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SUSTAINABLE DEVELOPMENT OF OIL SANDS AND HOST COMMUNITIES: PRELIMINARY SYSTEM DYNAMICS ASSESSMENT

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Abstract:
The global endowment of heavy oil and bitumen is vast, with recent estimates of approximately 2787.3 billion barrels (bbl) for deposits in place and 333.03 bbl for deposits recoverable. This resources are found in about 70 nations with the largest deposits located in Canada (Alberta), and Venezuela, others deposits in Africa include Nigeria, Angola, and The Democratic Republic of Congo.In Nigeria, the process for development of the Oil Sands (OS) resources located within a belt covering about 120 by 4-6 square kilometer area and extending through four states is gradually advancing with various policy formulation and decision-making activities ongoing. To attain a sustainable development of the OS, policy makers (decision makers) need to take into full consideration the local environmental governance perspective as represented by the host communities in which this resource is located. Since they will be the immediate recipients of the effects of development, appropriate policies that incorporate host community perspective need to be formulated. In this study, a logical framework for implementing sustainable OS and community was developed to capture interactions between local community, policy formulation process and OS development, from the three dimensions of sustainable development. This framework was then applied through System Dynamics methodology to identify cause-and-effect relationships and to project the trends of the identified indicators. A system dynamics model christened “POM-SOS-LC” was attempted to capture interactions between local community, policy formulation process and OS development by modeling OS development and policy formulation process where host community involvement is a major determinant. Future work on this validated model shall comprise simulation over a 50 years period from 2015 considering the four policy scenario options identified in this paper.

Keywords: host community, sustainable development, system dynamics, oil sands, local environmental governance, Nigeria

1. INTRODUCTION:

Currently, world energy consumption is expected to grow by 56% between 2010 and 2040, while fossil fuels are responsible for supplying almost 80% of this world energy use (U.S. EIA, 2013).In addition, world oil demand is estimated to increase by 1.2 million barrels per day (mbpd) in 2014 and by another 1.4 mbpd in2015, according to the US Energy Information Administration's Short-Term Energy Outlook (Oil and Gas Journal, 2013). Of recent, due to challenges in meeting up with current and likely future world oil demand, development of unconventional sources like oil sands and oil shale is on the rise. Oil production from these sources is estimated to be about 1652.6 billion barrels (bbl) hence having a potential to increase world oil reserves (BP, 2012; Brinkhoff, 2013). Recent estimates put world Oil Sands (OS) reserves at approximately 2787.3 bbl for deposits in place and 333.03 bbl for deposits recoverable (Oil Sands Truth, 2014).

Nigeria with an estimated OS reserve of around 43 billion barrels of oil equivalent (Geological Consultancy Unit (GCU), 1980) presently imports bitumen for road construction; and is looking into OS development for a diversified economy and increased earnings. Studies have shown that the exploitation of this resource will be profitable and viable in the long-term for the nation (Ayodele, 2011; Falebita, 2012; Falebita, 2014).However, with the development of this resource comes the challenge of environmental pollution, environmental degradation, and this creates local as well as global problems and poses a threat to all nations at large; and as such issues call for global environmental governance approach (United Nations Environment Programme (UNEP), 2009).

In order to achieve a sustainable development of this resource, the place of environmental politics and governance cannot be overlooked. This concept lays emphasis on an all-round system of management as a means to achieving sustainable development; as the potential for environmental degradation, pollution and problems associated with its development represents an integral part of environmental governance (Biermann, 2004).

The crisis caused by the impact of human activities on nature calls for governance, which include responses by international institutions, governments and citizens, who should tackle this crisis by pooling the experience and knowledge of each of the agents and institutions concerned. OS development no doubt has brought huge economic and social gains to a nation like Canada (Alberta Energy, 2014 a&b; CERI, 2014); although not without its accompanying environmental and community damage (Soderbergh et al, 2007). There is bound to be similar results if not worse in Nigeria with the advent of OS development and exploitation; with the weight of the effects bearing down on surrounding communities as the immediate recipients (Chindo, 2011b). The bottom-up approach for policy formulation and decision making advocated for sustainable development of resources; this is encapsulated in the local perspective to environmental governance (Elliot, 1956).As the legitimacy and effectiveness of policy decisions depends on the local population's participation rate and how well the participants represent that population (Suarez and Poats, 2008).

Keeping the above in view, the politics and dynamics involved in the policy formulation process governing exploration of natural resources and its interplay with local community involvement needs to be looked into hence this study. The study develops a framework and a system dynamics model christened “POM-SOS-LC” geared towards decentralized environmental governance rooted in the local community; for examining the interactions between community and OS exploitation, analyzing effects of OS development on the community, and exploring policy options in order to make appropriate recommendations.

