A thesis submitted to the Department of Environmental Sciences and Policy of

Central European University in part fulfilment of the

Degree of Master of Science

Towards an integration of power and practice into conceptual frameworks used in the governance of Social-Ecological Systems (SES):

Case study of Canadian oil sands

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July, 2015

Budapest

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ABSTRACT OF THESIS submitted by:

Akhshy THIAGARAJAN for the degree of Master of Science and entitled*: Towards an integration of power and practice into conceptual frameworks used in the governance of Social-Ecological Systems (SES): Case study of Canadian oil sands.*

Month and Year of submission: July, 2015.

Governance of Common Pool Resources (CPR) in Social-Ecological Systems (SES) requires a study into a complex cluster of interactions between law, policy, communities, individual actors and environmental outcomes. Conceptual frameworks like the Social-Ecological System (SES) framework and the Institutional Analysis and Development (IAD) framework developed by Elinor Ostrom help simplify this complexity and have been used extensively by scholars interested in institutional and governance related issues. The synthesis of the two was envisioned to provide a more comprehensive package for analysis. Consequently, the New Institutional Analysis in Social-Ecological Systems (NIASES) framework was proposed. The framework provides a blue print through which the top down IAD and the bottom up SES frameworks could be synthesized to produce a conceptual tool that harnesses the strengths of both.

However, one of the main drawbacks of the NIASES framework is the lack of inclusion of power of social actors over one another and the environment. Using the works of sociologist Pierre Bourdieu and the Canadian oil sands SES for illustration, this paper is an interdisciplinary theoretical attempt to introduce power within the frameworks. In doing so it proposes a modified version of SES and NIASES frameworks. The modifications are expected to improve their analytical and predictive abilities as well as to open up spaces for further interdisciplinary research in natural or ecological resource governance issues.

Keywords: natural resource governance, ecology, policy process research, policy studies, institutional analysis, conceptual frameworks, interdisciplinary theoretical frameworks.

Acknowledgements

For the opportunity, knowledge and skills to undertake this work I would like to thank the Department of Environmental Science and Policy at CEU. For his strategic guidance and unfettered encouragement through the entire process I would like to express my sincerest gratitude to my thesis supervisor Prof Laszlo Pinter. For their emotional and moral support and I am grateful to certain members of my cohort who wish they remain unnamed yet not unacknowledged. For her patience in dealing with the millions of crises that beleaguered my endeavors and for seeing me through those troubled waters I'd like to thank my department coordinator Irina Herczeg. For her assistance with academic writing this whole year I'd like to thank Eszter Timar who saved me from myself more than a few times this year. Finally, I'd like to thank Bernadett Kiss whose Hungarian lessons were as enjoyable as they were useful in getting me through the city that's been my home for the past year, köszönöm szépen.

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LIST OF ABBREVIATIONS

A – ACTORS

AESRD – ALBERTA ENVIRONMENT SUSTAINBLE RESOURCE DEPARTMENT

APD – ASYMMETRIC POWER DISTRIBUTION

BNA – BRITISH NORTH AMERICA ACT

CAA – CLEAN AIR AGENDA

CPR – COMMON POOL RESOURCE

ECO – RELATED ECOSYSTEMS

EPEA – ENVIRONMENTAL PROTECTION AND ENHANCEMENT ACT

IAD – INSTITUTIONAL ANALYSIS AND DEVELOPMENT

I – INTERACTIONS

IP – INTERNAL PRACTICES

LOC – LICENSE OF OCCUPATION

MMA – MINES AND MINERALS ACT

MSL – MINERAL SURFACE LEASE

O – OUTCOMES

P2PSES – POWER TO PRACTICE SOCIAL-ECOLOGICAL SYSTEM

P2PIASES – POWER TO PRACTICE INSTITUTIONAL ANALYSIS OF SOCIAL-ECOLOGICAL SYSTEMS

PA – PIPELINE AGREEMENT

PIAD – POLITICALIZED INSTITUTIONAL DEVELOPMENT AND ANALYSIS

PIASES – PROGRAM FOR THE INSTITUTIONAL ANALYSIS OF SOCIAL ECOLOGICAL SYSTEMS

PLA – PUBLIC LANDS ACT

RU – RESOURCE UNITS

RS – RESOURCE SYSTEMS

S – SOCIAL, ECONOMIC AND POLITICAL SYSTEMS.

SAGD – STEAM ASSISTED GRAVITY DRAINAGE

SES – SOCIAL-ECOLOGICAL SYSTEMS

T – TECHNOLOGY

1. Introduction

1.1 Background and rationale

Canada walked away from the Kyoto protocol in late 2011 effectively ending any international commitment it would have had to climate change by reducing its greenhouse gas (GHG) emissions, however it is still a part of the currently being negotiated Sustainable Development Goals. In the absence of Kyoto protocol's strategies to curb emissions, one of the tools through which Canada's carbon footprint and environmental externalities can be managed, is through better governance and development of its resources.

Governance as a term is a recent development that *"focuses less on states actions and more on a societies practices and activities"* (Bevir 2013). Within governance is a sub field that focuses on the institutional aspects of natural or ecological resource governance. However, design of, or research into, institutions delivering better governance involves a complex study into existing social-political systems and analysing various policies/arrangements that manage complex societal interactions over natural and ecological resources. Furthermore, these complexities are connected to each other through feedback systems.

Conceptual frameworks help simplify this complexity to aid policy makers in their quest to design better governance frameworks or researchers in their inquiries into such governance systems. Until now, those who studied the development of institutions to diagnose better management solutions used the Institutional Analysis and Development (IAD) framework (Polski and Ostrom 1999; Ostrom 2011, 2014). The IAD framework is a top down diagnostic and prescriptive tool to help policy makers or researchers design better governance systems. This framework competes with several others in the field of policy process research and is by

far the most relevant to studying institutional or policy developments in natural resource governance. In essence, it tells the researcher to look at the most important players, look at their strategies and interests and analyse those.

However, top down frameworks like the IAD miss the complexity of the social-ecological system over which these policies operate. In that by focusing on the top, the effects on the complex system at the bottom might be overlooked. This was recognized by Ostrom and colleagues who proposed the Social-Ecological System (SES) Framework (Ostrom 2007, 2009; Ostrom and Cox 2010; Cole *et al.* 2014). It allowed researchers to study a social-ecological system bottom up to be able to discover areas requiring better governance institutions. The SES framework is unique in its study of governance issues in the environmental context and is increasingly being applied to several conservation and resource governance programs world over (WWF 2013; Robson *et al.* 2014).

The existence of two frameworks while providing top down and bottom up research and design tools still lacked a holistic approach that combined the strengths of both. This was the challenge that Ostrom and colleagues realized in 2010 and began a program to synthesize the two frameworks into one coherent whole that would provide policy makers and researchers with the tools to address governance issues. Through this synthesized framework, policy makers and researchers could design and evaluate social-ecological system at the bottom and the governance structure at the top simultaneously to estimate/model the systemic environmental outcome. Last year a solution was proposed in the form of the New Institutional Analysis of Social-Ecological Systems (NIASES) framework (Cole *et al.* 2014).

Central to the NIASES and governance scholars in general are the institutional arrangements through which Common Pool Resources (CPR) are managed. In economics (one of fields through which the framework was developed) CPR is a type of resource characterized by high

costs of excluding people from using it and depletion of those resources through use. CPR's can be publicly owned, privately owned, not owned by anyone (true public goods) or communally owned.

Scholars like Ostrom, challenged the conventional wisdom, which believed that by altering the ownership status of land from public to private or *vice versa* better management outcomes could be produced. They found that trust, reciprocity and face-face communications between the different owners helped forge institutional arrangements that managed resources sustainably, transparently, equitably and efficiently. The economic nature of a CPR through its ownership also allows for its inclusion into those aspects of economic theory, focused on creating efficient financial regulatory systems or markets, one of the institutional aspects pursued by environmental economists.

A Social-Ecological System (SES) as the name suggests is a system comprising of CPRs and different governance systems, ownership patterns and institutional arrangements affecting the management of the resources resulting in systemic environmental outcomes.

Canada oil sands also known as tar sands are the common names for bituminous sands, which are a source of non-conventional oil in the world. In the of oil sands regions these CPRs could be the boreal forests in the region, the surface and underground water bodies, the air above, emissions into which feed into the global climate system and the biodiversity of the region. The SES comprises these CPR's which are mostly owned publicly but leased privately, in the hands of the Federal Government of Canada, the Provincial Government of Alberta, a few historical individual land owners "freeholds" and the oil companies (Hoberg and Phillips 2011). Today the First Nation communities are becoming increasingly important in these governance systems (Wright and White 2012).

Other than Canada, which by far has the largest recoverable reserves of this unconventional oil, the sands are also found in Venezuela, Kazakhstan and Russia (Yergin 2012). Some of the most important features of oil sands in Canada include, remoteness, challenging environmental conditions, where the winter temperatures can go low as -40 degree Celsius and the difficulty in extracting oil from oil sands given the fuel's particular characteristics. Not to be overlooked is that the oil sands reserves cover some 6 million hectares, a size of land comparable in size to countries like Scotland or Ireland (National Energy Board of Canada 2004). Some of these developments take place on treaty lands between 18 First Nations and 6 Metis settlements (comprising over 23000 people).

In a world increasingly dependent on oil, the near doubling of oil sands production over the last few years, from 1.3 to 1.7 million barrels per day between 2008 and 2015 and expectations of 4.3 million barrels per day in 2035 are likely to increase the environmental costs of such operations (International Energy Agency 2010). This has led to flashpoints between the companies, governments, environmentalists and citizens concerned about the health and safety issues arising out of such industries *(Hoberg and Phillips 2011; Gosselin et al.* 2010).

The development of Canadian oil sands is unlikely to slow down given the rising demand for affordable oil and energy services in the US (it's main and strategic importer) and Asia one of its potential markets and in doing so the industry will generate economic profit for Canada and jobs for its citizens (a politically desirable outcome). However, the environmental effects of such developments have at least one globally relevant outcome over and above the local issues of pollution, deforestation, health and safety concerns and violation of treaty rights.

This is because these resources are located in the high latitudes close to the Arctic Circle, where any development can have effects on the permafrost lying to the north of them. The permafrost is crucial to the heat balances in global environmental systems. These regions are also likely to

be disproportionately affected by changes in the global atmospheric and climactic systems specifically affecting the resilience of their infrastructure consequently the lives of the people living in the high latitudes (Anisimov *et al.* 2007). Management of resources is also important due to the lack of an international natural resource management framework and combined action among the Arctic Council countries (Young and Osherenko 1993).

This is relevant because 81% of the lands in which oil sands are found and 97% of the mineral resources are owned by the "Provincial Government of Alberta" and managed by several government institutions. The remaining 19% of the lands First Nations have the rights to use (but do not own) the land, the mineral rights are managed by the "Federal Government of Canada" through section 91 of the Constitution Act (1982) and other associated statutes. The provincial government leases lands or grant permits to companies under the Public Lands Act (Province of Alberta 2000c) to develop the oil sands resources. The "Federal Government of Canada" does the same through the Indian Oil and Gas Act (RSC 1985a), the Indian Land Agreements Act (RSC 1985b), Indian Land Act (RSC 1985c) and First Nations Oil and Gas and Moneys Management Act (RSC 1985d). Thus, the governance of the oil sands SES rests mostly with the provincial, federal governments and the respective permit and leaseholders which are oil developing companies.

Frameworks such as the SES, IAD and the NIASES help simply this historically conferred complex maze of ownership patterns, into devising institutional arrangement that either improve the sustainability, efficiency, inclusiveness, social equity and transparency of governance systems. They also help identify and study self-organizing systems, which are those institutions managing CPRs in the absence of government intervention. Another key strength of the SES framework is its ability to inform the "resilience paradigm" (Turner 2010; Walker *et al.* 2004). This paradigm is increasing in its significance in light of climate change

and the global efforts to prevent it. As discussed earlier the resilience of Canada's systems is relevant in light of climate change induced uncertainty.

The ultimate benefit of such frameworks to policy makers lies in their ability to prevent them from erroneously falling into the "panacea" trap (Ostrom 2007) which is the application of the same policy to qualitatively and contextually different problems in the management of CPR in SES.

However, both these frameworks do not explicitly include the power of the social actors as variables affecting the system. These charges were made against the frameworks, much before the attempts to synthesize the two frameworks took place. Several scholars in other fields of the social sciences such as political ecology, human geography, sociology and anthropology argued on the demerits of not including power and its effects on decision making within the SES or the IAD frameworks (Fabinyi *et al.* 2014; Clement 2012; Clement 2010; Epstein *et al.* 2014; Agrawal 2014).

While, there has been general recognition that power exists within social actors, much lesser work has taken place to explicate empirically or theoretically, how this power might affect the functioning of the frameworks. Specifically in answering all three following questions; what is the form of this power, how does it operate within the frameworks and how does it affect the environmental outcomes? Only one attempt to modify the IAD framework exists, namely the Politicized IAD (PIAD) by Clement (2010). No such work has been attempted for the SES framework. Given that the synthesizing of the IAD and SES in the form of the NIASES has taken place, it is now possible to attempt to introduce power within the NIASES in a theoretical manner as this paper does using the Canadian case for illustrating the concepts.

It is also felt that the very act of introducing power within these frameworks, irrespective of the particular choice of theories of powers, which are ubiquitous in some social sciences, would

necessitate a modification to the framework or the functional interactions between the components of such frameworks. Scholars in network science at the turn of the century were also particularly interested in this aspect (Skvoretz and Willer 1993).

A specific branch of thinking in the social sciences called practice theory is chosen for this work because they have been especially articulate in connecting the influence of power over time to the practice of individuals in this field of power. This power of one actor over another or of the field of power over an actor does not automatically connect it to the environmental outcome. This pathway must also be explicated within the frameworks this paper seeks to propose.

In summary, resource development in the northern latitudes has proximate impacts on global climate systems, which are likely to affect the resilience of regions such as Canada. Better governance of natural resources towards sustainable development is the need of the hour. To help design better governance systems or to help understand the institutional developments within existing governance systems in natural or ecological resource management conceptual framework such as the SES and NIASES are important. However, they suffer from a few drawbacks, specifically the lack of power of actors over each other and over their resources and connecting these to the environmental outcome. Overcoming these challenges and delivering a more comprehensive version of the NIASES is the main motivation for this paper.

1.2 Aims and approach

The central aim of the paper is to modify the NIASES to produce a product that draws on the analytical and mathematical strengths of the framework while being sensitive to the role of power and its effects on the decisions made by the agents within social-ecological systems.

Three considerations are kept in mind while modifying the frameworks to include power, firstly it must bridge the epistemic differences of the scholars criticizing the frameworks and those using it, secondly it must be able to conceptually connect power to the environmental outcome and thirdly, it must do so in a manner that maintains the structural and mathematical integrity of the framework while improving its analytical ability. To show the validity of the modified framework, a cursory application to the Canadian oil sands case is also undertaken.

The blue print put forward by Cole *et al.* (2014) essentially incorporates the SES within the IAD. Consequently, any attempt to include power within the NIASES must begin by introducing power within the SES framework. The NIASES is expected to provide a much better framework for policy makers and scholars to use in designing better governance systems through its focus on top down institutional analysis and bottom up social-ecological effects. A NIASES inclusive of power would provide a more comprehensive conceptual tool to study institutional developments in SES cases.

