

## **Governance of Commons and Institutional Reforms- A Case Study of Oil India Limited, Duliajan (Assam) and Commons in Context of Poverty**

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### **Abstract**

[Notes:

Formation Water: The compressions, impressions and the remains of the past zoological era, i.e., the fossil fuels are the mother of generation of hydrocarbons in the earth's sub-surface. Oil, water (H<sub>2</sub>O) and gas remain in the oil bearing strata according to their specific gravity. While producing crude oil, the water that is inherent to the crude oil also comes out along with the crude oil produced. This water is called formation water (produced or connate water) and is highly rich in minerals, hot and highly saline and hence, unsuitable for human use. The formation water is termed as pollutant in the oil field

EPS: In the post-discovery phase, of new oil wells, fluids are pumped directly to the Central Industrial Complex in Duliajan and are called Early Production Centers (EPS)

OCS: Subject to techno-economic viability of EPS, they are convened into Oil Collecting Stations (OCS) that produce oil or natural gas that can be separated, water disposed or and gas flared and/or compressed at an associated Gas Compressor Station (GCS)

Regulators: Pollution Control Boards of the Central and State Governments]

This paper studies the environmental implications of operations of the Oil India Limited (OIL) located at Duliajan in the state of Assam in India. The study, in context of OIL, examines the impact of extraction of crude oil and natural gas on Common Property Resources (CPR) and violation of the core principle of Coase Theorem and associated problems with reference to the Commons. This paper focuses on the issue of governance and a case study of Commons in the context of formation water, seepages and leakages (due to operations of OIL) that contaminates and damages the water bodies including rivers and agricultural land owned collectively by poorer sections of the society with average incomes below \$ 1 (one). This study also evaluates the loss of welfare of the local people living in the peripheral areas of the EPS and OCS due to the damages on Commons that goes uncompensated and the critical reasons behind total absence of its governance by regulators. Therefore, the paper attempts to explore sustainability of the commons, its governance and economic development incorporating stakeholders like marginal and poor farmers, tea tribe workers, regulators, etc. Parameters of Environmental Management System (EMS) of OIL and actual overall institutional governance of Commons by government regulators are examined to explore the possibilities of

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complementing economic development with ecological sustainability. The study critically evaluates absence of governance of Commons by regulators and tries to incorporate the External Costs with the Private Costs (of production) in order to derive a reflective and representative Social Cost of production. Finally, the paper provides policy prescriptions those are necessary conditions for meeting the environmental and social liabilities of the hydrocarbon industry, government regulators and also focuses on traditional management of commons by primitive and/or tribal societies for “the sustainability of the Commons”.

**Keywords:**

1. *OIL*
2. *Commons*
3. *OCS*
4. *Formation water*
5. *Local communities*
6. *Governance*

**THE RESEARCH PROBLEM**

This paper studies the environmental implications of operations of the Oil India Limited (OIL) located at Duliajan in the state of Assam in India. The study, in context of OIL, examines the impact of extraction of crude oil and natural gas on **Common Property Resources (CPR)** and violation of the core principle of **Coase Theorem** and associated problems with reference to the **Commons**. This paper focuses on the issue of governance and a case study of **Commons** in the context of formation water, seepages and leakages (due to operations of OIL) that contaminates and damages the water bodies including rivers and agricultural land owned collectively by poorer sections of the society with average incomes below \$ 1 (one). This study also evaluates the loss of welfare of the local people living in the peripheral areas of the **EPS** and **OCS** due to the damages on **Commons** that goes uncompensated and the critical reasons behind total absence of its governance by regulators. Therefore, the paper attempts to explore sustainability of the commons, its governance and economic development incorporating stakeholders like marginal and poor farmers, tea tribe workers, regulators, etc. Parameters of Environmental Management System (EMS) of OIL and actual overall institutional governance of **Commons** by government regulators are examined to explore the possibilities of complementing economic development with ecological sustainability. The study critically evaluates absence of governance of **Commons** by regulators and tries to incorporate the External Costs with the Private Costs (of production) in order to derive a reflective and representative Social Cost of production. Finally, the paper provides policy prescriptions those are necessary conditions for meeting the environmental and social liabilities of the hydrocarbon industry, government regulators and also focuses on traditional management of commons by primitive and/or tribal societies for “the sustainability of the **Commons**”.

## **METHODOLOGY**

### **I. VARIABLES MEASURED/STUDIED:**

- (1) Total Private Cost (TPC) of production of natural gas and oil by OIL, Duliajan and approximation of the magnitude of negative environmental externalities produced by the OIL, Duliajan during its operations.
- (2) Operational Performance Indicators (OPIs) and Management Performance Indicators (MPIs).
- (3) Response of the people to the activities of the OIL, Duliajan in the following categories was assessed –
  - (a) Employees of OIL.
  - (b) Non-employees indirectly engaged in activities of OIL.
  - (c) Public Stakeholders.

### **II. DATA USED AND COLLECTION METHODS:**

Data on the following was collected for use -

- (1) Total Cost of production of oil and natural gas by OIL, Duliajan (for specific time periods).
- (2) Total production / output of oil and natural gas by OIL, Duliajan (for specific time periods).
- (3) Magnitude of externalities in forms of emission of pollutants associated with exploration and production of fossil fuels like natural gas and mineral oil.  
*Note:* for this specific purpose, the 'Interim Externality Values' as published and enacted by "Ontario's Automobile Feebates"; "Federal Tax on Ozone Depleting Chemicals" as prescribed by the "National Energy Policy Act of 1992" of the U.S. Congress; Denmark's CO<sub>2</sub> Tax Structure (1992) and Sweden's NO<sub>x</sub>, Tax Structure was compared. Besides, the reports of the, Research & Development Department of the OIL, Duliajan and also that of the State Pollution Control Board, was examined.
- (4) For measuring / analyzing MPIs and OPIs, the following data of the OIL, Duliajan was used -

Environmental Policy, legal requirements, objectives and targets, Structure and responsibility, training awareness and competence programmes, communication, operational control, emergency preparedness and response programme, nonconformance and corrective and preventive action, records, EMS Audit, etc.

(5) Response of people (all categories - stakeholders).

