmental regulations to receive financial support from the Quebec government (MAPAQ 2014a). The criterion of eco-conditionality adopted includes the following requirements (MAPAQ 2014a):

- Animal producers must establish phosphorous balance and depose evidence to the MDDEP as needed to provide proof to the Ministry of Agriculture (Applicable from January 1st 2005 to December 31st 2010);
- An annual update of the phosphorus balance for all production areas must be deposited at the MDDEP before May 15th each year . In addition, this annual update must show that the soil is in balance and this balance must be maintained throughout the annual growing season (Applicable from January 1st 2011 to this date).

Another important policy principle is the creation of agricultural advisory clubs in 1993 (Tamini 2009). These clubs educate and engage farmers in sustainable agriculture (*Idem*). In 2008 the network of advisory clubs accounted with more than 300 advisors grouped into 83 clubs and serving more than 8300 farms or members (*Idem*). Among their activities we find guidance for management of fertilizer and pesticide use, methods of integrated pest management, practices of soil conservation, and management and protection of watercourses (*Idem*). In the Pronovost report, the CAAAQ indicated that the progress of farmers in terms of sustainability could be in part explained by the advice coming from experts who understand their needs (CAAAQ 2008, Tamini 2009).

Classification and coding of the *Réglement sur les exploitations agricoles*

In 2002, the Quebec government adopted the *Réglement sur les exploitations agricoles* (REA) This regulation framed agro-environmental practices at the farm level, reinforced pollution control measures for farms, and increased the number of farm inspections (Boutin 2004). The REA was selected for this study because it contains formal institutions that directly target diffuse pollution sources originating in from animal production units and emphasizes the reduction of the impact of intensive hog farming systems. Indeed, this regulation introduced (Boutin 2004):

- requirements that farmers have a watertight manure storage facilities;
- the priority to target non-point source pollution by striking a balance between soil carrying capacity for phosphorous and the quantity of fertilizer applied;
- the requirement of an agro-environmental fertilization plan, regular phosphorous balance reports, and compliance with restrictions on the spreading of livestock waste;
- administrative requirements to imposed temporary limitations on the development of new hog farming operations.

The French version of this regulation, updated to February 2015, was coded. It is important to mention that this is the first time the GoI framework has been applied to French language legislation. The regulation contained 6 chapters and 57 articles. The classification and coding of institutions was effected following the guidelines presented in the methodological framework. We identified 129 institutional statements, contained in chapters II, III, IV and VI. Chapter I was disregarded by the coding as it contained only the preamble and definitions. Chapter V was not coded as it contained the sanctions for not complying with chapters II, III, IV and VI. The results of the ADICO classification are detailed in Table 6.

The classification according to the ADICO syntax of the 129 statements showed that 109 statements posed a complete grammar (ADICO) and were coded as rules. These institutions represent the majority of institutions of the REA, counting for 84.5% of the institutions found. Moreover, the regulation contains 19 norms - institutional statements containing an Attribute, Deontic, and Aim and a Condition but without a sanction (ADIC).

***Table 6* :** ADICO classification of the *Réglèment sur les exploitations agricoles*

Type of institutions	Formula	Number of statements	Percentage of institutions (%)
Strategy	AIC	1	0.8
Norm	ADIC	19	14.7
Rule	ADICO	109	84.5

Only one strategy was found in the regulation, as seen in Box 2. This statement was classified as a strategy because it did not include a Deontic, a grammatical formulation that explains an obligation, permission or interdiction. Only 19 statements in the legislation contained a Deontic but did not include a sanction. These statements were classified as norms. Box 3 contains some examples of norms found in the regulation.

Example of a Strategy

Article 50.01

Attribute : *la détermination de la production annuelle de phosphore (P2O5)*

Aim : *est obtenue, pour l'application des articles 9.3, 22, 28, 28.1, 39, 42 et 48.4, en multipliant le nombre d'animaux présents et prévus d'une catégorie dans le lieu d'élevage, indiqué au bilan annuel de phosphore applicable à la saison de cultures en cours ou, le cas échéant, à sa mise à jour la plus récente, par le facteur attribué à cette catégorie à l'annexe VII.*

Conditions : *Malgré la définition de «production annuelle de phosphore (P2O5)» prévue à l'article 3*

***Box 2* :** Example of Strategy

Examples of Norms

Article 9
Attribute: *L'exploitant*
Deontic: *peut*
Aim: *disposer d'un ouvrage de stockage étanche, soit en propriété, soit en location, soit par entente de stockage écrite avec un tiers*;
Conditions: Absent (All times)

Article 20.1
Attribute: *Le calcul de la superficie minimale requise pour satisfaire au premier alinéa*
Deontic : *doit*
Aim: *s'effectuer conformément à l'annexe I.*
Conditions: Absent (All times)

Article 43
Atribute: *Toute demande de certificat d'autorisation*.
Deontic: *doit*
Aim: *être présentée*
Conditions: *sur le formulaire mis à la disposition par le ministre en y joignant les documents demandés.*

Article 50.3.1
Attribute: *La personne qui cultive la parcelle ou le terrain*
Deontic : *doit*
Aim : *fournir un exemplaire de cette recommandation sur demande du ministre dans le délai qu'il indique*
Conditions: Absent (All times)

Box 3 **:** Example of norms

Example of Rules

Article 5
Attribute: *Le propriétaire d'un terrain ainsi que la personne à qui il en a cédé la garde, le contrôle ou l'usage*
Deontic*: doit*
Aim: prendre les mesures nécessaires pour empêcher que les déjections animales atteignent les eaux de surface ou les eaux souterraines
Conditions: Absent (All times)
Or else: (*1) Une sanction administrative pécuniaire d'un montant de 2 000 $ dans le cas d'une personne physique ou de 10 000 $ dans les autres cas peut être imposée à quiconque fait défaut:* and *(2) Commet une infraction et est passible, dans le cas d'une personne physique, d'une amende de 10 000 $ à 1 000 000 $ ou, malgré l'article 231 du Code de procédure pénale (chapitre C25.1), d'une peine d'emprisonnement maximale de 3 ans, ou des deux à la fois, ou, dans les autres cas, d'une amende de 30 000 $ à 6 000 000 $,*

Article 6
Attribute: Implicit (Everyone)
Deontic : *Il est interdit*
Aim: *d'ériger, d'aménager ou d'agrandir une installation d'élevage ou un ouvrage de stockage*
Conditions*: dans un cours d'eau, un lac, un marécage, un marais naturel ou un étang et dans l'espace de 15 m de chaque côté ou autour de ceux-ci, mesuré à partir de la ligne des hautes eaux, s'il y a lieu. (Le premier alinéa s'applique aux sections de cours d'eau dont l'aire totale d'écoulement (largeur moyenne multipliée par la hauteur moyenne) est supérieure à 2 m^2. Le présent article ne vise toutefois pas les étangs réservés uniquement à la lutte contre les incendies ou à l'irrigation des cultures.)*
Or else: *(1) Une sanction administrative pécuniaire d'un montant de 1 500 $ dans le cas d'une personne physique ou de 7 500 $ dans les autres cas peut être imposée à quiconque fait défaut, and (2) Commet une infraction et est passible, dans le cas d'une personne physique, d'une amende de 8 000 $ à 500 000 $ ou, malgré l'article 231 du Code de procédure pénale (chapitre C25.1), d'une peine d'emprisonnement maximale de 18 mois, ou des deux à la fois, ou, dans les autres cas, d'une amende 24 000 $ à 3 000 000 $, quiconque contrevient*

Article 11
Atribute: *Les ouvrages de stockage*
Deontic: *doivent*
Aim: *être dépourvus de drains de surplus et de drains de fond*.
Conditions: Absent (All times)
Or Else *(1) Une sanction administrative pécuniaire d'un montant de 750 $ dans le cas d'une personne physique ou de 3 500 $ dans les autres cas peut être imposée à quiconque fait défaut and (2) Commet une infraction et est passible, dans le cas d'une personne physique, d'une amende de 4 000 $ à 250 000 $ ou, dans les autres cas, d'une amende de 12 000 $ à 1 500 000 $, quiconque contrevient*

Article 18
Attribute: *Les eaux contaminées provenant d'une cour d'exercice*
Deontic : *ne doivent pas*
Aim: *atteindre les eaux de surface*
Conditions*:* Absent (All times)
Or else: *(1) Une sanction administrative pécuniaire d'un montant de 2 000 $ dans le cas d'une personne physique ou de 10 000 $ dans les autres cas peut être imposée à quiconque fait défaut:, and (2) Commet une infraction et est passible, dans le cas d'une personne physique, d'une amende de 10 000 $ à 1 000 000 $ ou, malgré l'article 231 du Code de procédure pénale (chapitre C25.1),*
d'une peine d'emprisonnement maximale de 3 ans, ou des deux à la fois, ou, dans les autres cas, d'une amende de 30 000 $ à 6 000 000 $, quiconque contrevient

Box 4 **:** Example of rules

Moreover, the majority of the actions permitted, forbidden or allowed by the regulation have clear sanctions attached, implying a more regulative character of the institutions, and showing a complete grammar. Box 4 gives some examples of the type of rules found in the regulation. Beyond the type of institutions present in the regulation, it is interesting to see how the characteristics of each grammatical element describe the nature of the institutions found. In the following sections, institutions will be described and categorized according to their grammatical elements.