The introduction of power into the NIASES would make "deeper analysis" in SES cases (Ostrom 2011) which are either into factors affecting the structure of action situations or how outcomes from one action situation affect the next, a much simpler task. It is also likely to provide a platform for scholars from disciplines critical of the frameworks to converge in their research into institutional and governance issues in a SES. Disciplinary challenges have until now prevented the SES or NIASES from being sensitive to power. Overcoming this requires an inter-disciplinary approach such as the one envisioned in this paper.

The interdisciplinary approach the paper takes to modify the NIASES is through identifying ideas among practice theory in sociology specifically those which are a bridge between empiricist and critical realist scholars. This should alleviate the first concern elaborated above. The second concern is alleviated by conceptually identifying the mediating variable connecting

the decisions actors make within the frameworks to the systemic environmental outcome. The inclusion of power should not deter mathematical inclined researchers because the components and mathematical integrity of the SES or the NIASES are left untouched in the final product. A section is devoted to highlighting the mechanisms through which power might affect the mathematical nature of the framework. The modified NIASES framework also allows for empirically validating or verifying power's mathematical treatment. This would address the third concern highlighted above.

This paper is complex not in the least because it must juggle several epistemologically different ideas. As a result, the central ideas of the paper cannot be highlighted in the beginning without expanding on them first through the body of the text. Reference to the oil sands of Canada case helps put abstract ideas from the frameworks into empirical context. However, like the theoretical ideas that develop over time the narrative style of case study follows the expansion of the theoretical ideas. This translates into a request that the reader remain resolute until the very end of this work, to be able to grasp and appreciate or critique its contributions.

1.3 Objectives and Outline

In order to achieve the central aim of the paper following were the objectives pursued. They are preceded by the chapter titles of the paper to provide guidance on the outline of the paper.

Literature review

- Analyse and overview the SES and IAD frameworks, trace the mechanisms through which they were integrated into the NIASES and overview the synthesized framework.
- Review the strengths and weaknesses of the framework using the Canadian oil sands case to illustrate the weaknesses.

- Highlight the state of research that proposes the incorporation of or introduces power into these frameworks.

Interdisciplinary method and approach.

- To arrive at a methodologically relevant approach, overview practice theory, identify the works that would bridge the epistemic difference between scholars debating on power within the frameworks.
- Show how power and practice operate within a Social-Ecological System and use the Canadian oil sands case for illustrating it.

Integrating Bourdieu's practice theory into the Frameworks.

- Expand on practice theory if need be and incorporate elements into the SES framework to modify the SES. In doing so propose a modified SES framework in light of the findings from these works.
- Discuss how this conception of framework especially how power and practice are verifiable in cases like the Oil Sands of Canada and how power and practice operate in this field.
- Using the blue print provided by Cole *et al.* (2014) and modify the NIASES such that that the modified SES framework is incorporated into the IAD.

Results and discussion.

- Develop a normative aspect of the modified system, to show how future changes within the system can be analysed from within the proposed frameworks this paper develops.
- Contrast and compare the modified NIASES framework with the original frameworks namely the IAD, the SES and the NIASES framework. If any other attempts to modify

the frameworks exist compare them as well. Draw out the key differences between a frameworks modified using Bourdieu's ideas and those that do not.

- Discuss the mathematical implications if any of the revised framework.

1.4 Scope & limitations

The scope of this paper is limited to introducing power with the SES and using the blue print provided by Cole *et al.* (2014) to produce a version of NIASES that is inclusive of power. The limitations of this work are a result of challenges in integrating two epistemologically different disciplines within a restrictive timeframe. The paper is also limited by a cursory overview of the oil sands case through the use of publically available data.

By relying on open access data, some of the deeper implications that internal documents or insights that documents procured through right to information acts might have been provided have been left out of discussions. Interviewing experts from within the field was also seen as challenging since none of the works published on Canadian oil sands explicitly use modified variants of SES or IAD framework that factor in power. The relatively new NIASES has also not been applied to new areas in governance such as the oil sands.

2. Literature review

This section begins the task of unravelling the complexity that the frameworks are expected to simplify in issues related to governance. Given the particular order in which the frameworks were developed, section 2.1 overviews the IAD. In section 2.2 the SES is overviewed and analysed, elements from the Canadian oil sands case are brought in to complement the conceptual discussions on the frameworks. An overview of the critiques of these frameworks for their lack of inclusion of power and attempts to introduce power within them is undertaken in section 2.3. In section 2.4 the blue print used to create the NIASES is presented.

2.1 Institutional Analysis and Development (IAD) framework

Institutions could be an organization or a collective set of norms and rules of doing things. Institutions develop when actors interact in action arenas which comprises a set of action situations. Action arenas is a hypothetical space where the actors share the same meanings, they may compete, fight or collectively solve problems in this space. In an action arena, several situations exist and within these situations exist actors. Once these arenas, situations and actors have been identified, research proceeds to is to see how these actors interact.

Actors interact within a biophysical environment, referred as the "material conditions" in social and political spaces referred to as "attributes of community" using a set of "rules in use". Patterns of interaction develop which have outcomes and these outcomes can be evaluated along several criteria. While originally the "material conditions", "attributes of community" and "rules in use" were exogenous to the framework, the indirect feedback loops suggest they

might not always be so (Mcginnis and Ostrom 2010). The components of the Institutional Analysis and Development (IAD) framework are shown in Fig. 1.

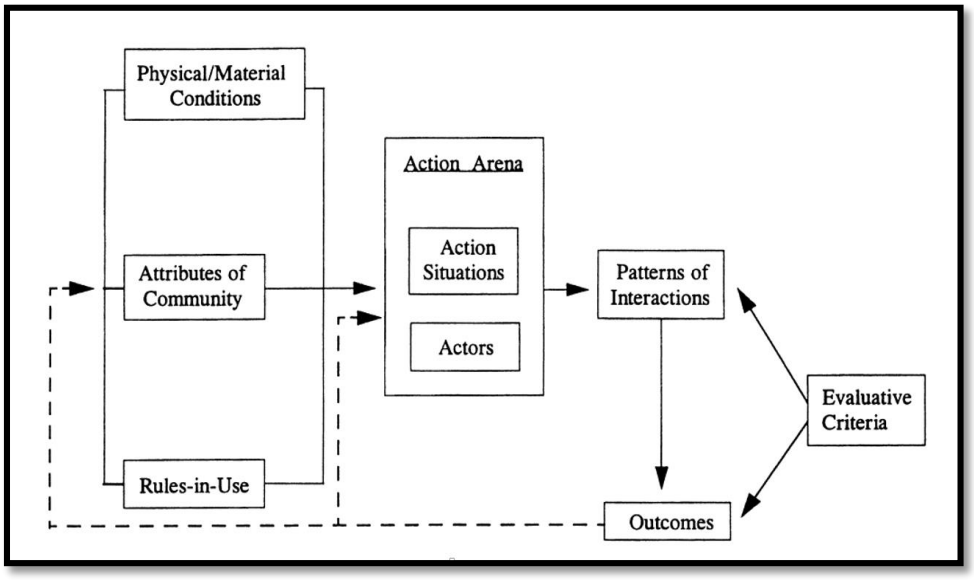

Figure 1: *Schematic representation of IAD. (Source: Ostrom 2014)*

Seven rules guide the interactions of actors, establishing an actor's positions and connecting these to the outcomes of the game. Fig. 2 schematically represents this**.**

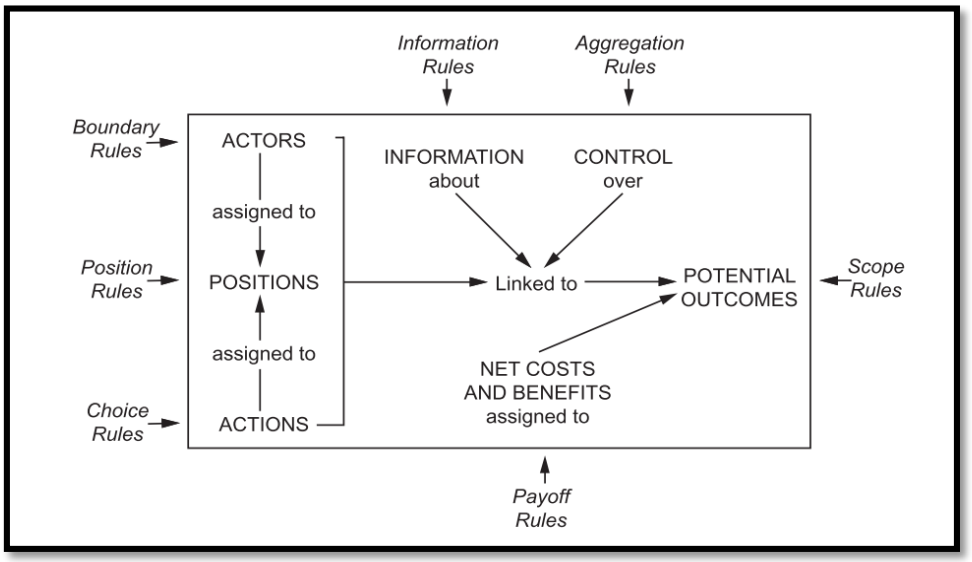

Figure 2: *Rules as exogenous variables directly affecting the action situation. (Source: Ostrom 2014).*

We see in Fig. 2 that the boundary rules affect the participants, the resources they possess weather they can play the game and how they may exit from the situation on arena. Position rules help the actor establish a position in the situation. Choice rules set the limit on the number of actions an actor can take. Scope rules limit the number of outcomes that can take place. Aggregation rules control the link between positions, choices and outcomes. Information rules control the information that are used to arrive at positions and how actors decide outcomes. Payoff rules govern the risks and rewards from each action. Put another way, scientific knowledge (information rules) presents the hierarchical set of actors (through boundary rules) with a number of choices (using choice rules) with certain limits (within the scope rules), with a matrix of costs and payoffs (payoff rules) such that their interactions using these (aggregation rules) produce outcomes.

Implicit within this scheme is that the outcome is a decision on some topic, the levels of analysis (discussed a little later) of the framework further narrow down the types of decisions that are made. It is unlikely to be always possible to decipher the positions of the actors in advance however the result of the game might allow for them to be inferred.

Power within this framework could be evaluated in two ways, the first was through a cluster of 4 variables about the actor (Ostrom 2010). These are:

“

1. *Resources in his possession*
2. *Valuation this actor assigns to the states of the world*
3. *The way actors acquire, process and retain knowledge and information*
4. *Processes through which actors select a particular course of action.* ”

The second method to infer power or organize actors in possession of it within such a framework are through the “rule in use”. For example, an actor with fewer boundaries, more

choices and more information could be more powerful than an actor with more boundaries, fewer choices and lesser information.

However, as mentioned earlier, the IAD was never applied exclusively to environmental cases, which is the reason the SES framework was developed. None the less, if the IAD is to be applied to environmental cases such that the outcomes were environmental, two leaps of logic have to be made with regards to inferring power using the methods discussed above. The first is that one actor's power over another is credibly going to result in a better environmental impact. This is not necessarily true, it will most likely result in a decision favouring the more powerful player. If the decision which is expected to benefit the environmental outcome is accepted by the inferior actor it will likely result in a better environmental outcome. If not then through passive resistance the environment might still degrade. The second assumption would be that actors are aware of each other's power in the game. This might not always be the case, for example, the use of strategies could hide this. Consequently, even with the IAD, a more comprehensive view of power is required, specifically one that connects it to environmental action.

The IAD can analyse action situations at four levels namely, operational, collective choice, constitutional or meta-constitutional action situations. At the operational level, actors combine to make rules affecting day-to-day operations. At the collective choice rules, they get together to decide on eligibility or ineligibility of an actor to perform certain action. At the constitutional level actors decide on the rule makers and enforcers. Finally, in the meta-constitutional level rules for making rules or institutions are discussed. It is logical that in each of these levels, different power positions are established due to different actors or situations. The issues of inferring power in these levels also suffers from the same problems highlighted above.

The level of analysis are nested such that rules at the top impinge on decisions of rules at the bottom, explicating this has been a challenge for institutional scholars (Ostrom 2010). However, power as construed in practice theory as will be shown in the remainder of the paper illuminates a different aspect of this nested nature.

The key areas that a researcher must focus on when using the IAD is to choose the right action arena, the right set of situations and identifying the actors, identifying the right set of rules and then evaluate the outcomes against the right set of criteria. Some examples of the criteria proposed by Ostrom are: 1) economic efficiency, 2) justice, 3) adaptability, resilience and robustness, 4) accountability and 5) conformance to general morality. These choices make the use of the IAD an art that needs to be developed, the science is inherent in the logical and economic consistency of the framework.

The strengths of the IAD framework lies in its ability to be used it in any type of institutional or democratic setting especially since an institution is both an organization and a collection of accepted rules. The other strength lies in its extensive use in the field of policy process research, which studies how policies come about in relation to a specific problem (Sabatier and Weible 2014).

Social-ecological systems (SES) posed a different type of problem to scholars working in the areas of natural resource management and ecology. The IAD was focused on the sociological aspects or action arenas in which institutional development was taking place. It did not factor in ecological parameters explicitly nor did it specify the pathways through which the environment could affect the situations themselves (Ostrom 2011). Consequently, Ostrom and colleagues proposed the SES framework.

2.2 Social-Ecological System (SES) framework

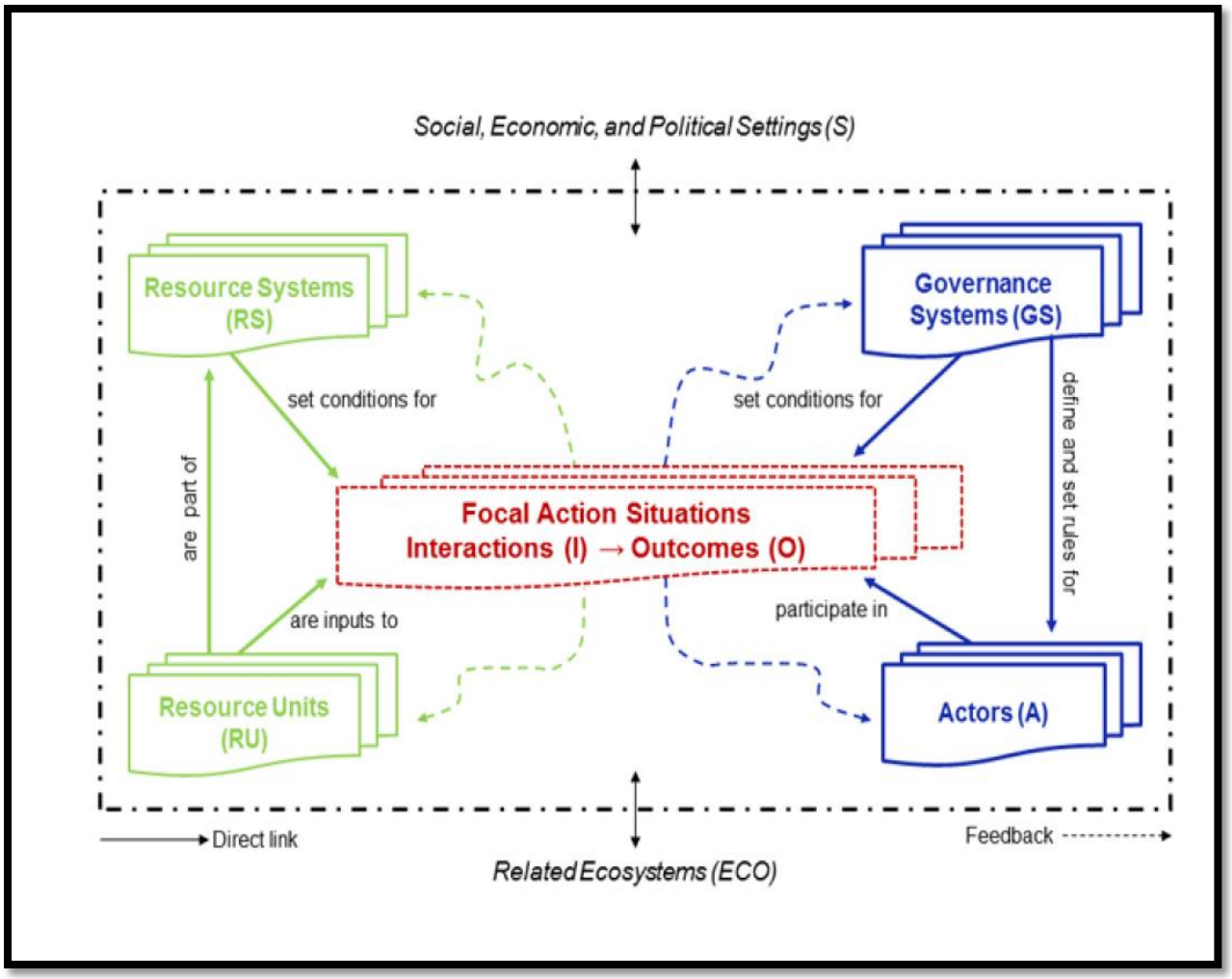

Figure 3: Eight core subsystems in the Social-Ecological-System. *(Source: McGinnis and Ostrom 2011)*

The SES framework shown above (McGinnis and Ostrom 2011) highlights eight core subsystems that interact to produce environmental outcomes. The interactions take place in focal-interactions, which are similar to the action situations found in the IAD. Within these subsystems, second order variables are also been identified, these are shown in Table 1.