The following Methods will be used for collection –

(i) Collection of Secondary Data through –

- a. Environmental Reports on operations of OIL, Duliajan.
- b. Environmental Assessment on operations of OIL, Duliajan.
- c. Management Policy and related official documents of OIL, Duliajan.
- d. Reports of the 'Safety and Environment' department of OIL, Duliajan.
- e. Reports of the State Pollution Control Board (SPCB) on OIL, Duliajan.
- f. Reports of the R & D Department of the OIL, Duliajan.

(ii) Primary Data was collected through interviews of–

- a. Officials of the OIL, Duliajan (especially from the department of Safety and Environment).
- b. Non-officials related to the OIL, Duliajan viz. contractors, social clubs, NGO's, etc.
- c. Other social organizations.
- d. Rural / Urban population (Random Sampling) affected / perceived to be affected by the operations of the OIL, Duliajan.

## **OIL AND ITS OPERATIONS**

Oil India Limited (OIL), is a central government Public Sector Unit (PSU) in India, and is nomenclatured as a *Navaratna*<sup>1</sup> company. OIL has undertaken extensive measures to

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<sup>1</sup> Navaratna is a term taken from the Hindi language and is synonymous with the 9 ratnas (jewels) in the Court of Emperor Akbar, of the Mughal dynasty. Hence, 9 profit making and highly reputed PSUs of the central Government of India are called the Navaratna companies, the others being ONGC, GAIL, BHEL, IOC,

control pollution and other environmental externalities<sup>2</sup>. Oil fields under OIL, Duliajan undergo various stages of production and operation. At the initial stage of operation, geo-physical survey<sup>3</sup> is carried out to establish the probable source of hydrocarbon bearing zones. This process of identifying the formation rocks is tedious and pain staking. This is followed by physically pumped shot holes between 20 to 30 feet in the identified formation rocks, for charging and blasting explosives. The blasts cause waves those are captured in geomagnetic tapes through highly modern and scientific equipments. The captured wave-data are sent to the Geo-physical Data Center at Duliajan where the results are derived. Subsequent to identification of viable hydrocarbon bearing points, drilling areas are released to the Drilling Department. The Drilling Department carries out the physical drilling that could be either vertical straight holes, deviated holes or horizontal holes. In the post drilling phase, further blasting is done for further perforations. In the post-discovery phase of new oil wells, Early Production Stations (EPS) are established from where fluids and gas are pumped to the nearest Oil Collecting Stations (OCS) through pipelines. Subject to techno-economic viability of EPS, they are converted into OCS that produce oil or natural gas that can be separated, water disposed or and gas flared and/or compressed at an associated Gas Compressor Station (GCS). In the post-discovery phase, of new oil wells, fluids are pumped directly to the Central Industrial Complex in Duliajan through establishment of Early Production Stations (EPS). Subject to techno-economic viability of EPS, they are converted into OCS that produce oil or natural gas that can be separated, water disposed or and gas flared and/or compressed at an associated Gas Compressor Station (GCS). There are approximately 16 OCSs managed by OIL Duliajan. They are located in Naharkatiya, Moran and Dikom Fields in Dibrugarh district and Digboi and Hapjan Fields in Tinsukia district of upper Assam. In each of the OCS, a flare pit is constructed in order to flare unused gas and the process continues till the construction of a Gas Compression Station (GCS). The drilling sites have the facility of holding ponds in which spent fluids are discharged. The oil produced from each site is received at the central tank of the industrial complex of Duliajan through a network of pipelines. The Liquid Petroleum Gas (LPG) plant too is located within the area of the industrial complex of Duliajan. The oil storage tanks have a bund as a separator and there exists a surface drainage system that is further connected through separators to a larger drainage system. All the OCS has a surface ground tank for storage of crude oil, surface tank for formation water<sup>4</sup>, phase separator, water treatment equipments, a flare pit for flaring unused gas and

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<sup>2</sup> Loss of welfare to a third party due to economic transaction/activity involving two or more other, parties

<sup>3</sup> The method is as per the theoretical and practical aspects of Applied Geology that is incorporated as 2-Dimension and 3-Dimension surveys

<sup>4</sup> The history of oil formation in the earth's crust dates back to the Jurassic age. The compressions, impressions and the remains of the past zoological era, i.e., the fossil fuels are the mother of generation of hydrocarbons in the earth's sub-surface. Oil, water (H<sub>2</sub>O) and gas remain in the oil bearing strata according to their specific gravity. While producing crude oil, the water that is inherent to the crude oil also comes out along with the crude oil produced. This water is called formation water (produced or connate water)

flare stacks. According to standard environmental practices<sup>5</sup>, absence of, concrete pads under the treatment tanks, drip pans under the valves, strong concrete drainage ditches around the facilities and presence of, stains along the walls of the drainage ditches that leads to overflow of oil to adjacent fields/grounds (especially during the monsoon season), oil stained crops or other forms of vegetation and any further evidence of staining are considered to be lack of control of pollution and related externalities on the part of the producer. Field visits to the various EPS, OCS, GCS and the central storage facilities were made in order to find the status of externalities based on physical verification.

The following field visits<sup>6</sup> were made during the study-

1. NAHARKATIA FIELD
  - OCS 1
  - OCS 2
  - OCS 5
  - Water Injection Station 21
2. MORAN FIELD
  - OCS 1
  - OCS 2
3. DIGBOI FIELD
4. DIKOM FIELD
5. HAPJAN FIELD

## **GENERAL PROBLEMS RELATED TO ENVIRONMENTAL EXTERNALITIES IN THE FIELD**

Formation water<sup>7</sup> as a byproduct is associated with extraction of crude oil in the oil fields and safe disposal of the former presents a prevailing and potential negative environmental externality. It was observed that there exist two methods of disposal of formation water. Disposal wells are constructed into which the water is pumped into. The other way is to pump the disposal water into flare pits and ponds. As per the records of the Geology department of the OIL, the disposal wells constructed with depths ranging from greater than 1000 m to less than 500m depending on the requirement. The potential threat from these disposal wells is “the potential for upward migration of the pumped-in water”<sup>8</sup>. The said formation water, disposed in wells and on up-migrating may adversely affect surface and ground water bodies, vegetation, aquatic life and indirectly the health of the local population. The OIL has a policy of collecting sample water from nearby tube wells/other sources of ground water on monthly basis

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<sup>5</sup> World Bank (1991), “Environmental Assessment Sourcebook-Volume III”

<sup>6</sup> Refer to Maps 1 and 2 in Annexure I for location in the OIL’s operational area

<sup>7</sup> See footnote 4

<sup>8</sup> O’Connor Associates Environment Insurance (1995), “Environmental Study-First Interim Report”, OIL, Duliajan

and is sent to the R & D facilities of OIL in order to carry out hydro-chemical analysis<sup>9</sup>.