Attribute

Attributes were categorized as either explicit or implicit. Table 7 summarizes the results of the categorization of the Attributes found in the legislation. One of the main observations is the presence of implicit attributes on 80 of the 129 statements. The explicit Attributes found in the legislation refer mainly to the producers *(exploitants)* and to the owners of the farms. Other actors such as agronomists and the Minister of Environment are also named in the regulation. Appendix 2 describes the Attributes appointed and their frequency.

***Table 7*:** Types of Attributes in the REA

Type of Attribute	Number of statements	Percentage of statements (%)
Explicit	49	38.0
Implicit	80	62.0
No attribute (Everyone)	8	6.2
Object	65	50.4
Subject	7	5.4

Among the implicit attributes, the coder detailed whether the attribute was not present in the statement (referring to everyone), whether the Attribute referred to an object and whether the Attribute referred to a subject present in another statement. In the cases where the Attribute was present in another statement, the pronoun "*il*" (he) was used to assign an attribute in 7 cases,

referring to an actor named in a preceding statement. In cases where there was no Attribute assigned in the statement, the Deontic formulations tacitly implied that everyone should conduct the actions. An example of this kind of implicit Attribute was the case of the "it is forbidden" Deontic. Even if there is not a specific actor named, we followed Crawford and Ostrom's (1995) guidelines, suggesting that the Attribute of a statement refers to everyone when the Deontic generalizes the action. Eight statements in the regulation displayed this kind of implicit attribute.

Example of implicit-object Attribute

Attribute: *Les eaux contaminées provenant d'une cour d'exercice*

Deontic : *ne doivent pas*

Aim: *atteindre les eaux de surface*

Conditions*:* Absent (All times)

Or else: *(1) Une sanction administrative pécuniaire d'un montant de 2 000 $ dans le cas d'une personne physique ou de 10 000 $ dans les autres cas peut être imposée à quiconque fait défaut: and (2) Commet une infraction et est passible, dans le cas d'une personne physique, d'une amende de 10 000 $ à 1 000 000 $ ou, malgré l'article 231 du Code de procédure pénale (chapitre C25.1),*
d'une peine d'emprisonnement maximale de 3 ans, ou des deux à la fois, ou, dans les autres cas, d'une amende de 30 000 $ à 6 000 000 $, quiconque contrevient

***Box 5* :** Example of Implicit-object Attribute

The third kind of implicit attribute was the presence of an Object as an Attribute of the action. As demonstrated in table 8, 65 statements in the regulation referred to an Object as an Attribute. Box 5 illustrates this type of formulation. In this case, it is the "polluted water coming from the exercise course" that should not (Deontic) reach surface water. In this statement, there is no subject attributed to the action even though there are sanctions that are to be applied in the event of non-compliance with the statement. The absence of an actor and this type of implicit-object raises several questions of interpretation and application of institutions. These issues will be further discussed in the next chapter.

Deontic

The kinds of Deontic found in the analyzed statements were mainly explicit and clearly described in the text. There were only 3 cases where the Deontic was classified as being implicit, attributed to an unusual verbal mode. The implicit Deontics found were:

- " *il ne peut etre fait"* (Art. 22),
- " *n'est permis que*" (Art 22),
- "*sont assujetis*" (Art 42) .

These examples of implicit Deontic were interpreted as action forbidden, allowed, and obliged to. Table 8 and 9 summarize the results of the categorization of the Deontic parameter.

Table 8 **:** Deontics present in the REA

Deontic	**Number of Statements**	**Percentage of Statements (%)**
Explicit	125	96.89
Implicit	3	2.32
Absent	1	0.77

Table 9 **:** Types of Deontic found in the REA

Types of Deontic	**Number of statements**	**Percentage of Statements (%)**
Forbidden	10	7.75
Permitted	14	10.85
Obliged	104	80.62

As for the types of Deontic found, most of the statements referred to an action that is obliged (104 statements). According to Crawford and Ostrom (1995), 'obliged' and 'forbidden' are associated with normative statements. Moreover, it is important to take into account that according to article 44.7 of the regulation, anyone who goes against an obligation commits an offence and is subject to a penal sanction in the form of fines. Thus, the presence of a majority of obligation statements and the sanctions attributed to them highlights the normative and regulative aspect of the institutions, expected to have a stronger influence on farmer s' behaviour.

Aim

As described in the methodological review, every institution, whether a rule, strategy or norm, requires an Aim. This element was coded considering the presence of the actions and processes prescribed. In the regulation, we found that only 97 of the 129 statements described the processes to achieve the desired outcome.

Table 10 **:** Aim found in the REA

Content	Number of Statements	Percentage of Statements (%)
Action (What)	129	100.00
Action and Process (What and How)	97	75.19

Conditions

The majority of statements contained specific conditions referring to the time or frequency of the action, the place of its execution, or the situation when the performance of the action was expected. Only in 46 statements were conditions not specified. According to Crawford and Ostrom (1995), if a statement does not include any conditions, the Deontic is applicable in all times and all places. This guideline was assumed during the coding process. Moreover, in 15 cases, conditions were found in another institutional statement. This is explained by the presence

of multiple institutional statements in one article. When present, conditions were specific on the settings of the actions.

Table 11 **: Type of Conditions found in the REA**

Type of conditions	Number of statements	Percentage of the Statements (%)
When	49	37.98
Where	9	6.97
If	19	14.72
Unless	5	3.87
In another statement	15	11.62
No reference (All times)	46	35.65

Or else

The majority of the institutional statements (109 statements) of the regulation were classified as rules and contained an 'Or Else' Parameter. The sanctions of the statements were found in chapter V of the regulation, under Section I, indicated as pecuniary sanctions, and under Section II, indicated as penal sanctions. Each article in these sections assigned a sanction to either an entire article in chapters II, III, IV and VI, or to a particular institutional statement of the article. By matching the sanctions to their respective institutional statements, we found that 88 statements were related to as pecuniary sanctions, 104 statements were attributed penal sanctions and 83 of the statements were attributed to the two types of sanctions.

Moreover, there are questions that arise when we look at the kinds of Aims associated with the sanctions. Table 12 outlines the association between the kinds of Attributes and their appointed sanctions. As mentioned before, in 80 institutions, the Attribute of the statements was coded as implicit. Among the statements including a sanction (rule), we find that the majority (64 of the 109 rules classified) are assigned to implicit Attributes. Furthermore, it is important to observe

that 49 statements have an implicit-object Attribute and are assigned a sanction. In 7 of these cases, penal sanctions are associated with non-compliance with the Deontic by an implicit-object Attribute; and 39 cases are associated with pecuniary and penal sanctions.

These situations present issues in the application of the regulation. The lack of a Subject to conduct the prescriptive actions, and the fact that the prescribed action is related to a sanction, make it difficult to determine who is the actor that will be punished if the action is not carried out. Moreover, the characteristics of the 'Or Else' parameter are an important tool to measure the impact of the identified institutions on farmers' behaviour. The following chapter will further discuss the characteristics of the grammar based on the conditions of the 'Or Else' parameter.

Table 12 **:** Type of Attributes and type of sanctions in the REA

Type of Attribute	**Total # of statements**	**Statements with a pecuniary sanction**	**Statements With a penal sanction**	**Statements with both sanctions**	**Total # of statements having a sanction**
Explicit	49	2	12	31	45
Implicit	80	3	9	52	64
No attribute (Everyone)	8	0	0	8	8
Object	65	3	7	39	49
Subject	7	0	2	5	7

Chapter 4 : Discussion

The introduction of the *Règlement sur les Exploitation agricoles* (REA) in 2002 is considered to be a step forward for the province of Québec towards the reduction of agricultural diffuse pollution. As shown in the results section, these rules and regulation differ from previous agro-environmental institutions in that it introduces a number of mandatory best management practices at the farm level, such as the obligation for all farmers to follow an agro-environmental fertilization plan.

Despite the introduction of this regulation, diffuse agricultural pollution remains an important consequence of current agro-ecosystems. As described in the literature review chapter, to this date, in the province of Quebec, several watersheds have high phosphorous concentrations, beyond the recommended nutrient levels. Among the effects of eutrophication in these watersheds, we find dissolved oxygen depletion, decreased light penetration in water bodies, increase in suspended solids, and a reduction in aquatic fauna and flora (Eastman *et al*. 2010). Moreover, the growth of algal mats at the surface limits recreational use of lakes and facilitates the growth of toxin, increasing the population of cyanobacteria, polluting surrounding water bodies, and rendering water unsuitable for human consumption, as shown in the case of the Missisquoi Bay. The persistence of these ecological disturbances directly brings into question the role and impact of the 2002 regulation.

It is important to note that the use of best management practices has increased, including the implementation of nutrient plans at the farm level. However, the question remains open regarding the adequacy of the institutions to induce behavioural change and to address the overall ecological problem. As shown in the preceding chapters, institutions such as rules, norms and strategies play a crucial role in framing ecological and social interactions, predicting behaviour and establishing the parameters for ecological changes.

This study assesses the role of agro-environmental institutions in encouraging hog farmers' environmental compliance in the Missisquoi Bay by analysing the grammar institutions contained in the *Règlement sur les Exploitations agricoles*. In the following paragraphs, we

analyze the results of the institutional classification in light of the conditions of the 'Or Else' parameter, linking the characteristics of the institutions with the institutional context of their emergence and application.