Table 1: *Second Order Variables within the core subsystems that enable self-organization.* (McGinnis and Ostrom 2011)

Resource Systems (RS)	**Governance Systems (GS)**	**Activities and Processes:**
	GS1– Government organizations	
RS1– Sector (e.g., water, forests, pasture, fish)	GS2– Nongovernment organizations	I1– Harvesting
RS2– Clarity of system boundaries	GS3– Network structure	I2– Information sharing
RS3– Size of resource system	GS4– Property-rights systems	I3– Deliberation processes
RS4– Human-constructed facilities	GS5– Operational-choice rules	I4– Conflicts
RS5– Productivity of system	GS6– Collective-choice rules	I5– Investment activities
RS6– Equilibrium properties	GS7– Constitutional-choice rules	I6– Lobbying activities
RS7– Predictability of system dynamics	GS8– Monitoring and sanctioning rules	I7– Self-organizing activities
RS8– Storage characteristics		I8– Networking activities
RS9– Location	**Actors (A)**	I9– Monitoring activities
	A1– Number of relevant actors	I10– Evaluative activities
Resource Units (RU)	A2– Socioeconomic attributes	
RU1– Resource unit mobility	A3– History or past experiences	
RU2– Growth or replacement rate	A4– Location	
RU3– Interaction among resource units	A5– Leadership/entrepreneurship	
RU4– Economic value	A6– Norms (trust-reciprocity)/social capital	
RU5– Number of units	A7– Knowledge of SES/mental models	
RU6– Distinctive characteristics	A8– Importance of resource (dependence)	
RU7– Spatial and temporal distribution	A9– Technologies available	
Action Situations: Interactions (I) → Outcomes (O)		
Outcome Criteria:		
O1– Social performance measures	O2– Ecological performance measures	O3– Externalities to other SESs
(e.g., efficiency, equity, accountability, sustainability)	(e.g., overharvested, resilience, biodiversity, sustainability)	

The SES framework shows how the Actors (A), Governance systems (GS), Resource systems (RS) and Resource units (RU) interact in a focal interactions (I) within a socio-political-economic system (S) to produce outcomes (O) that are related to or affected by other ecosystems (ECO). Within each core subsystem are second order variables (Table 1) which interact and these interactions can help identify areas where governance systems could develop or prescribe how they must develop. The concepts and elements of the IAD borrow from the

same institutional paradigm that allow for the application of concepts from game theory or economics when analysing the framework.

It is immediately obvious that the SES framework is a much denser and more explicit extension of the IAD framework. The focal interactions are the same as the action situations in the IAD, there could be more than one such interaction at a given point in time. Governance systems are not just state led mechanisms but they are also mutually agreed upon norms of individual actors. This is reasonable given the dual meanings of institutions as being both organization and mutually negotiated mechanisms for interactions. Socio-political systems remain an all-encompassing aspect of the framework as do nearby ecosystems that have indirect effects on focal interactions. While the rules in use are not explicit in this case, as this framework was conceived in the Bloomington School of New Institutionalism they can be used within this framework.

In approaching the Canadian oil sands case in the remainder of the section, Asymmetric Power Distribution (APD) will be at the heart of discussions in such social-ecological systems. This APD will be functionally connected to policy in section 3 and then to the environmental outcome in the modified frameworks presented in section 4 of this paper. Power comes in two forms, power over the resources and power to legislate on issues regarding the development of the oil sands. Both of these are historically originated phenomena as is shown a little later. These discussions also take place at the constitutional and meta-constitutional levels because they have a very clear and non-linear effect on any analysis at lower collective choice or operational levels. As Cole (2014) remarks that law and constitutional matters cannot be easily omitted from any analysis into governance systems or self-governance frameworks.

In the introduction it was shown the Provincial Government of Alberta owned 81% of the land containing oil sands and 97% of the mineral resources while the Federal Government managed

land treaty lands with First Nations along with a few historical individual landholders called "freehold". This complex system of land holding came about in 1869 through the surrender of the charter held by Hudson's Bay Company over Rupert's land (which included treaty lands with First Nations). Furthermore, the British Parliament through the British North America Act (BNA) of 1867 had already conferred powers to the federal government of Canada which was to hold domain over the provinces and in doing so laid the basis for Canada's constitution. As a result, the land was held by the Federal Government. However, the provinces were able to secure their interests through various negotiations and amendments to this Act until 1982. When it was formally ratified by Queen Elizabeth to create the Constitution Act 1982. Sections 92A and 125 of the Act granted Alberta province exclusive rights over its natural resources while preventing the federal government from taxing provincial resources (Gibbins 1992).

The neat allocation of resource systems, resource units, governance systems and actors in the SES belies a certain order to the focal interactions, which are unlikely to be observed in the real world. Continuing the historical rights over lands, discussed in the introduction, Fig. 4 shows the divisions of Alberta's oil sands into three specific regions, these are Athabasca (the largest and to the right), Cold Creek (left top) and Peace River (left bottom) denoted by brown.

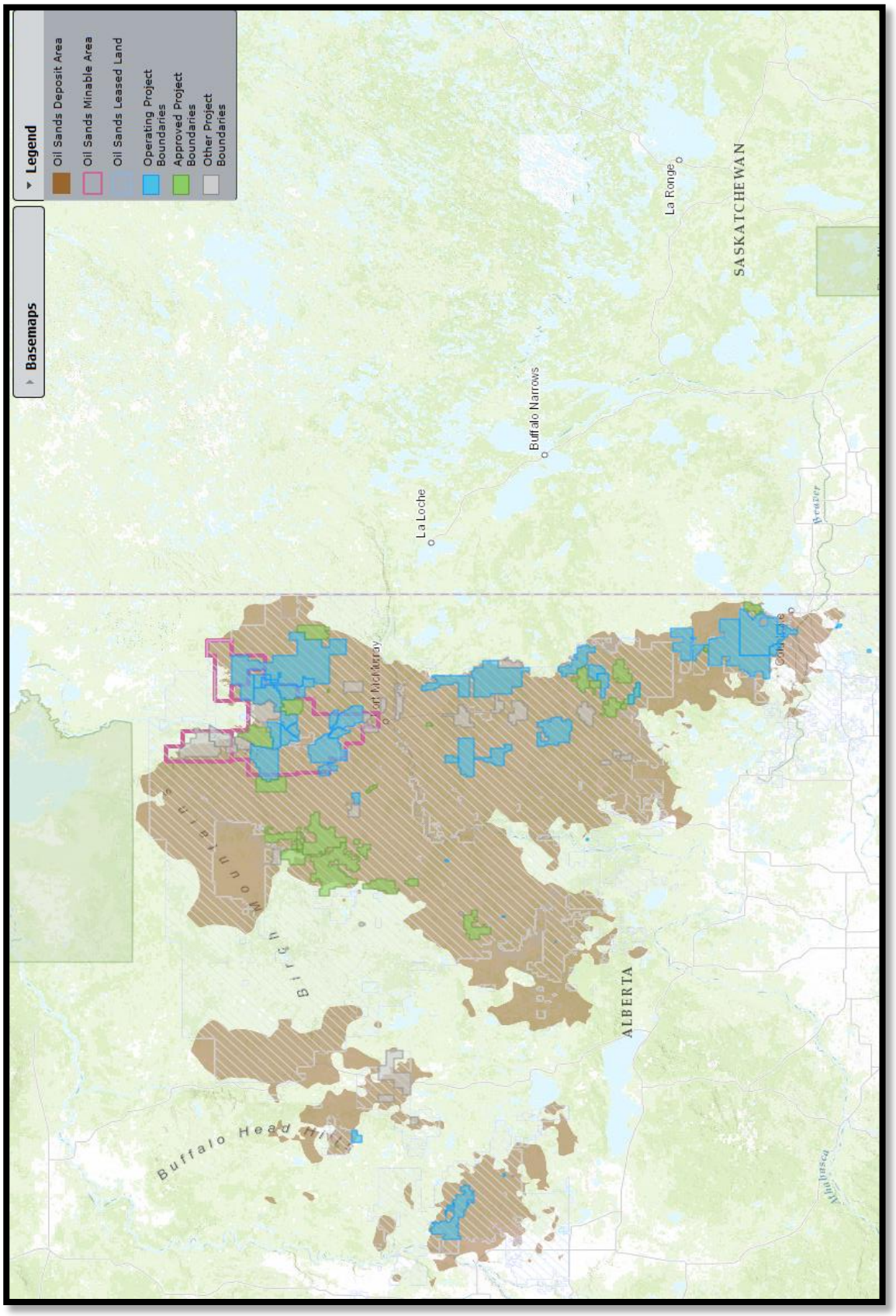

Figure 4: *Oil sands areas. (Source: Alberta Environment and Sustainable Resource and Development website osip.alberta.ca)*

As we can see in Fig. 4 within these three regions almost all the land has been leased or granted permits to, this is denoted by the diagonal white lines and the pink box are the areas of the oil sands that are mineable (about 3% of the total area). Leases have also been provided to areas outside the resources areas, these are either to create transport facilities or by way of easements which allow a user to approach his plot of land. The blue regions are those where some sort of development of the sands is already in place and the green boxes are where projects have been approved. There are several other projects that wait approval which are within the brown oil sands area.

Within the public lands owned by the Alberta Government, three types of licenses are possible for developers/explorers of oil sands: License of Occupation (LOC), a Mineral Surface Lease (MSL) and a Pipeline Agreement (PA). This also implies that ownership of the oil sands rights (which as discussed earlier are owned by the Provincial government of Alberta or managed by the Federal Government) is not a pre-requisite for a company to conduct exploration and extraction. The Alberta Environment and Sustainable Resource Department (AESRD) which administers the PLA and disposes the leases and permits is a complex maze of regulation from the PLA, the Mines and Minerals Act (MMA) (Province of Alberta 2000b) and The Environmental Protection and Enhancement Act (EPEA) (Province of Alberta 2000a). The specific regulations further complicating this process are covered in detail be Vlavianos (2007), but the point that need to be highlighted here is the focal interactions are not a result of neatly demarcated or discrete RU, RS, GS and A.

While Athabasca is a resource system within the framework, it is resource area in the eyes of the administration, it is ancestral land in the eyes of the First Nations and it is breeding or nesting ground for the migratory species that live here. Administration of these resources or

governance of them would need to be sensitive of these various conceptions but power of the administration over different actors can in effect marginalize some of these views in favour of others. This marginalization through the exercise of power is one type of practice which is expanded on in the substantive sections of this paper.

If we include other, second order variables from Table 1, the complexity of ownership and decision-making increases. Furthermore, it must be noted that at none of the steps in the disposition of mineral rights on public lands is the public consulted (Vlavianos 2007). This state of affairs as is explained by Greenbaum and Wellington (2010) is a result of the particular kind of democracy embraced by Canada post independence. This complexity can be simplified by picturing them as historically conditioned and propagated power asymmetries. Analysing these asymmetries and connecting them to the environmental outcome is the focus, of the modifications to the NIASES, proposed by this paper.

Furthermore, while the modifications proposed in this paper are likely to simplify the complexity by taking cognizance of the asymmetries of power, it is also worth connecting the use of frameworks once again to climate change and resilience, topics touched upon in the introduction. Fig. 5 shows the emissions of greenhouse gases (GHG) across the province of Alberta.

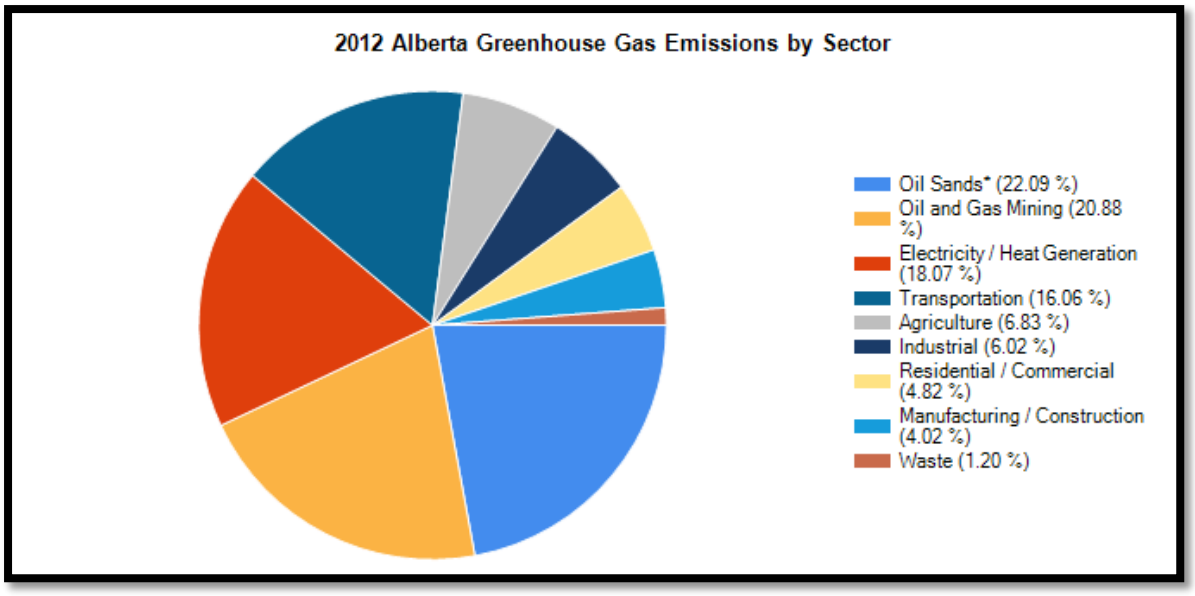

Figure 5: *Sectorial Contribution of greenhouses gases in Alberta. (Source: Canada National Inventory report 2012)*

As Fig. 5 highlights, there are two ways in which the oil sands contributes to GHG emissions. The first is through mining of the sands, representing about 3% of the resources in terms of volume but much more in terms of its spatial impacts. Extraction of oil through mining is one of the technological clusters used to extract oil from the surface sands. The remaining resources are deeper in the earth and consequently another suite of technologies are used to extract those resources. This is the reason for the differential GHG emissions estimated in the Fig. 5.