According to the reports of the OIL, there was no evidence of ground water contamination. Contrary to the claims of the OIL, local population in and around the OCS in some areas, like the Dikom field, reported<sup>10</sup> contamination of ground water. Observation of the water did present some evidence of contamination in the form of oiliness and a pungent smell in the water. The scope of this study does not undertake hydro-chemical analysis by the researcher as it is outside the ambit of Environmental Economics, except taking reports of hydro-chemical analysis done by competent and recognized agencies as exogenous variables or a given datum. No agency other than the R & D department of OIL had undertaken such an analysis. The records of the State Pollution Control Board (SPCB) located at the district headquarter of Dibrugarh too did not carry out the said analysis. However, the dissatisfaction on the part of the water consumer living in the peripheral areas of Dikom and other oil fields amounts to loss of welfare that goes uncompensated as the OIL does not recognize the contamination of the said water. Therefore presence of environmental externality cannot be ruled out and there is evidence of non-equilibrium in the extraction/production of crude oil as the core principle of the Coase Theorem is violated. The economist, who is credited to bring in the issue of environmental quality into the mainstream of public policies and economics in a specific way, is the first Nobel Prize winner for Economics on Environmental Economics (1991) is Ronald Coase. His widely referred and adopted solution for achieving sustainable development is grant of property rights to either the polluted or the polluters that leads to efficient outcome in terms of reduced pollution. Certain intricacies of the Coase's solution may be outside the ambit of layman's requirements of understanding, but the moot issue is that property rights on environment, be it in the form of rights on our local rivers or ponds that is source of livelihood of many poor people, or the air we breathe and land we use, can provide solution to the environmental problems. In case of right of ownership on any property, law ensures that infringement on that right can invite punitive action against the violator. Environmental optimality cannot be reached as neither the polluted nor the polluter is compensated, especially in the context of the fact that the tube wells producing ground water, perceived to be contaminated by the consumers, are owned by the polluted. Logically this should have led to compensation of the polluted in order to reach environmentally optimality. The contention of the OIL's R & D department should have been readdressed at the facility of some independent agency either by the OIL or the local populace. However, poor social and economic condition of the local people in the Dikom field, mostly belonging to the ex-tea tribe and tea tribe are not in a position to bargain on issues those are very technical in nature. Similar is the situation in the areas of other oil fields, except the fact that the caste and community of the local population is different. In absence of establishment of Gas Compression Stations (GCS), the OCSs are likely to flare large volumes of gas that is

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<sup>9</sup> Obid

<sup>10</sup> Based on Canvassed Questionnaire

produced along with crude oil, into constructed flare pits. According to the Safety and Environment Department (S & E) of the OIL<sup>11</sup> “the base of a flare pit is excavated to a depth of 1.5 m and the pit surrounded by 3 m to 3.6 m high refractory brick walls which cover an area of approximately 20 m by 20 m. On the outside of the walls earthen bunds are constructed to retain excess water that may flow outwards through the walls in the event that the pit becomes full of water. The volume of produced water pumped to the flare pits is not separately metered. It may be possible to determine the volume of water discharged to the pits based on tank dips, assuming that produced water is not pumped to other disposal locations at the same time. To date no regional soil survey reports, which indicate the nature and thickness of surficial soils on which facilities like the flare pits are constructed, are known or available. Of greatest significance would be the thickness, continuity and mineralogy of clay deposits. In addition, the depth to, nature and extent of shallow aquifers are important factors which control environmental impacts due to seepage losses from the flare pits. Published data concerning hydrological conditions appears to be lacking tube well logs in the vicinity of each flare pit should be reviewed. According to the S & E department staff, soil permeability testing is not undertaken at the time of flare pit construction and estimates of potential seepage losses are made. The study did not find any flare pits where the base and sides of the pits compacted or lined in order to control seepage losses. It is suspected that as the water in the flare pit evaporates, the concentration of dissolved solids increases thus adding to the potential consequence of seepage losses”. It is also seen that the OIL does not have in place any mechanism to check/monitor/analyze local water bodies to find potential environmental damages and/or contamination during its operation of extracting/producing crude oil and natural gas. Seepages from flare pits are observed from time to time in the various oil fields. However, lack of monitoring facilities implies that total cost of production of crude oil and natural gas will substantially increase if such facilities are incorporated into the management system of OIL. The current cost of production of crude oil and natural gas hence does not reflect the perceived costs in the context of monitoring and if the case may be, compensating the polluted. Litigation costs, in case the OIL authorities are faced with legal cases in the aforesaid context of seepages and groundwater contamination, too may be very high that in turn can increase the total costs of the operations of OIL. According to the officials of the OIL’s S & E department, monitoring, soil survey, etc. are conducted on the basis of complaints and also periodically and on regular basis. But there are some misgivings on the part of the perceived to be affected as far as ground water contamination and pollution is concerned. The prerequisite condition to make a reflective costing of the production of crude oil and natural gas can be done only if independent and competent/recognized agencies are allowed to carry out soil survey and ground water monitoring along with checking of potential and existing health disorders among the local populace that may be sourced to the

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<sup>11</sup> O’Connor Associates Environment Insurance (1995), “Environmental Study-First Interim Report”, OIL, Duliajan

operations in the oil fields. In this case of operations of OIL inflicting environmental damages can be minimized to a preordained sustainable level, the option for the regulators is to make Environmental Impact Assessment mandatory, prior to establishment of all EPS and/or their subsequent conversion into OCS.

