POLITICAL ECONOMY OF BIOENERGY IN DEVELOPING COUNTRIES: A CASE STUDY OF PUNJAB, INDIA

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DECLARATION

This thesis is submitted to Oxford Brookes University in fulfillment of the requirements of the degree of Doctor of Philosophy. This thesis represents my original work towards this research degree, conducted under the supervision of Prof Pritam Singh and Dr. Sara Le Roux. It contains no material which has been previously submitted for a degree or diploma at this university or any other institution; except where due acknowledgement is made.

I certify that all information sources and literature used are specified in the thesis.

NADIA SINGH

ABSTRACT

Bioenergy projects have been widely promoted across the world since the beginning of the 21st century. These green energy developments are being hailed as a panacea to the energy crisis facing humanity. In the last few years, the global energy sector has been engulfed in a multi-pronged crisis comprising of declining oil reserves, irreversible ecological damage owing to indiscriminate use of fossil fuels as well as widespread energy poverty across many developing countries. Bioenergy imperatives were endorsed as a solution to this multi-dimensional crisis in the global energy sector. It was believed that biofuels would provide an alternative to fossil fuels and also offer a means to solve the issues of energy access and poverty facing many developing countries of the world. A large body of scholars began to promote bioenergy as the "fuel of the future" due to its many desirable properties. However, in recent years a number of sustainability challenges associated with production of bioenergy have emerged. In view of these challenges, it is increasingly uncertain how far bioenergy would provide a sustainable energy alternative. There has been little research on the purported local level benefits of bioenergy projects. This thesis contributes to this critical, yet under researched area by developing an eco-socialist framework to inform sustainable bioenergy imperatives across developing countries.

Eco-socialism combines the key principles of Marxism and Ecology. This paradigm of sustainable development is based on the conglomeration of biological egalitarianism with the ideals of social justice. An eco-socialist framework was employed to evaluate the opportunities and constraints of bioenergy developments through in depth case study research. The case study was located in Punjab, India. The case study was based on participatory field based research, employing multiple methods of investigation. The findings from this research aim to provide theoretical generalisations and serve as an "exemplar" on the conduct of people centric bioenergy policies in developing regions of the world.

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LIST OF ABBREVIATIONS

ARC: Alliance for Religious Conservation

BIAS: Biofuel Environmental Analysis Analytical Framework

CERC: Central Electricity Regulatory Commission

CREST: Chandigarh Renewable Energy and Science and Technology Promotion Society

DLUC: Direct Land Use Change

EROI: Energy Returns on Investment

EU: European Union

FAO: Food and Agricultural Organisation

FDI: Foreign Direct Investment

GBD: Global Burden of Disease

GHG: Greenhouse Gases

GOI: Government of India

GOP: Government of Punjab

HYV: High Yielding Varieties

IADP: International Agricultural Development Programme

IDBI: Inter-American Development Bank

IEA: International Energy Agency

ILUC: Indirect Land Use Change

IMF: International Monetary Fund

IPCC: Intergovernmental Panel on Climate Change

IRRI: International Rice Research Institute

ISSC: International Sustainability and Carbon Certification

LCA: Life Cycle Analysis

LDC: Less Developed Countries

LPG: Liquefied Petroleum Gas

MAF: Million Acre Feet

MASR: Movement against State Repression

MCSM: Morinda Co-operative Sugar Mills

MGNREGA: Mahatma Gandhi National Rural Employment Guarantee Act

MNRE: Ministry of New and Renewable Energy

MPCE: Monthly Per Capita Consumption Expenditure

MSP: Minimum Support Price

MW: Mega Watts

NDP: Net Domestic Price

NEP: New Economic Policy

NFHS: National Family Health Survey

NGO: Non-Government Organisation

NPK: Nitrogen Phosphorus Potassium

NRSEP: New and Renewable Sources of Energy Policy

NSDP: Net State Domestic Price

NSSO: National Sample Survey Organisation

OBC: Other Backward Classes

OECD: The Organisation for Economic Co-operation and Development

PAU: Punjab Agricultural University

PCI: Per Capita Income

PEDA: Punjab Energy Development Agency

PL: Peace for Lunch

POP: Persistent Organic Pollutants

PSERC: Punjab State Electricity Regulation Commission

PSPCL: Punjab State Power Co-operation Limited

PSTCL: Punjab State Co-operation Limited

PUF: Plant Utilisation Factor

RBI: Reserve Bank of India

RSB: Roundtable on Sustainable Biofuels

SAP: Structural Adjustment Programme

SC: Scheduled Caste

ST: Scheduled Tribes

SDG: Sustainable Development Goals

SPV: Solar Photovoltaic

TERI: The Energy and Research Institute

UN: United Nations

UNDP: United Nations Development Programme

USSR: Union of Soviet Socialist Republic WWF:

World Wildlife Fund

VAT: Value Added Tax

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CHAPTER ONE
INTRODUCTION

1.1 Overview of the Research Project

This doctoral thesis presents an in depth case study of bioenergy projects in the region of Punjab, India, using an eco-socialist prism. The basic objective of this work is to advance an understanding of how alternative energy projects are deeply embedded in the political economy structures of a given region. These structures in turn condition the development of bioenergy projects, as well as their outcomes for different socio-economic groups in society. The research demonstrates how the current discourse on bioenergy, based on purely technocratic reforms is extremely limiting. It misses out on critical socio-economic and ecological aspects of sustainable energy development. An alternative framework to understand bioenergy imperatives has been developed in this project. This framework is rooted in an eco-socialist paradigm, and is informed by the four pillars of sustainability viz. social, economic, ecological and institutional, referred to in the literature (Neven et al, 2015). The framework was then used to evaluate the strengths and weaknesses of bioenergy developments in the case study region; and draw out empirical results as well as theoretical generalisations. The introductory chapter lays out an overview of the research project. It provides the context of the study, identifies the research aim and objectives, and elaborates on the methodological tools employed in the research.

1.2 Sustainable Development and Bioenergy Reforms

The word "sustainability" is a multi-faceted concept. The most widely used definition of sustainable development is the one given by Bruntland Commission Report, which says "Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (UN, 1987). The concept of "needs" in this definition refers to the essential needs of the world's poorest people, to which overriding priority should be given (UN, 1987).

Sustainability is a broad idea and is conceptualised differently by different schools of thought. The mainstream "green" capitalist framework views the concept of sustainability in terms of a "weak sustainability" approach (Jacobs, 1991).

According to this approach, intergenerational equity[1] will be maintained, if the overall stock of capital in the economy remains unaltered. This school believes that natural and human capital are essentially substituable. Therefore degradation of natural capital may be overcome by developing human made substitutes and instituting technical and managerial reforms. These technocratic reforms will help to make the growth process greener, and economic growth may continue unabated (Jacobs, 1991). However, other schools like eco-socialism and ecological economics contend that the "weak sustainability" approach does not recognise the "critical" nature of natural resources. Some natural resources such as the ozone layer, biodiversity, clean air and water are essential for both human well being and survival. Therefore sustainablility will be attained if the stock of "critical" natural resources in the economy is left unaltered. Strong sustainability approach requires the recognition of "limits" to the availability of natural resources and propounds that scaling down of economic activities is essential, in order to maintain intergenerational equity in the distribution of natural resources. Most authors of the "strong sustainability" paradigm believe that sustainable development can only be achieved through integration[2] of three pillars: social, economic and environmental (Neven et al, 2015). Within the sustainability paradigm, the conception of "trade offs" in traditional economics has been replaced by interdependency (Neven et al, 2015). It is contended that societal well-being is dependant on economic security, which in turn depends upon the health of the environment and global ecosystem. Environmental protection is thus the "ultimate bottom line" for the continued survival and economic well being of humanity (Jacobs, 1991).

Based on review of literature, a well rounded definition of sustainability has been adopted in the present study, where in sustainability is defined as, "A community's prudent use of natural resources (to minimize the ecological footprint), while taking into account the equitable distribution of these resources, so that the present and future generations can attain a high degree of economic security, while maintaining the integrity of the ecosystem, upon which all life and production depends"

[1] Equitable distribution of resources between the present and future generation.

[2] For a policy to be considered "integrated," three criteria must be met. Firstly the policy design should consider all issues and actors comprehensively. Secondly, policy must be designed from an overall perspective of social, economic and environmental prerogatives. Lastly, different components of the policy design must be in accord with each other (Neven et al, 2015). This definition of "integration" of the three pillars of sustainability has been employed in this thesis.

(Viederman, 1996: 46). This concept has been elaborated and concretized in terms of the three pillars of sustainability:

a) Economic sustainability or economic security refers to the control that individuals and communities have over their lives and the extent to which they are capable of shielding themselves from external shocks. A central tenet of economic sustainability in eco-socialism is the right to sustainable livelihoods for all sections of the community. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base of the economy (Krantz, 2001).

b) Ecological sustainability is maintenance of the health and integrity of the eco-system. Ecological sustainability implies recognition of the "essential" limits to the availability of natural resources in the economy, so that the rate of consumption of natural resources does not outstrip the long-run availability of key natural resources.

c) Social sustainability implies equitable distribution of opportunities and privileges for all members of the community, particularly from the viewpoint of protecting the interests of the most vulnerable and marginalized sections. Social sustainability can be attained through appropriate citizen participation in community decision-making supported by democratic processes, appropriate citizen education and decentralized institutions.

The key tenets in the concept of sustainability are essentially socially constructed in the approach I have followed in this thesis. I have demonstrated that ecological challenges faced by different communities are contextual in nature. Hence, sustainable development requires that the prerogatives of environmental policy, as well as distribution of key natural resources should be decided by the community itself through participatory decision making processes, supported by decentralized institutions. A number of scholars have supported this approach and contended that sustainability is a "socially constructed" concept, which cannot be objectively scientific or universal in nature (Jacobs, 1991; Harris-White, 2007; Daly, 2007). The constructs in defining sustainability, such as "health," "integrity" and "intrinsic value of the ecosystem" are ethical in nature. These principles can be used to inform policy, but cannot be empirically measured (Jacobs, 1991). Sustainability has not been given a testable definition in literature (Harris-White, 2007:92). This is because the science of sustainability is evolving. It is a continuing process, not a fixed target or a "steady state" (Daly, 2007). The environmental constraints that shape human civilization keep changing over time (Pirages, 1996). Therefore, a multifaceted approach is advocated to discuss the question of sustainability, which recognises the social, economic and ecological parameters in society. This approach has been followed in the study.

Sustainable energy has become the cornerstone of the sustainable development discourse, since the beginning of the 21st century. The UN declared 2014-2024 as the "decade of sustainable energy for all" (UN, 2012). Sustainable energy is defined as "energy providing affordable, accessible and reliable energy services that meet the economic, social and environmental needs of society, while recognizing equitable distribution in meeting those needs," (UN, 2012). The focus on sustainable energy development across the world has been primarily motivated by the multi-pronged crisis in the global energy sector comprising of "peak oil" crisis (Murray and King, 2012); increasing ecological damage associated with indiscriminate fossil fuel use (Harvey and Pilgrim, 2011) as well as high degree of political instability across many oil producing countries (Klare, 2008). These energy challenges are particularly profound in developing countries. Developing regions of Asia and Sub-Saharan Africa are home to eighty per cent of the "energy poor" population of the world, without access to modern sources of energy (World Energy Outlook, 2015).

In view of these manifold challenges, there has been a growing pursuit for renewable energy sources in recent years. Of all the renewables, bioenergy was widely hailed as a panacea for global energy challenges, since early 2000 (Dauverge and Neville, 2009). It was presumed that large-scale commercial production of bioenergy would lead to decline in carbon emissions, reduce oil imports, promote energy security among developing nations and reduce energy poverty (HLPE, 2013). These developments were believed to have the potential to incentivise agricultural research, create an additional source of revenue for farmers and develop the necessary inter linkages between the energy and agricultural markets (Schut et al, 2011).

Bioenergy reforms form a part of the larger discourse of "green" capitalist reforms in the world economy. These reforms are based on the twin planks of mainstreaming of renewable energy and development of green markets. It is believed that these reforms provide an ideal pathway for a "transition to a bio-based economy" (Schut et al, 2011: 5116) within the existing structure of capitalist economies. These developments provide technocratic solutions to the energy and ecological challenges facing humanity, while keeping the existing production and consumption structures of the global economy intact (Ponte, 2014). These "green capitalist" reforms have been instituted, within a "weak sustainability" paradigm. This paradigm is rooted in the belief that development is sustainable as long as the overall capital stock in the economy remains unchanged, whether it comes from human or natural capital (Luke, 2006). Thus, ecological degradation can be overcome through sufficient technical progress, managerial reforms and creation of green markets, so that we may be able to assign a market value to environmental goods and services (Friedman, 2008). Green capitalism is rooted in the belief that such forms of "ecological fixing" will ensure that the growth process in the global economy continues unabated, and also minimize ecological degradation (Friedman, 2008).

However, this approach to ecological reforms is limiting as it fails to recognise the inherent "socio-economic embeddedness" of green technical developments (Foster et al, 2010). Within this paradigm, there is little understanding of the inherent inter-linkages between ecological reforms and the larger socio-economic prerogatives of a community (Foster et al, 2010). Evidence shows that bioenergy projects are associated with a number of challenges. These include limited viability (Wang et al, 2012), land use change (Fisher et al, 2002) and competition with food crops leading to heightened food insecurity across many developing countries (Fargione et al, 2008). Sustainability of bioenergy developments remains a contested territory. Currently there is a lack of sufficient empirical evidence on how far bioenergy policies will provide a sustainable solution to energy challenges in developing economies. There is a strong need for research that explores the local level outcomes of bioenergy projects, with respect to its livelihood impacts and fulfilment of energy aspirations of local populations in developing countries (Hunsberger et al, 2014). This work contributes to this critical area in the bioenergy debates.

1.3 Political Economy of Bioenergy Developments: The Focus of the Research

This study aims to contribute to the bioenergy discourse by developing a people-centric approach to evaluate the local level outcomes of bioenergy developments; and analyse how these outcomes are in turn conditioned by regional political economies. The research is rooted in an in depth case study of bioenergy projects in Punjab, India. Punjab is being promoted for a leading role in the bioenergy sector in India and is touted as a "green power" economy (GOI, 2003). However, there has been little research on the sustainability of bioenergy projects in Punjab and their impact on the lives of the people concerned. In this doctoral thesis, I will conduct a multi-level analysis of bioenergy projects in Punjab, going from the policy discourse on bioenergy, the projects being implemented on the ground level and the efficacy of bioenergy developments in meeting the energy aspirations of the local community.

The conceptual framework of the work is located in Eco-socialism. This paradigm represents a conjugation of the Marxian principles of social justice[3], with ecological goals. Eco-socialists believe that humans and the natural environment are mutually dependant on each other (Foster et al, 2010). Hence, ecological reforms should be embedded in the larger development discourse, by taking a "systemic" view of complex policy issues, rather than a narrow technocratic view (Sarkar, 1999). Eco-socialists subscribe to the version of "strong sustainability," based on the recognition that nature provides us with "critical" inputs, which are a pre-requisite for human well-being and survival. They believe that green reforms can only succeed if they are more democratic in nature and responsive to the aspirations of the local populations (Magdoff and Foster, 2010; Singh, 2010). Thus, the formulation of ecological policies must be centred on the considerations of social justice (Sarkar, 1999). These are important considerations in a developing nation like India where the energy policies need to be cognisant of issues of poverty, marginalisation and

[3] Social justice refers to fair and just relationships between individuals and society, defined through equitable distribution of wealth and opportunities within society (UN, 1996). According to UN (1996) the concept of social justice should be extended to the realm of the sustainable development as well, defined by equitable access to natural resources as well as equitable distribution of costs and benefits of protecting the natural environment. The UN (1996) definition of social justice has been used in the thesis.

ecological justice[4] in its policy formulation. In the present study eco-socialism was used to inform a framework of sustainable bioenergy production. This framework was then employed to conduct empirical research on bioenergy developments in the region of Punjab, and propose a way forward.

1.4 Research Aim and Objectives

The overall aim of this research project was to develop an eco-socialist framework to situate bioenergy in the sustainability crisis of developing economies through a systematic analysis of theory followed by the conduct of an in-depth case study of Punjab, India. This research aim was achieved through the following set of objectives:

1) To analyse how bioenergy is being embedded in the fabric of modern capitalist economies as a solution to the global energy crisis on the basis of review of literature.
2) To critically review literature on the development of bioenergy, reflecting on its global development trajectory, nature of bioenergy policies being pursued across major countries, producing biofuels and providing evidence on sustainability of these initiatives
3) To develop a theoretical framework, rooted in the eco-socialist perspective to inform sustainable bioenergy developments in developing regions.
4) To analyse primary data and evaluate the opportunities and constraints of bioenergy projects in the region of Punjab, India.
5) To refine the conceptual framework, in view of insights derived from field research as a part of original contribution to knowledge.

1.5 Methodology

The project was based on an in depth case study of bioenergy projects in Punjab, India. Case studies are considered a useful method of "empirical inquiry on a

[4] Ecological justice is defined as an essential human right to a healthy and safe environment, equitable distribution of natural resources, and access to information and participation in environmental decision making (Bell, 2015).

contemporary phenomenon within its real life context" (Yin, 2008:18). The present case study endeavours to generate insights into the opportunities as well as the limitations of these developments as a sustainable energy initiative. The research aims to build a "web of explanation" and evaluate how local economic, social political and institutional factors locate themselves in the dynamics of bioenergy developments.

Case study research embraces "methodological pluralism" and is compatible with multiple research methods (Yin, 2008). Bioenergy projects were analysed at multiple scales and incorporated the voices of multiple ground level stakeholders in these developments. Policy documents and government survey data were assessed in order to create a macro-picture of the bioenergy sector in Punjab. This data was triangulated with interviews and focus groups with ground level stakeholders. The stakeholders were identified according to the Global Principles for Sustainable Biofuel Production developed by EPFL (2011) and a preliminary investigation of the field. Thirty two semi-structured interviews with key stakeholders in the bioenergy sector were conducted. Four focus group meetings with local rural residents were also undertaken, across two different regions in Punjab in order to gauge the perception of village communities as key stakeholders in Punjab's energy matrix. The data was collected over two rounds of fieldwork in Punjab between 2015-2016.

A growing body of scholars has advocated the use of qualitative methodologies in evaluating the complexities of socio-technical developments such as bioenergy (Paavola, 2008; Sovacool, 2013; Grimson, 2014; Goldsmith and Flanagan, 2017). Such an approach helped me to capture the richness, details and lived experiences of populations impacted by bioenergy developments. The work thus contributes to the growing body of empirical work, which uses a locally grounded, people centric approach to encapsulate the social, economic, political and ecological aspects of renewable energy and does not merely confine the analysis to its verifiable quantitative aspects.

1.6 Proposed Contributions of the Work

This research will help to generate policy insights for the government, the industry as well as research organisations and NGOs in Punjab on the conduct of inclusive green energy policies. The work is a timely contribution to policy because the state government of Punjab is currently developing a multi-pronged platform for sustainable economic development, in view of the UN's 2030 sustainable development agenda (UN, 2016). Renewable energy is one of the key areas in the sustainable development discourse.

The thesis aims to provide theoretical generalisations on the political economy of bioenergy in developing countries and serve as an "exemplar" (Flyvbjerg, 2006) for the conduct of similar studies in other parts of the world. The project aims to contribute to the contextualisation and further the development of eco-socialism. Eco-socialism has so far remained a theoretical paradigm. This research demonstrates how an eco-socialist framework can be used to inform more progressive green energy policies, which are democratic in nature and cognisant of the needs of local populations. This work can provide a starting point, and pave way for further application of eco-Socialist principles in the policy discourse on ecology and energy.

1.7 Thesis Structure

The thesis is divided into eight chapters, including an introduction and a conclusion. The introduction and the conclusion chapters help to present the work as a coherent body of research. The introductory chapter presents an overview of the research and its main aims/objectives. The intermediate chapters have been written to facilitate each of the five key objectives of the thesis. The concluding chapter summarises how the overarching aim of the thesis was achieved systematically through the course of the project.

- **Chapter One** presents an overview of the research project, as well the overarching aim and objectives of the research.