This paper would be of value to researchers and practitioners seeking to promote environmental governance as a practice; equip decision makers in government and industry with a tool to analyse policy alternatives especially with reference to community involvement policy formulation and decision making process; as well as contribute to the environmental politics and governance body of knowledge by demonstrating its application for planning and managing oil sands resource in Nigeria.

This paper is structured as follows: Section 2 discusses OS resource to enumerate the significant influence vis-à-vis its development, environmental and community impacts. Section 3 explains Environmental Politics and Governance (EPG) wherein the endeavor is to establish connectivity between sustainable development and EPG at the local community level. In section 4 the attempt is to first develop a broad framework for sustainable development by using a bottom-up approach followed

by an overall framework targeted at sustainable OS and local community development. Subsequent section argues the methodology adopted resulting in the cause-and-effect relationships and various policy options. Finally, in section 6 conclusions and future scope-of-work are presented.

2. OIL SANDS RESOURCE: DEVELOPMENT, ENVIRONMENTAL AND COMMUNITY IMPACTS

Oil Sand is made up of sand, clay and other minerals, water and bitumen. Bitumen is soluble organic matter derived from degradation of oil either as seeps that come to surface or within shallow subsurface reservoirs and in its natural state is heavy and extremely viscous; hence requires treatment before it can be extracted and used for production of usable fuels such as gasoline and diesel. Globally OS forms about 66 percent of the world's total reserves of heavy oil put at 3,396 bbl of original oil in place, spread across over 70 countries of the world (Meyer, 2007). The largest deposits are found in Canada (Alberta) and Venezuela, other nations comprise, the former Soviet Union, USA., Russia, Cuba, Indonesia, Brazil, Trinidad and Tobago, Jordan, Colombia, Albania, Romania, Spain, Portugal, Argentina; other Sub-Saharan African countries include: Nigeria, Madagascar, Angola, and the Democratic republic of Congo (Wykes and Heywood, 2010; Isaacs, 2011).Of these deposits, the most commercially developed is the Athabasca deposit in Alberta, Canada.Venezuela with 220 bbl of OS reserves and Canada with 168 bbl are leading in terms of world oil reserves, separated only by Saudi Arabia (World Energy Council, 2013 and OPEC, 2014).

The process of extracting/developing OS involves a number of techniques depending on the nature of occurrence of this resource; in terms of the depth at which it is located beneath the earth surface. For shallow depths below 75 meters, usually surface mining is employed as the most efficient method for large OS deposits and this involves the removal or excavation of the bitumen rich sand (overburden); for greater depths in-situ extraction methods are employed through the injection of heat or hot fluids into the deposit to separate the bitumen and make it more fluid (GCU, 1980; Meyer et al, 2007; Isaacs, 2011; Falebita, 2012 and 2014). Surface mining processes are usually accompanied with the generation of tailings; which are made up of sand, clay, water, and a small amount of residual oil (Flash Canada Oil Sands, 2014) and can be used in eventual reclamation processes to backfill the excavated portion (Stosur, et al, 1998).

The extraction processes usually require substantial volumes of water an average of 3.6 barrels and 0.5 barrels of fresh water per barrel of bitumen for surface mining and in-situ techniques respectively (Keith et al, 2013).This therefore generates a lot of strain on the environment and communities in areas where this type of development takes place as seen in the case of Canada; thereby exposing the community to environmental risks such as land, water and air contamination, displacement to mention a few (Wykes and Heywood, 2010).OS resources at varied levels of development in different nations of the world are characterized by varying degrees of environmental and community impacts; some of which are described in Table 1 (WEC, 2007; US EIA, 2011; Oil and Gas Journal, 2013). According to Carter (2010) these activities are responsible for creating degradation of global, regional and local environment. Considering the diverse effects the development of OS resource has on the environment and natural habitats, as well as its implications for communities in which the resources are located; likewise the social and environmental costs implications such as loss of houses due to excavation by surface mining processes in areas where the depth of occurrence of OS is shallow; there is the need for adequate measures to be taken.