Until now we have taken cognizance of the following facets about governance of complex Social-Ecological Systems (SES) such as the Canadian Oil Sands and the frameworks helping analyze it.

1. Law, land rights and ownership which are the key variables in an institutional analysis of democratically governed systems are historically complex and asymmetrically held.
2. This asymmetry is one source of complexity when studying the governance structures.

3. The resources systems or the resource units are consequently not divided or exploited keeping environmental connections in mind, the land ownership and its disposition and revenue generation take priority.
4. Power over land and the regulatory maze through which the land gets deposed is sometimes not done through public consultation.

In the next section we look at some of the other strengths and weaknesses of the frameworks and the charges levied against them by those who would consider power more relevant in analyzing the frameworks.

2.3 Strengths and Weaknesses of SES and IAD

The strengths of the SES framework are in the articulation of the environmental outcome. This is a result of interactions between the other seven core subsystems and in the interactions of the second order variables between them during focal interactions. Specifically, the decisions of the actors made in the focal interactions are connected conceptually to the environmental outcome. Other areas of strengths as pointed out earlier are its use in the resilience paradigm that is increasing in significance in light of the climatic and environmental risk and uncertainty expected to be brought about by climate change. A final area of strengths are the modelling capabilities the frameworks structure renders themselves open too, these are covered in some detail by (Schlüter *et al.* 2014).

Furthermore, the IAD, which was developed first, contributed to the field of policy process research. This is a sub discipline of policy studies. Later on when the SES framework was proposed, those testing it were primarily in the field of ecology or natural resource governance. Others in policy process research continued using the IAD autonomously. However despite the

relatively distinct nature of scholarly disciplines within which these two frameworks have been bred they have also been criticized along seemingly similar lines.

These criticism have come primarily from those in political ecology, anthropology and human geography. These criticisms have sometimes come from those dealing with natural resource governance issues, those dealing with resilience studies or those dealing with local community related issues from within these disciplines. These criticisms have tended to focus on the epistemological, methodological and ideological differences between the economist, institutional and governance scholars primarily using the frameworks and those within the fields from which the criticisms originate. However, they have all been working on roughly similar problems with regards to governance of natural or ecological resources in social-ecological systems.

This background is seen as relevant to the NIASES because while the criticisms of IAD and SES have a slightly longer history the fundamental blocks on which the NIASES has been built is the same as the ones through which the IAD and SES were built. Despite the criticisms few have actually succeeded in including power within the frameworks, an area in which this paper hopes to distinguish itself. The only attempt till now to modify the IAD Framework and to use power in it came through the work of Clements (2010) in the form of a Politicized IAD (PIAD) to study the development of policy.

The SES framework is an autonomous entity for those concerned with ecological or natural resource governance. Attempts to include power in the SES came from Fabinyi *et al.* (2014) who showed that the neat characterization of social units, individuals, social, traditional knowledge in the SES were contrary messy cleavages noticed in society. A point that was highlighted in the previous section with regards to Canadian oil sands. Consequently, they compared the insights research in anthropology and political ecology provide on power within

the SES case studies. Another critical attempt came from Cote and Nightingale (2012) where they showed how dynamics of social systems in the SES were understood in game theoretical terms whereas the complexity of power dynamics within the SES was understood in human geography differently. They too showed how conceptions of power could be considered in SES cases. Both of these attempts converged upon the SES framework through resilience studies and they established the need for the inclusion of power within the SES frameworks.

Epstein *et al.* (2014) were able to operationalize power in several second order variables by applying different definitions of power from theoretical works in different subjects. No significant reworking of the SES framework was undertaken but they showed that the introduction of power is possible. They also pointed to the challenges between the new institutional paradigm and the political ecological understanding of power.

Clement (2012) who was able to show the need for further inclusion of power and discourse structures into the SES framework. She insists the framework move out from its focus on institutional fit and instead help identify the political climate and create better management solutions. The logic being used here is that political legitimacy of solutions is likely to produce better outcomes among various stake holders than mere institutional fit that might have more to do with administrative imperatives.

Thus, we see that scholars have usually taken an epistemologically, methodologically and ideologically different path to study social-ecological systems or policy developments within the SES and IAD frameworks. They have provided locations within the SES and IAD frameworks where power, politics, context and discourse operate. However, except one instance of actually reformulating the IAD to include power and discourse, none of the others explicitly provide the pathways through which power operates within the SES specifically how it connects to the environmental outcome.

The frameworks have also been criticized from other fronts where amendments have been proposed to integrate the frameworks better with ecology (Vogt *et al.* 2015) and with population demographics and other contextual parameters (Agrawal 2001).

Despite these varied charges, what must not be overlooked is that a large group of interdisciplinary researchers broadly accept the structure of framework while reserving their differences on the mechanical aspects of its functioning. Consequently, this paper also does not disagree with or alter the structure of the framework however it does posit changes in the mechanics and reorders a few elements.

2.4 New Institutional Analysis of Social-Ecological Systems (NIASES) framework

Elinor Ostrom had hoped that the broader SES framework would subsume the IAD over time (Cole *et al.* 2014). When work began to do this under the Program for Institutional Analysis in Social-Ecological Systems (PIASES), Mcginnis and Ostrom (2010) showed how this task was more complicated than imagined. Eventually the simpler solution proposed by Cole *et al.* (2014) was to incorporate the SES within the IAD frameworks and they presented a blue print for doing so. This new framework is called the New Institutional Analysis and Development (NIASES) Framework and is shown below in Fig. 6. For clarity the orange box in Fig 6 highlights the elements that have been incorporated from the SES into the IAD.

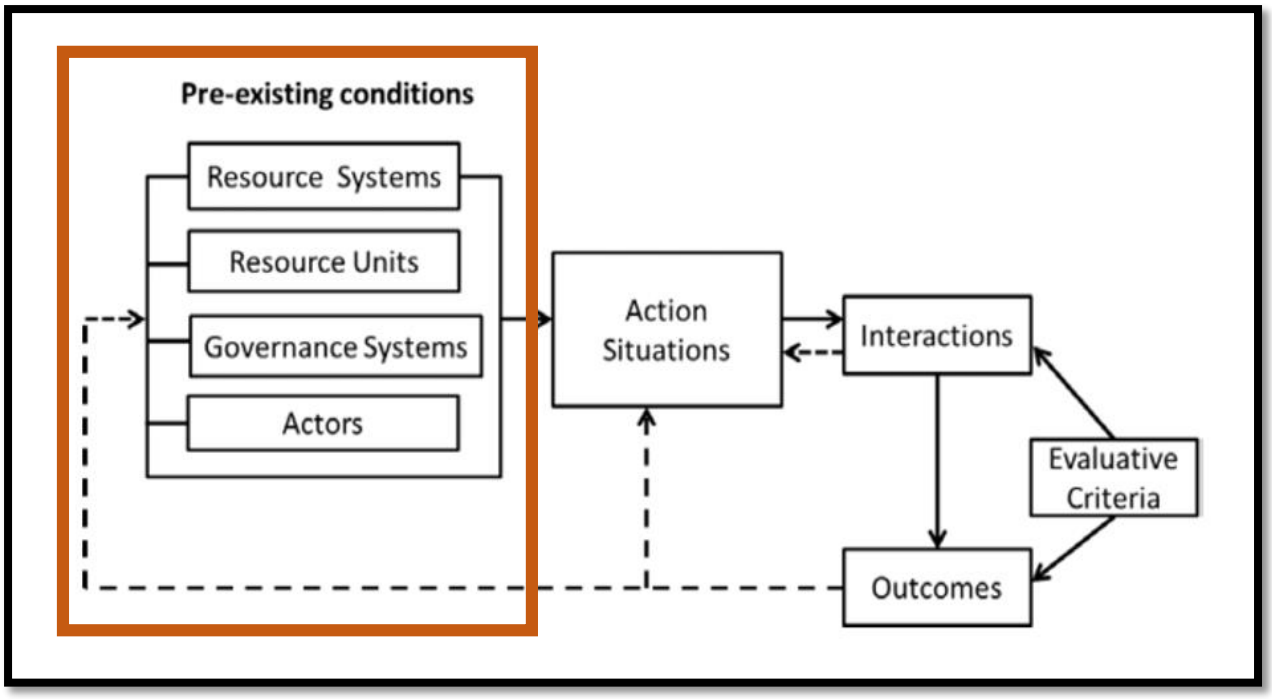

Figure 6: *Schematic representation of the NIASES. (Source: Cole et al. 2014)*

Their solution was counter intuitive and simple, instead of integrating the IAD within the SES, a better alternative would be the harness the SES's complexity within the simplicity of the IAD. Some changes to the IAD had to be made, these changes are the rules in use, the material and physical attributes and the community attributes were dispensed with. These were the components on the right hand side of the IAD referred to in Fig. 1. These have been replaced instead with Resource Systems, Resource Units, Actors and Governance Systems from the SES framework highlighted in Fig 3.

This was justified on the ground that community attributes and rules in use within and between these actors would still be the same, as they were factored into their conception within the SES. This should not be surprising since all mathematical edifices both the SES and IAD frameworks use the same building blocks from institutional paradigm literature, specifically concerning the rules, the levels of analysis and the rational or collective choice frameworks (Cole 2014)

Furthermore, since actors and governance systems were made explicit in the exogenous conditions the action arena and actors were removed from the main part of the framework leaving only action situations there (refer Fig. 1 for a more through comparison). This doubles as the focal interactions of the SES framework.

Having overviewed the frameworks and identified the grey areas where power could be envisioned and where it can be included the paper proceeds to identify works within practice theory which can be applied to these frameworks in explicating the link between power and practice.

3. Interdisciplinary method and approach

As stated in the introduction methodologically relevant theories in practice theory need to be chosen. In section 3.1, the larger discipline called practice theory is overviewed and one theoretical idea is identified. Having identified the works of Pierre Bourdieu as relevant to this paper, Section 3.2, is dedicated to highlighting a few concepts and ideas that are used in the modification of the SES framework. A lengthy discussion on the oil sands case is also undertaken in section 3.2 to highlight some of the manifestations of practice that Bourdieu's theoretical work highlights and connecting it to policy. Section 3.3 is dedicated to showing the functional similarities between the focal interactions in the SES or action situation in the NIASES frameworks. This is relevant because these interactions are the centre piece of the frameworks and the similarity validates the choice of the methods.

3.1 Overview of Bourdieu's theory of practice

Practice theory views the social order as a practice, which is a result of the exercise of power in a field. Contrary to the classical definition of "theory" associated with explaining and predicting events, the practice theory is more as a conceptual abstraction of social phenomena.

In practice theory, power is either granted or historic but each actor on the field has it. His position along the field in relation to other actors is a result of this power. His very existence on the field is a result of certain kinds of capitals he possesses. Four kinds of capitals are recognized in the field. These are economic capital or money, social capital is the family or society one belongs to, cultural capital is the result of the worldview one has and symbolic capital is the perception of an actor by other actors in the field.

The difference between practice theorists and scholars on one hand and governance scholars on the other hand, is a result of the author's epistemological proclivities. Practice scholars disagree with the contradictions between methodological individualism and methodological holism (Schatzki *et al.* 2001). Methodological individualism is premised on the idea that individual actions create social phenomena. An example of such a view in environmental literature is that of Howard Odum in (1982), who based on a paper by an economist Alfred E Kahn suggested that the root cause of environmental degradation is the cumulative effect of small actions by individuals at local levels. Methodological holism on the other hand gave undue weightage to the structures or groups of structures. An example would be Lynn Whites (1967) paper, holding Judaeo Christian environmental ethics as responsible for environmental degradation.

In rejecting the dichotomy between agent (common usage of the term methodological individualism) and structure (common usage of the term methodological holism), practice theory views practice as a social phenomenon which is produced, reproduced and reinforced in society at the intersection of agency and structure through the exercise of power. These practices then become the same reasons for resisting change.

Pierre Bourdieu (1930-2002) was a French sociologist and philosopher whose research spanned a range of social issues. Bourdieu was a prolific writer and his book *"La Distinction*" was considered the 6th most important sociological work of the 20th century by the academy of social sciences. Bourdieu interest in democracy, politics and globalization came much later in his life and resulted in the publication of three papers (Bourdieu 1987, 1999; Bourdieu and Wacquant 1999). In these papers, he took a more critical stance against global capitalism comparing it with imperialism. His criticisms stemmed from his analysis of these phenomena through the lens of power and practice, ideas he helped create.

In this paper, I am using and employing with some modifications specific elements from Bourdieu's (1977, 1992) articulation of practice. Bourdieu was chosen for this exercise specifically because his writings are the bridge between structuralism and post structuralism epistemological positions. This brings his ideas closer to those held by many practitioners using the IAD and SES framework. It also resonates with post-normal, post-structural, post-positive and post-modern thinkers due to his rejection of the distinction between agency and structure while still explaining his theories in those terms.

As Bourdieu's work is vast and a full overview is beyond the scope of this paper, I expand on the two ideas central. The first are those regarding practice and power in the context of governance systems and actors, specifically within the SES. The ideas of fields, "doxa" and capitals are undertaken in the next section.

3.2 Power and practice in social-ecological systems

Bourdieu understood power as the cause of practice. Below I expand on this idea and shows its contributions to the SES framework. The discussion starts with power and moves into practice. Power is asymmetrically distributed through social structure (what he calls the field explained a little later) and its origins are either historically given or historically devolved. Discussions on the Canadian oil sands till now have highlighted a few aspects of this asymmetry and have also highlighted this historical granting and devolution of power at the constitutional level of analysis. Power is also temporally dynamic, at different times different forces come to possess it. For example at the constitutional level Hudson's Bay Company held power and control over the oil sands region prior to 1869, then the Federal Dominion Government of Canada held that

power until 1930 and eventually the Provincial Government of Alberta holds ownership of these resources until now.

Possession of power results in its exercise, it is this exercise of power that develops into a practice. Having contextualized who had power over the resources, we now look at one of the ways in which this power was exercised with regards to the estimation and development of these resources.

The size of the deposits is determined through geological surveys and the provincial government of Alberta publishes the ST-98 update every year. The reports are available online from 2000 till 2015. The estimates have changed over the years. For example in 2000 it was estimated that 1635 billion barrels of oil were in place of which 177 billion barrels were recoverable under current technologies (Alberta Energy and Utilities Board 2001) by 2014 the reserves estimated were closer to 1845 billion barrels in place of which 175 billion barrels were recoverable under current technologies (Alberta Energy Regulator 2015).