- **Chapter two** presents the main elements of the energy crisis in the global economy. The analysis focuses on the inter-linkages and the relationship between the energy crisis and the overall crisis in capitalist economies. The ecological paradigm in the old style socialist economies is also explored in order to demonstrate how they too had been largely callous towards the environment. The chapter concludes by critically reviewing the reformist agenda of "green capitalism", which is being implemented across the world as a solution to the global energy/ecological crisis.
- **Chapter three** evaluates bioenergy reforms, which are being implemented across the world, as a part of the agenda of "green" capitalism. The first part of the chapter traces out the development trajectory of bioenergy in the global energy market. Following this, the policy discourse on bioenergy across major developed and developing countries is evaluated. The last part of the chapter reviews the sustainability challenges associated with biofuel production, documented in literature.
- **Chapter Four** presents the main theoretical constructs of eco-socialism. It draws out the inter-relationships and contestations between eco-socialism, Marxism and the green perspective. Following this, a framework for sustainable bioenergy production, rooted in eco-socialism is presented.
- **Chapter Five** discusses the methodological framework of the thesis. It puts forth the research paradigm; describes the methodological framework and justifies the various research methods employed. Following this, the details of data management and analysis are presented. The final section of this chapter reflects on the criteria for maintaining quality of the research.
- **Chapter Six** presents the historic overview of Punjab's development model, from the colonial times to the present age. The analysis focuses on the socio-economic and ecological contradictions of an agrarian oriented capitalist development model and its implications for the regional political economy. The chapter concludes by presenting how these contradictions have forced Punjab to move towards a more sustainable development model, with a leading role in the bioenergy sector in recent years, commensurate to the "green" developments in other developing and developed capitalist economies.

- **Chapter Seven** presents the main empirical findings from the research. The bioenergy projects in Punjab are evaluated at three levels: the policy discourse on bioenergy, the commercial bioenergy projects operating at the ground level and the role of bioenergy in the rural household energy matrix. The findings are based on in-depth participatory field based research.
- **Chapter Eight** discusses the larger implications of the empirical findings, and presents them in an eco-socialist paradigm. It lays forth the empirical and the theoretical contributions of the work, and finally presents some directions for further research in the area.

CHAPTER TWO
ENERGY CRISIS: A GLOBAL EVALUATION

2.1 Introduction

Energy has been a pivot of economic development and industrialisation since time immemorial (Smil, 2008). It is believed that there is a linear and positive relationship between the growth of national economies and energy consumption (Brown et al., 2011). The global energy system is primarily based on fossil fuels, which contribute to eighty per cent of the total energy supply in the world economy (IEA, 2016). However, in recent years some major challenges related to the use of fossil fuel energy have emerged. These challenges include the growing mismatch between energy demand and supply in the global economy (Nematollahi et al, 2016), increasing threat of exhaustion of oil reserves (Bettini and Lazaros, 2013) as well as high level of greenhouse gas emissions in the atmosphere (Living Planet Report, 2014).

Some scholars believe that these challenges in the energy sector are intrinsically related to the structure of production and consumption in the global capitalist economy. The capitalist form of economic organisation is based on relentless pursuit of wealth and capital accumulation, in order to achieve higher and higher profits (Foster et al, 2010). This form of economic organisation is highly intensive in the use of natural resources, especially fossil fuels (Foster et al, 2010). The indiscriminate use of natural resources, within capitalist economies has afflicted "harsh and irreversible damage to our natural environment" (World's Scientists Warning to Humanity, 1992).

Despite the introduction of environmental regulations in the last thirty years, many key natural resources such as oil have reached a "tipping point.[5]" There is also growing incidence of air and water pollution, loss in biodiversity, ozone layer depletion and global warming and (Living Planet Report, 2014). Today, ecological

[5] Tipping point" commonly refers to a critical threshold at which a tiny disturbance can alter the state of a system (Lenton et al., 2008).

destruction in capitalist societies has reached such an extent that the very future of humanity is in jeopardy.

This chapter explores the major elements of the energy crisis as well as the inter-relationships between the energy crisis and the overall crisis of capitalism. It will also analyse the ecological/energy paradigm in socialist economies, taking examples from Cuba, Soviet Union and China to illustrate how these old-style socialist economies had been callous towards the environment. The chapter concludes with a critical review of the reformist agenda of "green" capitalism, which is being implemented as a means to make the development process within capitalist economies more sustainable.

2.2 Elements of Crisis in the Global Energy System

The present energy system is faced with four major challenges: peak oil crisis, declining oil reserves, high degree of ecological degradation associated with burning of fossil fuels and extensive energy poverty in developing countries. These challenges are elaborated upon:

2.2.1 "Peak" oil crisis

"Peak" oil refers to the phenomena of destruction of world oil production, after reaching the point of maximum extraction of fossil fuel energy (Doug Craft 2013). Charles King Hubbert first described this phenomenon in 1956. He studied the pattern of domestic oil production in USA and concluded that US oil production would "peak" in 1970s, while world oil production would "peak" between 1995-2000 (Hubbert, 1956). Although Hubbert's initial calculations proved wrong, since then a number of scholars have refined Hubbert's original calculations and postulated that peak oil production would be reached around 2050 (Campbell and Laherre, 1998; Goswami, 2007; Aleklett et al, 2010; Kerr, 2011; Murray and King, 2012; Sorrell et al, 2012; Bettini and Lazaros, 2013). Similar findings have been made by international agencies such as the EU (2009)[6] and IEA (2013)[7]

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6 The European Union Energy Portal calculated the time of exhaustion of oil, gas and coal reserves on the basis of estimates of proven recoverable resources divided by present annual production. The

Thus, it will become increasingly difficult to fulfil high-energy demand of the global economy in the future, considering our dwindling oil supplies. The current trends in global energy supply and consumption suggest that our "energy system is at crossroads" (IEA, 2008:14). The "peak" oil crisis will have severe ramifications for the global economy. It will first impact the oil sector and then the effects will spill over across all the major sectors of the macro economy through global supply chains, similar to what transpired during the global financial crisis of 2008/9 (Lutz et al., 2012).

2.2.2 Lack of new oil fields and monopoly control of oil reserves

The "peak oil" crisis is compounded by the fact that since early 2005 crude oil production has become increasingly inelastic and is unable to keep pace with the growing demand (Nematollahi et al, 2016). No significant oil discoveries have been made in the last two decades to keep up with the rising demand of oil (Klare, 2008). All OPEC countries are operating beyond their production peaks (Simmons, 2006), while the world's largest oil fields in the Middle East, North America and South America are declining rapidly (IEA, 2016).

More than eighty per cent of the global oil reserves are concentrated in only ten countries of the world (Table 2.1 below). Many of these regions are plagued with high degree of political instability and conflicts (Sakr and Abo Sena, 2017). As a result, western companies are finding it increasingly difficult to operate in these regions (Klare, 2008). Whenever there is a geo-political conflict in any of these countries, it manifests in worldwide escalation of oil prices and shortages due to these countries' monopoly control over oil. In view of these factors, the global energy system has been described as a "system under stress" (IEA, 2014 b).

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estimates showed that oil reserves will be exhausted by 2047, gas reserves by 2068 and coal by 2144 (EU, 2009).

[7] In 2012 the IEA estimated that the existing oil reserves would only be able to sustain production capacity for another 45 years if energy demand continues to rise at the same pace (IEA, 2013).

Table 2.1: Distribution of global oil reserves, 2015		
Country	Oil Reserves (billions barrels)	% Of world Total
Venezuela	300.9	17.7
Saudi Arabia	267	15.7
Canada	172.2	10.1
Iran	157.8	9.3
Iraq	143.1	8.4
Russia	102.4	6
Kuwait	101.5	5.8
UAE	92.1	5.5
Libya	48.4	2.8
Nigeria	37.1	2.2
Total	1422.5	83.5
Source: Adapted from BP (2016)		

2.2.3 High ecological costs of fossil fuel use

Fossil fuels are now recognised as the primary sources of air pollution and global climate change. "Carbon from burning of fossil fuels has been the dominant component of humanity's ecological crisis for more than half a century and remains unabated" (Living Planet Report, 2014:17). Brown et al (2011) conducted an empirical study to assess the ecological costs of fossil fuel driven economic growth. They analysed IEA data for 200 countries over a time span of 24 years and showed that ecological footprint increases progressively with economic growth. The study concluded, "It is not possible to increase the production of socially desirable goods on the basis of fossil fuel use, without a significant negative environmental impact" (Brown et al, 2011:25). Some studies have shown that the carbon emissions from the use of fossil fuels have reached a "tipping point" and now exceed the absorption capacity of the biosphere. This is leading to the accumulation of a growing "carbon debt[8]" in the atmosphere (Yuwan and Xuemei, 2017; Rockstrom et al, 2009; Lenton et al, 2008; Steffan et al, 2007), and would have drastic consequences in the future in terms of climate change, loss of biodiversity and changes to the nitrogen cycle (Rockstrom et al, 2009)

The negative impact of fossil fuel use has been felt since long. Crutzen (2002:22) coined the term *Anthropocene* to denote the period coinciding with the beginning of

[8] Carbon debt refers to the overuse of carbon dioxide absorption capacity of world's oceans, vegetation and soil.

the Industrial Revolution. He contends that this period marks the beginning of severe human-induced changes in the atmosphere (Crutzen, 2002:22). The earliest incident of large scale pollution due to fossil fuel use was documented in 1700, when there were instances of widespread air pollution in Britain, as smoke from factories resulted in spread of noxious pollutants in the atmosphere (Commoner, 1968). Over the years, the continuous air pollution in Britain manifested itself in the tragic incident of the *Great London Smog*, resulting in deaths of over 4000 people (Commoner, 1968). This tragedy was attributed to the release of excessive sulphur dioxide in the atmosphere due to the burning of coal and fuel oil (Commoner, 1968).

The threat of fossil fuel induced climate change has become even more profound in recent years. The IPCC (2001:72) issued a warning stating that there is strong evidence that emissions from industrial production would lead to significant climate change if there were no significant reductions in carbon dioxide emissions. GHG emissions need to be stabilised and reduced by sixty-eighty per cent in order to prevent the detrimental effects of climate changes (Metz et al, 2000).

Some negative impacts of high level of carbon emissions are already being felt. There has been increased frequency of extreme events like droughts, floods and storms in recent years (IPCC, 2001; Erb et al, 2008; Singh, 2015). Indiscriminate use of fossil fuels has also caused irreversible damage to marine ecosystems. One third of the carbon content released by burning of fossil fuels ends up in seawater. This has altered the PH levels of seawater and threatened the survival of a large number of marine organisms like corals (Dooney, 2006). Some scientists have also contended that global warming due to fossil fuel use may have drastic consequences for productivity of major food crops, leading to lower yields and widespread crop failures (Lobell and Gourdji, 2012). Lobell et al (2011) conducted a comprehensive study that compared the global temperature trends with global productivity trends of wheat crop between 1980-2008 and concluded that climate change was responsible for a 3.8 per cent decline in productivity of wheat. Their research also predicted that by 2030 this decline in productivity would reach seven per cent.

2.2.4 Energy crisis and emerging economies

Energy challenges are particularly profound in emerging nations. These countries are highly susceptible to risks associated with global climate change, in terms of incidents of catastrophic natural events as well as the number of deaths and losses in national income due to these natural disasters (Kreft et al, 2016). According to the Global Climate Risk Index, out of the ten countries most vulnerable to climate change, nine are LDCs and only one; Thailand is an upper middle economy (Table 2.2)

Table 2.2: Countries most susceptible to climate change risk

Climate Risk Index (CRI) Rank	Country	CRI score	Death toll	Deaths per 100 000 inhabitants	Total losses in million US$ PPP	Losses per unit GDP %	Number of events (total 1995–2014)
1	**Honduras**	11.3	301.90	4.36	568.0	2.1	73
2	**Myanmar**	14.1	7 145.8	14.71	1 300.7	0.7	41
3	**Haiti**	18.1	253.2	2.71	221.9	1.4	63
4	**Nicaragua**	21.3	861.5	1	2 761.5	0.6	283
5	**Philippines**	19.1	162.9	2.94	234.7	1.9	44
6	**Bangladesh**	25	679.0	0.48	2283.3	0.7	185
7	**Pakistan**	31.3	339.7	0.41	2119.3	0.6	206
8	**Vietnam**	30.5	504.7	0.32	3 823.1	0.6	133
9	**Guatemala**	34.8	140	0.22	7 574.6	1.0	136
10	**Thailand**	33.8	97.2	0.75	401.5	0.4	75

Source: Adapted from (Kreft et al, 2016:7)

Fossil fuels are the dominant part of the energy matrix across most developing nations (IEA, 2016). As a result, these countries are experiencing very high level of pollution. As per the latest available data, China and India are the second and fourth largest emitters of carbon in the atmosphere (IEA, 2016). Also, many emerging countries are highly dependent on energy imports and therefore, are very vulnerable to fluctuations in international oil markets (HLPE, 2013).

Energy poverty is endemic to developing regions of the world. It is defined as the lack of access to adequate, affordable, reliable and environmentally friendly energy services to support economic and human development (Sovacool, 2013:273). As per the latest available data, close to 1.2 billion people across developing countries live "off the grid" and do not have access to modern sources of energy. Eighty per cent of the "energy poor" people live in rural areas of developing countries (IEA, 2016). As Table 2.3 below shows that the energy poor population is largely concentrated in developing regions of the world such as Sub-Saharan Africa and South Asia.

Table 2.3: Percentage of the energy poor in the world population, 2015

	% Population without access to electricity	% Population relying on traditional biomass
Sub Saharan Africa	53.4	32
China	0	16.5
India	20.5	29.8
Other South Asia	43.17	68.3
Latin America	2.2	2.3

Source: Own calculations compiled on the basis of IEA (2016)

The developed world has gone through two energy transitions from wood to coal and from coal to oil. However, most of the world's poor in developing countries continue to depend on carbon containing compounds: biomass, animal dung and plant material for their energy returns (Williams, 2010:64). Lack of access to energy has many detrimental effects. Poverty and energy deprivation are intimately related. A global assessment on energy poverty revealed that 20-30 per cent of the annual income of poor households is spent on fuels. The poor on an average spent eight times more for the same unit of energy, than other groups in society (Sovacool, 2013). Reliance on traditional biomass is also associated with negative environmental repercussions in terms of deforestation, denudation of the vegetable cover and land/soil degradation (Srivastava et al, 2012).

Energy poverty also has serious health consequences. Biomass combustion releases a cocktail of noxious substances such as particulate matter, carbon monoxide and nitrous oxide into the air (Khandelwal et al, 2017). It is responsible for 1.45 million premature deaths each year across the world. A majority of these are young children. Mortality levels due to biomass combustion are currently higher than deaths due to malaria and tuberculosis combined (GBD, 2015). Thus, energy poverty is one of the most serious human development challenges facing humanity today. The energy poor population in developing regions is exposed to manifold health and ecological vulnerabilities, which has a debilitating effect on the population as a whole (GBD, 2015).

This section elucidated on the multiple challenges facing the global energy system. While, fossil fuels are becoming increasingly scarce and more difficult to extract; indiscriminate use of fossil fuels over the years has led to irreversible damage to our natural ecosystem. These challenges have been further compounded by the high degree of energy poverty and lack of access to modern energy in a number of developing economies.

2.3 Energy Crisis as a Part of the Overall Crisis of the Capitalist System

The energy crisis has its roots in the deep-seated contestations in the global capitalist system, which "hit a wall" in 2008. This crisis revealed that the capitalist model of growth is both economically and ecologically unsustainable (Friedman, 2008). In 2008, the global capitalist economy was besieged by a multi-pronged crisis, which began with the sub- prime mortgage crisis in 2006 (Singh, 2011). The financial crisis in USA spread to other countries due to the close integration of the world economy and resulted in a slow-down of world economic growth (Harris, 2014).

At the same time, the world economy was also plagued by shortage of food and energy supplies and rising food/oil price inflation. The energy crisis commenced with severe supply side shortages in the energy markets due to political crisis in the Middle East (Klare, 2008: 227). Increasing oil prices led USA and other countries to invest heavily in bioenergy sources (Tienhaara, 2014). This resulted in large-scale diversion of agricultural land for the production of biofuels across many countries (Rogers, 2010). As a result food supplies began to dwindle, leading to severe food price inflation. Global food prices peaked by 130 per cent between 2002-2008 (Rogers, 2010). Seventy five per cent of this rise in prices has been attributed to the expansion of biofuels (World Bank, 2008). This massive food price inflation triggered food shortages and food riots across many developing countries (Rogers, 2010). These food riots began in Mexico in 2008 and spread to thirty other countries including Egypt, Somalia, Cuba, Indonesia, Thailand, Vietnam, Cameroon and Haiti (Finfrock and Wong, 2009).

The other major element of the food and energy crisis was the spatial shift in world capitalism, owing to the high economic growth of emerging economies, particularly India and China (Singh, 2011). It has been estimated that by the year 2050 India and China will account for 40 per cent of the world output in terms of purchasing power parity (UNDP, 2013). The rapid economic growth and growing consumption needs in these fast-growing developing economies has put immense pressure on the existing resource base of the global economy and is imposing “ecological limits” to further growth of the capitalist system (Singh, 2011). The current rate of growth of Chinese economy is roughly ten times more than that of England during the Industrial Revolution (World Bank, 2012:141). Due to the massive size and population of these economies, even a marginal rise in the income of these countries in the future will lead to a very high impact on aggregate demand and consumption of global natural resources, especially fossil fuels (Singh, 2011). UNDP (2013) has estimated that by 2025 annual consumption in emerging market economies will amount to $30 trillion a year. According to estimates of the IEA (2010b), primary energy demand will rise by 33 per cent between 2010-2030. The main drivers of this increase in demand for primary energy will be India and China, as their per capita energy consumption will gradually converge to that of the developed world (IEA, 2010 b). Countries like India and China also continue to suffer from high levels of inequity and poverty. These problems have manifested in massive energy poverty and further compounded the energy challenges facing the world.

This analysis demonstrates that the global economy today is in a perilous situation with multiple crises in the food, energy and financial sectors. The three on going crises are closely linked and feed on each other because of the very nature of the world capitalist system. This system is “one integral whole” with close links in the agricultural, energy and financial sectors (Singh, 2008a: 36). The multiple crises are reinforcing each other and have put the entire system in turmoil.

2.4 Explanation for the Crisis: Capitalism as a Threat to the Natural Resource Base of the World Economy

The current crisis is a revelation of the disjunction between demands placed on the modern economy and the ability of the environment to meet those needs (Singh, 2009:117). Capitalist accumulation and expansion over the years have turned nature into a source of human greed and resulted in the creation of a mounting “ecological debt.” This implies that the existing stock of natural resources and the assimilative capacity of the environment are unable to keep pace with the rate at which natural resources are being used in the global economy (Foster et al, 2010).

The rapid growth process in the global economy has resulted in a looming threat of exhaustion of key natural resource, especially fossil fuels. Marco Lambertini, the director general of WWF International stated in this context, “We are using nature’s gifts as if we have more than one earth at our disposal. By taking more from our ecosystems and natural processes than can be replenished, we are jeopardising our own future” (Living Planet Report, 2014). The depletion of key natural resources continues at an unabated rate across many capitalist countries. For instance, according to the Inter Government Panel of Climate Change, the amounts of GHG gases in the atmosphere have attained catastrophic levels today and are 350 per cent higher than the pre-industrial levels (IPCC, 2014).

This crisis has revealed that the capitalist mode of production, which is based on the twin planks of private enterprise and production for profits is essentially incompatible with environmental goals (Sweezey, 1989). This is because capitalism as an economic system requires perpetual growth in every economic sphere. This in turn requires ever increasing supply of natural resources. In this process, nature has been “commodified” as an input in the process of production.