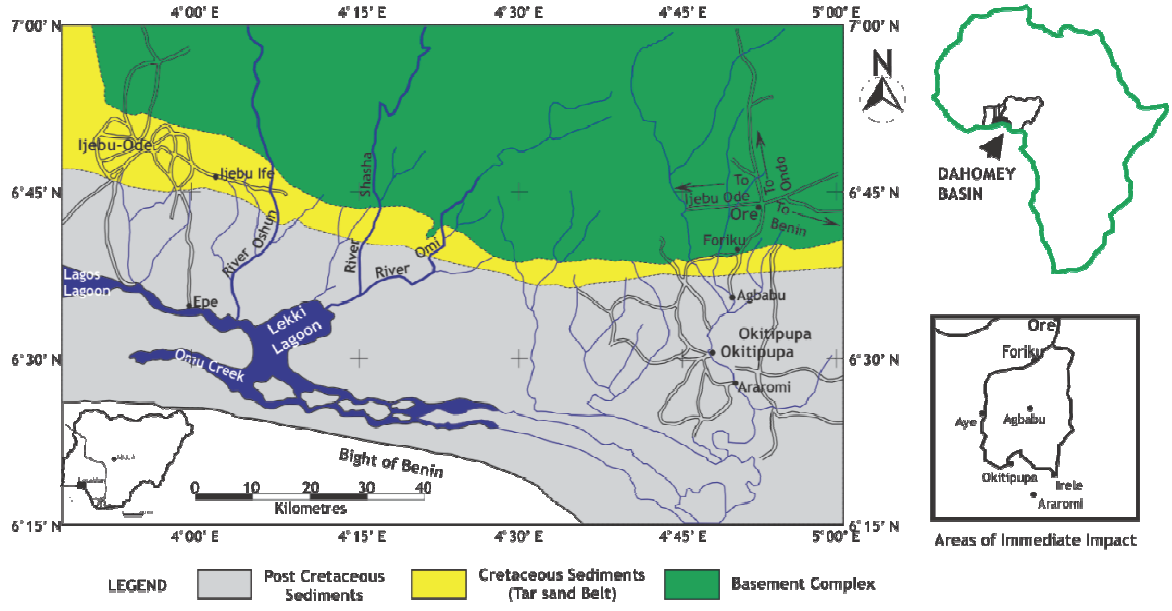
Hydrocarbon resources, of which OS is one, represent a very cardinal source of revenue for the Nigerian government and her economy; as is the case with the conventional crude oil representing about 95% of her foreign earnings. This has however generated huge environmental issues and unrest in the surrounding communities in Niger delta region (Onyeukwu, 2007).

Table 1: Major OS reserves and associated environmental challenges

Country	Estimates of OS reserves	Development Status	Environmental and Community Impacts
Canada	168 bbl[1] of recoverable oil =97% of total reserves, third largest worldwide	Most commercially developed deposit: about 1 mbpd[2]; 4mbpd target for 2020	▪ Cumulative GHG emissions and increased global warming ▪ Water and land pollution from tailings[3], huge water requirements ▪ Disruption of eco-systems and wild life ▪ Associated illnesses in surrounding communities
Venezuela	220 bbl of recoverable oil, presently the largest reserve worldwide =74% of total reserves	Commercial development: Average daily production of 0.6 mbpd; targeted at 2.1 mbpd	▪ GHG emissions and deforestation ▪ Water pollution, generation of solid, liquid and gaseous wastes ▪ Threatened environment and climate, effects on rain forest and local communities
Madagascar	Between 10-25 bbl of recoverable oil from 200 bbl	Production started: 30,000 bpd, projected to reach 280,000 bpd	▪ Potential threat to forests, treasured environmental features and animal species
Nigeria	About 27 bbl of recoverable oil to about 43 billion resource barrels	Developmental stages: not yet commenced exploitation	▪ Potential threat to residents', their settlements and means of livelihood ▪ Environmental degradation
The Republic of Congo	About 2.5 bbl of oil equivalent	Developmental stages	▪ Environmental damage ▪ Potential threat to over 50 percent of rain forest and other natural environment
Egypt	Average value of 64 million barrels of oil equivalent	Completed test projects: daily production at 800 bpd; projected to reach 10,000 bpd	▪ Water, land, and air contamination ▪ Challenge of water supply

[1] bbl= billion barrels; [2] mbpd= million barrels per day;[3]Tailings are created as a result of surface mining activities; they consist of sand, clay, water, and a small amount of residual oil.

Figure 1: Probable oil sands development impact outlook



Source: Modified after Falebita et al., 2014.

Likewise the development of OS resource located within a belt covering about 120 by 4-6 square kilometer area that cuts across four states (Ondo, Edo, Ogun, and Lagos) in the country (GCU, 1980)

has the potential of generating possibly greater environmental issues and impacts on the surrounding communities across the extent of the belt and possibly into the neighboring country the republic of Benin (Figure 1). The first effects and impacts will begin from communities such as Agbabu and Ode-Irele in Ondo State where there are surface shows of bitumen seeps and in which majority of the blocks ear-marked for development and approved licenses are located (Ayoade, 2007; Chindo, 2011a). Associated social and environmental costs of development is bound to weigh heavily on these communities (Figure 1); hence their importance in decisions pertaining to the resource development (Chindo, 2011 a&b; Ojo, 2012; Olatumile, 2012; Chindo, 2015). Furthermore, the non-disclosure agreements between companies and the government; as-well-as weak regulations and poor implementation in Nigeria make the task much more daunt (Chindo, 2015).

Hence such development activities require environmental governance and policy formulation processes involving the local communities for it to be effective and sustainable; as there is increased citizen awareness and expectation to participate in policy decision-making (Pulgar, 2005; Suarez and Poats, 2008). In addition, such policy decisions are very complex, hence can only be met through collaborations of various components and levels of the society such as private sector, individual citizens, civil society among others (Suarez and Poats, 2008; Armenia et al, 2011).