We assume in this study that institutions should have a complete grammar in order to influence compliance. This condition will be discussed in light of the results of the grammatical analysis. Moreover, we will question the sufficiency of a complete grammar of institutions by looking at the conditions of the 'Or Else' parameter. Furthermore, we will bring into question the legitimacy of the institutions contained in the regulation under scrutiny by analyzing the process by which it was adopted. Finally, this chapter will assess how the legitimization process affects the regulative and normative role of institutions.

A complete grammar

As shown in the results, out of 129 identified statements, 109 show a complete grammar, including all the elements of the ADICO framework, and, thus, were classified as rules. According to the literature, rules are important regulative statements, carrying an additional legal weight. As stated by Bromley (2009), these institutions are fundamental in establishing order in society as well as in systematizing economic relationships. Rules are key structural components of behaviour, establishing acceptable standards for individual and group behaviour (*Idem*). The main characteristic of rules, according to the grammar of institutions, is the presence of a sanction. In this case, there were two types of sanctions found in the regulation: pecuniary and penal sanctions. Thus, it is expected that regulations containing a majority of rules will have a significant influence on behaviour, as pecuniary and penal sanctions are linked to the noncompliance of the contained institutions.

However, as observed in the results, the grammar of the regulation showed interpretation and application issues. One of the issues when interpreting statements is the presence of implicit attributes referring to an object (54% of all statements). In other words, half of the institutions do not assign a specific actor to the expected and, in many cases, mandatory action. The legislation rather uses the passive voice to regulate a practice without assigning a clear responsibility to an

actor. This interpretation issue is accompanied by the fact that 49 out of the 109 rules are attached either a pecuniary or a penal sanction, leading to enforcement challenges as it remains uncertain who would suffer the sanction.

According to Sidikki *et al*. (2011), when the attribute is implicit, the researcher must understand the context of the institutional statement within the document to assure proper application. If we refer to the context and the grammatical characteristics of the attributes[14] found in the regulation, the "*exploitant*" (the producer) could be considered as the implicit attribute. However, the lack of clarity in the grammar renders the farmer's responsibilities as well as the application of the sanction more diffuse.

Additionally, we found an absence of conditions in 35.6 % of the institutions. According to Crawford and Ostrom (1995), when the conditions are not stated in the institutional statement, the Deontic applies *de facto* 'everywhere and every time,' without exception. The question remains open regarding the necessity or obligation to state conditions in order to better frame the behaviour of actors: should we assume that actors would easily understand the implicit aspect of conditions?

The above-mentioned issues outline the specific aspect that remains unclear within the grammar and may explain the difficulties in interpreting statements and the application of sanctions. Even if the grammar is at times 'fuzzy,' overall the regulation can be deemed to have a strong regulative role because it contains a vast majority of rules. Thus, the parameters and conditions of rules should be further analyzed in order to assess the effectiveness of the 2002 REA.

According to Ostrom (2005), it is not enough to have sanctions associated with a Deontic for an institution to be effective. As stated in the methodological framework, there are three requirements for an 'Or Else' to exist and to be socially embedded: transformation of the Deontic into an Aim, monitoring, and collective design. The first imperative is the presence of another rule or norm that changes the assigned Deontic to an Aim under the conditions that an actor fails to follow the rule. Sanctions and consequences presented in an 'Or Else' parameter are often

[14] See Appendix 2 : List and frequency of attributes

forbidden in most of conditions; for instance, incarcerating a citizen or imposing a fine is not usually allowed.

Thus, there should exist a prescription, a norm or a rule, which permits or requires the application of sanctions if someone does not comply with the rules (Ostrom 2005). This condition is met in the REA. In this case, the statements are found in Chapter 5 of the regulation, under the sections of pecuniary and legal sanctions. These statements were not coded in this study. However, they followed Ostrom's (2005) suggested structure by having the application of sanctions as an Aim under the condition actors do not comply with the rules of the REA.

Moreover, the REA contains a statement that assigns the responsibility to a monitoring agency in charge of enforcing the rules. This characteristic meets the second imperative of the 'Or Else' parameter. According to Ostrom (2005), at least one institutional statement must refer to the constraints and opportunities that actors face when monitoring the prescription. This implies that actors should only report non-conformance to someone responsible for sanctioning (*idem*). In this case, it is the Ministry of Sustainable Development, Environment and the Fight against Climate Change that is officially responsible of monitoring and reporting. According to article 55 of the regulation, "[t]he Minister shall […] report to the Government on the implementation of this Regulation, in particular on the necessity of changing the manure management standards based on current scientific and technical knowledge."

Moreover, Schluter and Theesfeld (2010) add to Ostrom's grammar, claiming that the required statement must also include the rights and duties of the monitoring agency. In our case, the statement only mentions the reporting duty of the Ministry. Furthermore, this regulation is part of the *Environment Quality Act*. In this act, the functions of the Ministry are well defined. Chapter I, Division II of the Act contains the duties and responsibilities of the Ministry of Sustainable Development as shown in Box 6.

Chapter I , Division II

2.The Minister may:

(a) coordinate research carried out by Government departments and bodies on the problems of the quality of the environment;

(b) (paragraph repealed);

(c) prepare plans and programs for the conservation, protection and management of the environment and emergency plans to fight any form of contamination or destruction of the environment and, with the authorization of the Government, see to the carrying out of those plans and programs;

(d) grant, on the conditions determined by regulation of the Government, loans or subsidies to bodies or individuals to promote the training of experts in the fields contemplated by this Act;

2.0.1. The Minister shall transmit to La Financière agricole du Québec any information, including personal information, enabling it to ascertain compliance with this Act and the regulations thereunder as provided in the last paragraph of section 19 of the Act respecting La Financière agricole du Québec (chapter L-0.1).

2.1. It shall be the responsibility of the Minister to elaborate and propose to the Government a protection policy for lakeshores, riverbanks, littoral zones and floodplains, to implement such policy and to coordinate its application.

Box 6 : Duties of the Ministry on environmental monitoring and management in Chapter I of the *Environment Quality Act*

So far, the rules contained in the regulation comply with the first two conditions of the 'Or Else' parameter. It is important to consider that even though sanctions are backed by other rules and a monitoring agency is assigned, these two conditions do not completely guarantee either the compliance with the institutions or the legitimate enforcement of the rules. The third and last condition for the effectiveness of the 'Or Else' parameter is that it must be collectively designed in an arena useful for discussing, prescribing, and arranging the enforcement of rules. Thus, the consequences stated in the 'Or Else' should be the result of collective action (Ostrom 2005). According to the author, a collective decision must have been made in a 'relevant collective-choice arena' to define the sanctions or consequences when not complying with a rule (Ostrom 2005). This last condition remains an important criterion for legitimizing rules and differentiates the rules in form from the rules in use.

The legitimacy of rules

In this section, we will argue that the rules found in the REA do not comply with the third and last 'Or Else' condition, and that the government only instituted participatory measures to discuss the pollution issues that the regulation aimed to reduce. Moreover, participation was constrained to a single consultation, weakening the collective decision-making process meant to design the norms and rules included in the legislation, as well as the derived sanctions. Limited participation perpetuates the distance between actors and the institution (Ostrom 2005). Moreover, as the third condition of the 'Or Else' parameter is not met, the rules of the REA can only by classified as norms, loosing its regulative character, and reducing the effectiveness of the regulation to influence behaviour.

As mentioned in the theoretical and methodological frameworks of this research, institutions have the capacity to control and constrain behaviour. In order to influence behaviour, institutions require social acceptability and credibility. These characteristics belong to the domain of legitimacy (Scott 2008). Furthermore, in order to legitimize institutions, the regulative and normative aspects of institutions should not be in conflict (*Idem*). On the one hand, the regulatory aspect of institutions accents on the conformity to rule, and legitimate actors and organizations are those that behave according to legal requirements (*Idem*). On the other hand,

the normative aspect of institutions proposes a socially constructed base for legitimacy, built on social obligations that are governed by morality (*Idem*). Actions are deemed legitimate if they are motivated by social rewards or sanctions. In other words, institutions can also be found to be legitimate because they are part of a common social understanding.

Ostrom (2005) relates the regulative to the normative aspect of legitimacy in the third condition of the 'Or Else' parameter by stating that "sanctions need to be the result of collective actions"[15]. It is required to differentiate the type of collective action processes that are required in crafting institutional statements leading to a more nuanced grammar and a better differentiation between rules and norms (Schluter and Theesfeld 2010). This last observation brings into question what makes an adequate collective action process to legitimize rules in form, and suggests that analyzing legitimacy could provide a useful extension the Grammar of Institutions.

There are various definitions of collective action. The three main important components are: (1) that a group of people is involved, (2) that actors share common interests, (3) that common and voluntary actions are organized to pursue these shared interests (Vanni 2014, Ostrom 2000). Furthermore, in order to promote collective action, participatory and democratic methods are used to craft policy and institutions. According to Carr (2015), management strategies decided upon democratic and accessible processes, including a fully representative group of participants, might be considered legitimate and fair. Thus, a process of collective action and participation might lead to a common understanding of institutions and to the internalization of rules, combining the regulative and the normative aspects of legitimacy. In the following section, we will discuss how participation was brought into the design of the institutions found in the *REA*, and assess whether the regulative and normative bases of legitimacy are met.