In order to reduce ecological degradation, a number of capitalist economies have imposed environmental regulations in the form of pollution taxes, subsidies for pollution abatement, tradable permits and environmental standards in recent years. However, these regulations have not been able to adequately compete with the logic of growth inherent in capitalism. These have been largely been captured by capitalist interests (Vlachou, 2005). This is reflected by the fact that while many large corporations have invested in green initiatives in recent years, they also continue to flout environmental norms. For instance GE was accused of dumping huge quantities of toxic waste in Hudson river in 2008 (Harris, 2010). Kovel (2002) analysed the Bhopal Gas Tragedy and showed how Union Carbide systematically dismantled labour and environmental regulations in view of declining share values in the months preceding the tragedy. In 2015, it became known that Volkswagen had been cheating on emission tests for diesel engines between the years 2009-2015. This resulted in on-road emissions vastly exceeding the legal standard for nitrogen oxide in Europe and US (Oldenkamp et al, 2016). Oldekamp et al (2016) estimated that 526 tonnes of additional nitrogen oxide emissions were released as a result of this scandal. They assessed that these fraudulent emissions are associated with 45 thousand disability-adjusted life years[9] and a value of life lost equivalent to 39 billion US dollars. The authors estimated that this amount is 5.3 larger than the 7.3 billion US dollars Volkswagen group has been asked to pay in compensation (Oldenkamp et al, 2016). These examples illustrate how market forces can potentially increase the likelihood of environmental and social problems in capitalist economies. In this context, in the present case study research (in Chapter 7) it will be instructive to see whether regulations in bioenergy projects have been captured by the inherent logic of growth in capitalist economies, or whether these bioenergy regulations have been able to reconcile growth with the larger agenda of sustainability.

The contradictions within capitalism are a serious threat to the long-run sustainability of the capitalist world economy (Alverty, 2007). The next two sections will elaborate on this point, by analysing the ecological paradigm in pre-capitalist societies and how this paradigm was fundamentally altered with the advent of capitalism.

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[9] Disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill health, disability or early death (Oldenkamp et al, 2016).

2.4.1 The environmental paradigm in pre capitalist societies

Ecological destruction, induced by human actions was prevalent even in pre capitalist societies (Tainter, 2000). For instance many ancient civilizations such as Mayans, Sumerians and Romans practiced unsustainable "slash and burn" agriculture, leading to widespread land degradation (Diamond, 2005). In feudal Europe overgrazing of commons was partly responsible for recurrent famines (Tainter, 2000).

The pre-capitalist societies were vulnerable to regional environmental degradation, as a result of human intervention aimed at extracting a surplus that was larger than required for maintaining sustainability (Singh, 2009:131). However, a fundamental difference between the ecological degradation within pre-capitalist societies and the current ecological crisis encountering capitalist economies is that even the largest of the destructive processes in pre-capitalist societies remained rare and regional (Sweezey, 1989: 3-4). For the most part, pre-capitalist societies treated nature with respect bordering on reverence (Singh, 2009: 45). In contrast to the modern capitalist societies, these pre capitalist societies gave emphasis to the maintenance of the conditions of production and living in harmony with nature (Singh, 2009:44). They adopted technological processes such as varietal improvements of seeds over successive generations through experimentation, periodic fallowing of land to regenerate soil fertility, not hunting during mating and calving periods, marking off areas of a hunt and not returning to it for a specific time period (Tainter, 2000 and Diamond, 2005). These practices allowed the natural habitat to recover and recoup so that production processes may continue over a period of time (Singh, 2009:45).

Marx gave a detailed treatise on how in comparison with the modern capitalist societies; pre-capitalist societies were much more in harmony with the natural environment. He investigated the relationship between humans and their natural environment through the course of history and contrasted the modes of production in pre capitalist societies and capitalist societies (Marx, 1962:53). He argued that in pre-capitalist societies, the extent of exploitation of the environment was very small as compared to the modern capitalist societies. Unlike modern capitalist societies, these societies recognised the intrinsic importance of nature and treated it with reverence.

2.4.2 The advent of capitalism and transformation of the environmental paradigm

The advent of capitalism brought about a radical transformation in the relationship of humans with their natural environment. This system resulted in a shift from agriculture to industry, as the main stay of economic development (Singh, 2009). This was accompanied by sweeping changes in the techniques and the scale of production. On one hand, fossil fuels replaced bioenergy sources and on the other hand human labour was replaced by machinery (Foster, 2000:118).

Prior to the industrial revolution the most commonly used forms of energy comprised of solid biofuels like wood and charcoal, as well as liquid biofuels based on alcohol, rapeseed and castor (Webb, 2013). These energy sources had been used since time immemorial (Webb, 2013). However, these biofuels became increasingly insufficient to meet the rising demand for fuels, in the face of rapid industrialisation in the western world (Steffan et al, 2007). Scientists began to make efforts to develop alternatives and by 1700s coal began to replace biofuels as the dominant source of energy (Steffan et al, 2007). Coal was widely touted as an energy source that would alter the course of human development (Jevons, 1865).

Gradually fossil fuels became the mainstay of development under capitalism. They fit in perfectly in the model of capitalist development due to their high yields, energy concentration as well as flexibility in consumption and transportation across space and time (Alverty, 2007:13). However, over time the new industrial system, powered by fossil fuels began to be associated with widespread ecological destruction (Commoner, 1972). Engels (1892) denunciated the ecological consequences of the industrial revolution, through a detailed study on the basis of appraisal of public health records in Manchester. He gave a vivid account of how the industrialisation process resulted in the ravaging of the natural environment. His analysis was particularly concerned with the air pollution caused by the release of toxic substances into the environment. He showed how toxins, released by factory smoke, played havoc with the health of poor factory workers.

As capitalism continued to develop, environmental degradation became more and more pronounced. Free market capitalism turned the “objects of nature” into “goods produced for sale” (Polyani, 1957: 130). This phenomenon gradually began to manifest itself in the form of “denudation of forests, pollution of rivers, the disruption of folkways and the general degradation of existence” (Polyani, 1957: 133). Rachel Carson conducted a seminal study on environmental degradation in capitalist economies in 1962. She referred to the ecological crisis as the “fundamental problem of our age,” which had resulted in “contamination of man’s total environment” and altered the “very material of heredity upon which the shape of the future depends” (Carson 1962, 68).

Kapp (1963) analysed the environmental costs of doing business between 1940-1960 and said that these costs added to almost 15 per cent of the overall costs. He estimated that since 1946, as more and more industrial capital was being created in western industrial societies, the stock of biological capital was dwindling rapidly. Both Bloom (1971) and Commoner (1972) propounded that with greater economic progress, environmental degradation was intensified as less productive technologies were replaced by new, environmentally faulty but more productive technologies. Pollution was thus an “unintended concomitant of increase in productivity” (Commoner, 1972:120).

Environmental destruction began to take place at an unprecedented pace, in the aftermath of the World War II (Commoner, 1972:119). There was intense focus on restoring industrial productivity without any concern for the natural environment (Dernbach, 2009). Another factor, which contributed to this process, was the American “throwaway” lifestyle, based on intensive resource use, which emerged in the Post World War II period in large parts of the world (Webb, 1991). “The throwaway society which emerged in the late 20th century uses so much energy, emits so much carbon and generates so much air pollution, toxin wastes and rubbish that it is strangling itself” (Webb, 1991).

2.4.3 Environmental degradation and developing capitalist economies

This callousness towards the environment has been even more profoundly experienced across developing and underdeveloped countries. In his address at the Rio Earth Summit (1992), Fidel Castro described emerging nations as, “Third world countries, yesterday’s colonies and today’s nations exploited and plundered by an unjust international economic order” (Castro, 1992). As the developed countries continued to prosper, they turned poor nations into, “the main victim of the ecological ravages of global capitalism” (Singh, 2009:29). Advanced capitalist countries began to use African and Asian countries as a site for polluting industries and a dumping ground for toxic wastes (Singh, 2009:101). Toxic and unsustainable industries began to be transported from the rich countries of the north to the poor countries of the south (Singh, 2009). The extent of callousness of the advanced capitalist economies towards poor nations came to the forefront in 1992 when an internal memorandum of the World Bank, written by its then chief economist Laurence Summers was leaked and published in *The Economist*. Summers gave an economic rationale for dumping toxic wastes in poor countries. He said that since poor countries were vastly “under polluted,” therefore “the economic logic behind dumping a load of toxic waste in a developing country is impeccable and we should face up to it” (The Economist, 1992).

This trend reveals a new form of “environmental colonialism” which has emerged in recent years (Singh, 2009:35). The natural resource base and the environment of the poor countries are being exploited, “not only as the capitalist answer to the environment crisis but also to create conditions for further capital accumulation” (Singh, 2009:35). This phenomenon gained further momentum in the aftermath of the Rio Earth Summit (1992) when many transnational firms began to expand to countries of Asia and Africa, in view of more stringent ecological regulations in their own countries (Karliner, 1997).

Also, most developing countries have adopted their own form of peripheral capitalism and are rapidly emulating the “American way of life” with little concern for indiscriminate exploitation of their natural resource base (Singh, 2009).

Developing countries are blindly following the path adopted by the advanced industrial nations in the logic of "grow first, clean up later" (Singh, 2009: 102).

Thus, from the analysis presented in this section one can conclude that the current ecological crisis is rooted in the process of capital accumulation, driven by "production for profits". This system has destroyed the fine balance between nature and humanity. Today, these contestations within the capitalist system have manifested in a crisis like situation.

2.5 Ecological Concerns in Alternative Forms of Social Organisation: Examples from China, USSR and Cuba

The last section established how the current ecological crisis is essentially rooted in the production and consumption structures within the global capitalist system, which is essentially contradictory to environmental conservatism. This section provides examples from countries pursuing alternative models of development and analyse the ecological paradigm in these societies. China has abandoned any pretence to an alternative model and is copying the capitalist model of maximum economic surplus. Alarmed by massive pollution caused by environmental destruction, it is belatedly showing some signs of environmental awareness in its policy making. USSR was rooted in old style socialism, with little concern for ecology. The economic doctrine in USSR was concentrated on raising economic productivity, with little environmental consciousness, in order to outbid the western capitalist economies in the growth process. Cuba has attempted to develop an alternative in some respects. This country is attempting to incorporate ecological goals within socialism in order to achieve an ecologically friendly development trajectory, rooted in the basic principles of socialism.

2.5.1 China: A case of indiscriminate environmental degradation

China's development model has been replicated on traditional industrial economies like UK and USA (Xu, 2014). The phase of rapid economic development in China began with the industrial reforms initiated by Deng Xiaoping in 1978 (Chiang, 2015). These reforms were based on proliferation of townships and village enterprises in China, which led to a rapid increase in industrial output (Xu, 2014; Chiang, 2015). However, environmental concerns were rarely given importance by the local government (Economy, 2004:21).

The Chinese economy is primarily fuelled by coal (Connor, 2015). China is the largest producer of coal all over the world and contributes to 45.5 per cent of the global coal production (IEA, 2014 a). Due to high levels of dependence on coal, air pollution in China has reached insurmountable levels (Yuwan and Xuemei, 2017). It is the largest emitter of carbon dioxide in the world and is home to six of the ten most polluted cities in the world (Yuwan and Xuemei, 2017). The level of pollutants in the atmosphere in China is fifty times higher than the acceptable levels (Connor, 2015). In 2013, dense smog enveloped the city of Beijing for three days and affected 800 million people. This phenomenon came to be known as the “airpocalypse” (Xu, 2014).

The high level of air pollution in China is translating itself into a large number of premature deaths and high disease burden in the country. Pollution is believed to be responsible for a large number of acute and chronic diseases of the respiratory systems and large number of incidences of cancers (GBD, 2015). A recent study by Greenpeace concluded that 90 out of 100,000 people living in the 31 provincial Chinese capitals are at risk of premature death due to exposure to high level of pollution (Greenpeace, 2015). 459 Chinese villages were termed “Cancer Villages” owing to large number of deaths, due to lung cancer (Liu, 2010). Lung cancer is also believed to be the primary cause of mortality in urban areas and contributes to over 25 per cent of deaths (Liu, 2010).

According to the estimates of the World Bank (2008) environmental damage costs China nearly 9 per cent of its GNP per year. It has also resulted in erosion of natural base of the country and irrevocable damage to the health and wellbeing of its citizens. Due to the large size of the Chinese economy and its rapid pace of growth, environmental degradation in China is adversely impacting not only the Chinese economy, but also the world as a whole (Xu, 2014).

2.5.2 The environmental paradigm in USSR

Soviet Russia represented a development trajectory, rooted in old style socialism. Some scholars contend that in the initial years of development of USSR, there was a robust ecological policy regime in place (Williams, 2010). It is believed that the Soviet thinking on the environment in the initial years was dynamic, dialectically complex, holistic and co-evolutionary (Foster 2009:183). A number of policies were implemented to support ecological research, agricultural sustainability, and maintenance of biodiversity, protection of natural reserves and forests as well as introduction of nature as a part of school curriculum (Foster, 2009:183). However, with the ascension of Stalin, ecological policies took a backseat and environmental research was gradually disbanded (Foster, 2009:185). Stalin demonised "Science for science sake" and insisted that the only purpose of scientific research was to further economic progress (Williams, 2010). Estimates reveal that there was a twenty-time increase in pollution levels in USSR between the years 1920s and 1965, after Stalin took over (Pryde, 1970). This period covers a major period of Soviet Union under Stalin's rule.

Particularly after World War II, the singular focus of the Soviet society was reconstruction of the country's war ravaged industrial capacity. There was little focus on environment concerns (Pryde, 1970). The post-war technologies adopted in the former USSR replicated those of America and Europe. They were based on gasoline driven automobiles, use of coal in factories and industrial units as well as agricultural production augmented by synthetic fertilisers (Sarkar, 1999: 69). A major drawback of the Soviet model of development was that just like the industrial capitalist economies, the Soviets too had a single minded focus on rise in productivity with little heed for the environment costs (Commoner, 1972:255).

Scholars believe that policymakers in the Soviet Union lost their vision of socialism and instead began to concentrate on "mania for economic growth, gigantism in planning and expansion of the military" (Foster 2009:76; Singh, 2009:121) with a view to defeat western capitalist economies in the process of overall economic growth (Pryde, 1970). This singular focus on economic growth and lack of ecological consciousness manifested in widespread ecological damage in the USSR (Singh, 2009: 227).

2.5.3 Cuba: A sustainable development trajectory

Cuba's stated aim of developing a socialist economy, by aligning the basic tenets of socialism with ecological goals has led to some positive effects. The Living Planet Report (2014) ranked Cuba as one of the few countries, which has achieved high human development alongside a low ecological footprint.

The Cuban Revolution in 1959 laid the foundation of a socialist model of development in Cuba (Nichols, 2000:17). The initiation of the socialist development model succeeded in eliminating extreme poverty and unemployment in Cuba (Nichols, 2000). There was large-scale creation of rural infrastructure and "sweeping land reforms" (Nichols, 2000). However, this model of development was essentially based on the Soviet doctrine of "Economics first" (Diaz-Briautes and Lopez, 2000). Environmental protection was a secondary concern and the country was plagued with a number of environmental challenges such as air pollution, oil spills, increasing, soil degradation and high level of dependency on imported fertilizers (Nichols, 2000).

However, with the collapse of the Soviet Union, which was Cuba's international ally, there was a re-orientation of environmental policies in Cuba (Kakonen et al, 2014). The period between 1989-1993 was termed as a "Special Period" where the country was faced with the challenge of producing food, medicines and energy locally and sustainably (Kakonen et al, 2014). The country responded to this challenge by investing heavily in bio technology, health, information technology and renewable energy in order to reduce its dependence on imported fertilisers, pesticides and energy (Kakonen et al, 2014).

The National Programme for Environment and Development (1993) was launched in order to fulfil Cuba's commitment to sustainable development under Agenda 21 of the Rio Earth Summit, 1992 (Nichols, 2000). A number of subsidiary schemes were launched between 1993-98 as an overall part of this programme, with focus on environmental education, sustainable food production and renewable energy (Nichols, 2000). The Cuban constitution was "reframed to define clearly the link between environment protection and economic development" (Evenson, 2010:3).

Cuba has made it mandatory for all the citizens of the country to work towards conservation and protection of the natural resource base of the economy (Evenson, 2010). One of the main planks of the environmental policy in Cuba was focused on development of renewable energy, in response to the local energy crisis (Bell, 2011). The country faced a deep energy crisis in 1991 with the collapse of Soviet Union, which was its main source of cheap fuel (Evenson, 2010). It was also plagued by problems of rising dependence on imported oil (Evenson, 2010).

Cuba faced this crisis through development of bioenergy substitutes based on bagasse extracted from sugarcane and rice husks, development of kerosene substitutes for cooking, and promotion of LPG cylinders for household use (Kakonen et al., 2014). Currently bioenergy constitutes 16-20 per cent of the total household energy needs in Cuba (Kakonen et al., 2014).

A massive drive for energy conservation has been launched in Cuba since 2006. The government has also started a social credit scheme to replace inefficient household devices with more efficient ones at subsidised rates. The annual electricity savings from the replacement of old electric devices has been estimated to amount for 1 147,5 million kWh (Seifried 2013). A massive campaign was launched to involve the general public in the practice of energy conservation. Energy festivals were held in different parts of the country. The government also launched programme in consonance with the Ministry of Education to teach students, workers, families and the larger community about energy conservation (Evenson, 2010).

A South-South cooperation initiative in renewable energy was launched along with three other countries: Venezuela, Haiti and Bolivia (Kakonen et al, 2014). Cuba's renewable energy programme has helped to reduce its dependence on imported oil by one million tons and cut down carbon emissions by 18 per cent (Kakonen et al, 2014). These measures resulted in the initiation of an Energy Revolution Cuba in 2006. Fidel Castro (2006) in his address about the Cuban Energy Revolution remarked, “We are not waiting for fuel to fall from the sky because we have discovered something much more important: renewable energy, which is like finding a great oil deposit” (cited in Stone, 2009).

Although the Cuban environmental programme has made considerable progress, it faces considerable challenges in terms of financial constraints and lack of access to international credit and technology in the face of US embargos (Kakonen et al, 2014).

2.6 The Reformist Agenda: “Green” Capitalism

The previous sections showed how neither capitalism nor socialism (with the exception of Cuba to some extent) have been able to reconcile economic development with ecological imperatives. As environmental degradation continues to take place at an accelerated rate, there is an increasing discourse on creating a new form of “green” capitalism so that economic growth and environmental conservatism can work in tandem with each other (Jacobs, 2012; Janicke, 2012; Dawson, 2013). Green capitalism is based on modification of traditional theory of economic growth to account for the role of natural capital in the production process in society (Matthews, 2011). The first plank of green capitalism comprises of mainstreaming of green technologies and renewable energy initiatives. In recent years many countries have started making large-scale investment in green energy in order to mainstream its use and create a viable green energy industry (Hodbod and Tomei, 2013). Renewable energy is being promoted as the next “green revolution,” which will help to replace fossil fuels, with “clean” environmentally friendly sources of energy (Friedman, 2008).

The second plank of green capitalism is to create “green markets” in order to make rational use of natural resources (Speth, 2008). Mainstream economists believe that ecological issues can be resolved by extending the standard neo-classical principles to the analysis of the natural environment (Venkatchalam, 2007). They locate the economic explanation of degradation of nature in terms of a lack of markets for environmental goods and services. They contend that due to the non-existence of markets for environmental goods, people fail to recognise the otherwise positive prices of environmental goods and services, resulting in "market failures" (Baumol and Oates, 1988).

One of the core pillars of mainstream environmental economics is the theory of externalities, first developed by Pigou (1920). According to this theory, ecological degradation is a problem in which economic agents impose external costs on society in the form of pollution, which are not accounted for by individual firms (Baumol and Oates, 1988). In the presence of these environmental externalities, markets do not lead to a Pareto-efficient[10] outcome, as there is a deviation between the private cost of production to the firm and the social cost of production to other agents in society. Due to an inaccurate price mechanism, there is no incentive for firms to bring about a reduction in polluting activities and the result is an excessive demand on the assimilative capacity of the environment.

In view of these conditions, the basic objective of the externality theory is to force the price mechanism to generate the market price of pollution and allocate the efficient amount of pollution in the natural environment (Fisher, 2014). Baumol and Oates (1988) developed a rigorous and comprehensive analysis of the theory of externalities and then applied this theory to the design of environmental policy. They proposed two types of instruments in order to internalize environmental externalities. The first set of instruments comprises of market-based regulations and the second instrument comprises of "command and control" policies or direct state regulation. Market based instruments are regulations that encourage firms and individuals to undertake pollution control through market based signals, rather than through explicit directives (Stavins, 1995). There are three categories of market-based reforms: a) emission taxes b) subsidies on abatement c) marketable permits (Baumol and Oates, 1988).