While the mapping of the discoveries of the oil sands in Canada continued in bits and spurts through most of the 20th century a few significant developments contained its expansion to commercial scale. Until 1965, the only access to Fort McMurray the main trading port was on the river Athabasca towards Athabasca Lake. In 1965 the railways, Makenzie highways and Great Slave Railways were opened. This opening also coincided with the decline in fur trade, which had been the main occupation in For McMurray until then. Hudson's Bay Company was primarily involved in fur trade prior to this decline. These new business opportunities transformed the character of economy in the Athabasca region and consequently timber, fishing, salt and oil sands industries got the environment favourable for their expansion (Hein 2000). Today, the Keystone pipelines are expected to deliver this oil to its main markets in the

Midwest of America. However, as they must traverse through several provinces is the concern of the Federal Government of Canada.

In 1906, Alfred Von Hammerstein drilled for oil in the banks of the Athabasca River and could not find any, however he did find salt. The technology used at the time to extract salt is in principle almost identical to the first successful process patented by Dr Karl Clarke of the Alberta Research Council in 1928 to extract oil from oil sands. In the case of salt hot water was pumped into the salt under the rocks, which dissolved it, the brine was collected, dried to recover the salt. In the case of oil sands, caustic soda and hot water allows the oil to be separated from the sands, this is one of the processes used today under the name of Steam Assisted gravitational drainage (SAGD). Another technology in using similar principles is the Cyclical Steam Stimulation (CSS), here heated steam is sent into the ground and heated bitumen is extracted on the top. All these processes require additional energy inputs.

Until now this source of energy came in the form of natural gas from the Western Canadian Sedimentary Basin in British Columbia, but production here is peaking and is expected to decline, consequently the cost of using natural gas is likely to put pressure on the oil and gas companies in the oil sands regions. This is the main impetus for a several pilot projects being undertaken in the oil sands region to reduce costs and improve recoveries (National Energy Board of Canada 2004).

Some of the companies that operate in this region today were formed in the 1960's to solve the technological challenges of the extraction for example the Great Canadian Oil Sands consortium formed in 1953 led by Sun Oil today referred to as Suncor Energy. The first lasting mining and upgraders came into operations in 1967. However these companies would not have been created by the provincial government of Alberta had it not obtained the power to control its natural resources, a different set of actors might have existed. The end of the Second World

War and the need for oil and other resources to expand and rebuild the nation provided additional push to fast track discoveries.

Consequently we have seen that the power has to be exercised for it to be observed, the several ways in which power is exercised in the oil sands case is through the geological surveys the creation of consortiums to investigate technologies to develop the sands. Subsidies to develop different types of technology for the continued exploitation of the resources. Lease and permits allowing companies to extract the resources etc. However, while a lot of effort and money is put into the estimation and development of the resources addressing its environmental impacts has at best been a secondary consideration (Carter 2010).

Governance would need to contain and guide are those multiple variants of practice on a landscape at the hands of the actors. It is why governance systems cannot have a single template. They must recognize the qualitative differences between different social-ecological systems. Practices that have been learnt and practiced are also the same reason that prevent oil company from becoming a wind energy company.

These inferences from power and practice are relevant in light of what Ostrom and Cox (2010) call the "panacea problem". This is where policy makers prescribe a one size fits all policy to any problem. For example, creating markets, developing property rights regimes or tradable permits. Their success is context specific precisely because practices vary. Practice theory shows this is not the problem; the lack of power over land is not the main issue. The institutions that promote stewardship values however need not originate from power over land, they must originate from how the exercise of power is mediated. It is over this exercise of power that they must have influence.

Thus, the SES in this conception is no longer a set of discrete agents acting with discrete powers over a discrete resource unit. It is a nebulous entity, which is an emergence of practices. The

practices need to change to produce a sustainable outcome over time. Since, practices are caused by the exercise of power then either the sources of power need reformulating or the exercise of it requires a new direction. The modified SES framework in this paper helps develop such an understanding, such that current practices can be conceived in a more holistic way within the SES and consequently actions can be better planned.

Consequently, while Ostrom has articulated the need for governance mechanisms that is self-organising institutions building the idea of sustainable development, practice theory shows where those organizations need to focused, the practice. Another extension of practice theory to a more contemporary and globalized world, is that social organization is no longer limited to a set of discrete individual actors, they have been aggregated into larger entities contractors, firms, companies etc. with capital. They are issued quotas for resources they must extract.

The most important aspect of power in an institutional setting apart from its historic origin and distribution, is, its contestation at the hands of individuals against institutions or between institutions through actions, inactions, negotiations and outright confrontations. Some known fora where these contestations can be observed are, the parliament leading to amendments to legislations, institutions, laws, policy. The courts leading to precedents, repealing acts that are constitutionally void. The media leading to public outcries or movements. Pleas of a department to the ministry for more support leading to institutional overhaul.

These aspects of power discussed above describe the contour and shape of power but also its practice. The observable form of practice is policy. Heclo (1972) states that policy exists not only in the actions of policy makers but also in the inactions. For example, in the oil sands case this exercise of power can be shown to be problematic in two ways. Fig. 7 shows the number of water quality monitoring stations currently in the oil sands regions and Fig. 8 shows the

number of proposed projects in the area. The growth of the industry is not resulting in more water quality measures being enacted.

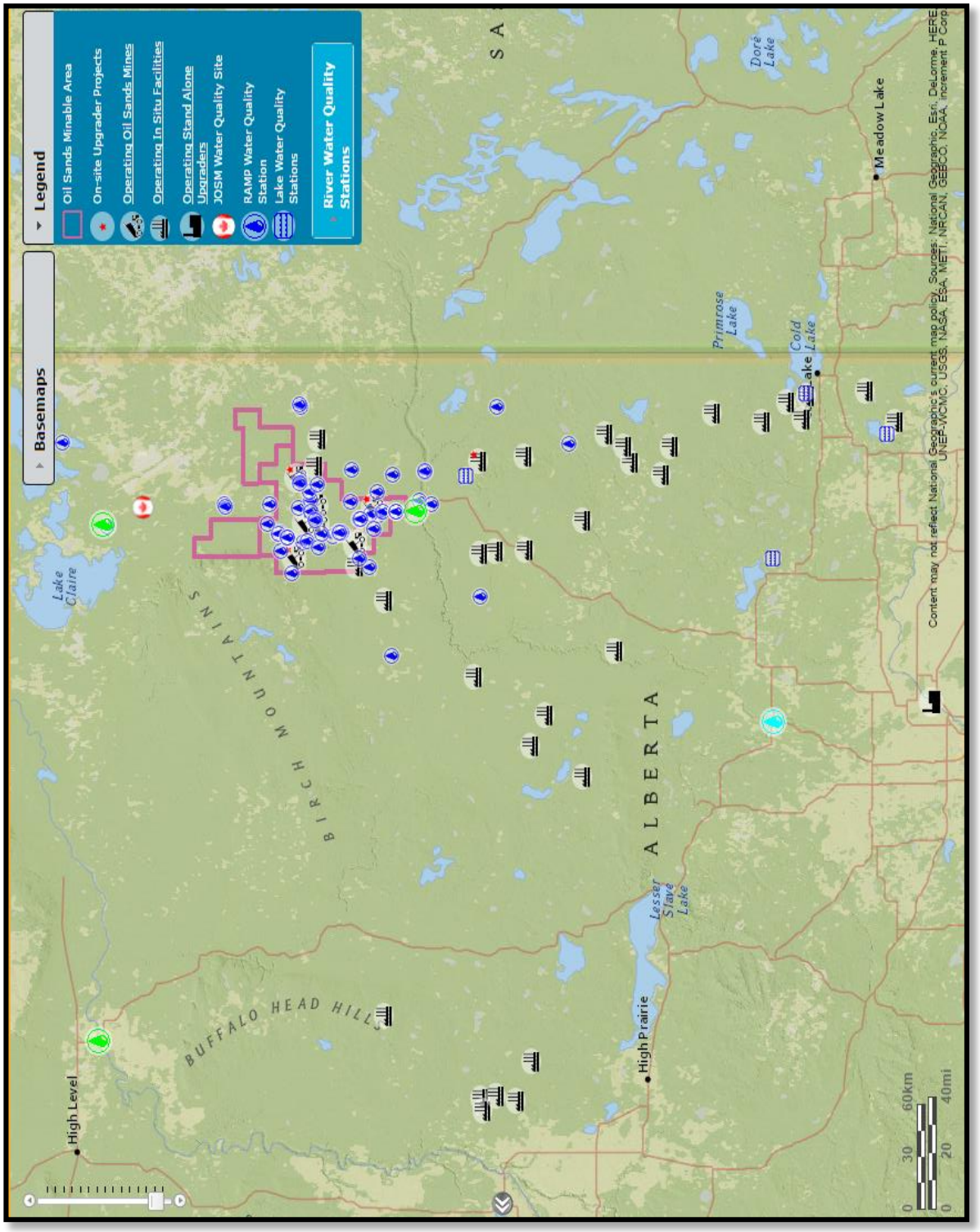

Figure 7: *Water quality monitoring stations. (Source: Alberta Environment and Sustainable Resource Development website www.osip.alberta.ca)*

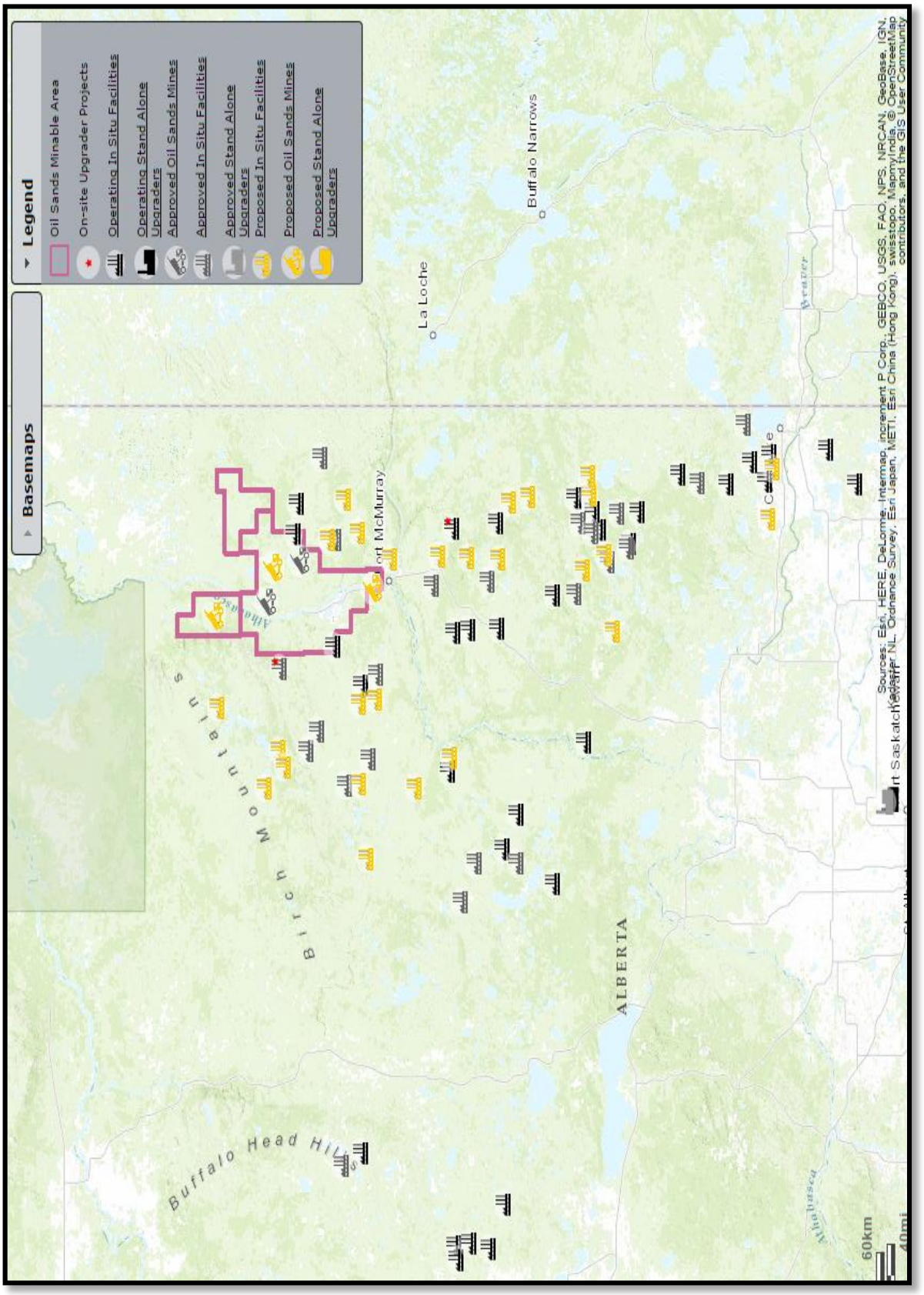

Figure 8: *Proposed, approved and operating oil sands projects. (Source: Alberta Environment and Sustainable Resource Development website www.osip.alberta.ca)*

The implications for the SES framework need to be drawn in asking power over what or power over whom. In drawing the pathways between power, practice and the environmental outcome, we must distinguish the governance systems and actors based on their power over the environment. Thus, four classes of social group's emergence, the ones with definitive effects on the environment are called change actors or change governance systems, industries and regulators being examples. All other organizations that may have significant power over these institutions but do not have effects over the environment in that they do not execute the change are called discourse actors or discourse governance systems for example timber consultants and lobbying firms.

A methodological outcome of this findings is that when looking at an SES from the perspective of an environmental outcome, the starting point needs to be the change actors, from there the focus must come on change governance systems (if they exist) and then arrange all other political voices into discourse actors or discourse governance systems. This does not mean that discourse agents are worthless, it only shows that no matter what a discourse agent claims, it is the change agent's actions that effect the environmental outcome. Then discourse agents can be ranked according to their influence on the change agent's behaviour.

The other finding is the levels of analysis are not independent, power and practice at constitutional or meta-constitutional levels exert influence at lower collective choice or operational levels.

A final note is about power of change agents over the environment is technological in nature. It also is a suite of technological systems that work in tandem with each other to result in an environmental externality. For example IHS CERA (2010) conducted an exhaustive survey of the types of technologies currently being used in the oil sands area. While each technology can produce different environmental outcomes for example by consuming less water but requiring

more energy its cumulative impacts on the environment require a different kind of assessment, one that analysis the life cycle of the oil sands. Lattanzio (2014) overviewed the various studies and found that when looked at from Wells to Wheels (WTW) which is study into the entire life cycle of the production scenarios the oil sands were on an average 15% more carbon intensive than other types of conventional oils. However on Wells to Tanker (WTT) analysis which focuses just on the extraction process they found that oil sands extraction is 80% more energy intensive than other types of fuel.

If the ideas of power, practice, change and discourse actors and governance systems are taken together the governance issue in the oil sands area looks different. It looks like an issue with a provincial government helping develop the resources in collaboration with global and local oil companies, while lowering the administrative costs to the producers to ensure competitiveness in the international oil market. Public consultation on this issue is still in the nascent stages, it is also important to unravel the maze of regulations to identify where is public participation most fruitful. The ad hoc manners in which environmental concerns are being treated by the governance system in place is a bit disconcerting not in the least because while the scope of developments are accelerating a corresponding acceleration in the pro environmental concerns is still largely absent. This, may not bode well for both the industry and the citizenry.