[15] Ostrom, Elinor. 2005. *Understanding Institutional Diversity*. Princeton: Princeton University Press. Page 50.

Participation and the design of institutions

Gauthier *et al*. (2011) recognize the importance of public participation to ensure an open, democratic and transparent decision-making process. Public participation increases population representativeness and is useful to identify and resolve conflicts (Gauthier *et al*. 2011). Moreover, intervention based on local knowledge and experience is more likely to be relevant, sustainable and legitimate (Cooke and Kothari 2001).

One must bear in mind that the agency that proposed the REA is the Ministry of Sustainable Development, Environment and the Fight against Climate Change. Moreover, as stated by Quebec's National Assembly, regulations are adopted by the government of Quebec, in a National Assembly session, and should be approved by *le Conseil du Trésor*, a Minister or an organization appointed by the Ministry (Assemblée Nationale du Québec 2015).

The usual process to propose a Bill includes a public consultation conducted by a parliamentary committee mandated by Quebec's National Assembly. This committee seeks input from concerned individuals and organizations before the Bill is introduced in the National Assembly (Assemblée Nationale du Québec 2015). However, parliamentary committees are rarely created when it comes to regulations (*Idem*). It is worth noting that regulations have become the dominant form of legislation, closely governing our social and economic lives. This type of delegated legislation often affects the individual and her rights in a more direct way than the law itself. Nevertheless, except in the case of municipalities and school boards, regulations are elaborated and adopted without public discussion since there are no consultations (*Idem*).

No evidence was found on a parliamentary committee or public consultation mandate with regards to the preparation and adoption of the REA. However, there was a consultation process on the development of hog farming in Quebec during the time the regulation came into effect. This consultation was conducted by the *Bureau d'audience publique sur l'environnement* (BAPE). The BAPE was established in 1978 under the Environmental Quality Act and its role is to inform and consult the public on environmental issues and concerns. BAPE reports to the minister of Sustainable Development, Environment and the Fight against Climate Change, who assigns its terms of reference. Its members are appointed by the government and

depending on the issue under investigation, they might be requested to conduct environmental impact assessments and reviews involving public participation (Boutin 2006).

BAPE hearings have two objectives. The first is to inform the public and the commission about the projects, and the second focuses on gathering public opinion. To fulfill the latter goal, any citizen may submit a brief or orally express their opinions concerning the mandate of the hearing (Boutin 2006). The BAPE commission then drafts a report containing an analysis of the opinions expressed, and summits it to the Ministry. The Ministry then has 60 days to make the report public. Moreover, the Minister makes his or her recommendations to the Cabinet in light of the BAPE's report and the environmental analysis prepared by the Ministry. The Cabinet is responsible for the final decision concerning the project or issue under consultation (*Idem*). As shown, the BAPE is not invested with a decisional power, but only a mandate of public consultation, informing without constraining governmental decisions.

From September 2002 through September 2003, the BAPE conducted an investigation and public hearing on the sustainable development of hog farming in Quebec. The commission had the following mandate (Boutin 2006):

- to evaluate the strengths and weaknesses of hog production models in Quebec;
- to draft a framework for sustainable hog farming;
- to propose one or more industry models capable of ensuring harmonious relationships and of protecting the environment.

The BAPE held a total of 132 public sessions, received almost 400 briefs from citizens and organizations, bringing together 9100 citizens and 260 experts (BAPE 2003). The commission briefed the Ministry on the presence of several socio-ecological conflicts concerning the development of hog farming in Quebec, and the presence of diffuse pollution coming from this animal production in most agricultural sectors of the province. To include the principles of sustainable development in hog production, the commission proposed a development framework as well as actions by formulating 14 findings, 54 notices and 58 recommendations.

Among its main recommendations, the commission suggested changing the decision-making framework concerning hog production in order to resolve the social tensions that arose in rural areas and avoid future social crises (BAPE 2003). Two measures were suggested to deal with the socio-ecological conflict. First, if a pig farm project is not subject to an evaluation procedure and an environmental impact assessment under the condition of studied legislation and in the Environmental Quality Act, the Commission recommended that the project still be subject to a social and environmental impact assessment, and that it involve public participation. The Commission suggested that this evaluation procedure apply to all projects that rely on an authorization certificate. As a second measure, the commission recommended that the provincial government allow the Regional Municipal County play a more important role in the development and planning of agricultural activities in their territory.

According to Gauthier *et al*. (2011) the recommendations of the consultation remained informative and did not have further repercussions on the framing of the institutions. Poirier (2010) shares this analysis when claiming that expected institutional changes are ignored, as was the case during the reforms proposed by the Agricultural Bill of 2004. The bill ignored the majority of the BAPE recommendations and various governmental commitments proposed in the action plan (*Idem*).

Moreover, Baril (2006) outlines several issues with BAPE consultations. In his book, the author reminds the presence of severe environmental issues after 30 years of environmental consultation and evaluation of the Bureau. For the author, public consultation and participation are brought in too late in the evaluation and policy-making process. Furthermore, participants frequently do not have access to all the relevant information during the audiences (*Idem)*. As the consultations are merely informative, citizens do not feel empowered and perceive the process as being a "waste of time" (*Idem*).

To sum up, we assessed the process of design and consultation of the REA and found that it was not the result of collective action. We uncovered that a single actor assumes the role of proposing and deciding the content of the institutions. Moreover, the BAPE's consultation process is not a decision-making process. The BAPE does not have decisional power and only informs the

government on the concerns of the actors without granting that recommendation will be taken into account in policy and institutional changes. We can therefore conclude that the sanctions of the REA do not follow all three conditions for the 'Or Else' parameter.

As showed throughout this case study, even if consultation and participation are considered important elements towards achieving sustainable policies, we recognize the limitations to participation tools and methods. According to Cooke and Kothari (2001), participation as a tool to build consensus under-theorizes existent power relations, and is therefore blind to unequal power distribution among participants Sometimes, consensus building is used by powerful groups to give the impression that they are sharing power through a decision-making process, while actually ensuring that the decisions fulfill their vested interests (Cooke and Kothari 2001).

We need to consider that in any participatory process, consensus might appear impossible to achievable due to the absence of a common interest among stakeholders (Carr 2015). In these cases, participatory approaches, rather than imposing a common vision, should "focus on facilitating negotiation and identifying appropriate penalties and incentives rather than enabling deliberation" [16] . Moreover, Côté and Gagnon (2005) show that participatory mechanisms contribute to the application of norms favouring the self-censorship of participants. The authors agree that there is a disconnect between participation theory and practice.

According to Baril (2006), consultation on environmental issues in Quebec requires moving beyond an administrative formality and to embracing a participative apparatus that truly influences policy and institutions. As shown in this case, participation does not enhance collective action, resulting in command and control policies and institutions.

The regulation under study is an example of a command and control (C&C) measure because it relies on coercion to influence behaviour. C&C is a regulatory approach built on the assumption that producers and consumers would not take action to reduce environmental degradation without coercion measures (Cole and Grossman 1999). In this framework, the government

[16] Carr, Gemma. 2015. "Stakeholder and Public Participation in River Basin Management—an Introduction." *Wiley Interdisciplinary Reviews: Water* 2 (4): 398.

"commands" pollution reductions (e.g. by setting emissions standards and regulations) and "controls" how these reductions are achieved (e.g. through sanctioning) (*Idem*). Through a positivist lens, a problem is identified. Is then developed and implemented a solution, which will be direct, feasible and effective over the relevant spatial and temporal scales, to control the problem (Holling and Meffe 1996).

Moreover, C&C measures assume ecological processes are linear and well defined, and follow cause-effect dynamics. However, Holling and Meffe (1996) show that applying C&C measures to complex ecosystems rarely leads to the expected outcome. Instead, there is a reduction in the range of variation of the ecological system, weakening the resilience of ecosystems (Holling and Meffe 1996). Furthermore, C&C measures might exhibit other issues such as those described by Dietz *et al*. (2003). These authors show that C&C institutions heavily rely on the government's will, and the effectiveness of the institutions depends mainly on sufficient governmental resources to monitor and enforce the institutions.

Overall, the REA and its sanctions are the result of C&C measures since the participatory processes were insufficient, leading to solutions and sanctions emanating strictly from the Ministry. Moreover, the consultative role of the BAPE is insufficient to channel collective action. By not meeting the third 'Or Else' parameter, the studied institutions fail to coordinate the regulative and the normative aspects of institutions. The normative role of the institutions is weakened as the actions and sanctions are not internalized by means of collective actions. Finally, the regulative role of institutions only stems from the coercive elements of the regulation, while its legitimacy arises mainly from its legal basis.

Norms instead of rules

The fact that the REA does not comply with the last condition of the 'Or Else' parameter diminishes the chances that the institutions will be deemed legitimate, normalized and socially embedded. Furthermore, if institutions are typified only based on their grammar, an institution that does not contain an 'Or Else' parameter, but exhibits all other grammatical elements, should

be classified as a norm. Henceforth, the 109 institutional statements initially classified as rules should now be typified as norms.

Based on this observation, the regulative feature of the REA is brought into question, as the vast majority of institutions contained in the regulation will not have a complete grammar, therefore loosing their effectiveness in influencing agricultural behaviour. Additionally, the limited collective action when crafting and consulting in view of the REA leads us to question the normative aspect of the institutions.