## 5.1 COMMONS:

The operations of OIL have implications and adverse impact on the Common Property Resources (CPR) popularly known as Commons in the literature of study of Commons<sup>12</sup>. Commons are resources those are collectively owned by the local community. The International Association for Study of Commons (IASC) is the single most premier body of international repute and excellence that has pioneered research in the field of Commons. **Commons** or **Common Property Resources (CPR)**<sup>13</sup> covers<sup>14</sup> resources relating to agriculture, fisheries, forest resources, grazing areas, land tenure and use, social organization, water resources, wildlife, information and knowledge commons, global commons, history and also theory and experimental commons. The study, in context of OIL, examines the impact of extraction of crude oil and natural gas on Common Property Resources (CPR) and associated problems with reference to land use, agriculture and water resource and grazing area **Commons**. This chapter focuses on the issue of governance and a case study of **Commons** in the context of formation water<sup>15</sup>, seepages and leakages (due to operations of OIL) that contaminates and damages the water bodies including rivers and agricultural land owned collectively by poorer sections of the society with average incomes below \$ 1 (one). This paper also evaluates critically the total absence of its governance by regulators<sup>16</sup>. Therefore, an attempt is made to explore sustainability of the commons, its governance and economic development incorporating stakeholders like marginal and poor farmers, tea tribe workers, regulators, etc. The study critically evaluates absence of governance of **Commons** by regulators. A case is made for grant of “property rights” to the local community and inhabitants or to the self-government for minimizing overexploitation of the Commons. The critical importance of property rights have been underscored in Hardin’s article on “Tragedy of Commons”<sup>17</sup> where he has laid emphasis on grant of property rights to reduce overexploitation of the Commons or CPR. His argument is that the cost of overuse or degradation of Commons

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<sup>12</sup>The nomenclature was changed from Common Property Resources (CPR) to Commons by the *International Association for the Study of Commons (IASC-[www.iascp.org](http://www.iascp.org))*

<sup>13</sup> CPR is more commonly used in the context of Indian Social Sciences literature

<sup>14</sup> *[www.iascp.org](http://www.iascp.org), Digital Library of Commons, Indiana University, Indiana, USA*

<sup>15</sup> The history of oil formation in the earth’s crust dates back to the Jurassic age. The compressions, impressions and the remains of the past zoological era, i.e., the fossil fuels are the mother of generation of hydrocarbons in the earth’s sub-surface. Oil, water (H<sub>2</sub>O) and gas remain in the oil bearing strata according to their specific gravity. While producing crude oil, the water that is inherent to the crude oil also comes out along with the crude oil produced. This water is called formation water (produced or connate water) and is highly rich in minerals, hot and highly saline and hence, unsuitable for human use. The formation water is termed as pollutant in the oil field

<sup>16</sup> Pollution Control Boards of the Central and State Governments

<sup>17</sup>Hardin, G (1968), “The tragedy of commons,” *Science*, 162

are not borne (mostly, not even partially) and therefore leads to the problem of 'free riders'. In the case of this study, OIL is the 'free rider' as it pays only the monetary compensation to the government or any other owner party for taking over temporary and/or permanent ownership of the area of operation. Moreover, in the context of the rules and/or laws promulgated to conserve the Commons by the State, they are hardly effective at the local institutional levels. These laws are not applicable either due to ignorance of the local community and where the reach of administration is very limited, or due to deliberate flouting of the said laws in order to meet the local community's livelihood and survival needs. Over the years, research<sup>18</sup> has shifted the emphasis from State managed conservation interventions to indigenous and traditional collective management of Commons<sup>19</sup>. The new ideas being generated lays greater emphasis of reverting ownership of Commons to local institutions so that the people at the grassroots develop a cost-benefit framework in relation to the Commons to which they have almost free access and use it abundantly. Pertaining to such ideas and practices, the role of OIL becomes critical as temporary ownership of the areas of extraction are held by it, and the local community practically cannot intervene in the management of Commons, excepting receiving some compensation that is largely within some politically (and strictly temporary) beneficial paradigm. However, traditional management of the Commons is also prone to skeptical outlook<sup>20</sup> as routine sabotage of such institutions by business mafia, quite common in underdeveloped and especially feudal societies, is recorded. These mafias have political patronage at many a times and tactfully take over the overuse and exploitation of the CPR keeping the local community members to camouflage their beneficial relationships. It has been witnessed, as in case of India<sup>21</sup>, even community based organizations providing voluntary welfare and other services have come under the scanner of the government and media vigilance for acting as conduits of smugglers and anti-social marketers. This however, in no way reduces the relevance of the non-market traditional institutions like the *Panchayats*<sup>22</sup> and in fact these institutions can play a vital role in conservation, management and optimal utilization of the Commons.

## 5.2 Commons affected by operations of OIL:

The study<sup>23</sup> reveals that the direct implications of the operations of OIL on the Commons can be found or observed relating to five aspects-

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18 Jodha, N S (1986), "Common property resources and the rural poor in dry regions of India," Economic and Political Weekly, 21(27): 169-181

19 Khatri-Chhetri, Arun (2006), "Local institutions and forest products extraction: evidence from forest management in Nepal", SANDEE working paper no. 16-06

20 Bose, Devashis (2007), "Common Property Resources And Mass Based Organizations: Corporate Liability And Social Activism", Seminar Volume Paper, Margherita College, Margherita (Assam)

21 "Blacklisted NGOs (2007)", Ministry of Finance, Government of India, New Delhi

22 Panchayats are a form of local self-government at the grassroots level covering a cluster of villages or a village or some other rural area and this institution has been accorded Constitutionally recognized status for devolution of power and financial resources by the Panchayati Raj Acts under the 72<sup>nd</sup> and 73<sup>rd</sup> Amendments (the latter for local self-governance in the urban areas) to the Constitution of India

23 based on canvassed questionnaire

1. River Water resources (especially covering the area where the local population is dependent on river water as a source of fishing)
2. Other water bodies like ponds, tanks (from where fishes are sourced, especially during the monsoons)
3. Agricultural Land (collectively owned by the local people and/or the village/tea garden management having issued temporary ownership to tenants)
4. Ground water sources (from where drinking water through tube-wells are sourced by the local population)
5. Ambient air quality

These are the Commons those are directly and adversely affected by the seepage, leakage and subsequent contamination by formation water as well as the sludge from the bund tanks and other storage points of the OCS. The water that is released in the open fields connecting the agricultural lands, grazing places, the locally flowing river and ground water and hence the issue of adverse effects on them becomes a pertinent issue.