3. SUSTAINABLE DEVELOPMENT AND ENVIRONMENTAL GOVERNANCE: A LOCAL COMMUNITY PERSPECTIVE

The concept of sustainable development has evolved over the years from 'development' (traditional development) (Rowstow, 1960; Streeten et al, 1981; Backhouse, 1991; Harris, 2000) to what is known today and defined as "development which protects the environment, advances social justice; hence meeting the needs of the present without jeopardizing the ability of future generations to meet their needs" (World Commission on Environment and Development, 1987). "A sustainable development process must therefore be democratized, decentralized and pluralistic as stressed by the World Bank's emphasis on social capital, role of state, local government and non-governmental organizations in development" (World Bank, 1997).

It has also been viewed as a social movement advocates sustainable livelihoods, global solidarity, corporate responsibility and globalization from below through inclusion of communities, states, provinces, and regions (Kates, Parris and Leiserowitz, 2005; Brecher, Costello, and Smith, 2000); having its goals enshrined in national, international and nongovernmental institutions, as well as science and technology initiative. It thus represents a huge compromise among various groups such as those concerned with nature and environment, economic development and human conditions; and encompasses open and democratic decision-making (International Council for Science, Initiative 2002; Mabogunje and Kates, 2004; (Kateset al, 2005).

In essence sustainable development allows multi-level participation from local to global and adaptation to tackle different challenges resulting in sustainable cities, livelihoods, agriculture, fishing and so on. It therefore necessitates participation of varied stakeholders and perspectives; representing various local and global efforts to create a positive world (Kateset al, 2005).

3.1 Aspects/systems of sustainable development

It has been identified to comprise three aspects, dimensions or systems (Holmberg, 1992; Reed, 1997):

1. *Economic Sustainable development*: refers to the production of goods and services continually, maintenance of manageable government levels and external debt, and avoid extreme social imbalances that can damage agricultural or industrial production. It essentially defines the maximization of human welfare over time.
2. *Environmental/Ecological Sustainable development*: is defined as a system that maintains a stable resource base, avoids over-exploitation of renewable and depleting non-renewable resources through limits on population and consumption levels, and advocates the sharing of resources among the system sustainably (Common and Perrings, 1992; Harris, 2000).
3. *Social Sustainable development*: is a system with equity in distribution and gender, adequate provision of social services, and political accountability and participation; seen as an integral part of sustainable development as herein formulation of policies for sustainable development

is sought (Holmberg, 1992; Anand et al, 1996; Harris, 2000). It employs the human development approach, thereby emphasizing basic needs and equity.

3.2 Sustainable development indicators and assessment

It is measured by means of indicators which are used to assess its viability and different dimensions of sustainability; indicators therefore are useful in representing complex issues in a simplified form ((Bossell, 1999); Niemeijer and de Groot, 2008).

Development indicator has been defined as a statistical measure that gives a hint to the sustainability of social, environmental and economic development, while sustainable development indicators are pointers or markers for measuring progress made in sustainable growth and development(OECD), 2005; Joint UNECE/Eurostat/OECD Task Force,2013).A number of studies on sustainable development have identified various indicators such as: Per capita gross national product or Gross Domestic Product (GDP), Human development index (combines life expectancy, adult literacy, and school enrollment ratios with per capita GDP); Local organization (through perspective, participatory, democracy; decentralization and social capital) (World Bank, 1997); ozone layer depletion; increased climate change; waste generation; air and freshwater quality; forest and energy resources; biodiversity (United Nations Development programme 1990-1998; OECD, 2001b; European Environment Agency (EEA), 2000;Niemeijer and deGroot, 2008)

These indicators can be categorized into environmental sustainability, ecological, agri-environmental and environmental vulnerability indicators to mention which are used for sustainable development assessment (OECD, 2001b).Methods involving the use of causal chain frameworks and causal networks of environmental indicators have been employed to depict the complexities and interactions among indicators and identify key indicators (EEA, 2000; OECD, 2001b; UNEP, 2002).

These frameworks identify indicators based on driving force: arise from social and economic developments; Pressure: represents stress on the environment from human activities; State: prevalent environmental conditions as a result of human activities; Impact: effects on ecosystems and human health; and Response: reactions by the society to combat or minimize causes of the environmental impacts (Niemeijer and deGroot, 2008). Dinya, 2011 also developed models for sustainable development at strategic levels and for a sustainable micro-region in Northern Hungary.

These methods through the development of frameworks have been employed to identify environmental issues such as climate change, ozone layer depletion, biodiversity and eutrophication and for clearly communicating information to decision makers; thereby providing policy guides and recommended management actions for addressing environmental problems (Hammond et al, 1995; Niemeijer and deGroot, 2008).