This observation is at odds with our preliminary results and brings to light some of the challenges in using the grammar of institutions (GoI) classification as a tool to determine the role and characteristic of institutions. As presented in the methodological review, it is difficult to draw the line between various institutions due to the complexity of their application, the actors' interpretation, and the effects of the 'Or Else' and Delta parameters. As shown, combining the results of the GoI framework with the institutional context and the characteristics of the 'Or Else' parameters might bring to the conclusion that the REA is inefficient because of its incomplete grammar and the fact that it lacks sufficient legitimacy.

However, the REA is a valid C&C measure, since it is part of Quebec's legal system. The enforcement of penal and pecuniary sanctions is evidenced by the 95 pecuniary sanctions administered by the Ministry of Sustainable Development, Environment and the Fight against Climate Change between November 7th 2012 and November 3rd 2014. During, these two years, according to the Ministry's records, pecuniary sanctions imposed were between $500 and $10,000 per producer (Government of Quebec 2015). It is important to mention that key informants during the exploratory interviews claimed that the enforcement and monitoring of the REA remained an issue. Thus, one could further question whether the monitoring and sanctioning efforts are sufficient to induce the desired outcomes, or whether these coercive elements are the only approach to ensure compliance with the regulation.

A weakness of C&C institutions rests on the fact that this kind of institutions relies solely on the will and efforts of the appointed authority. In this case, a single and centralized agent, the

Ministry, does the enforcement and other actors, such as farmers, community members, or watershed management organizations, are not involved in the enforcement of the institutions. As suggested by Schulter and Theesfeld (2010), monitoring can be accomplished in different ways, by the actors themselves (internal monitoring), by the community (social monitoring) or by formally assigning actors such as the government.

Moreover, it has been showed that internal monitoring might be more effective for the enforcement and application of certain institutions, *et al*. might work better using social monitoring or informal assigned monitors (Schluter and Theesfeld 2010). We need to consider that in order for the institutions to have internal or social monitoring, there needs to be a legitimization process so institutions stem from a common social understanding, therefore playing a central normative role.

So far, we have suggested that the compliance with the REA relies more heavily on the bureaucratic and coercive aspects of the design, application and enforcement than on the internal and socially rooted features of the institutions. Indeed, the REA can be considered as an example of a bureaucratic institution as defined by Cleaver (2002) as "those formalised arrangements based on explicit organisational structures, contracts and legal rights, often introduced by governments or development agencies"[17]. On the contrary, socially embedded institutions refer to "those based on culture, social organisation and daily practice[18]" Moreover, fixed and bureaucratic institutions are likely to fail to influence behaviour as they place too much emphasis on the current state of governmental knowledge, and are less designed to allow institutional adaptation due to unexpected shifts in biophysical and social systems (Holling and Meffe 1996).

[17] Cleaver, Frances. 2002. "Reinventing Institutions: Bricolage and the Social Embeddedness of Natural Resource Management." *The European Journal of Development Research* 14 (2): 13.
[18] *Idem*.

Conclusion

The goals of this thesis were to study the role of agricultural institutions influencing hog farmers' environmental compliance in the Missisquoi Bay by answering to the following question: What has been the role of agro-environmental institutions in encouraging hog farmers' environmental compliace in the Missisquoi Bay over the past 30 years? Moreover, we reviewed the agro-environmental and institutional history of the region and characterized the *Réglement des exploitations agricoles* (REA) based on the Grammar of Institution framework.

The results of the classification and characterization of the REA showed the presence of a complete grammar in the majority of statements found (84.5%). However, there were parts of the institutional statements that remained unclear and could induce difficulties in their interpretation and application. One of the issues is the absence of Conditions in 46 of the 129 statements. Moreover, there were 80 statements, representing 62% of the total statements, with implicit Attributes, and 65 statements (50.4%) referring to implicit-object Attributes. This lack of clarity hampers the application of the actions prescribed and the sanctions. Even if the grammar presents these 'fuzzy' aspects, the presence of all grammatical elements in the vast majority of institutional statements suggested a robust regulative role.

Moreover, the analysis of the conditions for the presence of sanctions ('Or Else' parameter) led to different conclusions. The process of designating institutions failed to follow one the three conditions established by Ostrom (2005). Indeed, according to the author, rules' punitive measures must be the result of a collective action process. As shown by the analysis of its legislative process, the content of the REA was not the result of collective action. On the contrary, the regulation is a command and control (C&C) measure.

There were participatory measures in place only to discuss the impact of hog farming in Quebec and the sustainability of the hog industry. However, participation was reduced to consultation without collective decision-making on the norms and rules to overcome the ecological problem, or on the sanctions for not complying with the agro-environmental regulation. The fact that the third condition of the 'Or Else' parameter is not met diminishes the likelihood of institutions to

be socially embedded and considered as social obligations, bringing into question the normative role of the REA and its legitimacy.

In light of the results of the analysis of the 'Or Else' parameter, the rules of the REA should be classified as norms, weakening the regulative role of the regulation and reducing its effectiveness. Finally, as a C&C measure, the design and the enforcement of the REA suggest that compliance relies mostly on the bureaucratic and coercive aspects of institutions rather than on a complete grammar on paper.

Based only on the analysis of the REA, we cannot generalize these conclusions to all the institutions influencing farmers' agro-environmental behaviour in the Missisquoi Bay. Indeed, further analysis of the grammar of formal institutions will be necessary to draw a complete picture of the role of policies and legislation and their effectiveness in influencing behaviour. However, an important conclusion of this study that could guide further institutional research is that legislation requires more than only the presence of complete grammar in order to play a strong regulative role. The analysis of the requirements for the legitimacy of sanctions and the institutional context is important to define rules. This type of analysis forces researchers to go beyond the legal boundaries and to scrutinize the institutional framework in which the legislation has been proposed and adopted.

This study only reviewed institutions affecting the Quebec jurisdiction of the Missisquoi Bay. As described, the Missiquoi Bay is a transboundary watershed shared between the province of Quebec and the State of Vermont showing an interaction of multiple institutional frameworks and governance structures at the national, provincial, state and regional level. It will be interesting to compare the grammar of institutions of the different agri-environmental policies and regulations in these two jurisdictions. Moreover, there is important research conducted comparing watershed governance frameworks of the Missisquoi Bay showing a fertile area for institutional research in the region (Koliba and Reinolds 2015, Tsai *et al* 2015).

Furthermore, institutions are not only contained in legislation and governmental policies; they are also shared and unwritten social conventions known as informal institutions. This study did not assess the role of informal institutions, yet it recognizes the existence of a plurality of institutions beyond the limits of legislation. Further research is necessary to identify and characterize informal institutions influencing agro-environmental farmers' behaviour. For instance, informal institutions could play a role complementary to the REA and could explain either the compliance or noncompliance with the regulation's requirements.

Moreover, it will be interesting to assess the interactions between legislation and social and individual norms. Other than the 'Or Else' parameter, there are additional punitive parameters such as 'internal' and 'external' Deltas that play a role in the monitoring of institutions. Delta parameters are considered to be factors relying more on emotions (Schluter and Theesfeld 2010). Considering these parameters stresses the fact that one cannot reduce actors' motivation to material self-interests; one needs to refer to the social context and socialization process in which they have evolved to understand the complexity of their behaviour (Schluter and Theesfeld 2010, Vatn 2005a). In other words, the evaluation of the interaction between rules and norms brings attention to the rules in use (truly lived by actors) and not only to the rules in form (in people's discourses) which describe a plurality of institutions (Schluter and Theesfeld 2010).

Another aspect that was not analyzed in this study is how actors needed exogenous information to comply with the legislation. For instance, farmers required training to be able to produce an agro-environmental fertilization plan or a phosphorous balance sheet. Requiring particular exogenous knowledge carries the risk of homogenizing agro-environmental practices on the long run. The homogenization of agricultural knowledge and production could affect the resilience of agricultural systems, diminishing the capacity for learning and adaptation at the farm level (Milestad and Darnhofer 2003).

Policy makers are faced with the challenge of proposing institutions that embrace plurality coordinating the regulative and normative roles of institutions to achieve desired socio-ecological outcome. Cleaver and Koning (2015) state that institutional plurality involves multi-stranded arrangements for natural resource management, reflecting the complexity of the

ecological system. The authors also suggest that institutions could induce a variety of intended and unintended outcomes, stressing that more than one institution is required to change and influence behaviour (*Idem*).

Moreover, in order to comply with the conditions for the existence and legitimacy of rules, processes other than C&C should be explored for the design of institutions. One of the processes proposed by Cleaver and Koning (2015) is institutional bricolage that implies the gathering and application of analogies of already-existing institutions that are not made on the basis of individual rational choice. According to the authors, institutional bricolage is a dynamic process that includes multiple levels of institutions' visibility and functioning (Cleaver and Koning 2015). Moreover, Ostrom (2008) proposes a polycentric system characterized by multiple decision centres at different scales (vertical institutional and horizontal geographical scales). Institutions arise as a product of competition between different ideas and interests, but with a shared understanding enforced culturally or institutionally (Aligica and Tarko 2012). This governance dynamism ensures that numerous individuals are involved in developing commonly acceptable institutions.