In the framework of the aforesaid developments in the study of Commons, the areas covering the OCS and ECS were surveyed during filed study and the results were more or less the same. These areas have been described in details in the first chapter of the thesis. Since the inception of the operations of OIL, especially after the establishment of the OCS, there was a general degradation of the Commons or the CPR. The Naharkatiya and Dikom oilfields of the OIL are dotted by all the aforesaid CPR. The Hapjan and Digboi oilfields do not have river bodies and have comparatively lower inhabitation, than those at the other oilfields. In addition to the CPR indicated above, the Hapjan and Digboi oilfields are covered by reserve forests, that is also a source of livelihood for some of the villagers and/or local inhabitants and communities. Agriculture is the primary source of livelihood of the inhabitants living in the peripheral areas of the Naharkatiya and Digboi oilfields. Employment opportunities in the form of casual labour in the OIL were also a major additional source of livelihood. The local community living in and around the Hapjan and Dikom oilfields, area dependent on employment, both permanent and seasonal, in the large and small tea plantations. However, because of availability of collectively owned (with conferment of temporary ownership by the collective institution) agricultural land and also due to proximity to river, agriculture and fishing continues to be a major source of additional livelihood in the latter areas. It is pertinent to mention that the study found evidences of the adverse effects on Commons due to operations of OIL.

### **5.3 Adverse Effects on River Water Resources:**

'Sesa' and 'Budi Dihing' are the rivers those flow adjacent to the Dikom and Naharkatiya OCSs. There are paddy fields, lower catchments, smaller and large water bodies, a few residential huts, etc. separating the flowing rivers and the OCSs. During the monsoon season, contaminants from the OCS freely flow to the rivers due to over-flooding of the

intervening areas. According to the local inhabitants living in the peripheral areas of the Dikom and Naharkatiya OCSs site the production rate of fresh-water river fish has been adversely affected. As per the older generation of inhabitants, in the pre-establishment period of the OCS, a day long fishing during the fishing season, especially in the post-monsoon period, yielded roughly 6 to 12 kg of smaller and medium sized varieties of puthi, tengra, pabo, godoi, chenga, etc fishes. A discussion with the officials of the state government's fisheries department of the areas studied echoed similar views. Currently, fishing during the same season yields no more than 1 to 2 kg of much lesser varieties during the same season. A very good monsoon at times increases the yield marginally. The fall in yield of fishes from the river Common is a case of negative externality. The root cause of this drastic reduction in yield of fishes, besides other probable exogenous factors<sup>24</sup>, is the operations of OIL that routinely discharges waste into the nearby agricultural fields from where the wastes find their way to rivers through the overflowing water during the monsoon season. The inverse relationship between pollutants entering water bodies and the yield of fishes or any other aquatic living organism is well established in research as well as in practice all over the world. This study found that there is a definite decline in the stock of fish yield over the years and that the fall in the yield has been drastic and sharpened after the establishment of the ECSs and subsequently the OCSs. According to the local inhabitants living in the peripheral areas of these ECS and/or OCS, waste and leakages freely flow into the river when the releases overflows from the nearby fields and find way into the river water. The rivers mentioned are also sources of recreational activities for the local people and visitors. Before the establishment of the OCSs, inhabitants used to take recreational bath, consume river water (though tube-well water is available in their habitations) during day-to-day visits and also by picnic parties. However, over the years, in the post ECS and OCS establishment period, people refrain from taking recreational bath in the river water, especially during those periods when contaminants freely flow into the river. Local people are apprehensive of some kind of adverse health effects due to use of the contaminated river water. During the recent times, local inhabitants or any picnic travelers refrain from consumption of river water out of fear of adverse health effects. The consciousness level of the villagers have improved because of some experiences like sudden discovery of floating dead fishes and other aquatic animals immediately after an accidental spillage of crude oil, sludge, other wastes, etc. into the river water and also periods following major accidents. For example, a major fire broke out in the Dikom oilfield during 2006 that was contained after some global level efforts and the whole affair entailed commercial losses to OIL in some thousand millions of Rupees, death of a couple of OIL's employees, extreme physical damage to the nearby areas, damage to crops and adverse effects of high magnitude to the ambient air quality. Large quantities of dead fishes were observed to be floating in the Sesa River during and immediately after the aforesaid accident.

#### **5.4 Adverse Effects on Other Water Bodies:**

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<sup>24</sup> The fall in the annual fish yield may be also attributed to global or regional pollution and/or other factors, but the fall in magnitude of yield in the other stretches of the rivers has been much lower compared to the stretches near the periphery of the OCSs.

Besides affecting the fish stock during that particular time which is very crucial from the point of view of the mating season during which all kinds of commercial fishing is banned in rivers by the state Fisheries department, the deposits of the wastes also in the extended areas of the river due to normal and abnormal flooding of the nearby fields. With the passage of monsoon and the flooding season, especially during the months of early September of a particular year to late May of the next year, the deposits of wastes remain in the nearby low lying agricultural tracts due to drying up of the patches of land connecting the fields and the river. The deposits remain in two categories of land, one being the low lands where sufficient water remains for a long time allowing some types of small fishes to procreate and/or grow (in adverse conditions created by release of wastes leading to lower procreation and/or growth), and the other being the low catchments of the agricultural fields. These catchments too are hence affected by the waste deposits and the narrow drains used for different agricultural requirements those are location for growth and procreation of very smaller varieties of nutritious and healthy fish stocks. Pollutants from the nearby OCSs freely flow from the sources of wastes during the monsoon due to overflowing water into almost all the nearby agricultural fields. The deposits of these wastes remain embedded in the soil of these fields. It is pertinent to mention that flow of wastes from the OCSs is a perennial phenomenon and hence, even at the end of the monsoon season, the wastes continue to get deposited in the nearby fields though sporadic rainfalls and also due to close proximity of the water bodies. But these wastes or contaminants do not find outlet to the flowing river because the passages of flow dry up completely during the post-monsoon period. The small and large ponds, other water bodies, etc. are sources of food for many local inhabitants, especially those who do not have permanent forms of employment and are so poor that they do not have the resources to purchase highly priced food items like fishes from the market. Moreover, fishing by these inhabitants and also by children of these inhabitants secure recreational value, this is lost due to non-availability of sufficient fish stock in these water bodies. According to the local people of the areas studied, a continuous and fast depletion of fishes in the aforesaid bodies have been witnessed since inception of the ECSs and OCSs. These water bodies used to be rich sources of smaller varieties of nutritious fishes those are unaffordable for the majority of the locals. According to medical practitioners working in the rural areas close by the all the OCSs opined that these fish items were essential part of staple diet of the local people and especially helped growing children, pregnant and lactating mothers and sick people during their stages of convalescence. Due to their poor economic condition, other sources of priced items including medicines for extra-nutrition or enriching hemoglobin<sup>25</sup> are out of reach of these people.