A note of conflict resolution forums also bears mention, especially the Ernst V/s AER (formerly ERCB) case currently being fought in the Supreme Court. The fundamental question of law the court must decide is that if section 43 of the Energy Resource Conservation Act (Province of Alberta 2000d) is constitutionally inapplicable as it bars a claim against the regulator for a breach under Section 2(b) of the Canadian Charter of Rights and Freedoms (1982) for a remedy under section 24 of the same act. This case is eagerly being watched by environmentally concerned citizens because it touches on an important issue with regards to the rights of the citizens if aggrieved by a regulator especially one as powerful as the AER.

3.3 Conceptual similarities between Bourdieu's fields and focal interactions

Social fields as Bourdieu envisioned them were arenas for the exercise of practice and a historically generated system of shared spaces. Fields as Bourdieu assumes it are autonomous. They are locus of struggles and through these fields a network of positions is established. It is immediately apparent that the field is conceptually similar to the focal-interactions in the SES framework are similar. For Bourdieu, the exercise of power over a period of time results in practice in the field, this is the same for the SES framework's focal interactions. Exogenous APD derived from the Social-Political and Economic Systems (S) core subsystem, repeatedly reproduces and reinforces itself in focal actions situations creating practice.

The boundaries of these fields for the individual agents are where the effect of the field on their lives loses meaning. The head of a big oil company whose interests in Canadian oil sands contribute to only 1% of his company revenues is less invested in the field than a company with 30% of their revenue from the activity. In the case of focal action situation then not all governance system or actors are equally invested in the focal-action situation. This is what are called the boundary rules in the IAD.

According to Bourdieu the battles within the field, between agents, are about strategies to change their relative position within the field. Their position in the field also limits there movement within the field that is their "Doxa". The "Doxa" defines what an agent feels about his place and his range of actions. Within the field of systems thinking specifically system dynamics the comprehension of the system by an actor within it is constrained by the his location within the system (Forrester 1969; Forrester and Sylvestre-Baron 1984). The Doxa then is a combination of choice and informational rules for actors within a system.

When a regulator opines that he cannot guide investment out of oil and into wind energy this is because his movement in field is constrained by the legislation granting his regulatory authority power. His subservience is towards maintain operations within that radius of power. His strategy to gain more power might be to testify in the House of Commons to grant him more power. In that, the APD prevents the regulator from exercising power over other relevant actors in the system. APD has prevented an actor from making decisions about a subject, it has curtailed is scope, his choice, his boundary, his information it has also probably curtailed his forums for contestation. Almost all the rules in used in the framework are affected by the asymmetric power distribution and consequently the exercise of this power is reproduced in the focal interactions and develop into a practice.

4. Integrating Bourdieu's practice theory into the frameworks

In the previous section power was introduced into the SES framework it was shown how it organizes the actors within the framework. Reproduction and reinforcement of power was called the practice. However, power was treated as exogenous to the system, historically contingent, dynamic and within an institution setting. In section 4.1, it is shown how exogenous power affects endogenous focal interactions. Also shown is how in sequential focal interactions exercise of power reproduces and reinforces itself. Thus, Asymmetric Power Distribution (APD) which has been a salient feature of the discussions on oil sands have thus far, is exercised in focal interactions to produce a practice. Section 4.2, the modified SES is included into the NIASES to produce a modified version of NIASES. This completes the task of introducing power within the framework.

4.1 Developing the power to practice SES framework (P2PSES)

Thus far from practice theory the following discoveries have been made into the nature of workings within the SES that are relevant to policy process research, environmental outcomes, governance systems and focal interactions. These are:

- For policy process research, asymmetric power and its exercise create policies. This repeated exercise of power conditions the views of the actors about their roles within the system and this then develops into a practice. Sometimes institutions are by themselves ad hoc creations to solve a specific outcome not a process. The contours and shape of this asymmetric devolution of state power is decipherable. Connecting this to the

practice/policy is also possible through inference, none the less causality might be hard to prove without reasonable doubt.

- For environmental outcomes, the practice of an actor on the environment is mediated through his use of technology. If technological investment (economic) is high or if the actors are symbolically invested in a technology (for example fishers in their practice with a particular kind of net) then change is expected to be slower than desired. Technology then is not just a medium or a second order variable. It is subsumed within an actor's identity, in that he creates meaning, power and practice out of it.
- Governance institutions – must develop with this specific understanding of practice and power as well as technology mediated power if they are to have an effect on the environmental outcome.
- In "focal interactions", exogenous APD is exercised to form endogenous practices within the SES. Strategies are towards altering one's power on a field that is exogenous to the focal action situation. However if those actions result in the success of an actor in reordering his position then the feedback is endogenous to the next focal action situation.
- Finally, change and discourse agents are two sets of agents or governance structures that are context dependent. Furthermore, the modifications to the SES framework presented here, postulates that an institution composed primarily of discourse agents without the participation and intent of the change agents are unlikely to produce any real practices because the exercise of power is not replicable over time.
- This last point feeds into what (Acheson 2006) calls institutional failure specifically in connecting governance, with the style of management and management techniques. This modified SES framework claims that understanding the power and practice dynamics of social-ecological systems might hold the key to designing and sustaining better governance systems.

In the modified SES framework called the Power to Practice in Social-Ecological Systems (P2PSES) framework presented below, I have shown how power and practice operate with the SES system, how the governance systems and agents can be bifurcated into change and discourse agents. How the ultimate environmental outcomes lies with change agents mediated with technology.

This conception requires certain modifications to be made to the SES framework to communicate its working under influence of Bourdieu's practice theory. Such a conception would then re-order the location of some of the second order variables and perhaps require some modifications on their relationships. Fig. 9 schematically represents the P2PSES. This is the positive interest of the P2PSES, is as much as it guides inquiry into how the system currently is and came to be.

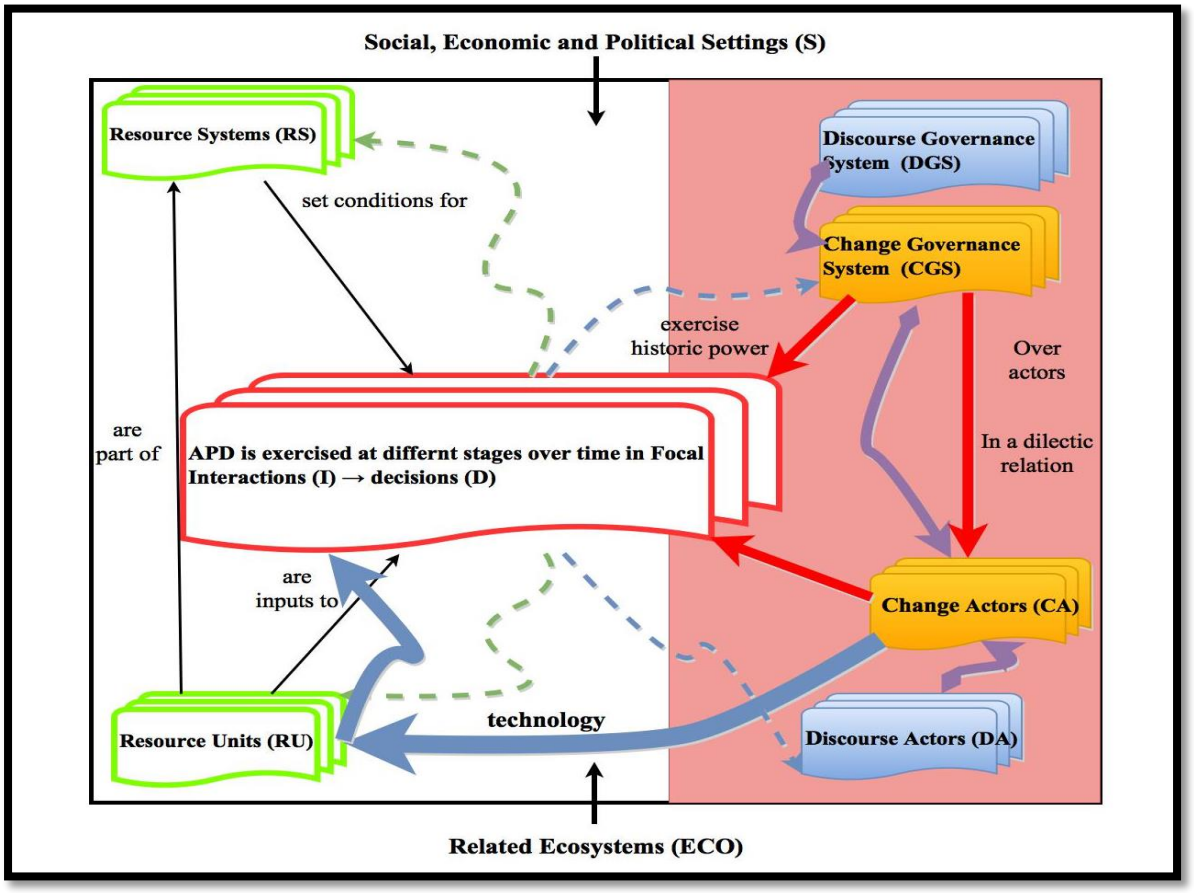

Figure 9: *P2PSES – Practice to Power Social-Ecological System. (Source: by author)*

In the P2PSES, red lines between CGS and CA depict asymmetric power distribution (APD). The shaded pink region is depicts the field this APD creates. The types of institutions have been dived along their power over the environment. Thus, four kinds of institutions within Actor and Governance systems emerge; these are Discourse GS agent (DGS), Change GS (CGS) agent, Discourse actor (DA), Change actor (CA). Their relation to each other and the environment are a result of their power over each other. In the P2PSES framework the relationship between them can be summarized as follows, APD in both its linear form that is the power of say the CGS over the CGA and its field form encompassing all actors in the field results in reproduction of certain practices towards environmental outcomes in the focal interactions. Internal practices denoted by purple lines are practices between the four types of agents due to their positions in the field a result of power or the four kinds of capital. The outcome from the focal interactions are decisions (D) which are then mediated through technology systems (T and denoted by the thick blue line) of actors on resource units and producing environmental outcomes (O). These outcomes are indirectly fed back into the next focal action situation. All other formulations of Ostrom's original framework remain unmodified. The changes to some of the second order variables and actions are as shown in Table. 2 below.

Table 2: *Second Order Variables in the P2PSES framework (Source: by author)*

Discourse Governance Systems (GS)	**Activities and Processes for Governance Systems**	**Discourse Actors (DA)**	**Activities and Processes:**
DGS1– Government organizations	I2– Information sharing	A1– Number of relevant actors	I2– Information sharing
DGS2– Nongovernment organizations	I4– Conflicts	A2– Socioeconomic attributes	I3– Deliberation processes
DGS3– Network structure	I6– Lobbying activities	A3– History or past experiences	I4– Conflicts
DGS4– Property-rights systems	I7– Self-organizing activities	A4– Location	I6– Lobbying activities
DGS5– Operational-choice rules	I8– Networking activities	A5– Leadership/entrepreneurship	I7– Self-organizing activities
DGS6– Collective-choice rules	I12 - Institutional establishment	A6– Norms (trust-reciprocity)/social capital	
DGS7– Constitutional-choice rules	I11- Asymmetric Power Distribution.	A7– Knowledge of SES/mental models	
DGS8– Monitoring and sanctioning rules		A8– Importance of resource (dependence)	
Change Governance Systems (GS)		**Change Actors (CA)**	
CGS1– Government organizations	I3– Deliberation processes	A1– Number of relevant actors	I10– Evaluative activities
CGS2– Nongovernment organizations	I4– Conflicts	A2– Socioeconomic attributes	I1– Harvesting
CGS3– Network structure	I5– Investment activities	A3– History or past experiences	I2– Information sharing
CGS4– Property-rights systems	I8– Networking activities	A4– Location	I4– Conflicts
CGS5– Operational-choice rules	I9– Monitoring activities	A5– Leadership/entrepreneurship	I5– Investment activities
CGS6– Collective-choice rules	I10– Evaluative activities	A6– Norms (trust-reciprocity)/social capital	I7– Self-organizing activities
CGS7– Constitutional-choice rules	I11 – Asymmetric Power Devolution.	A7– Knowledge of SES/mental models	I8– Networking activities
CGS8– Monitoring and sanctioning rules	I12 - Institutional establishment	A8– Importance of resource (dependence)	I9– Monitoring activities
			I10– Evaluative activities
APD+IP over time in Interactions (I) → Decision (D) mediated by Technology (T) produces environmental outcomes (O)			

The second order variables that have been introduced are, APD and institutional establishment as the activities and processes of the CGS. The activities and processes were segregated for the four types of agents. No changes are made to the outcome measures, resource units or resource systems. The process driven nature of the interactions in the P2PSES is that asymmetric distribution of power (APD) and internal practices between the four types of agents will be exercised in focal interactions. This exercise with reproduced and reinforced the APD to produce certain decisions (D). These decisions are then mediated by technology (T) systems of the change agents to produce environmental outcomes. The introduction of Technology as a

process mediator requires the removal of variable A9 from second order variables list. The introduction and the changes in conception have been highlighted to signify they have not yet been empirically tested. This is considered relevant to mention because the SES framework was developed after several empirical attempts at governance structures were carried out, it was a theory built on data. This modified SES framework is one that guides data collection, thus it must acknowledge its role as such.

In the oil sands case, APD can be observed on the legal as well as the institutional fronts. Continuing discussions from earlier, we saw how the provincial governments owned lands, how they developed resources and how a complex maze of law and regulation asymmetrically disposed on these rights to companies. The link between an Act and the Institutions it creates requires some highlighting. Government statutes such as the Environmental Protection and Enhancement Act, the Water Act or the Mines and Minerals Act essentially dispose what are in common law are known as eminent domains. Each of these acts stem from the recognition that within the province of Alberta all land and water resources are owned by the Provincial Government of Alberta except where they might be owned by individuals or the Federal Government of Canada.

Within the Acts themselves, the Minister, the Lt Governor in council of the Province and The department the Minister heads then become the locus of control and consequently power. In reading through the acts the first few sections clearly state that almost all the crucial functions with respect to these acts and the lands governed by them are controlled or legislated on by these few key personalities or institutions.

Consequently, substantive sections of these acts can be administered by different agencies. The recent administrative changes under the auspices of the acts should highlight the point of asymmetrical power distribution and contestation. On June 17, 2013 different regulatory bodies

were subsumed under the Alberta Energy Regulator (AER) which took on the roles from the Energy Resources Conservation Board (ERCB) and the acts it was allowed to make decisions on including the Oil and Gas Conservation Act. On November 30, 2013 it assumed functions from Alberta Environment and Sustainable Resource Development (AERSD) which until them managed the Public Lands Act (PLA). On March 29, 2014 the AER assumed responsibilities from AERSD under the Water Act and the Environmental Protection and Enhancement Act. However the AER is not responsible for the Alberta Utilities Commission board, Surface Rights Board or Alberta Energies responsibilities of Mineral rights.

It is unlikely that such regulatory changes could have come about were it not for the power vested with the legislative and ministerial personalities. It is also clear that these changes are administrative in nature, the regulations that derive their power from the act are essentially left unchanged. If anything they have been consolidated into one supra legal regulatory entity. What this means is that if the Water Act bans a certain chemical, the AER's responsibility extends to monitoring or banning its use and ensuring compliance. It doesn't necessarily have rights to decide which chemicals to ban.