Another institutional process is the nested institutional framework focusing on coordination among institutions (Yashiro *et al*. 2013), and conceiving governance across geographical space according to the economic characteristics of rivalry and excludability of ecosystem's goods and services. In this process, emphasis is placed on the hierarchical imperative of governing natural resources by aligning property rights regimes with the characteristics of ecosystems (*Idem*). The cohesion of a nested institutional design rests on the existence of social capital that builds trusting relationships within and across institutional levels through adaptive and iterative cycles, re-evaluating and articulating mutual understanding over time (Kolinjivadi *et al*. 2014). Institutional bricolage, polycentrism and the nested institutional framework are institutional design frameworks that could allow the coordination of the regulative and normative aspect of institutions, reinforcing their legitimacy and addressing the complexity of ecological systems.

Bibliography

Aligica, Paul D., and Vlad Tarko. 2012. "Polycentricity: From Polanyi to Ostrom, and Beyond." *Governance* 25 (2): 237–62. doi:10.1111/j.1468-0491.2011.01550.x.

Assemblée Nationale du Québec. 2015. "Règlement - Assemblée Nationale Du Québec." *Règlement*. Accessed November 3th 2015. http://www.assnat.qc.ca/fr/patrimoine/lexique/reglement.html.

BAPE. 2003. *Consultation publique sur le développement durable de la production porcine au Québec rapport d'enquête et d'audience publique.* Québec: Bureau d'audiences publiques sur l'environnement. http://collections.banq.qc.ca/ark:/52327/20832.

Basurto, Xavier, Gordon Kingsley, Kelly McQueen, Mshadoni Smith, and Christopher M. Weible. 2009. "A Systematic Approach to Institutional Analysis: Applying Crawford and Ostrom's Grammar." *Political Research Quarterly*. doi:10.1177/1065912909334430.

Baril, Jean. 2006. *Le BAPE devant les citoyens: pour une évaluation environnementale au service du développement durable*. [Québec]: Presses de l'Université Laval.

Baril, Pierre, Yvon Maranda, and Julien Baudrand. 2005. "Integrated Watershed Management in Québec: A Participatory Approach Centred on Local Solidarity." In *Abstract for the International Meeting on the Implementation of the European Water Framework Directive-EURO INBO*. http://www.riob-info.org/IMG/pdf/Euro-RIOB_30sept2005_Baril_doc.pdf.

Beckmann, Volker, and Martina Padmanabhan, eds. 2009. *Institutions and Sustainability*. Dordrecht: Springer Netherlands. http://link.springer.com/10.1007/978-1-4020-9690-7.

Berryman, D. 2008. *État de l'écosystème aquatique du bassin versant de la rivière Yamaska - faits saillants 2004-2006*. Ministère du Développement durable, de l'Environnement et des Parcs, Direction du suivi de l'état de l'environnement.

Boutin, Denis. 2004. "Réconcilier le soutien à l'agriculture et la protection de l'environnement: Tendances et Perspectives." In *Conférence présentée dans le cadre du 67e Congrès de l'Ordre des Agronomes du Québec*. http://agrecon.mcgill.ca/courses/430/notejh/boutin.pdf.

———. 2006. "The Challenge of Reconciling Water and Agricultural Policies – The Role of Public Hearings." In *Water and Agriculture*, 453–68. Organisation for Economic Cooperation and Development. http://www.oecd-ilibrary.org/content/chapter/9789264022577-31-en.

Bowles, Samuel, and Herbert Gintis. 2004. "The Evolution of Strong Reciprocity: Cooperation in Heterogeneous Populations." *Theoretical Population Biology* 65 (1): 17–28. doi:10.1016/j.tpb.2003.07.001.

Bromley, Daniel W. 1991. *Environment and Economy: Property Rights and Public Policy*. Oxford, UK; Cambridge, USA: Blackwell.

Bromley, Daniel W. 2009. *Sufficient Reason: Volitional Pragmatism and the Meaning of Economic Institutions*. Princeton, NJ: Princeton University Press.

CAAAQ. 2007. "Agriculture and Agrifood: Choosing the Future. Consultation Document." Commission sur l'avenir de l'agriculture et de l'agroalimentaire québécois.

———. 2008. "Agriculture et agroalimentaire: assurer et bâtir l'avenir." Rapport final. Commission sur l'avenir de l'agriculture et de l'agroalimentaire québécois.

Carr, Gemma. 2015. "Stakeholder and Public Participation in River Basin Management—an Introduction." *Wiley Interdisciplinary Reviews: Water* 2 (4): 393–405. doi:10.1002/wat2.1086.

Cleaver, Frances. 2002. "Reinventing Institutions: Bricolage and the Social Embeddedness of Natural Resource Management." *The European Journal of Development Research* 14 (2): 11–30. doi:10.1080/714000425.

Cleaver, Frances Dalton, and Jessica de Koning. 2015. "Furthering Critical Institutionalism." *International Journal of the Commons* 9 (1): 1–18.

Cole, Daniel H., and Peter Z. Grossman. 1999. "When Is Command-and-Control Efficient-Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection." *Wis. L. Rev.*, 887-938.

Coleman, James S. 1987. "Norms as Social Capital." *Economic Imperialism*, 133–155.

Conservation Baie Missisquoi. 2003. "Développement durable de la production porcine dans le bassin versant de la baie Missisquoi." Mémoire présenté par Conservation Baie Missisquoi à la Commission sur le développement durable de la production porcine au Québec, Bureau des Audiences Publiques sur l'Environnement. Conservation Baie Missisquoi.

Cooke, Bill, and Uma Kothari. 2001. *Participation: The New Tyranny?*. Zed Books.

Côté, Gilles, and Christiane Gagnon. 2005. "Gouvernance Environnementale et Participation Citoyenne: Pratique Ou Utopie? Le Cas de L'implantation Du Mégaprojet Industriel Alcan (Alma)." *Nouvelles Pratiques Sociales* 18 (1): 57–72.

Crawford, Sue E. S., and Elinor Ostrom. 1995. "A Grammar of Institutions." *American Political Science Review* 89 (03): 582–600. doi:10.2307/2082975.

Dietz, Thomas, Elinor Ostrom, and Paul C. Stern. 2003. "The Struggle to Govern the Commons." *Science* 302 (5652): 1907–1912.

Douglas, Mary. 1986. *How Institutions Think*. New York: Syracuse University Press.

Eastman, M., A. Gollamudi, N. Stämpfli, C. A. Madramootoo, and A. Sarangi. 2010. "Comparative Evaluation of Phosphorus Losses from Subsurface and Naturally Drained Agricultural Fields in the Pike River Watershed of Quebec, Canada." *Agricultural Water Management* 97 (5): 596–604. doi:10.1016/j.agwat.2009.11.010.

Environment Quality Act. 2015. *CQLR c Q-2*. Accessed October 29, 2015. http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/Q_2/Q2_A.htm.

Fehr, Ernst, and Armin Falk. 2002. "Psychological Foundations of Incentives." *European Economic Review* 46 (4–5): 687–724. doi:10.1016/S0014-2921(01)00208-2.

Frantz, Christopher, Martin K. Purvis, Mariusz Nowostawski, and Bastin Tony Roy Savarimuthu. 2013. "nADICO: A Nested Grammar of Institutions." In *PRIMA 2013: Principles and Practice of Multi-Agent Systems*, edited by Guido Boella, Edith Elkind, Bastin Tony Roy Savarimuthu, Frank Dignum, and Martin K. Purvis, 429–36. Lecture Notes in Computer Science 8291. Springer Berlin Heidelberg. http://link.springer.com/chapter/10.1007/978-3-642-44927-7_31.

Gangbazo, G, and F Babin. 2000. "Pollution de l'eau des rivières dans les Bassins versants agricoles." *Vecteur Environnement* 33 (4): 47–57.

Gangbazo, G, D Cluis, and E Buon. 2003. "Comportement de l'azote dans une rivière drainant un bassin versant agricole excessivement fertilisé." *Vecteur Environnement* 36 (1): 58–67.

Gangbazo, Georges, Pierre Vallée, Jacques Roy, Richard Beaulieu, and Émilie Gagnon. 2006. *Contrôle de la pollution diffuse d'origine agricole : quelques réflexions basées sur la modélisation de scénarios de pratiques agricoles pour atteindre le critère du phosphore pour la prévention de l'eutrophisation dans la rivière aux Brochets*. Ministère du Développement durable, de l'Environnement et des Parcs, Direction des politiques de l'eau,. http://www.researchgate.net/publication/242754495_Contrle_de_la_pollution_diffuse_d'origine_agricole__quelques_r_flexions_bases_sur_la_modlisation_de_scnarios_de_pratiques_agricoles_pour_atteindre_le_critre_du_phosphore_pour_la_prven-_tion_de_l'eutrophisation_dans_la_rivire_aux_Brochets.

Gauthier, Mario, Louis Simard, and Jean-Philippe Waaub. 2011. "Public Participation in Strategic Environmental Assessment (SEA): Critical Review and the Quebec (Canada) Approach." *Environmental Impact Assessment Review* 31 (1): 48–60. doi:10.1016/j.eiar.2010.01.006.

Ghorbani, Amineh, Pieter Bots, Virginia Dignum, and Gerard Dijkema. 2012. "MAIA: A Framework for Developing Agent-Based Social Simulations." *Journal of Artificial Societies and Social Simulation* 16 (2): 9.

Gillespie, Jeffrey M., Kostas Karantininis, and Gary G. Storey. 1997. "The Expansion and Evolution of Vertical Coordination in the Quebec Hog Industry." *Review of*

Agricultural Economics 19 (2): 350–70.