### **5.5 Adverse Effects on Agricultural Land:**

Local inhabitants claim that there has been a definite fall in crop yields over the years and that the fall has been noteworthy after the establishment of the ECS that was subsequently converted into OCS. As the crop grown in these areas is mostly for self-

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<sup>25</sup> The smaller varieties of fishes like singi, magur, godoi, chenga, kuchia, etc. are considered by the medical fraternity to be highly nutritious and helpful in increasing hemoglobin levels and are hence routinely prescribed to patients in states of convalescence by the local medical practitioners

consumption of the growers and is subsistence in nature, commercial and official data recording crop yield for the last many years is not available. However, the local community claims that there has been drastic fall in the quality of crop after the establishment of the EPS and subsequently the OCS. Setting aside the controversy surrounding yields of crop, fish, etc. there is no second opinion on the difference between the wholesomeness of a crop grown in a field that receives continuous deposits of wastes and that of a crop grown in field free of such pollutants. Any counter claim of the OIL bureaucracy that pollutants created by the operations of OIL do not harm crops shall amount to nullify the scientific veracity of the inverse linkages between pollutants of the nature produced while extracting crude oil and natural gas and wholesomeness of crop, fishes and groundwater and/or other resources those fall under the category of Commons, or otherwise. Therefore implications can be drawn that the areas near the OCSs located in the Naharkatiya, Digboi, Moran and Dikom OCS, the CPR are adversely affected due to the negative externalities created by the operations of OIL.

### **5.6 Adverse Impact on Ground Water:**

Wide spread contamination of ground water sources during field study of the various OCSs and EPSs were reported by the local inhabitants and community leaders. Formation water as a byproduct is associated with extraction of crude oil in the oil fields and safe disposal of the former presents a prevailing and potential negative environmental externality. It was observed that there exist two methods of disposal of formation water. Disposal wells are constructed into which the water is pumped into. The other way is to pump the disposal water into flare pits and ponds. As per the records of the Geology department of the OIL, the disposal wells constructed with depths ranging from greater than 1000 m to less than 500m depending on the requirement. The potential threat from these disposal wells is “the potential for upward migration of the pumped-in water”<sup>26</sup>. The said formation water, disposed in wells and on up-migrating may adversely affect surface and ground water bodies, vegetation, aquatic life and indirectly the health of the local population. The OIL has a policy of collecting sample water from nearby tube wells/other sources of ground water on monthly basis and is sent to the R & D facilities of OIL in order to carry out hydro-chemical analysis. According to the reports of the OIL, there was no evidence of ground water contamination. However, as mentioned earlier and contrary to the claims of the OIL, local population in and around the OCS in some areas, like the Dikom field, reported<sup>27</sup> contamination of ground water. Observation of the water did present some evidence of contamination in the form of oiliness and a pungent smell in the water. The scope of this study does not undertake hydro-chemical analysis by the researcher as it is outside the ambit of Environmental Economics, except taking reports of hydro-chemical analysis done by competent and recognized agencies as exogenous variables or a given datum. No agency other than the R & D department of OIL had undertaken such an analysis. The

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<sup>26</sup> O'Connor Associates Environment Insurance (1995), “Environmental Study-First Interim Report”, OIL

<sup>27</sup> Based on Canvassed Questionnaire

records of the State Pollution Control Board (SPCB) located at the district headquarter of Dibrugarh too did not carry out the said analysis. The local medical practitioners reported high incidence of intestinal disorders amongst the people that may be traced to intake of contaminated water along with other factors. But there are no systematic records available with any office or organization to compare the magnitude of intestinal disorders in the period prior to the establishment of the ECSs and OCSs. In this context, it may be inferred that the SPCB can play the determining and active role to analyze the severity of ground water contamination by the operations of OIL and its relation with various kinds of diseases including those of the intestine. After discussion with a large number of stakeholders and taking into consideration of their views, it is perceived that the SPCB in collaboration with research institutions like the local University departments, medical organizations, etc. should have carried out considerable amount of work in this direction. Ground water contamination and its adverse effect on human health or any other form of life is a serious threat to the conservation and sustainability of Commons. Besides, such contamination is a form of violation of human rights.

### **5.7 Adverse Impact on Ambient Air Quality:**

Another problem relating to adverse impact on Commons is gas flaring. Gas flaring from sources of OCS is a normal operation of the OIL and continues round the clock till the depletion of commercially viable crude oil and natural gas stock in that particular area. The problem of gas flaring and its implications on Commons is well recognized and even the World Bank, during the recent past, has taken initiatives to reduce<sup>28</sup> the levels of flaring at the global level. Though the impact of gas flaring is local to global, the extent and severity of such activities on the Commons at the peripheral areas of the source of gas flaring is much higher. The Commons, like the water bodies, farm lands, forests and plantations along with the overall environment, are severely impaired by the effects of gas flaring. Based on the theories of natural sciences the fact could be derived that impact of pollutants at the site of the source of pollution is always higher and severe. This statement is not to underestimate the global impact of such pollution. Rather, it is to highlight the chronological order of the expansion of the effects from such sources of externalities.

### **5.8 Governance of Commons:**

In these contexts, governance of Commons becomes a pertinent issue. The CPCB and its subsidiary, the SPCB are the sole regulatory body authorized to govern the sustainable quality or environmental quality of the Commons. Local inhabitants reported that the officials of the state regulatory bodies have never visited and initiated any measure to check the quality of the Commons, even after the establishment of the EPS and its subsequent conversion into OCS. The local elected Panchayat body also held

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<sup>28</sup> Keynote Speech by Rashad Kaldany, Director Oil, Gas, Mining and Chemicals Dept, World Bank Global Forum on Flaring & Gas Utilization, Paris, December 13th, 2006