The first market based instrument for internalizing the externality is through a system of per unit emission taxes. These taxes are based on the "polluter pays" principle. A per unit emission tax is imposed on the polluting firm equal to the marginal social damage accruing to all victims in society. The tax allows the price to reflect the

[10] An allocation is said to be pareto-efficient if an action makes one individual better off without making another individual worse off (Baumol and Oates, 1988:17)

"true" social cost of producing the good and results in a socially efficient outcome. It also provides an incentive to firms to invest in pollution reducing activities so as to reduce their cost of production (Baumol and Oates, 1988:21). However, these emission taxes have certain limitations. *Firstly,* it is very difficult and costly for the state to define and monetarily measure the per unit marginal external damage caused by emissions. Most of the necessary information is in the hands of the polluting firms, who have a vested interest in concealing true information from the regulator (West and Wolverton, 2003). *Secondly,* a number of studies have empirically examined the distributional impact of carbon taxes and concluded that these taxes are regressive in nature and are not an ideal solution on grounds of distributional justice (Stavins, 1995; West and Wolverton, 2003; Fisher, 2014 and Vlachou, 2005).

The second alternative is to give subsidies to firms in the form of grants, low-interest loans and rewards per unit of emission abatement from some initial baseline pollution level (Baumol and Oates, 1988). At the theoretical level, a subsidy per unit of pollution reduction will produce the same level of pollution control as an emission tax. However, Baumol and Oates (1988) have shown that taxes and subsidies will have different implications for long-term profitability and entry-exit of the firm. They prove that in the long-run competitive equilibrium, with subsidies to a polluting industry, too many firms will enter the market, resulting in a larger output for the industry and a lower price for the commodity generating the externality.

The third alternative is to create a "cap and trade" scheme or a system of marketable permits (Baumol and Oates, 1988). Under this system a regulatory authority determines the aggregate quantity of emissions that are socially efficient[11]. The central authority then issues permits for waste emissions through the market system. In the aggregate, the total emissions are at a level that equates marginal abatement cost of emissions and the marginal social damage of emissions. Trading of these permits among firms establishes the market-clearing price of emissions. Firms acquire the optimal level of pollution permits from the market depending on their pollution demand. Under this system, firms, which acquire an excess amount of

[11] To attain a level of pollution control, which maximises net benefits to society, at the least cost.

permits can sell their surplus permits to firms, which have a shortage. In this way, this system of marketable permits gives an incentive to firms to invest in pollution control, as they can then sell the surplus in the market (Baumol and Oates, 1988:58). Permits help to resolve some of the problems associated with the tax/subside regime. Policymakers do not have to measure the marginal damage per unit of emissions and instead can decide the acceptable level of pollution. It also allows policymakers to determine with certainty the level of pollution, which will result after the scheme comes into effect (Baumol and Oates, 1988:59).

However, some scholars believe that these permits effectively give polluters a "license to pollute." For instance Lohmann (2006) analysed the EU's Emission Trading Scheme (ETS) and concluded that this scheme had helped "heavily polluting" industries. Heavily polluting industries and nations were granted roughly as many free pollution rights, as they needed to cover current emissions. As a result, some of the worst offenders, such as the German utilities group RWE earned hundreds of millions of euros in windfall profits for pursuing business as usual. Meanwhile ordinary citizens have suffered from higher electricity prices. Lohmann (2006) also analysed how due to the many loopholes in these schemes, polluting firms were able to buy cheap credits from developing countries. Other studies have shown that "emission trading" encourages monopoly practices. It gives rise to entry barriers, since new entrants must purchase permits from existing holders (Vlachou, 2005). This point was reiterated by Teeter and Sandberg (2006) in their study of the Australian emission trading scheme. They showed how large-scale polluters were able to control a significant number of permits, restrict output and advance their position in the sector. On the other hand many small and medium polluting firms found that the pollution abatement costs were prohibitive for them.

The other set of neoclassical instruments for pollution abatement comprise of "direct controls" or " command and control" policies. Neo-classical economists believe that market based regulations may not work in every situation. Baumol and Oates (1988) rigorously analysed the technical relation between the externalities and non-convexity in production sets. They proved that when an industry imposes a large detrimental externality on another industry/ individuals, the normal conditions for maximising social welfare break down due to the fact that the production possibility set becomes non-convex in nature for the two activities: one generating the externality and the other being affected by it. Instead of a unique equilibrium point, where the concave production possibility frontier is tangent to the community indifference curve, there are many local equilibrium points in the presence of an externality. In such a setting, market processes will not result in a socially optimum outcome. As prices do not give the correct signals in this case, the point at which the society eventually ends up has to be chosen collectively. Under these conditions, the optimal solution to dealing with externalities is regulation by an external agency. The regulator sets standards of pollution control with respect to technology and performance, which all the firms have to adhere to. However, state regulation is considered an inefficient mechanism by many neo-classical economists as it involves heavy costs of enforcement and monitoring (Wallace and Oates, 1975:106). For instance Tienterberg (1985) compared the costs of direct regulations with their least cost alternatives and found that these costs were prohibitive. There is also the possibility of "regulatory capture" by large firms. Baumol and Oates (1988:241) stated, "In case of direct controls, the polluter may be able to negotiate with the regulatory agency, or may take it to courts and find an easy escape." Evidence has shown that environmental regulation across many countries tends to be dominated by networks between special interest groups and government authorities (West and Wolverton, 2003).

Within the neo-classical paradigm, Coase (1960) presented an alternative approach to deal with environmental externalities. He believed that environmental externalities arose due to the absence of well-defined property rights over environmental goods and services. He propounded that if property rights over relevant resources are well defined and transaction costs are zero, then parties who may disagree over the initial allocation of resources will negotiate an efficient solution, regardless of to whom the property rights are initially assigned. He gave several examples from real world situations to illustrate how private bargaining can solve the problem of externalities, provided property rights are well defined. In the second part of his analysis Coase (1960) relaxed the restrictive assumption of zero transaction costs. He said that even with transaction costs, if the size of the transactions are relatively small, bargaining might still be the most efficient solution. If the transaction costs are sufficiently high, then the next best alternative would be litigation. Finally, if the transaction costs are very high, then the government may act as a "super firm" and impose regulations on the firm in order to force agents to take account of their behaviour (Coase, 1960:17).

Coasian solution has been criticised by a number of scholars. For instance Stern (2013) stated that for Coasian bargaining to work, those affected by pollution must be able to quantify the damages resulting from pollution, which is virtually impossible in case of issues like climate change because of the extreme complexity involved. Gruber (2010:131-134) has expressed three criticisms of the Coasian theorem at the theoretical level. He categorised them as the assignment problem[12], hold out problem[13] and free rider problem[14]. Another criticism of the Coasian bargaining solution was levied by Kennedy (1981). He proved that initial allocation of property rights always matters in reality. Kennedy (1981) proved that the party, which has the initial entitlement is likely to request more to give up the entitlement, than the party, which is initially without the entitlement.

Thus, the above section reveals that within the "green" capitalist approach, dominated by neo-classical economics, it is contended that environmental problems can be effectively solved either through mainstreaming green technologies or market-based regulations. Only in extreme cases, when market regulations may not function that neo-classical economists favour government regulations as a last solution. As Coase (1960:18) propounded, "the only cases where government should intervene is when the number of people involved is very large and the cost of handling the problem through market or firms may be substantial."

[12] In case of environmental externalities such as climate change, it may be extremely difficult to determine which parties are affected by the externality and who has caused it.

[13] When property rights to environmental resources are held by more than one party, the shared property rights may give each owner power over the other, resulting in a breakdown of negotiations.

[14] If multiple parties benefit from the negotiations, each party will have an incentive to free ride and withdraw from the negotiations.

2.7 Critique of "Green" Capitalist Reforms and Alternative Approaches

Some scholars, have expressed reservations about the efficacy of green reforms under capitalism, and regard these reforms as an inadequate solution to the ecological crisis facing humanity at many levels.

The externalities approach to analysing environmental issues has been critiqued by a large number of scholars. D' Agre and Hunt (1971) have questioned the internal consistency of the externality theory and propounded that Pareto optimality conditions, which the externality theory uses to justify its contributions to socially optimal outcomes is essentially flawed. They point out to four weaknesses of the Pareto-optimality theory a) Some buyers are large enough to control prices. b) Some commodities are "consumed socially" and their scale would seldom be profitable in a large-scale economy. c) The costs to the producers of producing a commodity may differ significantly from the social costs of producing the commodity. d) Externalities are "pervasive" in nature. Production and consumption are essentially social activities, and it is extremely difficult to identify, which social or private actions can be characterised as externalities. "Unless people in modern societies are completely homogeneous self-serving robots, responding only to price and costs, any deviant behaviour can be called an externality" (D'Agre and Hunt, 1971:275)

Graaf (1957) stated that for efficient allocation of resources in a competitive economy, there are a number of restrictive assumptions such as a) any individual's welfare is identical with his preference ordering b) productivity is not affected by distribution of wealth c) there are no risks and uncertainties. These assumptions must be met before the market system can attain "optimal economic efficiency" in the Paretian sense. If any of these assumptions are not met, Pareto efficiency is no longer desirable.

In mainstream environmental economics, the social, cultural and political status of an individual is reduced to that of an economic agent (Adman and Ozkaynak, 2002:115). However, some scholars contend that economic processes cannot be analysed without understanding the social and natural environment, of which the economic system is a part (Adman and Ozkaynak, 2002:115; Ramon and Toman, 2017). Institutional economists contend that mainstream economics does not account for how formal (property rights and the legal system) and informal institutions (cultural attitudes) impact environmental decisions (Paavola, 2001). Ostrom (1990) made profound contributions in the application of institutional economics to ecological issues. In her research, Ostrom (1990) applied rational choice theory with insights from institutional/development economics to solve the problem of management of common pool resources. She challenged Hardin's (1968) theory of "Tragedy of Commons," which argued that unrestricted access to communal resources would inevitably lead to over-exploitation of these resources. Traditional economic theory suggests that the only way to avert this "tragedy" is either through imposition of property rights over commons or government ownership of common-pool resources.

Ostrom (1990) posed a challenge to this form of theorising. She developed alternative game theoretic models to include the role of institutions and demonstrated how individual players committed themselves to a cooperative strategy that they themselves work out. She argued that Hardin's (1968) stark choices between ecological collapse (tragedy), privatisation and government control could be replaced by flexible, locally governed institutions for regulation of commons. She showed how communities of individuals have relied on institutions resembling neither the state nor the market to govern some resource systems with reasonable degree of success over long time periods (Ostrom, 1990:1). Her research was empirically supported by case studies of common pool resources such as forests, fisheries and meadows in a number of countries: Nepal, Spain, Indonesia, Nigeria, Bolivia, Sweden and the US. She contrasted successfully managed commons, with commons that had failed and devised certain design rules, through which the "tragedy of commons" could be avoided. These eight principles include clearly defined boundaries (knowing physical and ecological properties of the resource), clear rules of membership (knowing who is entitled to use the resource), congruence between rules of provision and local conditions, mutual monitoring, collective decision making, "graduated" sanctions on parties who misappropriate common resources, low cost conflict resolution and a state that is willing to recognise local rights of organisation (Ostrom, 1990:91-101).

Ostrom's work demonstrated how alternatives can be created "beyond markets and states" for conservation of our natural resource base. However, she was against advocating "panaceas" for solving the problem of degradation of the natural environment. She believed that "contextual variables" are essential for understanding the challenges to the long-run sustainability of the eco-system (Ostrom, 1990). She advocated that market, states and commons are all forms of institutions, which are being used to overcome the problems of environmental degradation. She believed in a "polycentric" approach and advocated a diversity of approaches and creating new forms of institutions for environmental governance.

One of the main criticisms of Ostrom's work was that it was rooted in rational choice theory and methodological individualism and the idea that "social outcomes can be explained in terms of perceived costs and benefits of individual actions" (Ostrom, 1990:243). Her approach systematically captured the micro factors that led to the success or failures of commons, but it did not look at macro factors in relation to social class, historical conditions and the nature of the state regime, and their relationship to communal property systems (Wall, 2014).

Mainstream environmental economics has also been critiqued by some development economists. They contend that mainstream economists have simply added environment to the existing understanding of market/state-led development ("add environment and stir") (Pietrese, 2010). Within this approach, sustainability has not emerged as a core concern and a part of a wider approach to economic development (Pietrese, 2010). Pieterse (2010) argued that within a green capitalist framework efforts have been focussed on the "hardware of development" such as infrastructure, capital and green technology. In the development economics tradition equal importance should be given to the "software of development" such as institutions, processes and management, education and knowledge, in the context of environmental projects. This implies a reorientation from a preoccupation with the exterior or the façade of development (infrastructure, capital inputs) to its "inner conditions" (institutions, education and knowledge). It also implies a reorientation from a one-dimensional understanding to a multi-dimensional understanding of environmental issues (Pietrese, 2010:198).

A strand in development economics contends that the market based environmental instruments, promoted under green capitalism have limited applicability in the context of developing countries. According to this strand, the institutional, monitoring/enforcement mechanisms, and government machinery, which are needed to make market based instruments like emission taxes, tradable permits and emission subsidies work well have not been fully developed within a developing countries' context (Lopez and Toman, 2017; West and Wolverton, 2003). "For these instruments to work in a developing countries' context will require restructuring of a broad set of institutions including property rights, legal system and management of the public sector" (Lopez and Toman, 2017). It has also been contended that market based environmental policies primarily focus on industrial emissions and environmental problems in the context of developed countries (Lopez and Toman, 2017). However, in the context of developing countries many ecological problems, such as water borne diseases, lack of sanitation, energy poverty and indoor pollution associated with burning of solid biomass have not been adequately considered within the ambit of mainstream environmental economics (Lopez and Toman, 2017). In this tradition in development economics it is contended that creation of decentralized institutions and stakeholder participation are needed to solve these problems (Lopez and Toman, 2017).

Bioenergy reforms, which form the focus of this research have not been promoted through market based instruments in developing countries (as shown in Chapter 3 for the global context of bioenergy reforms and Chapter 7 for the case study region). Rather, these projects have been promoted through a mix of fiscal concessions for bioenergy industry and government regulations. In the context of government regulations, it has been argued that these regulations have limited efficacy in developing countries. Developing countries are embedded in the world capitalist system as production centres for labour intensive goods and suppliers of cheap labour (Pietrese, 2010). Survival of dominant business interests is viewed as crucial for the continued growth and development of these economies (Pietrese, 2010). Therefore, the capacity of the state to "neutrally" regulate the problems of "market failures" in the context of the environment is extremely limited in the context of developing countries (Pietrese, 2010). Studies have shown that in countries like India the regulatory regime has favoured corporate interests at the cost of other stakeholders in society (Sood et al, 2014). These questions pertaining to the efficacy of government regulations in bioenergy reforms will be explored in depth for the case study region in Chapter 7.

The above discussion shows that development and institutional economics have helped to include environmental prerogatives within the larger development discourse. However, the question of distribution of gains of development are not a central part of this discourse. Here in lies the contribution of eco-socialism. Eco-socialism provides a vision of a new development trajectory, where in the socialist ideals of equality/ social justice are integrated with environmental concerns. For eco-socialists the power structures and inequities across class and gender divisions are the central explanatory parameters in explaining the process of ecological degradation in society (Kovel, 2002). In an eco-socialist perspective, a primary objective of sustainable development is environmental justice (defined in footnote 4).

Eco-socialism and the basic tenets of some traditions in institutional/development perspective are in harmony with each other. Both these approaches condemn a "one size fits all" framework and favour a polycentric, participatory approach by relying on multiple institutions-markets, states and community to solve the problems of environmental degradation. However, institutional/ development economics does not give adequate attention to the power structures in the macro economy, while considering environmental issues (Adman and Ozkaynak, 2002). In contrast, eco-socialism considers the power relations in society and economy and their impact on the environment as of central importance. They consider power as a function of individual socio-economic characteristics such as wealth, gender and ethnicity, as well as the political set up in which an economy operates (Boyce, 1994).

Eco-socialists have also expanded the critique of "green" capitalism, provided by other schools. They contend that a fundamental weakness of environmental regulations under green capitalism is that they fail to take account of "the socio-economic as well as ecological inequalities of commodity production under capitalism" (Luke, 2006:101), which have manifested in a crisis like situation in the present times. According to eco-socialists, the second major weakness of the neo-classical, green capitalist framework is that it is rooted in a "weak sustainability" approach. In the weak sustainability approach, as long as the overall stock of capital is left unchanged, economic development is said to be sustainable. According to the "weak sustainability" paradigm ecological degradation can be overcome by assigning a "price" to natural resources through the creation of green markets or development of technical substitutes (Sweeney, 2015). However, eco-socialists contend that this approach fails to recognise how technical substitutes cannot be developed for some key natural resources like ozone, water and clean air, which are "critical" for human survival. Also, assigning market value to natural resources does not account for the future scarcity of these goods (Tienhaara, 2014).

In the last two sections, we presented the neo-classical approach to environmental protection as well as its critique by alternative schools. Neo-classical economics essentially relies on creation of technical substitutes, green markets, imposition of government standards and market based regulations to solve the problems of environmental degradation. However, this approach has been critiqued by alternative schools like institutional/developmental economics as it does not account for the role of institutions and community participation in ecological imperatives. Mainstream environmental economic instruments have essentially been formulated from a developed country's perspective and do not account sufficiently for the problems of resource depletion and ecological issues faced by developing countries.

Other approaches like eco-socialism have further broadened the critique of neo-classical environmental economics by bringing in the role of socio-economic inequities, power structures and issues of environmental justice within the ecological discourse. These issues are particularly pertinent in developing countries' where widespread poverty and inequitable resource distribution are primary concerns of the development discourse. Questions also remain on whether the "weak" sustainability approach, which is the driving force behind "green" capitalist reforms can ensure sufficient protection of the natural environment. Critics believe that within a "weak" sustainability paradigm, continued economic growth remains the primary concern of the development discourse and environmental prerogatives figure lower in the hierarchy of development priorities. These questions require further probing and investigation, and will be analysed in detail in the subsequent chapters.

In the course of this research, I will attempt to provide empirical evidence on the contestations surrounding green capitalist reforms and explore alternative approaches to sustainable development, with a focus on bioenergy reforms. As mentioned before, green energy is a major pillar of green capitalism. These green energy reforms are taking place through massive fiscal concessions, subsidies and support for green energy industry. This research will explore how far these measures have been sufficient to create a green energy trajectory and reconcile the socio-economic and ecological parameters of sustainable development.

2.8 Summing Up

This chapter explored the multi-pronged challenges in the global energy system and explored the inter-linkages between the energy crisis and the overall crisis in the global economy. This multi-pronged crisis is rooted in the production and consumption structure of the global capitalist economy. In its drive for profits and capital accumulation, the capitalist system places little value on the conservation of our natural resource base. The analysis also dealt with the environmental paradigm in socialist economies and illustrated how these economies have also been deficient in environmental prerogatives.

As ecological destruction continues unabated, many national governments are attempting to move towards a new form of "green capitalism. This from of capitalism is based on development of clean energy technologies and creation of green markets to foster resource conservation and application of standard neo-classical tools to the analysis of the environment. These reforms are however being critiqued by alternative schools such as development/ institutional economics and eco-socialism. Questions are being raised on whether purely technocratic reforms, without accompanying changes in institutional structures of capitalist societies, and stakeholder involvement may be a sustainable solution in the long run.

Following from this analysis, the next chapter will focus on bioenergy developments, which form a major plank of green capitalism. It will analyse the opportunities and limitations of green energy developments and evaluate how far do these bioenergy imperatives have the potential to be a sustainable energy alternative.

CHAPTER THREE

UNDERSTANDING BIOENERGY DEVELOPMENTS- A POLITICAL ECONOMY PERSPECTIVE

3.1 Introduction

As the last chapter showed, a major prerogative of “green” capitalist reforms is the development of renewable energy sources to replace the fossil fuel system. Dependence on fossil fuels is now recognised as the major trigger for the current ecological crisis facing humanity (Friedman, 2008).