Gilson, C. 1990. "Canadian Agricultural Policy 1967 to 1990: Issues, Review Process and Decisions." *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 38 (4): 541–548. doi:10.1111/j.1744-7976.1990.tb03487.x.

Gintis, Herbert. 2000. "Beyond Homo Economicus: Evidence from Experimental Economics." *Ecological Economics* 35 (3): 311–22. doi:10.1016/S0921-8009(00)00216-0.

Gintis, Herbert, Samuel Bowles, Robert Boyd, and Ernst Fehr. 2003. "Explaining Altruistic Behavior in Humans." *Evolution and Human Behavior* 24 (3): 153–72. doi:10.1016/S1090-5138(02)00157-5.

Government of Quebec. 2002. "Quebec Water Policy." Accessed October 10, 2015. http://www.mddelcc.gouv.qc.ca/eau/politique/index-en.htm.

———. 2015. "Registre des sanctions administratives pécuniaires." *Registres Publics*. Accessed November 3, 2015. http://www.registres.mddefp.gouv.qc.ca/sanctions/recherche.asp.

Government of Canada. 2015. "2006 Census of Agriculture: Farm Data and Farm Operator Data: Tables." Accessed November 3, 2015. http://www.statcan.gc.ca/pub/95-629-x/2007000/4123856-eng.htm.

Government of Canada. 2010. "Phosphorus at the Mouths of Lake Saint-Pierre Tributaries - Water - Environment Canada."Accessed October 15, 2015. https://www.ec.gc.ca/stl/default.asp?lang=En&n=11281F1B-1.

———. 2012. "Phosphorus and Nitrogen Levels in the St. Lawrence River - Environmental Indicators - Environment Canada." Accessed July 3, 2015. https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F7F5426B-1.

Government of Canada, Statistics Canada. 2007. "2006 Census of Agriculture." Accessed May 16, 2015. http://www.statcan.gc.ca/ca-ra2006/index- eng.htm.

———. 2014. "2011 Census of Agriculture." Accessed October 28, 2015. http://www.statcan.gc.ca/eng/ca2011/index.

———. 2015. "CANSIM - Search Results." Accessed August 26, 2015. http://www5.statcan.gc.ca/cansim/a03?C2DB=PRD&pattern=0040200..0040242&p2=50&retrLang=eng&CII_SuperBtn=Search&copyVersion=0&lang=eng&typeValue=1.

———. 2016. "Census of Agriculture." Accessed January 1, 2015. http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3438.

Gunjal, Kisan, and Benoit Legault. 1995. "Risk Preferences of Dairy and Hog Producer in Quebec." *Canadian Journal of Agricultural Economics/Revue Canadienne*

D'agroeconomie 43 (1): 23–35. doi:10.1111/j.1744-7976.1995.tb00105.x.

Healy, Hali. 2013. *Ecological Economics from the Ground up*. London; New York: Routledge.

Holling, C.s., and Gary K. Meffe. 1996. "Command and Control and the Pathology of Natural Resource Management." *Conservation Biology* 10 (2): 328–37. doi:10.1046/j.1523-1739.1996.10020328.x.

Holt, Richard PF, Steven Pressman, and Clive L. Spash. 2009. *Post Keynesian and Ecological Economics: Confronting Environmental Issues*. Edward Elgar Publishing. https://books.google.ca/books?hl=en&lr=&id=cSTmZLXH7GoC&oi=fnd&pg=PR1&dq=Vatn+post+keynesian&ots=3g7aaFNSmY&sig=cd0He1UmGG4tXmF3sJoIHZ6HkpQ.

Kapp, K. William. 1963. *The Social Costs of Business Enterprise*. Bombay: Asia Publishing House.

Karantininis, Kostas, Rémy Lambert, and Robert Saint-Louis. 1995. "Quebec Hog/pork Industry: Making New Moves or Simply Marking Time?" *American Journal of Agricultural Economics* 77 (5): 1207–12.

Keatley, Bronwyn E., Elena M. Bennett, Graham K. MacDonald, Zofia E. Taranu, and Irene Gregory-Eaves. 2011. "Land-Use Legacies Are Important Determinants of Lake Eutrophication in the Anthropocene." *PLoS ONE* 6 (1): e15913. doi:10.1371/journal.pone.0015913.

Koliba, Chris and Adam Zabzdyr Reynolds. 2015. "Isomorphic Properties of Network Governance: Comparing Two Watershed Governance Initiatives in the Lake Champlain Basin Using Institutional Network Analysis." *Complexity, Governance, and Networks* 1 (2): 99–118.

Kolinjivadi, Vijay, Jan Adamowski, and Nicolás Kosoy. 2014. "Recasting Payments for Ecosystem Services (PES) in Water Resource Management: A Novel Institutional Approach." *Ecosystem Services* 10 (December): 144–54. doi:10.1016/j.ecoser.2014.08.008.

Lehner, Bernhard, Colline Gombault, Bano Mehdi, Aubert Michaud, Isabelle Beaudin, Marie-France Sottile, Anne Blondlot, *et al*. 2014. *Increasing Agricultural Watershed Resilience to Climate Change and Land Use Change Using a Water Master Plan: A Case Study for the Missisquoi Bay*. http://www.ouranos.ca/media/publication/379_RapportLehner2013.pdf.

MAPAQ. 2014a. "Écoconditionnalité." *MAPAQ*. Accessed September 23,2015. http://www.mapaq.gouv.qc.ca/Fr/Productions/Agroenvironnement/mesuresappui/ecoconditionnalite/Pages/ecoconditionnalite.aspx.

———. 2014b. "Prime-Vert." Accessed September 20, 2015.

http://www.mapaq.gouv.qc.ca/fr/Productions/md/programmesliste/agroenvironnement/Pages /primevert.aspx.

Marshall, Gordon. 1998. *A Dictionary of Sociology*. 2nd ed. New York Oxford University Press.

Martínez Alier, Juan, and Klaus Schlüpmann. 1987. *Ecological economics: energy, environment, and society*. Oxford [Oxfordshire]; New York, NY, USA: Basil Blackwell.

McGinnis, Michael D. 2011. "An Introduction to IAD and the Language of the Ostrom Workshop: A Simple Guide to a Complex Framework." *Policy Studies Journal* 39 (1): 169–83. doi:10.1111/j.1541-0072.2010.00401.x.

McNeill, J. R. 2001. *Something New Under the Sun: An Environmental History of the Twentieth-Century World*. Reprint edition. W. W. Norton & Company.

MDDELCC. 2013. "La qualité de l'eau - quelle est la situation et quelles sont les Causes? - la qualité de l'eau des rivières et du fleuve Saint-Laurent." http://www.mddelcc.gouv.qc.ca /rapportsurleau/Etat-eau-ecosysteme-aquatique-qualite-eau-Quelle-situation_Rivieres- Fleuve.htm.

Milestad, Rebecka, and Ika Darnhofer. 2003. "Building Farm Resilience: The Prospects and Challenges of Organic Farming." *Journal of Sustainable Agriculture* 22 (3): 81–97. doi:10.1300/J064v22n03_09.

Mimeault, M. 2002. "Mise en valeur de la baie Missisquoi et du lac Champlain." *Agrosol* 13 (2): 92–96. Mimeault, Martin. 2010. "Suivi environnemental des eaux du bassin versant de la baie Missisquoi." presented at the Séance d'information de la Comission mixte internationale, Saint Armant, Québec, October 13.

NATO. 1988. "Glossary of Terms and Definitions." Standarization Agreement AAP-6 (R). Brussels: NATO.

OBVBM. 2011. "Le portrait du bassin versant de la baie Missisquoi." Document 3. Plan directeur de l'eau. Organisme de bassin versant de la baie Missisquoi.

Ostrom, Elinor. 1998. "A Behavioral Approach to the Rational Choice Theory of Collective Action: Presidential Address, American Political Science Association, 1997." *American Political Science Review* 92 (01): 1–22. doi:10.2307/2585925.

———. 2000. "Collective Action and the Evolution of Social Norms." *The Journal of Economic Perspectives* 14 (3): 137–58.

———. 2005. *Understanding Institutional Diversity*. Princeton: Princeton University Press.

———. 2008. "Institutions and the Environment." *Economic Affairs* 28 (3): 24–31. doi:10.1111/j.1468-0270.2008.00840.x.

Patoine, M., S. Hébert, and F. D'Auteuil-Potvin. 2012. "Water Quality Trends in the Last Decade for Ten Watersheds Dominated by Diffuse Pollution in Québec (Canada)." *Water Science and Technology: A Journal of the International Association on Water Pollution Research* 65 (6): 1095–1101. doi:10.2166/wst.2012.850.

Poirier, Luc. 2010. *De L'histoire et de La Politique Agricole Au Québec À L'émergence D'une Agriculture Soutenable*. Groupe de recherche en intérêt public (GRIP-UQAM). http://www.er.uqam.ca/nobel/grip/web/wp-content/uploads/2011/02/Poirier_Agriculture.pdf.

Rasouli, Sogol, Joann K. Whalen, and Chandra A. Madramootoo. 2014. "Review: Reducing Residual Soil Nitrogen Losses from Agroecosystems for Surface Water Protection in Quebec and Ontario, Canada: Best Management Practices, Policies and Perspectives." *Canadian Journal of Soil Science* 94 (2): 109–27. doi:10.4141/cjss2013-015.