similar views. Frequent and regular monitoring of air quality, contamination of water and agricultural bodies, grazing lands, etc. located near any source of pollution, especially highly polluting sources of hydrocarbon industries is not only an international norm, but is also quite routinely done in India in states like Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka and even in underdeveloped states like Orrisa. Cross verification of the records of OIL too confirmed the reports of the local inhabitants and the Panchayat. Therefore, there is total lack of governance of the Commons. In the earlier Chapter on Analysis of Environmental Externalities (Chapter 2), initiation of Environmental Impact Assessment (EIA) has been stressed that could have looked into the issue of creation of negative externalities and adverse impact on Commons could have been pre-estimated or foreseen and preemptive measures could have been taken. However, as EIA was not undertaken by the OIL and as this practice is still not mandatory for strategic industry like Oil in India. Cross-verification of the official records of the SPCB headquartered at Dibrugarh confirmed the veracity of the claims of the local inhabitants and Panchayat pertaining to lack of monitoring and total absence of governance of the Commons and Environmental Quality. Since the inception of the EPSs and/or OCSs at the aforesaid areas of study, the SPCB officials never visited and hence question of checking ambient air quality, contamination of ground and surface water bodies including rivers (if any), agricultural land, etc. does not arise. Absence of governance by the regulatory body SPCB is proof of the passive role played by the SPCB and the CPCB. Their role is limited to control of damages in the post-externality creation scenario. The SPCB becomes hyper-active in case of major accidents those cause grave damages to human life and all other forms of bio-diversity of these areas. The basic issue that comes out of the field study is that there is lack of conservation efforts on the part of the regulatory body and also the local government. Moreover, OIL being a commercial entity, cannot be expected to be take any measure that cuts into its profits by hampering the process of extraction of crude oil and natural gas. The regulatory bodies need to control all the operations of OIL for ensuring sustainability and conservation of the Commons through mandatory adoption of cleaner technology measures by OIL so that the norms of ISO 14000 and all other international standards are met with.

On the basis of the above study, it may be said that the Commons proximate to the EPSs, OCSs and other operational areas, are adversely affected by the operations of OIL. In other words, neither OIL uses the latest clean technology or green technology to ensure mitigation of environmental damages, nor it pays any compensation to internalize the environmental externalities. Due to total absence of governance of the environmental quality and the Commons by the regulators, the External Costs are not incorporated with the Private Costs of production by the OIL. Once again it is revealed that operations of the OIL, Duliajan does not incorporate negative externalities (pertaining to the environment) in its Total Private Costs (TPC) and hence the production function does not exhibit the true Total Social Cost (TSC).

## **6.2 POLICY PRESCRIPTION**

The OIL and its operations are a major source of environmental externalities in the areas of study that is more or less representative. The study carried out in the oilfields found evidences of contamination of **CPR**. In this context, some policy prescriptions may be made so that compatibility between corporate liability and the principles of sustainable development is reached in the context of control of externalities. The study of oilfields and as well as of the central industrial complex, also found some lacunae in the application of EMS. In this context, some policy prescriptions may be made so that compatibility between corporate liability and the principles of sustainable development is reached. The following policy changes may be made with reference to the control of externalities by OIL and application of EMS.

1. OIL must carry out EIA of all the future OCS and GCS. The thrust of the EIA should be essentially to dispel the apprehension of the local populace, the pollution control/prevention regime and all other stakeholders. However, all efforts must be carried out to prevent entry of politically affiliated (officially or otherwise) elements as stakeholders as their motivation and ends do not fit into the sustainability model<sup>29</sup>.
2. There is widespread perception<sup>30</sup> and evidence (as gathered by the researcher) of adverse effects to CPR (groundwater). Therefore it is most urgent to undertake hydro-chemical analysis of the groundwater in the peripheral areas of the oilfields at an independent facility. Institutions like the Indian Council for Medical Research (ICMR), Assam Agricultural University (AAU) those are locally located, or at any other competent institutions must be carried out. If contamination is scientifically proved then the OIL shall have to either use technology that shall prevent such damages to the CPR or facilitate supply of water to the affected local population from treated water supply installations or relocate the people if financially viable.
3. The SPCB seems to be at loss as far as prevention of environmental externalities is concerned. According to the official records, OIL complies with all the environment related laws and are up-to-date. Interestingly, as the newspaper reports suggest, the SPCB officials (especially from the state headquarters) barge into the oilfields and issue press statements regarding criminal non-compliance by OIL. Besides making some news it hardly changes much as the consent and or compliance letters are issued on time that in itself is contradictory to

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<sup>29</sup> Entry of politically affiliated organizations including student unions is a routine affair witnessed in the day-to-day operational problems of OIL. Their motivation and ends are oriented more towards appropriating personal material and/or political gratification than fitting into the model of sustainability. Moreover, these organizations and/or unions do have direct links with certain political parties

<sup>30</sup> The questionnaire canvassed to ranging between 30 to 40 percent population of the rural/tea garden areas surveyed pointed out that almost 90 percent of the sample found the drinking water having lot of oiliness, smelly and attributed intestinal disorders to the operations of OIL

- the claims of SPCB brass. Therefore, it is essential that the SPCB ensures that the consent and compliances are rigorously met and letters are subsequently issued or otherwise, instead of issuing press statements on the one hand and issuing compliance documents to OIL on the other.
4. OIL must take up soil permeability testing during the time of flare pit construction and estimates of potential seepage losses needs to be made.
  5. Estimation of the external costs of production of oil and natural gas needs to be done by securing inspection and survey of the actual amount of seepages, leakages and all other forms of environmental degradation caused by the operations of the OIL (and not as the current practice of official reporting by OIL), by an independent organization with ample expertise and experience in conducting such works. Of course such a measure is not the sole responsibility of OIL. All the stakeholders, regulatory bodies, local governments and research institutions can come together to carry out such an exercise that shall bring out approximate estimates of the external costs. Incorporation of these external costs to the private costs of OIL can ensure sustainability as a voluntary corporate liability.
  6. Although OIL has completed ISO 14000 certifications for 3 (till 2006) important departments and the process have already been initiated for another three, the need to do the same for another 4 departments at the earliest is urgent. The departments of Drilling, Production-Gas, Field Engineering and Materials are all likely to be the producers of negative environmental externalities. Therefore, it is prescribed that ISO certification of all these installations are done at the earliest and the costs thereof incurred are incorporated into the total costs<sup>31</sup> of production.
  7. The OIL management must set time-bound and quantified environmental objectives and/or targets for giving practical shape to its Environmental Policy.
  8. The time allocated for environmental sensitization of OIL employees is not only insufficient; it represents only some kind of lip service. Even if the quality and content of the three and half hours allocated during the 3-day internal training programme is excellent, it may fail to create the atmosphere of seriousness that should be attached to Environmental management.