3.3 Environmental politics and governance

Governing the planet's rich and diverse natural resources is an increasingly complex challenge, especially in our globalized world of interconnected nations, economies and people. Managing environmental threats, especially those that cross political borders such as air pollution and biodiversity loss will require new global, regional, national and local responses that will involve a wide range of stakeholders (UNEP, 2009).

This has resulted in the concept called Environmental Politics and Governance (EPG) or interchangeable Environmental Governance (EG) which advocates sustainable development in the management of all human activities. It is defined as multi-level (local, national and global) interactions and processes of decision making among major stakeholders; for the control and management of the environment and natural resource through formulation and implementation of policies [IUCN, 2014].

EPG is aimed at achieving sustainable development by entrenching the environment in all levels of decision making through a multi-tier concept involving; global, state and local environmental governance it emphasizes the connection between people and the communities/ecosystems in which they reside (Elliot, 1956; Newell, 2008; IUCN, 2014).Associated environmental effects that EPG include; climate change, GHG emissions, soil deterioration, biodiversity, water use, environmental pollution and disruption of ecosystem; to mention a few (Beeton et al, 2006; McIntyre, 2010; UNEP,

2014). EPG is thus relevant in the 21st century for the translation of technical and scientific knowledge about causes of several environmental problems into politically feasible policy regimes for handling challenges posed by environmental issues (UNEP, 2014).

Good and effective EPG takes into consideration the role of all actors that impact and influence the environment such as governments, private sector, the NGOs, community and civil society; as cooperation among these stakeholders is essential to achieving a more sustainable future. Its structure consists of: assessment of environmental status; international policy development; formulation of Multilateral Environmental Agreements (MEAs); policy implementation and assessment; enforcement and sustainable development (UNEP, 2014).

EPG Multi-Levels

A) Global Environmental Governance
This approach represents an answer to the call for new forms of governance stemming from the increased complexity and diversity of impacts of environmental activities involving multi-lateral management (Elliot, 1956; Biermann, 2004).
Global Environmental Governance (GEG) can thus be defined as a continuous process comprising rules and actions of governance at all levels of human activity spanning from family to international organizations; in tackling global environmental problems arising from development such as global climate change, biodiversity loss, and environmental pollution amongst others (UN Commission on Global Governance (UNCGG), 1995; Rosenau, 2002). The characteristics of GEG include; i) Increased degree of participation of all actors (diversity through inclusion); ii) Increased involvement and cooperation of the private sector (negotiation through partnerships) and iii) Segmentation of policy making into vertical: multi-level, and horizontal: multi-polar governance (complexity through fragmentation) [Gupta, 2005; Biermann, 2004].
B) State Environmental Governance
This refers to the roles and activities of states/nations in EPG through the exertion of political authority vested in these units; it represents the intermediate level of governance; that involves policy making and implementation at national levels for the protection of the environment. As it were, without continuous policy making at national and sub national levels, the concept of global EPG is inconceivable and unachievable (Gupta, 2005; Biermann, 2004).At this level, environmental management is achieved through establishment of committees, development of empowerment strategies and integration of various actors as well as establishment of legislative and executive powers (World Humanity Action Trust (WHAT), 2000; Laime, 2008).
C) Local Environmental Governance
This involves the increased degree of participation by non-state actors such as NGOs activist groups, business associations, policy research institutes, networks of scientists, grassroots or local population and communities (Raustiala, 1997; Betsill and Corell, 2001; Biermann and Bauer, 2004). Advocates of local EPG/EG believe that in order to achieve sustainable development, the local level solutions and initiatives designed by and with the local communities are a necessity; hence an integral part of local EPG is community participation and involvement in environmental governance (Elliot, 1956; Leach at al, 1997; Breecher at el, 2000).

Local EPG plays an important role in giving a voice and power to local communities in the global fight for environmental protection; since at the global level there is marginalization of local communities in decision making. Here, the institutional framework for decision making on the access to, development and use of natural resources takes the community into consideration through decentralization. This level is important in the protection of biodiversity through stakeholder involvement in environment improvement projects; transparent and effective communication; formulation of effective policies for sustainable development of the environment (Pulgar, 2005; Suarez and Poats; 2008; Ioppolo, 2013). Olatumile, (2012) and Chindo, (2015) also justified the inclusion and involvement of local community in policy development for sustainable resource development.

In section 3 we have been able to establish a link between sustainable development and EPG. The fall out is the identification of influences that are of importance at the local community level (factors including fight for environmental protection and establishment of local level solutions and initiatives) and governance (factors including community involvement and decentralization of decision-making).

4. THE FRAMEWORK FOR SUSTAINABLE RESOURCE DEVELOPMENT

From the foregoing, a framework for the implementation of sustainable OS through local community participation is attempted utilizing a modified model for sustainable development Dinya (2011). It comprises the developing of a two level framework.