In the issue of pollutants in water, another set of complexity interacts. At the federal level following are the acts that govern hazardous substances, the Canadian Environment Protection Act which has some provisions of hazardous substances, the Pest Control Products Act, Fisheries Act (an areas of contestation between the land rights and developments of the provincial government affecting the water quality of federal water bodies) and the Canadian Environmental Assessment Act. At the provincial level all of these contaminants are governed under one Act the Environmental Protection and Enhancement Act which as was shown earlier is now administered by Alberta Energy Regulator. They have for the oil sands developed several monitoring stations for both river water quality and lake water quality. What is clear is that the number of monitoring stations are lesser than the number of projects in operation, at

each project the number of wells in an out of operation could run into the hundreds. This has been highlighted earlier in Fig. 7 and Fig. 8.

It is also unclear that in case of a spill or contamination how much of the blame is apportioned to the company and how much by the regulator. What is also unclear is that within Tort law (Law relating to Tort or damages arising out of action of one legal entity over another) what the possible recourses are for communities that are harmed by these chemicals. This is one of the areas of contention between the First nation communities and oil companies (Carter 2010; Wright and White 2012).

This is where the P2PSES provides the grounding to sift through this complexity. Power and Practice have been shown to be historically contingent and temporally dynamic. In Canada's case constitutionally or meta-constitutionally granted power is asymmetrically devolved through the creation of several acts while the main decision makers remain a few key personalities. This also allows for regulatory overhauls that is the exercise of power to take place at different points in time. The cause for this regulatory overhaul in most cases is unlikely to have anything to do with the environmental considerations. Any and all environmental concerns are taken care by bureaucracies under the Water Act, Environmental Enhancement and Protection Act, Fisheries Act and the Canadian Environmental Assessment Act and their corresponding regulations after another set of bureaucracies have disposed of other powers which in turn constrict the powers and practices of these environmental considerations.

The same is the case with climate change regulation, in 2008 Alberta legislated Specified Gas Emitters Regulation under the Climate Change and Emissions Management Act which created a tradable permits system for greenhouse gases. All facilities releasing more than 100,000 tonnes of Carbon per year were required to reduce their consumption by 12% to 2008 and each year caps were put. The cost of noncompliance is CN$ 15 per tonne. In 2012 about 40% of the

reductions were achieved by paying The Alberta Climate Change and Emissions Management Fund set up under the Act (Alberta Environment and Parks Website). This program expired on June 2015 and no new notifications are currently available for the future.

Thus, while the development of Canadian oil sands is given priority, there are essentially no additional mechanisms in place to contain the environmental impacts of this development, the case of water quality and GHG emissions are highlighted. Additional mechanisms here could be capacity addition or increased research into these areas, which at the moment are lacking.

The consolidation of power either with certain personalities, ministries or recently regulatory agencies is at the heart of the issue, while such consolidation by itself is not bad it doesn't at present seem to be directed specifically at improving the environmental outcomes, it should however bring down the administrative costs and consequently improve the competitiveness of the Industry in the global market. This state of affairs is what the modified frameworks help unlock and as a result they allow researchers to propose more holistic solutions within these constraints.

4.2 Developing the power to practice institutional analysis of social-ecological systems (P2PIASES)

In this section, the blue print developed by Cole *et al.* (2014) is used to produce the final product of this paper the Power to Practice Institutional Analysis of Social-Ecological Systems (P2PIASES) frameworks, which was the central aim of the paper. In the chapter it is compared with the NIASES and the PAID to highlight key areas of differences.

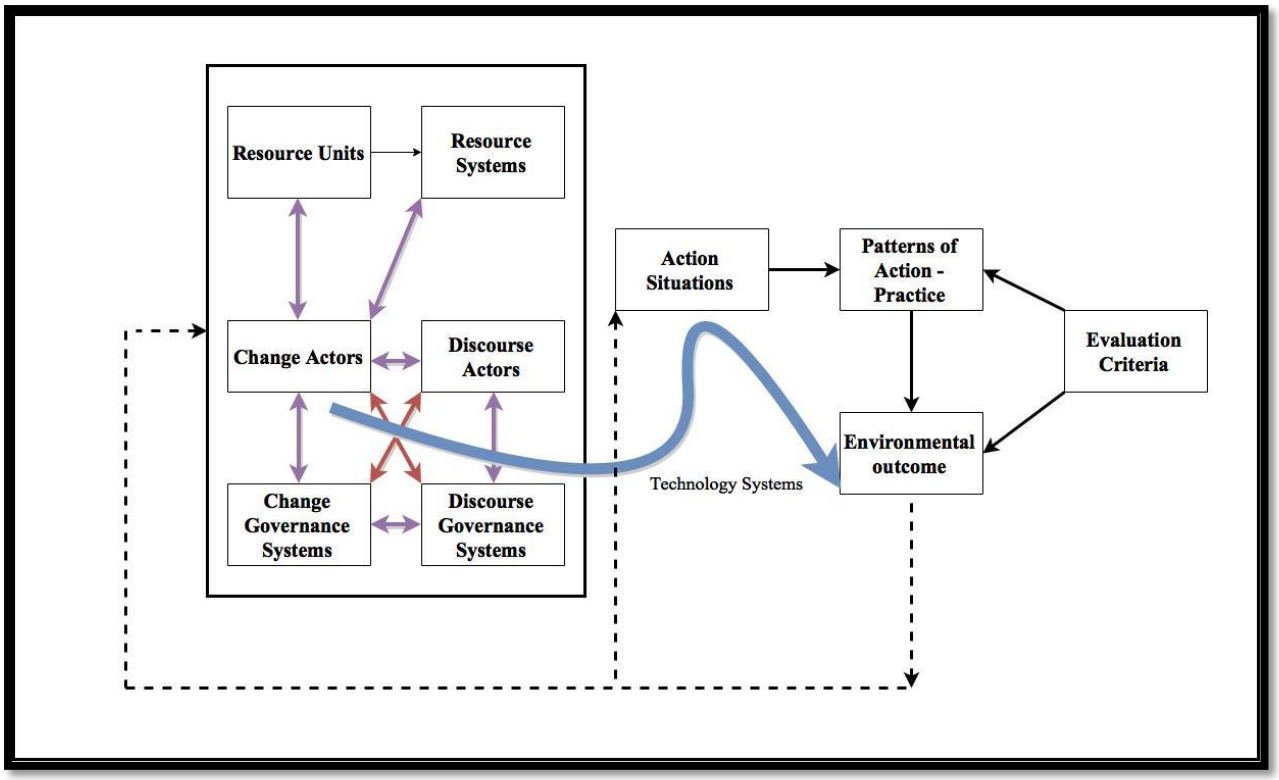

Figure 10: *Power to Practice Institutional Analysis of Social Ecological Systems (P2PIASES). (Source: by author).*

This paper uses the same logic and blue print from the NIASES to incorporate the P2PSES into the P2PIASES. This is schematically shown below in Fig. 10. The red arrows highlight the APD, the practice by the purple. Technological system mediation towards the environmental outcome is shown by a blue line curved towards the action situation, to show that the action situation might result in technological change. All other elements of the IAD remain unchanged. Multiple levels of analysis are also possible within this revised version.

Thus in the modifying the two frameworks, three salient features have been highlighted, the first is the conception of the Asymmetric Power Distribution and the practices, the two classes of actors with regards to their environmental outcome and finally, the technological pathway through which decisions of these actors can be connected to the environmental outcomes.

5. Results and Discussions

Having spent considerable time on describing the Modified SES and NIASES framework, the products are discussed along three separate lines in this section. In section 5.1, the normative implications of the P2PSES and P2PIASES are discussed specifically in relation to three main items that have been introduced, the APD, the technological pathway and the types of actors. The same task but in comparing the modified framework to the IAD, SES, NIASES and PIAD is undertaken in Section 5.2. In section 5.3 to show that the mathematical integrity of the frameworks is still intact, a note on the mathematical nature of APD is provided.

5.1 The normative implications of the P2PSES

Having described the positive interests of the P2PSES, we now look at the normative side of it. The normative interests of this modified SES framework lies in what it has the ability to inform policy development in delivering sustainable development or sustainable environmental outcomes. Specifically in informing the "where" in the causality leading from process to outcome interventions are necessary. The "what" is also crucial to such a task, however in the particular conception of the P2PSES this is only diagnostically possible when an elements from another discipline are combined into its structure, namely those from system dynamics?

The "where" provided in the framework, in the pathway from the APD's influence on the internal practices, which are reproduced in the decisions of focal interactions, which are then mediated through technological systems to the environmental outcome. To answer the "what" the paper incorporates the works of Donella Meadows (1997; 2004), a student and contemporary of Jay Forrester who is credited with the development of the field of system dynamics (Forrester and Sylvestre-Baron 1984; 1969; 1985). At the heart of the field is a

particular focus on seeing the world and social problem in a structural way. It is both an art and science in that these structures if not self-evident must be designed in the hands of the practitioner. A good design of the structure is crucial to arrive at a good understanding of the processes, where variables can be tested rigorously.

At the broadest conceptual level, the treatment of power, in systems dynamics is different, while in practice theory it can be context and value laden in system dynamics, it is a "tap" to control the flow of something from a source to a sink. Whether the controller of the tap must increase or decrease the flow is dependent on feedback loops. A feedback loop is a signal from one part of the structure to another regarding the flow, if the feedback loops in the system are positive the flow will increase because it signals opening the taps. If feedback loops are negative, they will correct the flow by sending that signal that something is overflowing. A double feedback loop (positive or negative) accelerates the process because for each signal to increase or decrease something another signal increases that rate of that increase or decrease.

When these taps fail to control something, more often than not system dynamics ascribes the cause to the structure of taps or suggests creating a greater number of taps or changing the feedback loop structure. Thus, in a complex system, system dynamics at the hand of skilled professional can narrow down the problem to the structural elements and suggest the optimal strategy to counter something. However, whether the agent or the controller of the tap takes this advice and turns it on or off is beyond anyone's control.

After many years of advising policy makers on designing better policies or institutions to cope with a problem, the scholars in the field began to see key leverage points in the system. These points are those structural connections in a system that must be targeted to produce real and lasting change. This idea was further developed by Donella Meadows (1997; 2004; 2009) who

identified a list of pressure points that would help policy makers develop better regulatory systems.

Within systems thinking and system dynamics, a leverage point is the structural unit which if modified can produce the most amount of change to the whole systems functioning. She then went on the list 12 such leverage points in order of importance. This order is not fixed but at different times different orders will emerge but the elements will most likely be the same. I choose five in the P2PSES Framework to study the most important drivers of the interaction between change and discourse agents, namely.

- The structure of information flows (who does and does not have access to information) – In the P2PSES, this highlights the relative access or lack of access to information a discourse GS/A might have about a change GS/A's operations?
- The rules of the system (such as incentives, punishments, constraints) – Should a discourse GS/A disagree with a change GS/A what are the mechanisms through which it can influence the latter?
- The power to add, change, evolve, or self-organize system structure – Through what measures might a discourse GS/A affect the change GS/A's functioning or structure.
- The goals of the system – If acting in unison, what do the discourse GS/A and the change DS/A achieve or what is their goal?
- The mind-set or paradigm out of which the system — its goals, structure, rules, delays, parameters — what is the perspective and view of themselves that the discourse DS/A and change GS/A share?

Changes in these leverage points along with their location in the process described in the P2PSES are good indicators of change within the SES. However how these changes alternate power and how they reorder practices is also an important element to consider. Consequently,

from an environmental point of view, it is reasonable to assume that any in ADP and IP between CA and CGS is more significant that those between DGS and CGS is more significant that between DA and CA is more significant that between DA and DGS. All of these are exercised in focal interactions to produce decisions. These decisions are what Meadows works helps us analyse better. They must then be mediated through technology to produce the environmental impacts. This is what policy makers must pay attention to when crafting policies towards sustainable development, likewise these are the same elements those interested in building governance systems must be aware of and attuned to when facilitating trust, reciprocity and face-face communications within the SES framework.

Technological changes then are also equally important in that they can reorder the whole system but usually only when the breakthrough is significant enough. Furthermore, technological transitions have a temporal spatial characteristic of their own some longer (Grubler 2012) some shorter (Geels 2002). These relations are not the only ones and highlighting them does not mean they are always more relevant. It only illustrates where changes in the pathway are prima facie considered important and how these changes can be ordered in their relevance.

The main reason for keeping the focal action situation intact in the P2PSES instead of replacing it with a continuous body of practices is to emphasize that actors operate in cycles. Farmers for example have a routine of farming, industries have business cycles and development projects have stages and periods. CGS and CA then are not always static entities but fluid ones. In case of mining activities, CA's and CGS at the prospecting stage are different from the ones at the license granting stage. They are also different at the operation stage than the ones at the decommissioning stage. At each of these stages, environmental impacts are taking place at the hands of the actors through technological systems. Likewise, at each such stage, APD's are different and consequently so are the practices.

As explained earlier, the regulatory overhaul a couple of years ago in Alberta is an important direction of change, while no clear indications have been provided or detailed assessments available as to why these changes took place, they will remain an interesting area for future research.

5.2 Comparison of the P2PSES with other frameworks

The PIAD was proposed by to include elements of discourse and power within the IAD such that the key components of the IAD were left untouched and discourse and power mediated the interactions within the action. Schematically the PIAD framework is similar to the IAD in its specific application it comes close to the method adopted in this paper and shown in Fig. 11.

Here political economic context and discourse are introduced into the IAD to study institutional development. The specific nature and function of these introductions stem from the works of Michael Foucault's (Foucault 1980) treatment of discourse and Luke's (2005) treatment of power. This introduction is not entirely exogenous, in that the dotted lines in the IAD framework are made endogenous using the feedback loops.

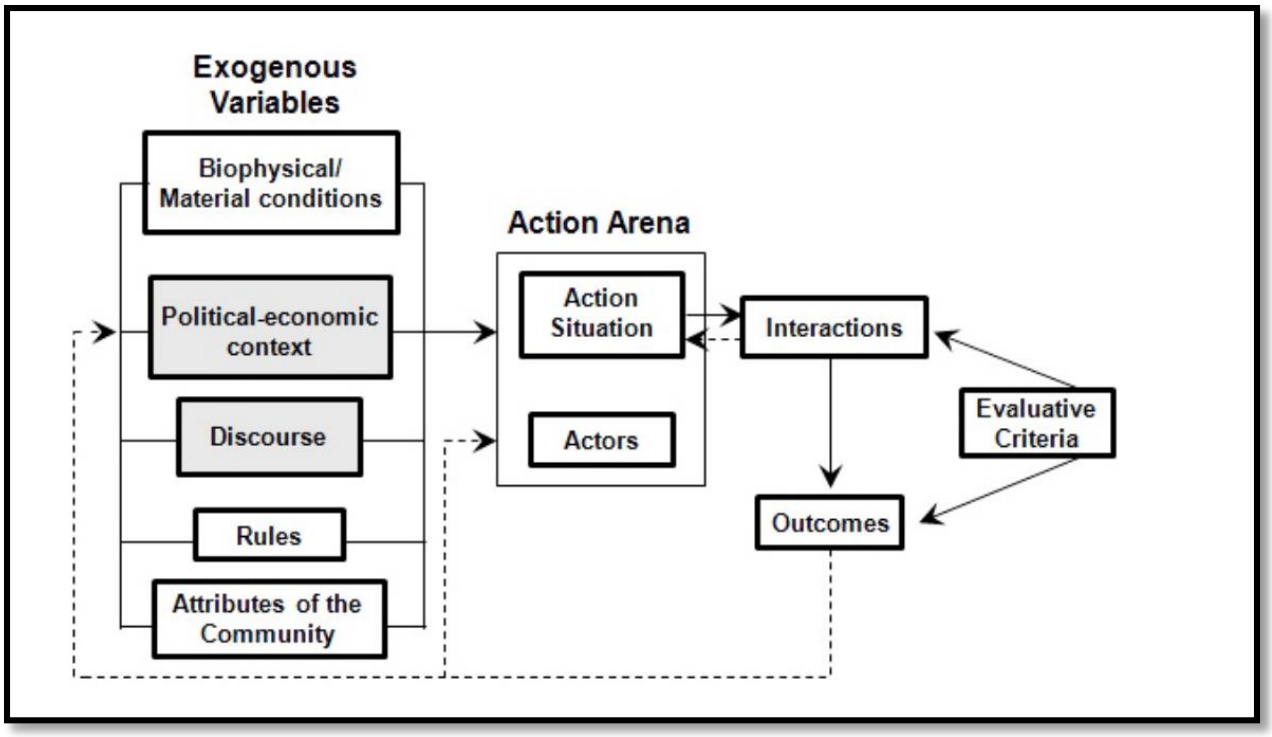

Figure 11: *Politicised IAD (PIAD). (Source Clement 2012)*

Key differences between the IAD (refer Fig. 1), SES (refer Fig. 3), the NIASES (refer Fig. 6) and the Politicized IAD (Refer Fig. 11) frameworks and the one presented in this paper namely the P2PIASES (refer Fig 10) and P2PSES (refer Fig 9) are highlighted below.