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<sup>31</sup> OIL calls these raising costs

9. OIL can initiate maintenance of an 'Environment Effects Register' for the purpose of book-keeping the environmental inventory.
10. OIL cannot achieve application of an efficient EMS and meet the needs of sustainable development in absence of EMS Audit. OIL should conduct regular EMS Audit conducted by reputed and competent external agencies.
11. OIL needs to adopt the principles of Eco-efficiency by attempting to progressively reducing ecological impacts and resource intensity throughout the lifecycle of its products, to a level at least in line with earth's carrying capacity. This can be done by adopting the principles of Preventive Environmental Management System (EMS) that is in practice as a voluntary as well as mandatory current management practice in many nations including India.
12. The estimated amounts of Contamination Fee or External Costs (calculated on the basis of this study) ranging between roughly Rs. 7 to more than 8.5 crore needs to be added annually, to the Total Private Costs (TPC) of production of crude oil by the OIL, for internalizing the externalities. These fees may be charged by the SPCB or any other pollution and externalities regulatory and control body. However, internalization of the externalities through payment of compensation and/or contamination fees does not lead to physical abolition or reduction of the environmental externalities.
13. "Property rights" may be granted to the local community and inhabitants (the polluted) or to the self-government for minimizing overexploitation of the Commons can mitigate environmental damages to the Commons.
14. Independent Environmental Externalities and Pollution Regulatory body having the status of High Courts and/or State Election Commissions at the sub-national level, and Supreme Courts and/or Election Commission (of the national level) needs to be established immediately. Such an organization can have a panel of experts drawn from relevant disciplines like environmental sciences and management, natural sciences, engineering, economics and so on and some reference may be made to the reputed Inter-Governmental Panel on Climate Change (IPCC), while drawing experts to the aforesaid regulatory body/bodies. Powers of this organization should be parallel to that of the national level Election Commission or the Supreme or High Courts, where a judgment and/or directives can be subverted by legislations.

15. Governance of Commons should be the responsibility of the SPCB and the CPCB, but needs to be under the direction, control, regulation and scanner of the aforesaid suggested independent regulatory authority.
16. The governments at the state and central levels need to pass legislation making international environmental certification and Environmental Impact Assessment (EIA), in case of the polluting industries, mandatory for ensuring standardization of the environmental norms that may also lead to international trade benefits.

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## BIBLIOGRAPHY

- Andrew & Jackson (1972), Environmental Science, Longman Publications, UK.
- Adhikari, B. (2003), "Property Rights and Natural Resources: Socio-Economic Heterogeneity and Distributional Implications of Common Property Resource Management," Working Paper No. 1-03, Kathmandu, Nepal: South Asian Network for Development and Environmental Economics (SANDEE).
- Agrawal, A (1995), "Dismantling the divide between indigenous and scientific knowledge," *Journal of Development and Change*, 26 (2): 413-434.
- Arnold, J. E. and J. G. Campbell, (1986), "Collective management of hill forests in Nepal: The Community Forestry Development Project," in "Proceedings of the Conference on Common Property Resource Management," April 21-26, Washington DC: National Academic Press.
- Barret, S. (1991) – "Greening the World Economy", Earthscan Publishers, London, UK.
- Bray, D. B., L. Merino-Pérez, P. Negreros-Castillo, G. Segura-Warnholtz, J.M. Torres-Rojo and H. F. M. Vester (2003), "Mexico's community managed forests as a global model for sustainable landscapes," *Journal of Conservation Biology*, 17: 672-677.
- Brown, D., Y. B. Malla, K. Schreckrnberg and O. S. Baginski (2002), *Form Supervising "Subjects" to Supporting "Citizens": Recent Developments in Community Forestry in Asia and Africa*, London, UK: Overseas Development Institution.
- Cavendish, W., (2000), "Empirical Regularities in the Poverty-Environment Relationship of African Rural Household," Working Paper Series 99-21, London: Center for the Study of African Economies.
- Collard, David, Pearce, David & Ulph, David. (1988), "Economic Growth and Sustainable Environments", Macmillan, London, UK.
- Chiang, Alpha C. (1984), "Fundamental Methods of Mathematical Economics", McGraw-Hill Book Co., Singapore.
- Chopra, K., G. Kadekodi and M. Murty (1990), "Participatory development: people and common property resources," *Studies on Economic Development and Planning*, No. 52, Delhi: Delhi Institute of Economic Growth and Sage Publication.
- Coase, R. H., (1960), "The Problem of Social Cost", Journal of Law and Economics, The University of Chicago press, Chicago, USA.
- Gottlieb, Robert (1995) , "Reducing Toxics", Island Publications.
- Gupta, S., N. Urvashi and V. Klaas Vant (2004), *Poverty and the Environment: Exploring the Relationship between Household Incomes, Private Assets, and Natural Assets*, Santa Barbara, USA: Department of Economics, University of California.
- Hardin, G. (1968), "The Tragedy of Commons", *Science*, 162. Harry Freeman *et al* (May, 1992) – "Industrial Pollution Prevention: A Critical Review",

- Journal of Air and Water Management, University of Cincinnati, Pittsburg, USA.
- Jodha, N. S. (1986), "Common property resources and the rural poor in dry regions of India," *Economic and Political Weekly*, 21(27): 169-181.
- Meadows, D. H., *et al.*, (1972), "The Limits to Growth", Universe Books, New York, USA.
- Miller, G. Taylor (1994), "Living in the Environment", Wadsworth Publications, Belmont, CA.
- Mebratu Desta (1998), "Eco-efficiency Indicators and the Sustainable Enterprise", IIIIEE, Lund, Sweden.
- Netherwood, A. (1996), "Environmental Management System", eartscan Publications, London, UK.
- Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press.
- Pigou, Arthur C. (1952), "The Economics of Welfare", Macmillan, London, UK.
- Peter, C., A. Gentry and R. Mendelsohn (1989), "Valuation of an Amazonia Rainforest," *Nature*, 339: 655-656.
- Rogene, Buchholz A. ((1998), "Principles of Environmental Management: The Greening of Business", Prentice Hall, New Jersey, USA.
- Sterner, T. (2003), *Policy Instruments for Environmental and Natural Resource Management*, Washington, DC: Resource for the Future.
- Titenberg, T. (1992), "Environmental and Natural Resource Economics", Oxford University Press, India.
- Koutsoyiannis, A. (1979), "Modern Microeconomics", ELBS, Macmillan Publishers Ltd., Hong Kong.
- Sankar, U. (2001), "Environmental Economics", Oxford University Press, India.
- Sengupta, R., *Ecology and Economics*.
- Wellford, Richard (1996), "Corporate Environmental Management", Stylus Publications, VA, USA.