The first, depicting a broad view of sustainable development (after Dinya, 2011) uses a bottom-up approach. In this first level as at Figure 2a a comprehensive view of sustainable development on a global scale stemming from a sustainable community. It typifies different levels at which sustainable development can be approached, which are at the global (regional), national, and local community level. In this case, it is only the OS local community. Furthermore, since sustainable development is essentially made up of three systems (Economic, Environmental and Social); these are therefore represented as the pillars upon which the sustainable local community sits. From here, the sustainable local community then feeds into the national and global & regional through policies in a bottom-up approach. The Local community in this case represents small towns and localities in which the OS resource is located.

At the second level, from the identified dimensions of sustainability that is the three pillars in Figure 2b; the specific effects (economic, environmental and social) resulting from OS development and associated with each of the pillars are identified. Following which particular indicators related to these effects from the perspective of the three pillars of sustainability, vis-à-vis the surrounding local community are also shown. Herein, the OS local community and sustainable OS development are linked bi-directionally by policy formulation; also, there exists an exogenous national and global economy having a two-way interaction with OS development. Additionally, there exists a bi-directional linkage between the OS local community on one-hand with the three dimensional economic, environmental and social effects on the other hand, as-well-as among these three categories of effects manifested in the pillars (Figure 2b).

Associated indicators for each of the effects are as follows:

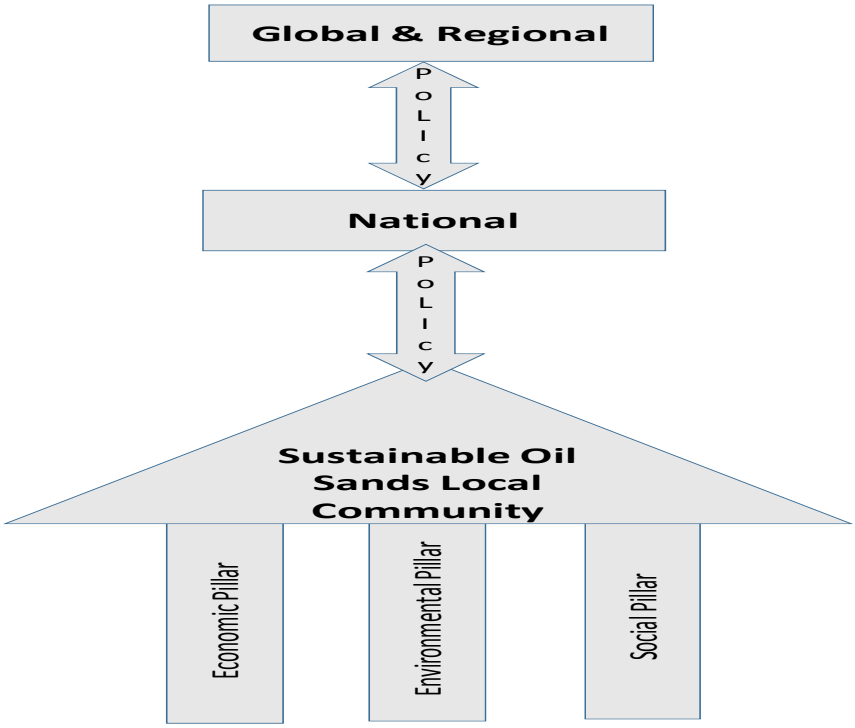
1). *Economic*: Employment; created by OS industry in the community. Education; this is as a result of the desired relevance of the community in the OS industry. Decreased farming and output; stemming from decreased availability of land as a result of land use for OS development.

2). *Environmental*: Water demand; this arises from the competitive use of water for OS extraction and consumption of same by residents of the community. Heavy metal emission; results from OS exploitation activities into the immediate environment of the local OS community Land demand; land use and demand becomes intense due to surface mining and other OS development activities. Greenhouse gases emission; including carbon dioxide, nitrous and Sulphur-oxides will be generated as part of the exploitation process. Waste generation; solid, liquid and gaseous wastes and gangue materials such as tailings are produced from OS activities.

3). *Social*: Displacement/relocation; will occur for parts of the community that sits directly on portion of the OS deposit close to the surface due to excavation from surface mining. Infrastructure; provision of road network, transportation and communication network are associated effects. Safety/security of lives as well as health of community residents is also impacted. Public services; including hospitals, schools, potable water, access to electricity should be made available within the community.