In the IAD, SES, NIASES and PAID ambiguity exists about levels of analysis being independent of each other. In the frameworks presented in this paper they are highly dependent on each other due to asymmetric distribution of power. In the 4 frameworks, there is a generic term for all actors in the situation, in the frameworks developed in this paper there is clear classification based on their power over the environment. This crystalizes the link between an actor and the resource unit or system. It further expands on this through the APD this actor has over his environment through technological mediation.

The classification of actors on their power over the environment through technological mediation and the operationalization of APD through practice or policy are considered to be

the key difference between the IAD, SES, NIASES and PAID versus the ones developed in the paper. While the components from the other frameworks have been borrowed and modified the structural integrity remains intact, as do any mathematical extensions of the framework. The changes are conceptual as they are theoretical, other main changes include how the mathematical functions and field are envisioned within this framework. These are highlighted in the next section.

The P2PIASES makes the following observations; firstly it shows that power permeates the levels of analysis, thus, what is operational constitutional or meta-constitutional levels will have implications on lower collective or operational levels. Secondly, power over the environment is perhaps more crucial than power over actors since effects on natural or ecological resources is shown to be a result of mediation through technological systems in the hands of the actors, these are practices in their own right. Thirdly, by dividing the actors into discourse and change, a filter is provided for making sure when analysis a focal interaction or system, a discourse actors claims are crucial only if his power over a change actor results in a practice of the change agent accepting the discourse agents advice. Fourthly, while several conceptions of power exists in various disciplines, those interested in governance or institutional management of resources need to focus more on the practices that result from that power, shifting power is not always necessary to changing practices.

This last point can and has been explained in another way through the panacea problem and self-organizing governance institutions. Ownership of resources or land is one source of power, which does not automatically translate into a practice that is beneficial for the environment. Cultivating and institutionalizing such practices must be the objective of designing effective governance systems. Cognizance of APD, its practice and consequently the technology system through which an environmental outcome is achieved should be the key areas of interest. Taking from meadows, information, goals, ability, forums for contesting decisions and shared

meanings are some of the areas in which asymmetric power and the observed practices within it can be changed towards a better environmental outcome.

However, the P2PIASES limits the analysis of actual impacts to the relevant actors and governance systems who produce change. This leaves the field open for studies into the interactions between these types of agents but prevents the researcher from making causal inferences from discourse to action based on rhetorical proclamations. Simply put if the change agents are not changing the discourse does not matter. The change agents might simply ignore those pleas. This phenomenon is what Clements (2010) also points to in the legitimacy issue of governance systems. If the agents do not feel compelled by the discourse then they will not be compelled to act. If they are to act then the actions need to be mediated by the technological systems into environmental outcomes.

While in the approach technological mediation is usually talked about in terms of connecting, change actors to environmental outcomes, it becomes a part of the power a governance system can exercise in the form of monitoring as well. While this is an interesting area of research in its own right, it is not explored in this paper.

The rationale of this paper is not to provide an alternative to the SES or the IAD but to introduce power within its boundaries and show how to affects the organization of actors and governance systems within the SES. The task of introducing power into the SES framework is achieved by synthesizing a few key ideas on power and practice from the works of French Sociologist Pierre Bourdieu (1977, 1992) with the SES framework. This power is asymmetric within the system, giving rise to a key deliverable of the framework called Asymmetric Power Distribution (APD). The APD reorders the actors and governance systems and consequently mediates their effect on the environment. The conception of the SES and NIASES framework under the effects of power and practice is believed to provide a more holistic and comprehensive way of

designing governance schemes and mechanisms to manage common pool or other natural resources.

5.3 Guidance on the mathematical nature of APD

In this paper, power is not seen as an emergent phenomenon within the SES, it is historic as it is dynamic and exogenous to the SES. It becomes endogenous to the focal action interactions by reproducing and reinforcing itself, which overtime develops into a practice. Those who look at the SES from with the intension of modelling outcomes, economists, modellers, system dynamics practitioners or policy researchers describe the processes within the frameworks mathematically.

For example if variable A and B affects variable C, then mathematically (A, B) → C. If set theory is applied to this relationship, it could be (A U B) → C, that is the common elements between A and B affect the outcome C. Another example could be if probability theory is applied then P(AUB) → P(C), where the A, B and C are treated as events and that the probability of event A or B occurring together will affect the probability of event C occurring. As (Schlüter *et al.* 2014) has pointed out the challenge for modellers using the SES has been in applying the variables within the framework rigorously to mathematical or statistically based models.

Thus, APD in this case should be seen at the force affecting the process itself, it reworks the theories on which mathematical relationship are drawn. In Set Theory's case, it affects the elements in set A and set B and as a result it affects the outcomes in set C. In probability theory's case, it affects the probability space within which the events A or B occur and consequently the probability space of event C. Thus, the mathematical nature of the variables

in the SES are conditionally affected by the APD. Within the institutional paradigm itself, boundary rules affect the conditions of the focal actions situation.

The mathematical nature of the APD's effect on the system can be explored only after it is included within the framework as a variable that changes the properties of other variables. One way to conceive it is the magnetic force field ordering metallic fillings around it. Another way is to imagine it as a gravitational field that orders the other variables in relation to it. Explorations into the precise set of mathematical or statistical properties that would most likely explain the APD are not attempted in this paper due to space constrains. At this stage acknowledging APD within the framework, showing it exists, conceptually tracing the pathways of its exercise and identifying empirical evidences of its existence suffices the cause, rationale and aim of this paper.

6. Conclusion

6.1 Rationale, approach and objectives of the paper

In section 1 and 2, it was shown that the SES and IAD frameworks and their synthesized product the NIASES, are at the cutting edge of resource governance due to their ability to simplify the complexity inherent in the process of analysing complex institutional mechanisms in diverse social-ecological systems. One of the main drawbacks of these frameworks were recognized to be the lack of explication of the role of power of the social actors over each other and over the environmental outcome within the frameworks.

It was concluded that while other attempts to remedy this situation resulted in critiques of the frameworks, or pointing out pathways through which power and discourse could operate within the framework, in only one instance did the reformulation of the frameworks actually take place. This attempt gave birth to the Politicized IAD (PIAD) framework. The relatively recent SES and NIASES frameworks have yet to be subjected to the same intellectual attempt.

However, these previous attempts were able to show this gap in knowledge existed. They were also able to show that the framework's structure allowed for a wider set of interdisciplinary researchers and scholars to interact and debate over similar issues in governance. It also highlighted the main areas of differences were those emanating out of epistemological differences

Over and above these considerations, power and discourse mostly affect only the decisions made by the actors in a Social-Ecological System (SES). The pathways connecting the decision still needed explication. In the SES framework technology was seen as a second order variable. It was felt that this conception of technology was narrow. A better alternative was felt to be

technological systems that would both limit and guide the implementation of the decisions made by the actors.

Thus, the challenge this paper attempted to overcome was to introduce a specific formulation of power within the frameworks such that it would firstly, bridge the epistemic differences of the debating scholars; secondly, be able to conceptually connect it to the environmental outcome and thirdly, do so in a manner that maintained the structural and mathematical integrity of the framework while improving its analytical ability. The rationale for doing this was explained in 1.2.

To achieve this aim, the work was broken down in to several tasks. In section 2, the frameworks were reviewed and the Canadian oil sands case was used to highlight the issues that the frameworks overlooked in their current conception. In section 3, an overview of practice theory was undertaken to show how it might be able to provide insights into operationalization of power within society and as a result its explication in the system. Pierre Bourdieu's work was seen as a good fit within this paper because in sociology his work could be a bridge between epistemic differences of the debating scholars. This brings his ideas closer to those of researchers on both sides of the governance debate. Also identified were conceptual similarities between the centre pieces in this framework, namely the action situations in the IAD and NIASES and the focal interactions in the SES frameworks with the fields as Bourdieu envisioned them. Bourdieu also believed that the exercise of power resulted in practice, this too was found to be similar to the idea of policy that is when analysing institutional actions by those with in constitutional power policy is the exercise or the in-exercise of power.

Furthermore, it was felt that introducing this conception of power within the framework would not alter the mathematical integrity of the structure. However, as work progressed it became apparent that it would alter certain theoretical assumptions or choice of functional relationships

should work in modelling proceed. To remedy this a section of the mathematical implications of the introducing power within the framework was planned.

6.2 Summary of findings

By Section 4, in light of the findings of Bourdieu's theories and the explication of those ideas in the Canadian oil sands case it was realized that power was not a singular construction within the framework. Combined with the nested nature of the levels of analysis of the frameworks power would become a field that operates in the society. In this case, it would order the actors, limit the choices each had in the action arena and decisions would be arrived at through repetitive focal interactions within the SES framework and the action situations in the IAD and NIASES frameworks.

Bourdieu also believed that the repeated exercise of power would result in a practice. In doing so power, produces, reproduces and reinforces social phenomenon. However, in considering institutions and at a constitutional level of analysis, power was felt to be historically contingent, asymmetrically devolved and temporally dynamic, as was observed with in the oil sands case. Consequently, Asymmetric Power Distribution (APD) as a conceptual idea was introduced into the conceptual frameworks.

The APD would work in two ways, in one it was a field on which players were organized and in a specific instance of interactions between two players or in a specific sub-system it would result in a practice. For example in oil sands, the power over the land and the exercise of it in the form of oil sands development concentrates power asymmetrically between a few personalities or ministries. Such that the environmental outcome is at best a secondary concern left in the hands of departments that can easily be dissolved or marginalized. The water quality

monitoring stations v/s pace of approvals in the oil sands reason was evidence of such developments.

Thus, until now, through the works of the scholars interested in governance and practice scholars such as Bourdieu, the paper had identified APD and it had identified that the pathway from decisions made by actors in the action situations or focal interactions of the frameworks would be mediated through technology systems to an environmental outcome. This two findings assisted in the realization that actors and governance systems in the SES framework needed to be segregated based on the proximity to the environmental outcome. Thus, two classes of actors and governance systems were created, those that were change-based and those that were discourse-based.

These three conceptions, namely APD, technological systems and classes of actors and governance systems were incorporated into the SES framework, modifying it into the P2PSES framework. This modification in keeping with the blue print provided by Cole *et al.* (2014) was incorporated into the IAD to produce a modified form of the NIASES which was called the P2PIASES.

6.3 Relevance of the findings to the case

The Canadian oil sands case was chosen to illustrate this largely theoretical paper because it is currently an important issue in the global environmental debate due to its greenhouse gas (GHG) emissions close to the Arctic Circle. The permafrost in the Arctic are crucial to the global environmental systems and likewise these regions are also likely to be disproportionately affected by any changes under climate change scenarios.

Juggling the case and interdisciplinary theoretical ideas was a complex task one this paper attempted to do. These were considered to be its key limitations. However, through the case, the paper was able to highlight APD in section 1.1 and section 2.3, when the historically granted and asymmetrically devolved constitutional power, at the constitutional or meta-constitutional level of analysis, were shown to result in the current state of governance in the oil sands region.

In section 3.2, these APDs were shown to tentatively explain the practices being adopted in the region through the exercise of power by those in possession of it. In that, bureaucratic departments with more power were able to create environments for accelerated developments of the oil sands, while departments entrusted with containing the environmental effects were left with few options to sustainably develop resources. The specific ownership patterns also prevent self-organizing systems from forming. Likewise, the competitive global demand for oil puts a strain on the abilities of the system to cope.

Finally, the contestation of decisions at local levels in the hands of people was shown to also be hampered by cases like the Ernst v/s Alberta Energy regulator where, the asymmetric devolution of power and its exercise prevented citizens from challenging unconstitutional decisions made by the regulator. While this case is still being debated in the Supreme Court of Canada, it does illustrate the issues being faced in public participation or public voice in the development of Canadian resources.

Several technological systems have been reviewed by others and comprehensive inventories of the pros and cons of each exist. However, at this point policy makers are yet to come up with the plan to improve and upgrade the technological status of the oil sands operation. A competitive global market and cost savings also prevent the government from having more room to move. This was noticed when instead of cutting emissions, companies paid the fine

under the Specific Gas Emitters Regulation (SGER). The price companies paid was also lesser than the global average or the social cost of producing carbon, as was shown.

6.4 Future directions

While APD and its resultant practices have been the focus of this paper, it is important to acknowledge that the devolution of power will not by itself result in better environmental outcomes. However, attempts to develop better management solutions and deliver better environmental outcomes are likely to benefit from recognizing the specificities of the APD and its associated practices in the system.

Thus, while the IAD, SES and NIASES were developed with the intention of preventing policy makers from falling into the panacea trap, the P2PSES and P2PIASES are likely to assist in a deeper understanding of where this change needs to take place by understanding where the interests of the actors lie and where their strategies are likely to be directed. It also builds a case for being sensitive to the technological environment, which is crucial because technology is used by the actors and they in turn create meaning around them.

The frameworks presented in this paper, while attempting to correct a few limitations of the previous frameworks, also suffers from a few gaps. The most significant gap is in the cursory application of the revised frameworks for the case of oil sands in Canada. This was acknowledged in the introduction and consequently efforts were made to allow the case to illustrate the theoretically complex aspects of the modified frameworks. Further, preventing a more thorough analysis of the case, were time constraints. However, it is felt that if this intellectual endeavour is sound then such a task could be attempted in the future.

The connection between an actor and the meaning he associates with his technological system is also left unelaborated. This knowledge exists in the field of science and technological studies,

but introducing it in this paper would have further complicated an already complex endeavour and distracted from the key messages the modifications hoped to provide. Consequently, this is also an area of omission to be taken up in the future.

A complete mathematical exposition of the APD within the framework was also provided at a cursory level. This main motivation for this section was to show that the inclusion of power did not modify or nullify any mathematical or models that would in the future use the frameworks. The mathematical integrity of the frameworks remained intact.

These omissions compromise the fullness of the proposed frameworks but not its applicability. And thus facets of the system namely, practices, APD, technological pathways, mathematical integrity of the paper are areas where research likely to be undertaken in the future.

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