There has been increased impetus on renewable energy in recent years. In 2015, the Paris Climate Change Summit and the development of seventeen sustainable development goals by the United Nations placed green energy at the centre of the global development discourse (Arndt et al, 2016). In view of these developments, this chapter presents a critical review of the bioenergy reforms, which are taking place under “green capitalism.”

I trace out how biofuels emerged from a minor player in the energy markets to being touted as the “fuel of the future” and eventually became a highly contested energy alternative. At the beginning of the 21st century there was widespread euphoria about bioenergy in the global energy market (Dauvergne and Neville, 2009). It was promoted as a means to cut down carbon emissions, reduce energy poverty and meet the growing demand of oil in the face of declining fossil fuel reserves (HLPE, 2014). However, over time the tall promises of bioenergy developments were belied by a number of adverse outcomes of bioenergy developments. The sustainability challenges associated with bioenergy projects included threats to food security across many developing nations (Hammod and Bo, 2016), land grabs by bioenergy producers in Asia and Africa, putting the livelihoods of rural local populations in these countries at stake as well as excessive deforestation and land use change (Baka 2011, 2014). Large agro-industry players in the global energy markets have captured the gains from bioenergy developments (Neville, 2015). Little benefit has accrued to the energy poor population in developing countries (Hunsberger and Ponte, 2014). On the contrary these vulnerable groups in society have emerged as net losers from bioenergy projects. They have been subject to rising food price inflations, exploitative working conditions in bioenergy plantations and growing incidents of land appropriation by biofuel producers. These points have been elaborated upon below.

The analysis presented in this chapter is divided into three sections. The first section introduces biofuels and analyses the main drivers responsible for the current upsurge in bioenergy production. The second section evaluates the global trends in bioenergy production, as well as the bioenergy policies across major countries, promoting biofuels. The final section reviews the sustainability challenges associated with bioenergy developments through a detailed review of literature.

3.2 Bioenergy: A "Clean" Energy Alternative

Bioenergy is a form of non-fossil fuel energy, derived from biomass and organic matter (FAO, 2008). It is one of the earliest forms of energy known to humankind, having been used as a fuel for cooking and heating purposes since time immemorial (Webb, 2013). However, post the industrial revolution, bioenergy was relegated to the role of a minor player in the energy sector and fossil fuels took over as the dominant form of energy in the global energy market. Bioenergy largely remained an inconsequential source of energy in the global energy sector till the beginning of the 21st century (Neville, 2015). It is only since early 2000, in view of the multiple challenges faced by the energy sector that a number of developing and developed countries have scaled up efforts to promote bioenergy on a commercial basis (Dauvergne and Neville, 2010). Various types of bioenergy sources are being developed across the world, with a view to make it a viable energy alternative. These alternatives include modernisation of traditional biomass, as well as development of modern, technologically enhanced sources of bioenergy (HLPE, 2014)

Traditional biomass remains the dominant source of household energy across many developing countries in Asia and Africa (as elaborated upon in Chapter 2). Biomass fuel, in its current form is an inefficient source of energy. It is associated with widespread pollution and a number of adverse health impacts (WHO, 2012).

However, it is believed that with adequate technological development these drawbacks could be addressed (Bluemling et al, 2013) and biomass may emerge as a key source of locally produced energy in developing countries (Gomerio, 2015). A number of initiatives are being promoted for use of technically enhanced biomass energy for household use and electricity generation in rural areas (HLPE, 2014). These initiatives include installation of improved biogas stoves in rural areas of developing countries, promotion of sustainable harvesting of wood, improvement in fuel processing technologies and setting up of biomass power generation projects (Kammen, 2006; Sovacool, 2013).

A number of liquid biofuels are also being promoted. These biofuels primarily include ethanol and biodiesel. Ethanol is derived from food crops such as sugarcane, wheat, maize and corn, while biodiesel is extracted from oil-based crops including rapeseed, soybeans and palm oil (GBEP, 2011). Biofuels based on agricultural residues, organic components of municipal waste and algal matter, referred to as second-generation biofuels are also being researched upon (Andree et al, 2017).

3.3 The Promise of Bioenergy

Bioenergy is believed to have a number of desirable properties, which makes it a favourable alternative to fossil fuels (HLPE, 2014). *Firstly,* biofuels can be used as a substitute to fossil fuels for cooking and lightning purposes, and also be employed as a transport fuel (EU Committee, 2006:12). *Secondly*, direct carbon emissions from biofuels are believed to be insignificant as compared to those from fossil fuels (Arndt et al, 2016; EU Committee, 2006).

Thirdly, bioenergy is perceived as a means to reduce energy dependence of oil importing countries and strengthen their energy security, since it can be produced locally with “home-grown” feed stocks (HLPE, 2014). *Fourthly,* bioenergy is seen as a means to boost rural electrification across Asia and Africa and promote a new source of livelihood for farmers in developing agricultural economies through creation of “green” energy markets (Gomerio, 2015).

Due to the perceived benefits of bioenergy, there was great enthusiasm about these developments and they began to be seen as the "fuel of the future" (Dauvergne and Neville, 2009: 1089). Bioenergy represented a potential solution to the energy crisis, which could be conveniently instituted within the existing structures of the industrial economies. It did not require any fundamental changes in the patterns of fuel consumption and production. "Biofuels merely required a shift to a new form of fuel, without change in fuel consumption" (Dauvergne and Neville, 2009: 1090). Owing to their reputation as a "clean" fuel, bioenergy projects also garnered the support of many international NGOs between 2000-2006 (Neville, 2015). NGOs such as Greenpeace UK saw biofuels as a local alternative energy initiative, which would help to cut down carbon emissions and counter the dominance of large oil corporations (Neville, 2012:124).

3.4 Bioenergy Production and Policies across Countries

Many major world economies such as US, EU, Brazil and China are attempting to reduce GHG emissions through the creation of a profitable green energy industry for both agriculture and energy companies, which lie at the intersection of bioenergy production (Neville, 2012:115). It is being promoted as a "win-win" situation, which would help to develop a new profitable industry and also help countries to meet their climate change commitments (Neville, 2015). Since early 2000, bioenergy policies began to be promoted across many countries of the world, fostered by extensive government support in the form of production and input subsidies, capital subsidies, research grants, tax concessions and legislations (Shouvic, 2015).

In the last decade, political backing for bioenergy prompted a number of large oil companies like British Petroleum, Shell and Exxon to make investment in a range of biofuel projects (Kolk and Levy, 2001). Many of these companies began to support bioenergy development with a view to garner positive media attention as an environmentally friendly company to secure credibility and reliability (Kolk and Levy, 2001: 503). British Petroleum launched a new slogan "Beyond Petroleum" in early 2000 and spent $200 million to rebrand themselves as an environmental friendly company (Cherry and Sneirson, 2010:999). Many oil companies began to move decisively towards investment in renewable energy through extensive research and development efforts in the arena (Kolk and Levy, 2001: 501). These companies began to develop bioenergy as a supplementary source of income to increase their market share and maintain competitiveness (Neville, 2015). Large agricultural and food corporations also began to promote biofuels as a new markets for their product and establish control over agricultural prices and technology (Neville, 2015). Fuelled by government and industry support, there has been a rapid rise in bioenergy production in recent years (Table 3.1).

Table 3.1 Biofuel production across the world (1000 tonnes per oil equivalent)			
Region	**2005**	**2010**	**2014**
North America	7612	26322	31275
Latin America	8043	17859	20348
Asia	834	4097	8716
World	19651	59605	74208
Source: BP (2016: 38-39)			

3.4.1 Bioenergy policies in developed economies

USA is the frontrunners in the production of bioenergy, and controls 41.4 per cent of the global bioenergy production, as per 2015 estimates (BP, 2016). Bioenergy production in USA was first initiated in response to the Gulf Crisis of 1970s and the oil embargos of 1973-74, which put the US economy in turmoil (Babcock, 2011). In the face of this crisis, the US government attempted to give impetus to the domestic bioenergy production by passing a number of mandates on bioenergy production, introduction of subsidies, insured loans for producers and price guarantees (Grafton et al, 2014).

These alternative programmes were however abandoned in 1980s, to promote US oil companies, in the face of lowering oil prices in the global market (HLPE, 2013). 2013). However, since early 2000 biofuel production in the USA again began to gain momentum owing to commitments to reduce GHG emissions under the Kyoto Protocol, uncertainty in Middle Eastern countries and dwindling oil supplies. These factors made it imperative to search for alternatives (HLPE, 2013). The Renewable

Fuel Standard Legislation was introduced in 2003, which stipulated that by 2022 biofuel production in USA should be expanded to 36 billion gallons (National Research Council, 2011). Under these provisions of this legislation, the government has provided a number of incentives for alternative energy producers viz. state subsidies, grants and loans as well as tax exemptions (Schnepf and Yacobucci, 2013). As a result of these measures ethanol production in USA has been rising steadily and USA is now the largest producer of bioethanol in the world energy market (BP, 2016).

Due to extensive government support towards biofuels, large oil and agricultural corporations in the USA are also investing in biofuels. Bioenergy is seen as a subsidiary "green energy" market by these corporations (Neville, 2012:116). Many large companies such as Shell and Texas A&M, along with large agricultural corporations in the USA are exhibiting interest in biofuel production (Kolk and Levy, 2001). In 2008 four companies viz. Archer Daniels Midland, DuPont, Deere and Monsanto, representing agro-chemical, farm equipment and seed supplies sectors, established the "Alliance for Abundant Food and Energy" to lobby the US government to promote biofuels (Dauvergne and Neville, 2009: 1099). Thus, biofuels in USA are being promoted as a strategy to mainstream "green" energy markets. Large oil companies as well as food/agricultural corporations are embracing this strategy. In view of the number of mandates and subsidies provided by the USA government, biofuels have emerged as a profitable avenue for these companies to expand their market share and influence agricultural/energy prices and technologies as well.

The second major player in the biofuel market, since early 2000 is the European Union. Bioenergy policies in Europe were based on a three-pronged agenda, to strengthen energy security and reduce oil imports, capture environmental benefits and develop competitive trade in bioenergy with agricultural economies (Helliwell and Tomei, 2017). The EU issued a directive in 2003 and stipulated that all countries across the European Union needed to replace 5.75 per cent of all fossil fuels with biofuels by 2010 with the "objective of meeting climate change commitments, maintaining energy supply and promoting environmental friendly techniques of production" (EU Committee, 2006). The overall goal was replacement of 20 per cent of conventional fossil fuels with substitutes by 2020 (EU, 2003; IEEP, 2012).

The EU policies on bioenergy attempted to build trade ties with Asian and African nations to create an international bioenergy market (Fulquet and Pelfini, 2015). The biofuel policies in Europe were concentrated on development of biodiesel through import of feedstock such as rapeseed, soy, palm oil and jatropha from countries of Asia, Africa and Latin America through a north-south co-operation (Banse et al, 2008). This north-south co-operation was intended to create a globalised biodiesel market, which was largely dependent on agriculture sector of developing nations for feedstock (Helliwell and Tomei, 2017). Brazil was a key player in these initiatives along with India, China and South Africa (Dauvergne and Neville, 2010).

However, EU biodiesel policies began to be associated with a number of negative repercussions in many Asian and African countries including direct and indirect land use change, land grabs by commercial biofuel producers, rainforest depletion and food inflation (BBC, 2008). In January 2008, the then EU Environment Commissioner Stavros Dimas announced that EU is rethinking its policy on biofuels and stated, "We have seen that the environmental problems and social problems caused by biofuels are bigger than we thought they would be. We have to move forward very carefully" (BBC, 2008). In October 2012 the EU was forced to revise its biofuel targets and imposed a blending cap of 5 per cent for food crop based biofuels (Noorden, 2013).

Thus, the biofuel policies in EU were primarily aimed at creating a global energy market for biofuels by launching cooperative initiatives with a number of agrarian oriented developing countries. However, the impact of these policies on the local rural populations of these emerging nations was relegated to the background in these north-south trade agreements, which manifested in a number of adverse outcomes across developing countries (elaborated in section 3.5).

3.4.2 Bioenergy policies in developing economies

Among the developing countries, Brazil was the first country in the world to launch an extensive programme for the development of ethanol based biofuels called *Programa Nacional do Ãlcool* (PROALCOOL) in 1975 (HLPE, 2013:28). This programme was launched in response to the oil crisis in the Middle East, which caused a steep rise in oil and put the Brazilian economy in peril (Moreira et al, 2005). PROALCOOL was initiated to promote commercial use of biomass and comprised of a mixture of R&D support for biofuels, subsidies for expansion of sugarcane distilleries, price controls, instalment of ethanol pumps and development of ethanol fuel cars (Wilkinson and Herrera, 2010,). In its early years the PROALCOOL programme was a great success and the production of sugarcane based biofuels in Brazil expanded rapidly from less than 1 billion per year in 1975 to more than 12 billion per year in 1984 (Lebre et al, 2011). However, by the late 1980s there was a downward spiral in petroleum prices all over the world, while the international price of sugar increased. This led to a large proportion of sugarcane production in Brazil being diverted to the production of sugar and ethanol became a relatively more expensive substitute for gasoline. In view of these developments, the government's commitment to production of ethanol also began to wane (Pousa et al, 2007).

Since early 2000, with a rapid increase in oil prices world over, ethanol again began to be seen as a competitive substitute for petroleum in Brazil (Lorenzo and Vazquez, 2016). The government enforced compulsory blending targets of 25 per cent ethanol in gasoline. They also enforced a number of other measures like elimination of price controls over sugar and ethanol and removal of export restrictions on sugarcane (HLPE, 2013, 2014). By 2008 there was a huge influx of investment in ethanol producing sugar mills in Brazil from petroleum companies and transitional grain corporations (Lorenzo and Vazquez, 2016). However, concerns began to be raised on the impact of ethanol production on food security, loss of biodiversity and workers' rights and conditions. According to FIAN International (2008), working conditions in Brazil's sugar mills infringed on basic human rights of workers. Workers were subjected to serious occupational hazards and poor housing and dietary conditions, which compromised their physical integrity. The study also found that the bioethanol industry in Brazil was the source of largest number of cases of child labour and slavery. Peskett et al (2007) conducted a study on the bioethanol plantations in Brazil. Their study showed that the rapid expansion of sugarcane production led to increasing concentration of land in Brazil. 340 sugar mills own seventy per cent of the land under sugarcane production and the average size of these landholdings is 30,000 hectares. The remaining thirty per cent of the land, under sugarcane cultivation is owned by small-scale landholdings whose average size of the landholdings is only 27.5 hectares. Similar conclusions have been reached by some other studies on the bioenergy sector in Brazil. These studies contend that biofuel development has led to the emergence of deep asymmetries in Brazilian society, and favoured the powerful actors in society at the cost of the under privileged. This has undermined the sustainability benefits of biofuels (Bauen et al, 2009; Timilsina et al, 2010).

A number of other developing countries like India and China also launched bioenergy policies with a view to reduce energy dependence in the face of burgeoning growth and also curb GHG emissions (HLPE, 2014). The production of biofuels in China was initiated in the wake of growing concern over national energy security (HLPE, 2014). Oil imports are expected to constitute 75 per cent of China's oil needs by 2030 (IEA, 2014b). China is currently the second largest importer of oil in the world market, next only to USA (IEA, 2016). In addition to this, environmental degradation and pollution are major problems in the Chinese economy. The problem of environmental pollution has reached critical levels and China is under increasing pressure from international agencies to cut down on emissions (Yuwan and Xuemei, 2017).

China initiated its bioethanol programme in early 2000. It set a target to meet 10 per cent of its total energy demand through bioenergy by 2010, further increasing the contribution of bioenergy to 15 per cent by 2020 (Shiyan et al 2012). Five large-scale plants capable of producing 1.87 billion tonnes of bioethanol were set up in 2000 (Shiyan et al 2012). Production began to expand rapidly. China is now the third largest producer of bioethanol in the world (Yuwan and Xuemei, 2017). However, there are growing threats of expansion of bioethanol production on food security and soil degradation. In view of these concerns, the sustainability of these bioenergy imperatives remains questionable (Qui et al 2012).

India's biofuel policies were also promoted by concerns similar to that of China. The Indian economy has been experiencing rapid growth in the last two decades (Singh, 2008 a). It is increasingly dependent on import of crude oil, to fuel its high growth trajectory (Krishna et al, 2015). 75 per cent of the total energy needs of the country are met through imports and it is the fourth largest consumer of energy after USA, China and Russia (IEA, 2016). India is the fourth largest emitter of GHG emissions in the atmosphere, among all other countries of the world (IEA, 2016). The energy sector in India is facing an unprecedented crisis owing to the growing mismatch between energy demand and supply. This has led to increasing level of oil imports and exposed the country to geopolitical risks and the vagaries in fluctuations of international prices (Ahn and Graczyk, 2012). Therefore, as a response to the increasing energy dependence and a means to achieve environmental sustainability, India made a decisive commitment to develop bioenergy (HLPE, 2013).

Traditional biomass energy has been promoted in India since 1970s as a component of rural energy policies of the national government (Singh and Setiawan, 2013). India ranks second in the world for biogas production (Ahn and Graczyk, 2012). In recent years, policymakers in India began to recognise the potential of bioenergy as a commercial fuel and are attempting to mainstream its use (Ahn and Graczyk, 2012). In January 2003, the government launched the National Policy on Biofuels (GOI, 2003). This policy targets to increase the contribution of bioenergy to 20 per cent of India's energy mix by 2020 (GOI, 2003). Another major imperative of bioenergy policies in India is to create a "green" energy market by attracting Indian agro-industry as well as foreign investment in this sector (Pradhan and Shaun, 2014). A number of fiscal incentives have been instituted for promotion of bioenergy sector like income tax holiday for ten years, concessional custom and excise duty on machinery and equipment, exemption on sale tax, easy availability of loans through nationalised banks and compensation for 100 per cent depreciation on equipment in the first year (GOI, 2003). 100 per cent Foreign Direct Investment is permitted in biofuel projects (GOI, 2003).

The Indian bioenergy sector is growing at a rapid pace. Electricity generation from biomass sources is gaining increasing acceptance in India (Pradhan and Shaun, 2014). Between 2007-08 and 2015-16 the growth rate of power generation based on bioenergy was estimated to be 22.5 per cent per annum (Energy Statistics of India, 2016). However, there has been very little research on the regional impacts of bioenergy imperatives in India. The few case studies that have been conducted on bioenergy plantations in different regions of India reveal that these projects have been associated with negative repercussions for the local rural populations. The adverse outcomes include exploitative practices by bioenergy plantations (Pradhan and Shaun, 2014), land use change and loss of property and grazing rights on village commons owing to setting up of bioenergy plants (Baka, 2014), as well as ground water depletion and soil erosion (Gmunder et al, 2012)

Thus, from this section one may conclude that governments across both developed and emerging economies are promoting bioenergy as a means to solve their energy problems and promote a "clean" source of energy. Bioenergy production has been promoted through a number of mechanisms like tax concessions, subsidies and legislations. While USA, Brazil and EU have had a head start in biofuel production, in recent years Asian countries like India and China have also started promoting alternative energy sources in a big way. The focus of bioenergy policies across different countries remains on making bioenergy a profitable and commercially viable source of energy and mainstreaming its development. However, in pursuing the objective of profitability, sustainability concerns associated with bioenergy have been ignored by policymakers, which is creating a host of problems. These sustainability challenges are elaborated upon in detail in the next section.

3.5 Challenges in the Implementation of Sustainable Bioenergy Policies

Sustainability is based on the integration of social, economic and environmental prerogatives (Neven et al, 2015). An analysis of the bioenergy developments across the world reveals that there are serious concerns with respect to the sustainability of bioenergy projects on all the three counts.