Règlement sur les exploitations agricoles. 2015. *RLRQ c Q-2, r. 26*. Accessed April 30. http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=3&file=/Q_2/Q2R26.htm.

Schlüter, Achim, and Insa Theesfeld. 2010. "The Grammar of Institutions: The Challenge of Distinguishing between Strategies, Norms, and Rules." *Rationality and Society* 22 (4): 445–75. doi:10.1177/1043463110377299.

Scott, W. Richard. 2008. *Institutions and Organizations: Ideas and Interests*. Los Angeles: Sage Publications.

Shogren, Jason. 2006. "A Rule of One." *American Journal of Agricultural Economics* 88 (5): 1147–59.

Siddiki, Saba, Christopher M. Weible, Xavier Basurto, and John Calanni. 2011. "Dissecting Policy Designs: An Application of the Institutional Grammar Tool." *Policy Studies Journal* 39 (1): 79–103. doi:10.1111/j.1541-0072.2010.00397.x.

Singh, Supriya. 2013. "Local Governance and Environment Investments in Hiware Bazar." In *Ecological Economics from the Ground up*, by Hali Healy. London; New York:

Routledge. Smajgl, Alex, L. Izquierdo, and M. G. A. Huigen. 2010. "Rules, Knowledge and Complexity: How Agents Shape Their Institutional Environment." *Journal of Modelling and Simulation of Systems* 1 (2): 98–107.

Statistics Canada. 2014a. "2001 Census of Agriculture." http://www.statcan.gc.ca/ca-ra2001/first-premier/farmop-explagri/03livestock- betail-eng.htm.

———. 2014b. "The Changing Face of the Canadian Hog Industry." http://www.statcan.gc.ca/pub/96-325-x/2014001/article/14027- eng.htm.

Steinfeld, Henning, Pierre Gerber, T. Wassenaar, V. Castel, Mauricio Rosales, and C. de Haan. 2006. "Livestock's Long Shadow."

http://www.fao.org/docrep/010/a0701e/a0701e00.HTM.

Suchman, Mark C. 1995. “Managing Legitimacy: Strategic and Institutional Approaches.” *The Academy of Management Review* 20 (3): 571–610. doi:10.2307/258788.

Tamini, Lota D. 2009. “Agri-Environment Advisory Activities Effects on Best Management Practices Adoption.” MPRA Paper. August. https://mpra.ub.uni-muenchen.de/21955/.

Tsai, Yushiou, Asim Zia, Christopher Koliba, Gabriela Bucini, Justin Guilbert, and Brian Beckage. 2015. “An Interactive Land Use Transition Agent-Based Model (ILUTABM): Endogenizing Human-Environment Interactions in the Western Missisquoi Watershed.” *Land Use Policy* 49 (December): 161–76. doi:10.1016/j.landusepol.2015.07.008

Vanni, Francesco. 2014. “The Role of Collective Action.” In *Agriculture and Public Goods*, 21–37. Springer Netherlands. http://link.springer.com/chapter/10.1007/978-94-007-7457-5_2.

Vatn, Arild. 2005a. *Institutions and the Environment*. Edward Elgar.

———. 2005b. “Rationality, Institutions and Environmental Policy.” *Ecological Economics* 55 (2): 203–17. doi:10.1016/j.ecolecon.2004.12.001.

———. 2009a. “Combining Post Keynesian, Ecological and Institutional Economics Perspectives.” In *Post Keynesian and Ecological Economics, Cheltenham,* Edward Elgar, 114–38. Cheltenham. https://books.google.ca/books?hl=en&lr=&id=cSTmZLXH7GoC&oi=fnd&pg=PA114&dq=Vatn+post+keynesian&ots=3g7aaFNSmY&sig=xokPEPuyUz8RA8DpclWf0RVOw1Q.

———. 2009b. “Sustainability, Institutions and Behavior.” In *Institutions and Sustainability*, edited by Volker Beckmann Dr and Martina Padmanabhan Dr, 293–314. Dordrecht: Springer Netherlands. http://link.springer.com/chapter/10.1007 /978-1-4020-9690-7_14.

Veblen, Thorstein. 1998. “Why Is Economics Not an Evolutionary Science?” *Cambridge Journal of Economics*, 403–414.

Wilson, Sacoby M, Frank Howell, Steve Wing, and Mark Sobsey. 2002. “Environmental Injustice and the Mississippi Hog Industry.” *Environmental Health Perspectives* 110 (Suppl 2): 195–201.

Wing, Steve, Rachel Avery Horton, Stephen W. Marshall, Kendall Thu, Mansoureh Tajik, Leah Schinasi, and Susan S. Schiffman. 2008. “Air Pollution and Odor in Communities near Industrial Swine Operations.” *Environ Health Perspect* 116 (10): 1362–68.

Yashiro, Makiko, Anantha Duraiappah, and Nicolas Kosoy. 2013. “A Nested Institutional Approach for Managing Bundle Ecosystem Services: Experience from Managing Satoyama Landscapes in Japan.” In *Governing the Provision of Ecosystem Services*, edited by Roldan Muradian and Laura Rival, 191–205. Studies in Ecological Economics 4. Springer Netherlands. http://link.springer.com/chapter/10.1007/978-94-007-5176-7_10.

Appendix 1: Approved interview guideline

Open-ended questions

1) What are the five institutions i.e. laws, regulations, agreements (formal and informal) that you consider to have a strong influence on hog production in the past 60 years? List them according to their importance (1:high importance ; 5: lower importance)
    1.
    2.
    3.
    4.
    5.

    (Based on the previous answer, the researcher will present the main institutional statements (1-2) included in the institutions named by the interviewee)

    For each of the institutional statements presented, answer to the following questions

    1) What part of the statements directly influences your work? Which part of the statements directly influences hog producers work?

    2) How hog producers practices changed after the statement was adopted?

    3) What are the main obstacles to comply with this statement?

    4) What would you change in order to better comply with the statement?

    5) Have hog farmers developed a common strategy to comply with this statement?

    6) Did they require help/information to comply with this statement

Appendix 2: List and Frequency of Attributes of the REA

Attribute	Number of Statements	Attribute	Number of Statement
L'exploitant	14	L'exploitant de l'ouvrage de stockage qui reçoit des déjections animales	1
Chaque parti du bail ou entente	4	Celui qui stocke des déjections animales	1
L'exploitant d'un lieu d'épandage et, l'exploitant d'un lieu d'élevage	3	L'exploitant d'un lieu d'élevage existant le 15 juin 2002, qui a été établi conformément à la loi et dont la production annuelle de phosphore (P2O5) produite par le cheptel combinée à toute autre matière fertilisante utilisée, s'il y a lieu, est supérieure à la charge fertilisante de phosphore (P2O5) qui peut être épandue conformément à l'annexe	1
L'exploitant d'un lieu d'élevage, qui expédie les déjections animales qui y sont produites vers un établissement autorisé en vertu de la Loi sur la qualité de l'environnement (chapitre Q-2) pour les traiter et les transformer en produits utiles ou pour les éliminer,	2	La personne qui cultive la parcelle ou le terrain	1
Un agronome ou une autre personne visée au premier alinéa de l'article 24	2	L'exploitant d'un lieu d'élevage qui procède à l'épandage de déjections animales et à l'épandage d'autres matières fertilisantes	1
La personne qui cultive une parcelle sur laquelle l'épandage de matières fertilisantes est autorisé en vertu d'un plan agroenvironnemental de fertilisation	1	L'exploitant d'un lieu d'épandage qui procède à l'épandage de matières fertilisantes	1
Cette personne ainsi que le propriétaire de la parcelle	2	Le signataire (l'agronome)	1
Le propriétaire d'un lieu d'élevage ou d'un lieu d'épandage visé au paragraphe 1,2 ou 2.1 du deuxième alinéa de l'article 50.3	2	L'exploitant d'un lieu d'élevage, autre qu'un lieu d'élevage avec gestion sur fumier solide dont la production annuelle de phosphore (P2O5) est de 1 600 kg ou moins,	1
Le propriétaire d'un terrain ainsi que la personne à qui il en a cédé la garde, le contrôle ou l'usage	1	L'exploitant d'une parcelle cultivée visée par un plan agroenvironnemental	1

Attribute	Number of Statements	Attribute	Number of Statement
L’exploitant et le propriaitaire	1	Tout exploitant de lieu d'élevage visé par les paragraphes 1 et 3 du deuxième alinéa de l'article 22	1
L'exploitant qui, en vertu du deuxième alinéa de l'article 22, est tenu d'établir un plan agroenvironnemental de fertilisation	1	Tout exploitant de lieu d'épandage visé par le paragraphe 2 du deuxième alinéa de l'article 22	1
L'exploitant d'un lieu d'élevage ou d'un lieu d'épandage qui, conformément à l'article 9.1, procède au stockage en amas de fumier solide dans un champ cultivé	1	L’agronome	1
Celui qui exploite un ouvrage de stockage, ou qui en a la garde ou le soin,	1	L’ingenieur	1
Celui qui stocke des déjections animales dans un ouvrage de stockage	1	Le ministre	1
L'exploitant d'un lieu d'élevage qui expédie des déjections animales vers un ouvrage de stockage appartenant à un tiers	1	Tout exploitant de lieu d'élevage visé par les paragraphes 1 et 3 du deuxième alinéa de l'article 22	1