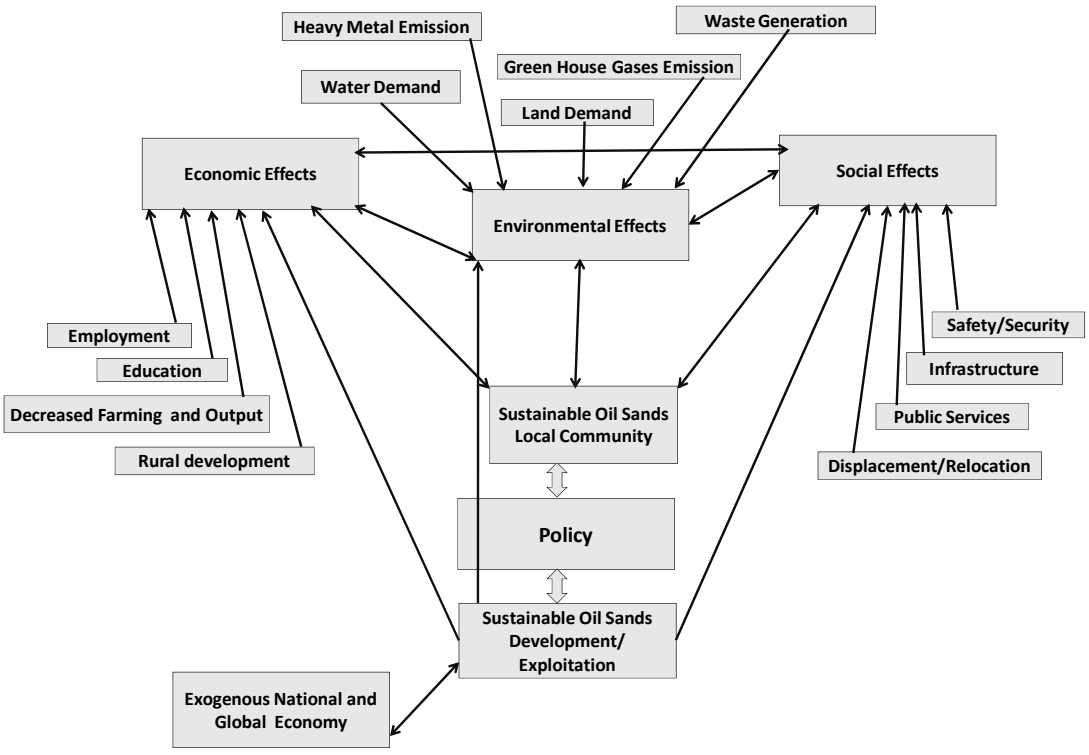
Thereafter, the three-dimensional effects through the OS local community feed into sustainable OS development by means of policy formulation. The two-way process of the OS local community feeding into the policy formulation can take place in form of social interaction forums, town-hall meetings, and stakeholder consultations resulting in widely-accepted agreements and policy documents; eventually expected to culminate in sustainable OS development. Feedbacks from such forums and consultations at different levels have proven useful in prioritizing and reducing the number of indicators as seen in the following examples; Federal Statistical office of Switzerland (FSOS), 2009; Joint UNECE/Eurostat/ OECD Task Force on Measuring Sustainable Development, 2013).

Figure 2a: Broad view of sustainable development: a bottom-up approach



Source: Modified after Dinya, 2011

Figure 2b: overall framework for sustainable oil sands and host community development



The application of this framework is expected to achieve some results presented in following (Table 2) and will be explored using SD models; this however is not presented in this study.

Table 2: Expected outcome of framework application in os development?

Involvement	Results
	Contributory policy making
	A sense of belonging to communities
	Community support and cooperation
	Capturing of community needs and fears in policy process
	Improved public perception
Non-involvement	**Results**
	Lack of cooperation form community
	Social unrest
	Poor community development
	Destruction and vandalization of company facilities and equipments by local/ residents
	Poor public perception due to secrecy in policy formulation
	Uninformed public

5. METHODOLOGY

5.1 System dynamics approach for policy modeling and formulation

System Dynamics (SD) as a methodology is based on the concept of 'systems thinking' which attempts to understand a system by taking into consideration the reverberating effects and interactions of the elements that constitute a system (Forrester, 1961). It rests on the belief that the components represents and determines the behavior of the whole. There exists other approaches for policy modeling such as analytical mathematical models and/or linear econometric model; these however have some challenges for application in public policy context (Forrester, 1961; Armenia, et al, 2011).

As a result of the use of SD over the years for studies in varied sectors including: sustainable development, environmental policy analyses and formulation, applied energy, transport, disaster recovery, water management, tax and transfer policy, as well as public policy science; it has become better suited for depicting and understanding interrelations, behaviour, uncertain environments and exploring policy options compared to other modeling methods.

Examples of such applications are seen in conservation policy analysis by Ford and Bull (1989); effects of energy-environmental policies by Chun-jie (2007); a model for sustainable land use planning and development by Shen et al (2009); governance and policy modeling by Armenia et al (2011); a model for analyzing eco-agriculture system and policy recommendations (Li et al, 2012); energy development policy analysis in Qinghai Province by Yang et al (2013).