3.5.1 Low Energy Returns and economic unviability

A number of studies have emerged in recent years, which reveal that contrary to popular perception, it is highly unlikely that bioenergy will become a viable alternative to fossil fuels in the near future (Smil, 2008, Wang et al, 2012; Gomerio, 2015; Gallejones et al, 2015). Ragauskas et al (2006:484) forecasted that with the current level of technological development; biofuels will only be able to meet 30 per cent of the needs for transport fuel by 2025. The most comprehensive study on energy returns from biofuels was conducted by Pimentel and Patzek (2005). They investigated ethanol and biodiesel production in USA and showed that on an average ethanol production requires a total energy input of 6597 kcal/ litre and produces energy value of only 5130 kcal/ litre leading to negative energy returns of 29 per cent.

Smil (2008) defined power density of a source of energy as the rate of flow of energy per unit of land used. He estimated that the power density of biofuels was two times less than hydro and solar energy, and three times less than that of fossil fuel energy Wang et al (2012) and de Castro et al (2014) estimated the net energy returns on investment (EROI)[15] for biofuels. The findings from both these studies revealed that although many biofuels like sweet sorghum, sugarcane molasses and jatropha are net energy providers with EROI>1, however their net energy returns are currently quite low and it is unlikely that these will be a sustainable alternative in the near future. Borrion et al (2012) also estimated the net energy returns on investment in starch and sugar based biofuels. Their results showed that returns vary greatly with the type of feedstock grown as well as the region in which it is grown. Hence, it cannot be conclusively established whether biofuels may be a viable energy alternative in the near future. Carriquiry et al (2011) conducted a detailed study on the cost of production and relative economic merits of fossil, first and second-generation biofuels. Their findings showed that currently the cost of producing biofuels is five times higher than fossil fuels. They concluded that it is highly unlikely that biofuels will become cross- competent with fossil fuels in the near future. Another study by

15 EROI is defined as ratio of the energy delivered in a process to the total energy used (directly or indirectly) in that process.

Gomerio (2015) evaluated that EROI on major first-generation biofuels lie in the range of 0.8-1.6, while the EROI on fossil fuels falls in the range of 20-30.

Thus, one can conclude that with the current level of technological development, the energy returns from bioenergy are quite low, while their cost of production is substantial in comparison to traditional fossil fuel sources of energy. It is still uncertain whether biofuels can become a viable energy alternative in the near future.

3.5.2 The ecological footprint of biofuels

The effect of biofuels on mitigation of pollution and reduction in GHG emissions remains highly contested. Some studies based on Life Cycle Analysis (LCA)[16] techniques postulated that bioenergy developments will bring about reduction in Green House Gas emissions relative to fossil fuels, since biofuel production requires much less use of fossil fuel inputs (Goldemberg, 2007; Mitchell, 2008; Gopal and Kammen, 2009; Gallejones et al, 2015). Other scholars believe that although biofuels are less intensive in the use of fossil fuel inputs, the GHG emissions from the use of biofuels are only marginally lower than those of biofuels (Farrell et al, 2006; Searchinger et al, 2008; de Castro et al, 2014). Fargione et al (2008) propounded that biofuel production will create a “biofuel carbon debt” by releasing a stock of soil and biomass carbon that is 17 to 420 times higher than the annual GHG reductions that bioenergy developments would bring about through replacement of fossil fuels. Scharlemann and Laurance (2008) conducted a comprehensive study on the environmental costs associated with thirty-six sources of bioenergy. These environmental costs were estimated by assessing the impact of biofuels on natural resource depletion as well as health and well-being of human actors. This study found that twelve out of thirty six most commonly used biofuels like ethanol, sugarcane, and palm oil have very damaging aggregate environmental impacts. Hammod and Bo (2016) estimated that the environmental footprint of biofuels was

[16] LCA model aggregates the materials (quantity of fuel, electricity, water, chemical and pollutants and the embodied energy flow) associated with production and consumption of a particular commodity (Farrell, 2006).

0.29 gha (global hectares) in 2010 and is likely to grow to 2.57 gha (global hectares[17]) by the year 2050.

Another major concern with the commercialisation of biofuels is their impact on soil quality. The cultivation of biofuels requires extensive use of fertilisers, insecticides and pesticides, which lead to deterioration of soil quality and is also responsible for high degree of groundwater pollution (Pimetel and Paztek, 2005; Farrell, 2006; Searchinger et al, 2008; Kim and Dale, 2011). According to Farrell (2006: 26), "The adverse consequences of the use of biofuels include soil erosion, eutrophication, impacts of exposure to pesticides, as well as habitat and biodiversity loss due to land use change." Another major concern with production of biofuels is that chemical plants involved in the production of ethanol produce large amounts of polluted water and chemical toxins, which are harmful for the natural environment. Pimetel and Paztek (2005) showed that the production of one litre of ethanol generates thirteen litres of polluted water. Their research also revealed that currently there are no proper procedures in place for disposal of waste generated through biofuel production. Hammod and Bo (2014) conducted a similar study, and evaluated the water footprint of liquid biofuel production between 2010-2050. They estimated the water footprint of biofuels is currently 9 per cent and is expected to rise in the future.

Although bioenergy is being promoted as a "clean" technology, doubts remain on whether it would help to reduce GHG emissions. On top of this production of biofuels is intensive in the use of fossil fuels, electricity, fertilisers, pesticide and insecticides (Neimark, 2016). Thus, production of biofuels leaves large ecological footprints (Neimark, 2016). In this context, a number of scholars have propounded that the production of biofuels will only be sustainable in the long- run if fundamental changes are made to the cultivation practices of the food crops

[17] Global hectares are units of measurement, which are used to quantify the biocapacity of the earth (the capacity of the ecosystems to regenerate the resources people demand from it) and its regions as well as the demands placed on the biocapacity of the earth through human activity (measured by the ecological footprint). One global hectare measures the net productivity of all biologically productive areas (measured in hectares) on the earth. Examples of biologically productive areas include forests, fishing grounds and croplands.
(Source: https://www.footprintnetwork.org/resources/glossary/) [accessed on 14/12/2017].

associated with biofuels (Pimetel and Paztek, 2005; Searchinger et al, 2008; Kim and Dale, 2011; and Hammod and Bo, 2014).

3.5.3 Biofuels and land use change

There are serious concerns about the expansion of biofuels, with respect to land use change. Biofuel production competes for land use with other agricultural activities like production of food crops, and also with other environmental objectives like protection of rainforests and tropical lands for maintaining biodiversity (HLPE, 2013:77). Fischer et al (2002) and Field et al (2008) conducted two comprehensive studies, based on satellite imagery to assess the global land availability to sustain the current levels of production of biofuels. Both these studies found that almost all of the available land for bioenergy production across Asia, Africa and America is either under cultivation or under forests. Thus, expansion of biofuel can only come through substitution with other crops or bringing in forests, grasslands and pastures into production of crops. This may lead to two types of changes in land use patterns viz. Direct and Indirect Land Use Change.

a) **Direct land use change (DLUC)** occurs when feed stocks for biofuel production are grown on forests, rainforests and tropical lands, which were previously not under crop production (HLPE, 2013). Tilman et al (2006: 1600) stated, " Accelerating the use of food crops for biofuels has raised concerns about biodiversity loss if extant native ecosystems are converted to meet demand for both food and biofuels." A number of studies have illustrated that DLUC will have alarming consequences for the environment. Kenney and Hertel (2008) analysed the impact of ethanol in USA and found that the current level of productions of corn ethanol will reduce pastures and grasslands by 35 per cent and 53 per cent respectively in the next ten years. Searchinger et al (2008) estimated that an increase in US ethanol production by 56 million had led to a decrease in area under food crops by 10.5 million hectares between 2000-2005. Dauvergne and Neville (2010) analysed the environmental impact of palm oil plantations in Indonesia and concluded that these bioenergy plantations have led to an 18 per cent rise in deforestation of timber forests between 1990-2010, with grave consequences for ecology and wildlife. Kwon et al (2013) applied the LCA model to USA national statistics database for the year 2005-06 and concluded that in the next 10 years production of ethanol will reduce grasslands and forests by 20-30 per cent across 22 states of USA. A similar methodology was adopted by Giuseppe et al (2012), who applied the LCA model to US national statistics on crude oil production, land availability for food crops and biofuel production and forecasted that biofuel production would decrease land availability for food crops in US by 54000-68000 hectares by 2025.

b) **Indirect land use change (ILUC**) occurs when biofuel production leads to changes in land use, not on site but elsewhere due to the need to compensate foregone production (Arndt et al, 2010; Kim and Dale, 2011). ILUC due to biofuel use is extremely difficult to ascertain because it involves establishing a link between biofuel production in a particular region and the new crop production established on forests/grasslands elsewhere (Ahlgren and Di Lucia, 2014). It is contended that ILUC can only be established indirectly through agricultural models but cannot be directly assessed (HLPE, 2013). However, some scholars have attempted to model the ILUC due to biofuel use and their consequences for the environment by using various agricultural models. Dumortier et al (2011) estimated the trade-off between biofuel use and food production in the USA and world agricultural markets. They employed 2006/07 data and generated predictions for the next 10 years up to 2016. The multipliers generated in the study showed that land demand is highly sensitive to the global production of biofuels. Land will increasingly move away from crop production to use for biofuel feedstock production in the next decade, if biofuel production in the USA continues unabated. On the other hand Kim and Dale (2011) modelled the impact of USA corn ethanol production between 2002-2007 on changes in corn croplands across countries, which were major trading partners of US in ethanol production. They could not find any significant relationship between the two and concluded that indirect land use change does not exist. ILUC remains a deeply contested subject. While the results of some empirical studies have confirmed significant ILUC (Ahlgren and Di Lucia, 2014; and Hammod and Bo, 2016) others contend that ILUC due to biofuel production is insignificant (Palmer and Owen, 2015). These divergences are found because currently there is no systematic methodology for estimation of ILUC through biofuels

(Finkbenier, 2014). Questions remain on the robustness and consistency of the current estimates and it is feared that most studies either underestimate or overestimate ILUC through biofuel production (Finkbenier, 2014).

Thus, from this section it can be concluded that there are widespread implications of the expansion of biofuels in terms of deforestation and changes in land use patterns. These implications need to be carefully thought about if biofuels are to be produced on a commercial basis in the near future.

3.5.4 Food versus fuel debate

The most serious concern about the commercialisation of biofuels is their impact on food security and food price inflation, especially so in developing countries. The massive rise in global biofuel production between June 2007-08 was accompanied by the steepest increase in global food prices since 1980s (HLPE, 2013). In 2008-09 cereal prices rose by two to two and a half times while sugar prices rose by eight to ten times in the global food markets (Abbott, 2011). Prices continued to remain volatile in the subsequent years leading to severe food shortages and sparking food riots across many developing nations (HLPE, 2014). It is believed that the rapid expansion in production of corn and vegetable oil for use as a fuel was a key factor in triggering the crisis (HLPE, 2013). Biofuel production was described as an “amplifying” factor in the global food price surge (Abbott, 2011). The inter linkages between biofuel production and global food price rise have been confirmed by many international agencies (IEA, 2013; FAO, 2010 and World Bank, 2012). According to Action Aid (2013), “The current EU biofuel production could produce enough food to produce 185 million hungry people across developing nations.”

A number of studies were conducted between 2008-2012 to analyse the extent to which the global production of biofuels and the EU/US biofuel mandates impacted the food security in developing countries during this time. The key results of some of these studies reveal that bioenergy developments were the main trigger for the food price inflation and food shortages in 2007/2008 global food crisis (Table 3.2).

Table 3.2: Review of impact of biofuel policies on prices of food commodities			
Study	**Scope of the Study**	**Methodology**	**Findings**
Mitchel (2008)	Key factors in 2007/08 global price rise	Adhoc methodology	70-75% rise in global food prices was due to biofuel expansion
Rosegrant (2008)	Comparison of actual price of food grains in the global food market between 2000-08 with simulated prices had expansion of global biofuel production not occurred.	Partial equilibrium Analysis	Biofuel expansion responsible for 30% wheat price rise; 39% maize price rise and 21% rice price rise
Baier et al (2009)	Impact of worldwide biofuel production on food price rise since 2005	Partial equilibrium analysis	12 per cent rise in global food price index of IMF due to expansion of biofuels. 60% US biofuel contribution; 15% EU biofuel contribution and 14% Brazil biofuel contribution in global food price rise.
Fischer et al (2009)	Impact of global biofuel use on world food prices in 2020 keeping reference scenario of biofuel use at 2008 levels.	Ecological modeling using FAO Agro Ecological Zone Model	Global biofuel production will lead to 35% rise in cereal prices by 2020
Lagi et al (2011)	Impact of US ethanol production on food price hikes between 2007/08	Comparative static partial equilibrium model	US biofuel production between 2007-08 is responsible for 20 per cent global rise in prices
IEEP (2012)	Impact of EU biofuel policies on world food prices between 2007-08 and 2011-2012.	Review of 10 studies based on agricultural models	EU biofuel policies caused 8-20% rise in oilseed prices; 8-13% rise in cereal prices and approximately 22% rise in sugar prices
Timilsina et al (2011)	Impact of global biofuel production on prices of agricultural commodities since 2005	Dynamic Computable General Equilibrium Model	Biofuel production responsible for 5% global cereal prices and 7-10 % rise in sugar prices.
Drabik (2012)	Impact of US ethanol production on corn prices	Comparative Spatial Partial Equilibrium Model	26-45% rise in corn prices between 2008-2011 in USA are attributed to expansion of ethanol production.
Source: Self Compilation based on review of literature			

3.5.5 "Green" Grabs

In 2008 John Vidal coined the term "green" grabs in order to describe how individuals, charities and corporates in the West were appropriating large tracts of land in Africa in the name of bioenergy development (Vidal, 2008). Evidence has emerged that biofuels are the primary source of land grabs by Western corporations in countries of Asia and Africa, leaving the local populations in a deep peril.

Action Aid (2013) conducted an in depth study on land grabs by corporations in the Sub-Saharan Africa region. Their study found that 98 European biofuel companies in Sub-Saharan Africa have acquired 6 million hectares of land. In another study Arndt et al (2010) found evidence that *Senhuile Senethanol*, an Italian company acquired 10,000 hectares of agricultural land in Tanzania in order to produce biofuels. This led to the displacement of 9500 inhabitants spread over 37 villagers. They were not given any guarantee with respect to land use change. Polack et al (2007) reviewed 16 case studies on large-scale land acquisitions by commercial biofuel producers in Africa and concluded that weak land laws and governance frameworks were the primary cause of these land grabs. They found that although on paper the land acquisition procedures of bioenergy plantations were progressive and participatory, there was huge difference between theory and actual practice. Villagers were often excluded from land deals and trade agreements governing biofuel production. Baka (2014) conducted a detailed study on biofuels produced through jatropha cultivation in the state of Tamil Nadu, India on the basis of detailed review of land records and interviews with key stakeholders. Her findings showed that jatropha plantations in the region acquired large tracts of wastelands from local village councils at very low prices and re registered these lands in their own name without any prior knowledge of the original owners. This resulted in displacement of property and grazing rights of local villagers on the village commons, especially those from poorer households.

Thus, from this analysis one can say that the production of biofuels has so far proven to be unsustainable on social, economic and ecological counts. On the economic front biofuel projects are not economically viable with the current level of technology, owing to their high cost of production and low energy returns. The impact of bioenergy developments on reduction in pollution remains questionable. Bioenergy developments have also resulted in adverse socio-economic outcomes across the world. They have exacerbated food and nutritional insecurity due to competition for land between food and biofuel crops. These have also proven to be a source of land grabs in many countries of Asia and Africa and displacement of indigenous populations and violating their livelihood rights.

3.6 Summing Up

In conclusion one can say that bioenergy policies, which were widely promoted since early 2000 in the global energy markets have failed to live up to their expectations. They were being seen as a means to develop " clean" sources of energy, curbing the hegemony of large oil companies and promoting energy security in developing countries. However, so far bioenergy developments have merely provided a subsidiary market to large oil and food companies and strengthened their control over energy and agricultural prices. Despite their low energy returns, questionable ecological benefits and adverse socio-economic outcomes these projects receive continued support from national governments in the form of subsidies and incentives. On the other hand food and livelihood security of rural populations in developing countries, who were touted as the principal beneficiaries of bioenergy developments, have suffered due to commercial biofuel production.

The review illustrates that purely technocratic "green" energy projects are not a sustainable alternative. Bioenergy is not merely a technical development; it has deep inter-linkages with socio-economic, political and ecological prerogatives. Unless these linkages are taken into account bioenergy policies will not prove to be long run solution to the current challenges in the energy sector. Narrowly framed bioenergy policies will only exacerbate the existing ecological challenges and socio-economic inequities across developing regions.

The next chapter will take the analysis forward by developing an alternative framework rooted in an eco-socialist perspective to inform sustainable bioenergy policies. This framework will be based on a people-centric approach to bioenergy developments and recognise the inter-linkages between bioenergy developments and the larger socio-economic prerogatives of a developing economy.

CHAPTER FOUR
TOWARDS SUSTAINABLE BIOENERGY DEVELOPMENT- AN ECO-SOCIALIST PERSPECTIVE

4.1 Introduction

In the last chapter, we discussed how bioenergy reforms within green capitalism are proving to be inadequate to address the environmental crisis. I concluded how the deficiencies of the current bioenergy reforms are rooted in the very nature of these reforms. These bioenergy developments are exclusively focused on creating technocratic solutions to the energy crisis and implementing them as an "ecological" fix. There is little recognition of the socio-economic aspects of these developments and the impact of bioenergy projects on the lives on the stakeholders involved. As a result these reforms are proving to be counterproductive to the interests of the local populations involved.

In view of these concerns, in this chapter I present an alternative framework of bioenergy developments rooted in the key tenets of eco-socialism. Eco-socialism is a radical response to the ecologically destructive vision of capitalism. It aims to bring about a structural transformation of human society, based on harmony with nature through alternative development practices (Ma, 2012). This chapter employs the eco-socialist perspective to inform sustainable bioenergy reforms, across developing nations. An eco-socialist framework is based on the integration of social, economic and ecological realms of sustainability (Neven et al, 2015). This approach to green energy imperatives is cognisant of the social, economic, institutional and ethical aspects of sustainability. The eco-socialist paradigm does not treat bioenergy reforms as a "technical" fix, but attempts to embed these green energy imperatives within the larger political- economy of a region. Such an approach to green energy developments will facilitate the formulation of people centric, inclusive policies that are responsive to the energy needs and aspirations of local populations at the ground level.

The chapter is divided into five sections. The first section reflects on the theoretical construction of eco-socialism. The second section analyses the relationship between eco-socialism and the Marxian perspective on ecology. The third section evaluates the inter-linkages between eco-socialism and the green perspective. The fourth section elucidates how eco-socialism represents an amalgamation of the two schools of thought: Marxism and Ecology and integrates the social, economic, institutional and ecological aspects of sustainable development. In the final section I present the framework of bioenergy developments, informed by the eco-socialist paradigm.

4.2 The Theoretical Constructs of Eco-socialism

In chapter two, I analysed how some scholars view the capitalist mode of production as the principal cause of the energy/ecological crisis, facing humanity. They contend that this system is based on the "uni-directional process of production, distribution and consumption of resources, without assigning value to the natural resources used in the growth process" (Moore, 2015:2). At the same time, these scholars also recognise that the development pattern in old-style[18] socialist economies, rooted in "productivism[19]" has also been destructive to the natural environment. Thus, both these systems have proven to be inadequate to address the ecological question.

In early 1960s and 70s some ecologists like Commoner (1972) and Kapp (1963) began to subscribe to the Marxian analysis to explain the ecological contradictions in capitalist societies and develop a new socialist paradigm, aligned with ecological goals. However, it was only in late 1970s and early 1980s that an alternative perspective of eco-socialism began to be systematically developed by connecting the fundamentals of Marxist socialism to the insights derived from ecology (Lowy, 2005). Eco socialists believe that socialism is a natural ally of the green movement and the amalgamation of the two schools: Marxism and Ecology can help to create a viable third alternative to both old style socialism and capitalism (Eckersley, 1992:120; Dobson, 2007:110; Singh, 2010 b: 33).

[18] Old-style socialist economies refer to countries of Eastern Europe, USSR and China, which claimed to follow a socialist pattern of development. However, environmental protection did not emerge as a core concern in the central planning process in these countries.
[19] Productivism is the belief that measureable economic productivity and economic growth is the basic purpose of economic development (Commoner, 1972).

A diverse group of scholars have conceptualised eco-socialism since the 1970s (Commoner, 1972; Parsons, 1977; Wainwright and Elliot, 1982; O'Connor, 1988; Pepper, 1993; Sarkar, 1999; Lowy, 2005; Kovel, 2008; Foster, 2009; Singh, 2010b and Moore, 2015). This heterogeneous group of scholars shares a vision for the development of an ecologically sustainable society, founded on the basic principles of social justice, as espoused by socialism. Eco-socialists endeavour to provide a radical alternative to the "environmentally destructive progress under capitalism" by framing a development perspective, which recognises societal needs[20] as well as the imperatives of environmental protection" (Lowy, 2007).

Eco-socialism provides a vision to transform the production process in society, from a system centred on commodity production to one in which the protection of the ecosystem is the centre of social activity (Kovel, 2008). Eco-socialists have developed a new perspective on environment by analysing the problems of ecological degradation from a Marxian political economy lens so that ecological challenges can be located within the existing class structures and mechanisms in the society. Eco-socialists believe that environmental concerns are not divorced from larger societal concerns (Pepper, 1998). Some studies have empirically shown that environmental degradation has had a disproportionate impact on vulnerable and marginalized groups in society, who are often left out of the mainstream environmental discourse (Merchant, 1992; Boyce, 1994; Ma, 2012 and Karrouchi, 2016). Therefore, eco-socialists contend that ecological problems need to be analysed within the context of class and gender inequalities and inequitable distribution of natural resources in the community.

Eco-socialists reject the conception of "mastery of humans over their natural environments" and contend that "We should not try to dominate or exploit nature in the sense of trying to transcend natural limits and laws[21], but we should collectively plan and control our relationship with nature for the collective good through

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[20] Societal needs, refers to the essential needs of the world's poor to which over-riding importance should be given, as stated in UN's Brundtland Commision Report (UN, 1987).

[21] Ecological limits here refer to the "Limits to Growth" thesis, published by the Club of Rome (1972), which states that there are limits to the capacity of the ecosystem to sustain the growth process in the global economy. Transcending natural limits to growth refers to attempts through technical means to transcend the limits to the availability of natural resources.

democratic processes and creation of decentralized institutions" (Pepper, 1993:233). They recognise that continuous economic growth and capital accumulation under capitalism cannot be achieved without indiscriminate exploitation of our natural resource base. This is borne by empirical evidence. A study by Jorgensen (2003), for example, modelled the impacts of per capita income, market concentration and urbanization on per capita resource use or ecological footprint and found that per capita income had the strongest positive effect on the ecological footprint, followed by urbanisation. Similarly the World Wildlife Fund (2014) found that Cuba was the only country in the world, which had an ecological footprint of 1.7 global hectares (GHZ)/person.[22] The world average was 2.7 GHZ/person; while in the three most advanced capitalist economies: USA, Japan and EU, the ecological footprint was estimated to be 8.9 GHZ/person (Bell, 2015).

If this literature is summed up, three basic foundations of eco-socialism emerge a) Ecologically friendly production processes, which minimises the ecological footprint of economic activities b) democratic planning of investment and production decisions for preservation ecological resources through creation of decentralised institutions and stakeholder participation in environmental projects c) new technological structure of productive forces which recognise the "limits" to the availability of natural resources (O'Connor, 1998: 278). This thesis uses these three principles to understand and analyse the field experience.

4.2.1 Pathway to an eco-socialist society

Eco-socialists recognise that the transition to a socially just as well as an ecologically sustainable society is a dynamic and multi-faceted struggle for a new social order (Magdoff and Foster, 2010). This transition is a long-term process. Different eco-socialist scholars have varied perspectives on how to bring about a transition to an eco-socialist society. Scholars like Commoner (1972), O'Connor (1988), Foster (1999), Sarkar (1999), Singh (2009) and Moore (2015) critique green reforms within capitalism as "green wash." They believe that a transition to eco-socialism will only

[22] The sustainable level of ecological footprint is 1.8 GHZ/ person

occur in the face of the radical changes in the political economy of existing capitalist economies.

On the other hand, other authors such as Lowy (2005), Luke (2006), Singh (2010), Harris (2010) and Harris (2010, 2014) believe that green reforms within capitalism should be supported, as an interim measure to help move the global economy towards a sustainable development trajectory. They contend that these reforms might become a vehicle for more radical changes in the ecological paradigm of industrial economies in the future (Lowy, 2005). These green reforms include support for "green" capitalist reforms like development of renewable energy, international climate change agreements, development of ecologically designed housing with a high degree of energy efficiency and better waste disposal techniques (Singh, 2010b). These scholars contend such measures can help to reduce the mounting pressure on our natural resource base (Harris, 2010, 2014).

Mainstream environmental economics has primarily focussed on ecological issues in advanced capitalist economies. However, some eco-socialist scholars have also analysed environmental challenges faced by the poor in third world countries, such as infringement of land rights of local rural populations in the wake of expansion of agri-business enterprises in the countryside (Delyse, 2003); the reciprocal impacts of poverty and climate change in developing countries (Karrouchi, 2016); appropriation of "wastelands" and "commons" for expansion of green businesses (Baka, 2014). In a developing country's context, the class dimensions of environmental problems are particularly relevant. Evidence shows that many of the ecological challenges in developing countries disproportionately impact the poor and vulnerable groups in society. Therefore, in these contexts eco-socialists advocate that a road to sustainability can be created based on a coalition between grass root environmental movements, labour movements and socially responsible corporations (Harris, 2010). These grass root environmental movements are discussed in the subsequent sections.

Eco-socialists believe that green reforms within capitalism should be made more people-centric and inclusive of vulnerable groups in society, especially in the context of developing countries (Luke, 2006). This can be accomplished through a "bottoms up" approach, rooted in democratic and decentralized institutions, and community participation in environmental decision-making. These scholars believe that green capitalist reforms, when implemented democratically, can be a vehicle for the creation of an **eco-democratic** society. According to Lowy (2005:21) "the struggle for ecological reforms under capitalism can be a vehicle for dynamic change, a transition between minimal demands and maximal program, provided that one rejects the pressures of the ruling class for competitiveness and modernization in the interests of the rules of the market." These measures will constitute a starting point for the formulation of an ecologically sustainable society and a means to mobilise public support for such initiatives (Lowy, 2005). In the field based research in the subsequent chapters, I have essentially drawn on the concept of eco-democratic reforms to assess the sustainability of green energy developments.

After presenting the key ideas of eco-socialism, in the next sections I will elaborate on how eco-socialism draws critical insights from both Marx as well as the ecological school to arrive at a framework for achieving sustainable development.

4.3 Relationship between Eco-Socialism and the Marxian Perspective on Ecology

The eco-socialist paradigm essentially draws from the Marxian interpretation of the dialectical link[23] between humans and nature in order to understand how capitalism creates a "metabolic rift[24]" between humans and their natural environment (Foster, 2009: 163). According to Burkett (2007: 24) "Eco-socialism seeks to understand the

[23] "Dialectical link" between nature and humans is a concept developed by Foster (2009) using the Marxian theory of dialectics. According to this theory, as humans have developed through the course of history, they have transformed both themselves as well as external nature. Nature is the essential basis of human existence. However, the advent of capitalism created a "rift " between nature and humanity. In this context, Marx (1993) showed that with the development of agricultural sciences in the 18002, the fertility of soils was manipulated in order to increase productivity. Manufacture of fertilizers generated industrial wastes, along with land and water pollution.

[24] Foster (2009) says that "metabolic rift" essentially refers to the mismatch between the demand for natural resources under capitalism and the ability of nature to meet those demands. Capitalism does not recognise the essential "limits to growth" and the "limits" to the availability of finite natural resources. It believes that growth process can continue indefinitely by developing technical substitutes, creating markets and expanding the resource base of the economy. The conception of metabolic rift has been applied by Foster (2009, 2015) to analyse environmental issues like ozone layer depletion and destruction of marine ecosystems.

ecological context of Marx's historical materialism as a means to critically transcend existing green theory."

Many scholars believe that Marx had profound insights into ecology (Parsons, 1977; Ryle, 1988; Pepper, 1993; Foster, 1999, 20015; Foster et al 2010 and Singh, 2009). Marx was much ahead of his times, and in the early 19th century and posed many of the ecological questions that are relevant even today: the relationship between nature and human society, the exploitation of natural resources under capitalist system as well as the question of sustainable economic development. According to Foster (2015) Marxian analysis provides critical ecological insights into the process of social transformation and reflects on how egalitarian human development may be attained in consonance with the requirements of the natural ecosystem. In the subsequent sections I will elucidate on the key aspects of Marx's writings on ecology, which have informed the eco-socialist paradigm.

4.3.1 Marxian concept of the dialectical link between humans and the natural ecosystem

Marx referred to nature as "man's inorganic body" and humans as a "part of nature" (Marx, 1970:112). He recognised nature as an essential basis of human existence. He believed that humans are dependent on nature and it is imperative to take care of the ecosystem, for the very survival of humanity. This understanding of the relationship between humans and their natural environment by Marx was in in sharp contrast to the other scholars such as Francis Bacon, Descartes and Leibniz, who believed that nature and human beings are diametrically opposed to one another, and scientific and technological progress are the means by which humans can attain mastery or conquest over the natural environment[25] (Singh, 2009:109). For instance Bacon believed that science and technology would enable humans to regain control over nature (Singh, 2009:110). Descartes, the father of western philosophy claimed that new science would enable humans to become the masters and possessors of the

[25] This view of the relationship between nature and humans is referred to as the Christian anthropocentrism, which subscribed to the idea of humans as the center of the universe. Some philosophers of this school like Descartes also believed that only humans had minds and other creatures were merely bodies (Sessions, 2008:168).

earth (Sessions, 2008:168). In contrast to these scholars Marx accepted the interrelationship between humans and the natural environment.

"The life of the species, both in man and animals, consists physically in the fact that man (like the animal) lives on inorganic nature; and the more universal man is compared with an animal, the more universal is the sphere of inorganic nature on which he lives Nature is man's inorganic body-nature, that is, in so far as it is not itself the human body (Marx, 1970:112).

He believed that humans have been created as an evolutionary product of natural processes. As human development takes place, with the unfolding of new human potential, emergence of new needs, skills and talents, as well as development of higher forms of production and consumption, humans transforms both themselves and their natural environment (Singh, 2009:114). He thus conceptualised external nature as the other side of humans, which is constantly transformed by human intervention.

Marx believed that humans are nurtured by their natural environment, and in turn through the process of human labour; they transform nature for their own purposes. Thus, Marxian analysis contends that humans and their natural environment cannot be viewed independently of each other; they are connected in history through the process of historical materialism[26] (Parsons, 1977:148). He believed that humanity and nature are intertwined in the process of social metabolism, which is historically conditioned through social production relations. Marx believed that nature is not an abstract or a supernatural concept but it is a humanised product, and cannot be separated from generic human needs (Marx, 1970: 143)

4.3.2 Recognition of nature as a source of wealth

Marx believed that nature is the ultimate source of wealth, which he expressed in terms of use value[27]; he believed that all material goods could only be produced with the help of nature (Marx, 1993:472).

[26] Historical materialism is defined as the lens through which Marx views the process of historical development of human society on a scientific basis, by uncovering the general processes and laws that govern nature and society (Woods, 2016).

[27] Marx had defined value in terms of unity between use value and exchange value. He believed that use value is the actual content, particularity of the commodity while exchange value is the

He recognised nature as a source of creation of wealth, along with labour. He was critical of other socialist scholars of his time who believed that labour is the sole source of wealth, endowed with “supernatural creative powers” and disregarded the role of nature (Marx, 1904:33).

4.3.3 Capitalism: A source of “metabolic rift” between humans and nature

Marx believed that the capitalist production relations have alienated humans from nature and created a “metabolic rift” between humans and the ecosystem (Foster, 2009:180). He believed that capitalism destroys both the material and the social relationships of production and “dehumanises humans” and “denatures nature” (Parsons, 1977:19). He contended that the violation and destruction of human and the natural environment are intimately connected, since human beings are themselves an “organic part of their natural environment” (Parsons, 1977:20). Marx thus viewed ecological issues, not as abstract or independent questions but as a part of his overall critique of capitalist society (Marx, 1993: 489).

He subscribed to the view that the social and material basis of capitalist societies is essentially flawed, as capitalism erodes both human wealth (labour power) and natural wealth in the pursuit of capital accumulation. Marx believed that capitalism was necessarily based on “subjugation of nature to fulfil human needs” (Marx, 1977:19). Capitalist relations of production represent one-sided, exploitative relations with nature and other humans and are thus, in direct contrast to the requirements of an ecological sustainable and healthy life (Marx, 1993: 409-410).

4.3.4 Recognition of environmental and human degradation in capitalism

A recurring theme in Marx’s writings is the exploitation, pollution and degradation of the natural environment under the capitalist system. Marxian analysis focuses on how capitalism leads to ruination of both humans and nature through deforestation,

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monetary value of the commodity, which arises during the process of economic exchange (Keen, 1993).

degradation of soil, intensive agricultural production that despoils the earth, disruption of nature's cycle of matter and neglect of human welfare (Marx, 1999:297).

Marx also wrote comprehensively on the pollution and inhumane working conditions in industrial factories and working class neighbourhoods to explain the dehumanisation of the capitalist system. In his writings, he described the deplorable conditions of workers who were condemned to live in poverty and squalor, endure hunger and disease and work in deplorable conditions, characterised by noise, dirt, radiation, toxic chemicals and unsafe machinery (Marx, 1999:262).

4.3.5 Marxian conception of sustainable human development

The most widely used concept of sustainability is the one given by the Brundtland Commission Report (1987). This report defined sustainable development as "development, which meets the needs of the present generation without compromising on the ability of the future generations to meet these needs," (UN, 1987:12). Many eco-socialists believe that Marxian conception of sustainability was very close to this idea, when he conducted research on the crisis of the soil brought about by capitalist agriculture (Singh, 2009). Marx believed that the preoccupation with immediate monetary gains diverted from the basic purpose of agriculture, which is the fulfilment of permanent human needs at present and in the future (Marx, 1977:812).

Marx was also conscious of protecting the earth and the natural resource base of the economy for future generations, which is one of the principal ideas in the currently understood concept of sustainability.

"Even a whole society, a nation, or even all simultaneously existing societies taken together, are not the owners of the globe. They are only its possessors, its usufructuaries, and, like boni patres familias, they must hand it down to succeeding generations in an improved condition" (Marx, 1977:776).

Marx focused on transcending the ecological contradictions in capitalism towards development of socialism wherein human labour and the relationship between nature and society will be transformed. He believed that socialist society would be based on rational co-operation between humans and the natural environment, freedom from the oppression of ruling classes, release from backbreaking labour and overcoming the social separation between producers and the natural conditions of production (Marx, 1970: 135).

4.4 Limitations of Marx's Ecological Analysis

From the previous sections, we can conclude that Marx provides a rich analysis of the dialectical relationship between humans and the natural environment. He also elucidates on how capitalism creates a rift between the natural unity of humans and the ecosystem. Marx's writings also provide profound insights into how the emergence of socialism can restore the metabolic relationship between humans and nature and create a humane and ecologically sustainable society. However, Marxian analysis of ecology suffers from certain limitations. *Firstly,* Marx was aware of the ecological destruction under the capitalism, but he did not envisage that the size of the problem was so large that it might threaten the future of capitalism altogether (Singh, 2009:111). Some scholars believe that this may be due to the historical context of Marx's work. Marx was writing at a time when the ecological destruction by nascent industrialists was still limited and localised (Singh, 2009:111).

Secondly, some scholars like O'Connor (1988:13-15) have criticised Marx for not recognising how capitalist production system limits itself by impairing the ecological conditions, which are necessary for production to take place. This ecological destruction manifests in the form of rising costs and declining profits under capitalism, as is being experienced in the current times. Some examples include acid rains, global warming and pesticide poisoning; all of these are threatening profit making in modern capitalist economies (Dobson, 2007:167). Marx thus did not envision how "natural barriers" may lead to "capitalist barriers" in future. In this respect Sarkar (1999:18) noted, "The deeper aspects of the present day ecological crisis, with respect to nature's ability to absorb man-made environmental disruptions cannot be adequately explained within the Marxist paradigm."

Thirdly, Marx did not recognise the problem of limits to the availability of resources that nature imposes on the development of humanity and rather considered "nature as a free gift" (Marx, 1977:745) to be used in the process of production.

Fourthly, according to some authors such as De Kadt et al (2001) Marx had a positivist conception of nature and did not see any value of nature outside of its contribution to the productivity of labour. Marx under theorised on the importance of natural conditions that place limits on the production process (Benton, 1989) This emerges from his writings in Grundrisse where he describes how nature, independent of labour has no value

"The purely natural material in which no human labour is objectified, has no value, since only objectified labour is value" (Marx, 1993:366).

Fifthly, Marxian analysis on environment has not been thoroughly developed. The ecological contradictions are not systematically dealt with and resolved in this analysis. Marx simply assumes that the transition from capitalism to socialism will create an ecologically sustainable economy (Singh, 2009). He does not systematically reflect on the intrinsic value of nature and changes in the patterns of production and consumption, which are necessary to bring create an ecologically friendly development trajectory.

Lastly, some ecologists like Dobson (2007:165) are sceptical about bringing in the socialist ideas into the ecological movement, as they believe that socialists were dismissive of the ecological question till recently and side-lined it as a "middle class" concern, with little relevance to the working class and the "fundamental battle between labour and capital."

Eco-socialists recognise these weaknesses of the Marxian analysis on ecology. They therefore, draw from Marx with respect to the dialectical link between humans and nature and the ecological critique of capitalism. But at the same time recognise the limitations of his analysis and the need to develop the ecological question more systematically in the quest for an ecologically just and sustainable society. Eco-socialists have been able to accomplish this by bringing in the green perspective into socialism.

4.5 The Relationship between Eco-Socialism and the Ecological School

Eco-socialists believe that the ecological school has helped to recognise the importance of biological egalitarianism and the idea that the interests of both humans and non-human nature should be upheld for the creation of a sustainable society (Pepper, 1998). This school has helped to make us conscious of the ecological damage to the planet owing to the present mode of production and consumption in capitalist societies (Lowy, 2005: 17).

The greens and the eco-socialists share a common vision of creation of a new socio-economic system in harmony with nature (Porritt, 2005:9). Eco-socialists endorse many ideas of the mainstream greens, particularly in relation to recognition of natural limits to growth, particularly with respect to “limits to growth” and the finite availability of natural resources. They also support “green” ideas like the need to reduce conspicuous consumption, adopt a more ecologically friendly lifestyle at the individual level, importance of large-scale development of renewable energy and the adoption of more ecologically friendly technologies[28] (Singh, 2010).

In this section I will elaborate upon the foundations and the key theoretical constructs of the ecological school. I will also put forth the common themes in the green and the eco-socialist perspective and the differences between the two schools of thought: Ecology and Eco-Socialism.

4.5.1 The emergence of the ecological school

Ernst Haeckel first coined the term ecology in 1866 (Foster, 2015). Ecology was originally understood as a means of addressing the complexity of plant communities (Foster, 2015). It was only in the 19th century that ecological ideas emerged as a

[28] Some of these ideas are also being recognised under “green” capitalism as well. However, as we analysed in chapter 3 (in the context of bioenergy), these reforms have only had limited success so far. Also empirical evidence cited in the course of the thesis reveals that environmental destruction under capitalism has not been slowed down through green capitalist reforms. Many key natural resources have reached a “tipping point”

"critical reaction to the European enlightenment tradition."[29] Ecologists rejected the ideas advocated by scholars like Darwin, Malthus and Bacon, which accorded a central place to human beings and propounded that nature is simply an object to be manipulated for human use (Dobson, 2007: 23). A prominent figure in the ecological movement during this time was Justin von Leibeg who presented a critique of British agriculture in 1850s and 1860s and regarded it as "robbery culture," which was systematically depriving soil of its essential nutrients (Foster, 2015). In 1845 Julius Robert von Mayer gave the concept of the relationship between the biotic and abiotic components of the natural ecosystems, which became the cornerstone of modern ecological theory (Foster, 2015).