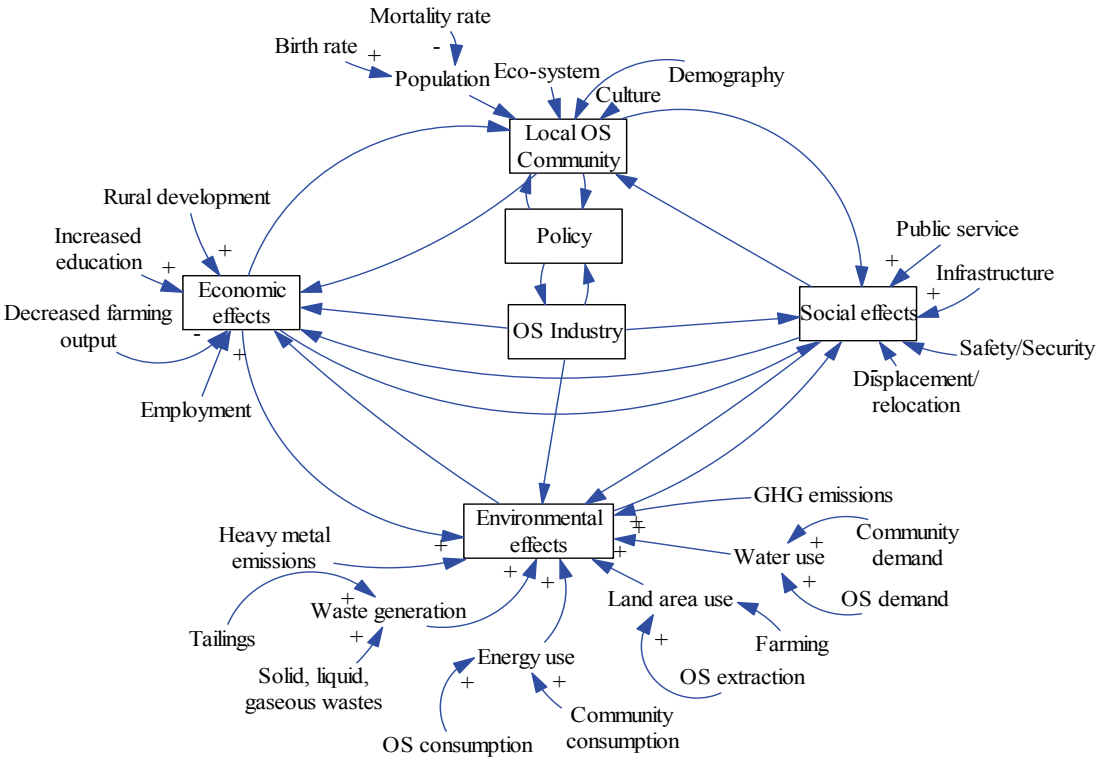
In addition, recently SD has been adopted by a number of researchers to study sustainable development and planning of resources such as land, energy and water (Chun-jie, 2007; Shen et al, 2009; Li et al, 2012; Armenia et al, 2011; Yang et al. 2013). These studies have shown the applicability and usefulness of SD as a tool for modeling the environment and policies governing its development; hence the choice of SD for this study.

5.2 Model description

A system dynamics model christened "POM-SOS-LC" (Policy Model for Sustainable Oil Sands and Local Community) was developed to capture interactions and feedback between policy formulation process and OS development.

This was followed by developing an overall cause-and-effect diagram to capture and address the factors and variables of interest in order to enable the implementation of sustainable development of OS through its interaction with the local community for policy formulation. The cause and effect diagram exhibiting the ongoing interactions in the overall system is shown (**Figure 3**). Here the positive signs (+) indicate a positive effect while negative signs (-) indicate negative effect of one factor on the other.

Figure 3: Cause-and-effect diagram of POM-SOS-LC model



5.3 Policy options

By explicitly modeling OS development, policy formulation, host community involvement and the three-dimensional effects, the following policy options will be explored.

A. *Do nothing-No policy Scenario*: Business as usual case, where OS is not developed at all.
B. Development policy excluding the Community Scenario: Start developing the resource based on policy formulated without the involvement of the host community in the policy formulation process.
*C. Development policy involving the Community Scenario: D*eveloping the resource with the involvement of the host community in the policy formulation process.
D. *Environmental protection policy Scenario*: developing and implementation of policies to ensure environmental protection and preservation in compliance with world standards.

6. CONCLUSION AND FUTURE WORK

The study having established the link between sustainable development and environmental politics and governance also acknowledged the relevance of local community in achieving global sustainable development as-well-as local sustainable OS development.

The study went further to identify the interactions between OS development, the local community and the effects on sustainable development, by developing a framework incorporating the same. Moreover, the study shows the cause and effects relationships among the factors and variable constituting the system.

Future work: Combination of two or more sectors from the Figure 3 model is being calibrated and validated; to test simulations for a period of 50 years from 2015.

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