Despite these early forays to understand the gravity of the ecological challenges, it was only in the 1960s and 1970s that environmental problems began to be recognised in mainstream circles (Dobson, 2007:25). This was with the publication of some important studies on the ecological question at this time. In her seminal study Carson (1965) documented the detrimental impact of fertilisers and pesticides on our natural ecosystem. She analysed how chemical fertilisers were systematically developed in the post-world war II period from the agents of chemical warfare during the war period. Some of these chemicals were found to be lethal to insects (Carson, 1965:25). These insecticides were much more potent compared to the inorganic insecticides of the pre-war days (Carson, 1965:25).

She described these chemical fertilisers as "elixirs of death" and "biocides" which were being sprayed on forests, farms and homes, "killing insects-good and the bad, stilling the songs of the birds, coating the leaves with a deadly film and lingering on in the soils" (Carson, 1965: 11). This work helped to create awareness about ecological issues among the American public and helped to highlight the "sinister impact of technological progress" and the control of natural environment by humans (Carson, 1965:11). The other important work on ecology published at this time by Bookchin (1962). In the first part of this treatise Bookchin illustrated, how the advent of the Industrial Revolution, science and technology had made humans the "master of nature". In the second part of the book he described how these changes

[29] This tradition was based on a strongly scientific and materialistic perspective of nature (Vincent, 1992: 211-212).

led to creation of new problems (Bookchin, 1962). Bookchin demonstrated this through examples of exposure to automobiles exhausts, noxious fumes, and intensive working days for office workers, sedentary lifestyle and a high percentage of processed foods in the diet as well as reliance on chemical fertilisers and insecticides to boost agricultural production. In the final section he issued a dire warning that the creation of this "synthetic environment" will lead to an "ecological boomerang" and the more we try to master nature, more we would become entangled in the very forces we seek to master (Bookchin, 1962).

The "crisis of humanity" theme in ecological literature gained prominence with *The Limits to Growth* (1972) published by the Club of Rome. This report developed a model to investigate the trends pertaining to industrialisation, population growth, malnutrition, and depletion of natural resources, pollution and deterioration of the natural environment in the global economy. The central premise of this work was that there are natural barriers to economic growth, which cannot be overcome through technological sophistication and therefore continuous economic growth alongside high population growth cannot continue unabated (Meadows et al, 1972:23).

The widely publicised findings of these studies posed a challenge to the belief that we could continue in the "business as usual" scenario without any concern for the natural environment. For instance fuelled by the critique of chemical pesticides by Carson (1965), The United Farmworker's Union in the late 1960s demanded a ban on certain pesticides including DDT. This campaign ultimately led the US government to impose an outright ban on DDT in farming (Cole and Foster, 2008:281). Another important grass root movement was the anti-toxics movement, launched in the late 1970s. This movement forced President Jimmy Carter to evacuate residents from a housing development constructed on a toxic dumping ground in New York and provide them with housing at an alternative location in New Jersey (Freudenberg and Stiensapir, 1991). At this time there was also increased attention on the occupational health and safety hazards faced by workers. A number of trade unions such as oil, chemical and atomic workers union began to pay increased attention to issues of hazardous working conditions (Cole and Foster, 2008:284).

Ecological movements emerged in third world countries as well. Many of these movements were aimed at protecting the land rights of indigenous populations from being ravaged by the global market economy (Tokar, 2008: 110). These movements included Rainforest activism against the colonisation of Brazilian rainforests by multinational corporations as well as the Green Belt movement in Kenya (1977) where women across the country planted twenty million trees to protest against deforestation (Tokar 2008:111). The most prominent of these movements was the *Chipko* movement in India (1973) where men and women of the Himalayan highlands protested against displacement of indigenous ecosystems by plantation of commercially valued trees. They adopted means such as fasting, embracing ancient trees, laying down in front of logging trucks and removing planted eucalyptus seedlings that strain groundwater supplies as forms of protest (Tokar, 2008:110). Other important grass-root environmental movements in India were the anti-dam movements in the 1980s. The most prominent of these was the *Narmada Bachao Aandolan* in the 1980s, against the construction of Sardar Sarovar Dam on River Narmada. The project was supported by the World Bank. It was estimated that the construction of this dam would submerge 350,000 hectares of forestland, 200,000 hectares of agricultural land and displace about one million people (Nayak, 2015). The strategy of resistance was based on Gandhian tactic of *satyagraha* (non-violent civil disobedience) campaign. This movement was supported by NGOs, intellectuals and activists from other parts of India and the world (Nayak, 2015). It had widespread impact and forced the central government in India, as well as the Word Bank to review their policies with respect to construction of big dams and rehabilitation packages for indigenous populations. The Silent Valley movement was another important anti-dam movement in India. A network of local rural teachers and citizens brought about a sharp focus on the biodiversity losses, which would result from the construction of a large hydroelectric project on *Kunthipuzha* River, which flew through the Silent Valley in the Malabar region of South India. This movement got extensive support from the World Wildlife Fund. As a result of this movement, the Government of India ordered the project to stop in 1983 (Nayak, 2015). Environmental protest movements have however had limited impact in the post-liberalization era in India (Nayak, 2015). Nayak (2015) used case studies of environmental protests against setting up of mining and bauxite industry in the Odisha region of India[30]. He showed that despite widespread protests by the local tribal populations, international NGOs and activists, these movements failed to have an impact. His study showed that due to the growing nexus between the Indian state and large corporations, environmental movements have been suppressed since the 1990s. He concluded that the nature and direction of government policy on environment has a profound impact on the influence of these grass root movements.

To sum up, in this section we summarised the key tenets of the ecological school. Ecological questions came into prominence in 1960s and 1970s, with the publication of some major academic works were published on ecology. These works highlighted the ecological destruction under the present day industrial society and helped to create ecological consciousness in mainstream circles. At the practical level these academic works helped in mobilising a number of grass root movements for the protection of the ecosystem. These movements have been taking place across both developed and developing countries.

4.5.2 Key theoretical constructs of the ecological school

The central construct of "green" paradigm is the critique of anthropocentrism[31] or the mistake of giving preferential treatment to human interests over the interests of the non-human natural world. In contrast, greens believe in eco-centrism, which places value not only on humans, but also plants, animals and the ecosystem (Spretnak and Capra, 1985:234; Devine, 1995:10; Goodman, 2010:148). Eco-centrists critique the anthropocentric view of regarding humans as superior to other forms of nature

[30] These projects have led to displacement of 715,000 tribals in Odhisha. As per government records, collected by the Ministry of Rural Development, Government of India, 75 percent of the displaced have not been rehabilitated These projects have also resulted in destruction of 200,000 acres of forest land in Odisha (Nayak, 2015).

[31] Anthropocentrism is defined as a set of attitudes that consider human beings to be distinct and independent of all other forms of nature (Dawson, 2013). Anthropocentrists do not consider humans as animals at all, but a unique entity that transcends biological classifications (Martinelli, 2008:82). They believe that only humans are intrinsically valuable, all other forms of nature have value only to the extent that they serve human interests (Devine, 1995:12).

(Eckersley, 1992:50). They believe that promotion of humans at the cost of the non-human world is the primary cause of ecological degradation, which has now propelled into a crisis like situation (Dobson, 2007:42).

Greens aims to recognise the intrinsic value of the nature.[32] Thus, in contrast to the anthropocentric view of nature, greens subscribe to the eco centric view of the relationship between nature and humanity. Eco-centrism is based on an ecologically informed view, according to which all organisms are interrelated with the environment. They consider the world as a dynamic, interconnected web of relations, with no dividing line between human and non-human environment (Eckersley, 1992:49).

Greens believe that veneration towards nature and advocates that the principle of bio spherical egalitarianism or "the equal right to live and blossom" extends to all forms of life (Naess, 2007: 144). Some greens advocate going back to the traditional way of life and indigenous societies where in there is perceived to be harmony between humans and nature (Cannanr, 2000). They are heavily influenced by eastern and Native American traditions, which are in contrast to the anthropocentric Christian philosophy of "domination of humans over their natural environment" (Cannanr, 2000).

Greens critique traditional economics, which views the economic system as a circular flow of money, connecting households and firms. Ecologists contend that this model ignores the physical aspects of economic activities and neglects the fact that there is also a circular flow of matter in the economy; wherein matter is derived from the environment, used in the process of production and consumption and then returned to the environment in the form of waste (Jacobs, 1991:13-14). Greens subscribe to the law of entropy, which captures the impact of human activities on nature. Entropy is defined as the measure of disorderliness or unavailability of energy and matter (Jacobs, 1991:12). All economic activities lead to an increase in entropy, which is kept in check through natural processes by conversion of waste

[32] Intrinsic value of an object may have three interpretations 1) an object has intrinsic value if it is an end in itself as opposed to a means to some other end. 2) The value of an object solely on the basis of its intrinsic properties 3) The objective value possessed by an object, independent of the valuation of valuers (O'Neill, 1993:9)

into usable energy (Jacobs, 1991:12). However, nature's capacity to absorb waste generated by human activities is limited. When waste generation exceeds the absorption capacity of earth, it results in pollution, which leads to degradation of productive natural resources (Jacobs, 2012). Greens believe that a fundamental weakness of mainstream economics is that it fails to recognise nature as a fundamental part of the economy and vice versa (Jacobs, 1991:12-15).

4.5.3 Green conceptualisation of a sustainable society

There may be a number of interpretations of the concept of sustainability, depending upon one's paradigm. Pearce (1993) made the distinction between the idea of sustainability as understood by mainstream economists and alternative schools (greens, ecological economists and eco-socialists) and classified it as "weak" and "strong" sustainability. He argued that mainstream economists subscribe to the notion of "weak" sustainability. This approach considers environment as another form of capital. Weak sustainability paradigm believes that natural and manufactured capitals are perfect substitutes for each other. Therefore sustainability may be achieved by compensating for depletion of natural resources with development of man-made substitutes and technical progress, so that the overall stock of capital in the economy remains unchanged (Pearce, 1993:15-16). This approach advocates a managerial approach to environmental problems and believes that these can be solved through technocratic developments, without any fundamental changes in present patterns of production and consumption of modern societies (Dobson, 2007:2). Pearce (1998:100; 1993:16) pointed out to three main weakness of this paradigm.

a) Some forms of natural capital such are irreversible and cannot be created, destroyed and re-created like manufactured capital. Once lost, such assets are lost forever. For instance ozone layer depletion, and extinction of rare species of animals and birds. These assets cannot be replaced with human-made substitutes.
b) There is extensive uncertainty and lack of knowledge about the functioning of the ecosystem and the consequences of impairing the functioning of the ecosystem.

c) Due to the existence of "thresholds" with respect to the carrying capacity of the earth, there may be extensive ecological damage once these threshold limits are reached.
d) There are some natural assets, which are critical for human well-being, and a loss of these assets may lead to irreparable damage to the quality of life on the planet.

In view of these criticisms, greens prescribe to the alternative concept of strong sustainability, which believes that sustainability is attained if the stock of "critical natural" capital in the economy is left intact during the growth process. Critical natural capital refers to those ecological assets, which are essential for human survival and well being (Pearce, 1993:16). In contrast to the managerial approach to dealing with ecological challenges, prescribed by mainstream economists, greens believe that a sustainable society can be created through radical changes in the relationship between humans and the natural world and in the social and political modes of life (Dobson, 2007:3). Greens argue that this could be achieved through scaling down of economic activities, so that the scale of economic activities are limited to the "carrying" capacity of the eco-system; and waste emissions do not outstrip the assimilative capacity of the biosphere.

The main points of difference between weak and strong versions of sustainability are summarised in table 4.1 below.

Table 4.1: Strong and weak sustainability-A comparison		
Criterion	**Strong Sustainability**	**Weak Sustainability**
Conception of sustainability	Protection of nature is **necessary for the very survival of humanity**, as critical inputs provided by nature cannot be substituted by manufactured/ human capital.	Nature is a critical **factor in the process of production**, so natural resources should be conserved in order to keep the growth process in the global economy intact.
Path to sustainability	Technical progress along with **radical changes in production and consumption patterns** in society to make them ecologically friendly. Consumption and production should be scaled down so that the demands placed on our natural resource base do not exceed the assimilative capacity of the ecosystem.	**Technical reforms** and creation of green markets to make up for environmental degradation, while keeping the consumption and production patterns in society unchanged.
Nature of Ecological policies	The protection of **nature and human wellbeing is intrinsically related.** Ecological policies should be embedded in the larger development policy	Ecological projects are developed as **stand-alone projects,** divorced from the larger political economy of the region.
Objective of Sustainable Development	Keep the stock of **"critical" natural capital unaltered**. Development should not be at the cost of damage to the natural ecosystem.	Keep the **overall stock of capital** (human, natural and manufactured) capital unaltered. Ecological degradation within capitalism should be compensated by requisite technical/scientific progress so that overall development remains intact.
Source: Own compilation based on review of literature, Pepper (1998); Lowy (2005); Jacobs (2012) and Harris (2014).		

Greens thus recognise that continued economic growth and high level of consumption of resources cannot be accommodated in the long run because of the scarcity of natural resources. They therefore advocate sustainable development, which is based on a "needs-based[33]" economy, rather than the profit oriented neo-

[33] Needs based society is a vision of development, which is essentially rooted in the difference between use value and exchange value of a commodity. According to Kovel (2002) in a market economy, goods are not produced to meet basic societal needs, but are instead produced to be exchanged for money. Money is then used to acquire other goods and services. Kovel (2002) stressed

classical model of development. The advocates of this model espouse sustainable local economies, which are based on a diverse set of locally owned and operated co-operations that make communities self-reliant in necessitates (Zovanyi, 2013:145). Greens favour the creation of sustainable self-reliant-communities based on rural self-sufficient farms, worker's communes and community ownership of essential resources (Zovanyi, 2013:144). Greens believe that creation of such "needs" based communities would lessen vulnerabilities to external economic forces and help to curtail waste of energy, raw materials and production of superfluous goods that are aimed at only maintaining effective demand and keeping the economic machinery going (Zovanyi, 2013:144).

The second aspect of the green concept of sustainable economy is centred on "ecologizing" the market economy through creation of small ecologically friendly businesses; which are heavily scaled down in terms of material-energy flows and responsive to ecological considerations (Eckersley, 1992:141). Greens promote reform of corporations to enable greater worker and community participation in investment decisions. In addition to this greens support fiscal measures instituted by the state machinery through taxes on plastic bags, pollution charges and taxes, marketable permits and resource depletion quotas (Dobson, 2007:132).

The third important aspect of green sustainable economy is to advocate for changes in individual lifestyle and patterns of consumption and use of natural resources. Greens believe that individuals should be encouraged to adopt a more ecologically friendly lifestyle as "personal transformation leads to altered behaviour, which in turn can be translated into a sustainable community living" (Scales, 2014). In recent years, behavioural economics has provided rich insights on creating individual consciousness about environmental decision-making (Fehr and Schmidt, 2005; Milinski et al, 2008; Brekke and Johanson-Strenmen, 2008). Economists like Stern (2008) contend that individual responses to environmental protection are more

that this contradiction has reached such an extent that the production of many essential goods is unrewarded. Instead, a needs based economy espouses a vision, where production takes place according to the needs of the community. These needs are defined by the community itself through decentralised institutions like workers' commune and community based organisations. The basic emphasis of a need-based economy is to create economic stability and self-reliance among local communities.

complex than standard economic theory (rooted in the premise of rationality) suggests. He proclaimed that adoption of environmentally friendly technologies and changes in consumption patters of households depend upon a range of behavioural motivations including individual perceptions of risks and uncertainty, social norms and pressures, and procrastination. For instance, Marshall (2014) argued on the basis of anecdotal evidence and case studies that individuals are "hard wired" to ignore climate change, despite mounting scientific evidence because they do not see it as an immediate threat. Some studies have empirically evaluated how individual behaviour impacts issues like energy efficiency and conservation (McNamara and Grubb, 2011; Gowdy, 2008). Other behavioural studies have shown how social norms (Knetsch, 2010) and individual notions of fairness, social norms, altruism and well-being can be used to condition positive environmental action (Gowdy, 2008). Behavioural economists contend that if these insights are recognised by environmental regulators, individuals can be "nudged" to make better environmental choices (Stern, 2008). According to OECD (2012) behavioural insights can prove useful in improving the efficacy of existing policy mechanisms such as emission taxes, as well as the nature of market regulation and the processes needed to induce energy conservation at the household level.

Behavioural economics has provided keen insights on improving environmental policy architecture. However, Stern et al (2010) contend that behavioural changes on their own may not be sufficient to solve complex environmental problems like climate change and renewable energy deployments. These micro level insights need to be complemented with macro level changes in production structures in society, and the nature of environmental regulation. For instance Marshall (2014) argued that one of the reasons for people's cognitive bias and poor understanding of climate change issues is that public perception and mass media is dictated by the lobby of fossil fuel companies. These companies have a vested interest in denying the severity of environmental problems. These macro-structural issues are especially relevant for developing countries. Studies have shown that structural variables like the level of economic inequality, poverty, employment, the political institutions and legal institutions have a profound impact on environmental decision making (Rosser and Rosser, 2006).

As the aforementioned literature suggests, behaviour changes on their own may not be enough to address environment problems in developing countries like India, where there exist deep divides across classes, castes, gender and other identities. These divides inevitably create immense complexity and diversity in notions of social norms, fairness, understandings around distributive justice, gains and losses from development policy, and market failure and so on. All this limits the possibilities of taking either singular behavioural insights or homogenous production structures as starting points to address the environmental challenges. The nature of state and markets in developing countries further limits the possibilities of using micro level 'nudging' to address the larger social objective of environmental degradation. Harris-White (2014) writes

"Everywhere markets are structured 'customarily' through non-market forms of power and authority (expressed through gender relations, religion, ethnicity, caste, locality, the clan and the family) and their forms of political authority. These operate outside the market but are also constitutive features of markets, affecting endowments, assets and capacities to bargain and trade."

And writing on the State in the context of meeting the goals of human development in developing countries, Harris-White (2014) writes,

"*In awarding provisioning responsibilities to the market, the state cannot avoid creating a structure of private economic interests. Once established, the private providers of commodities and services needed for human development know they are too important to fail. Private providers then commonly start to supply the state with skills and policy advice, which the state, now confined to a regulatory role, no longer independently possesses. A community of expertise bridging the state and the market but dominated by the market - emerges, a community which, if it has to choose, must put profit above the public interest because if it did not it would go out of business. Conflicts of interest are deeply embedded: for the services to persist the 'problem' the providers are to solve must persist."*

Thus, as Harris-White (2014) argues, the specificity of both market and state is very different in the developing countries and is deeply socially embedded in the local context. Based on such understanding, in a developing country context therefore it is argued that decentralised institutions are needed to reinforce co-operation in environmental decision making, promote equality in access to natural resources and create democratic and participatory political processes. In my empirical investigation in Punjab, as discussed in the subsequent chapters, I have evaluated how environmentally conscious individuals and small community based organisations have created egalitarian institutions. However, these have remained small efforts. These community-based institutions have not been able to create mass support for green initiatives primarily because of lack of institutional support. Perhaps, what is needed is an eco socialist lens to the environment question where both, macro and micro approaches complement each other. This could potentially create the possibility of averting environmental destruction and creating a pathway to sustainable development.

4.6 Limitations of the Ecological School: The Eco-Socialist Critique

Eco-socialism and ecology have a number of common threads. Both these philosophies support participatory democracy, ecological consciousness, decentralisation of economic and political power and protection of human rights (Eckersley, 1992:140). These schools critique the neo-classical paradigm of continued economic growth as the primary objective of the development process. They recognise the natural limits to the growth process and the scarcity of natural resources. They also critique the neo-classical version of "weak sustainability" and the technocratic/managerial approach to resolving ecological challenges. Eco-socialists agree with the greens in advocating for a "strong" sustainability approach, which recognises the critical inputs provided by nature. However, eco-socialists believe that the green perspective suffers from a number of limitations.

Firstly, greens critique the process of large-scale industrialisation as the primary cause of environmental destruction. However, they fail to recognise the root cause of ecological destruction is not industry as such but the production process in capitalist societies. These societies use industry to create goods for profits rather than to fulfil societal needs. They fail to build the relationship between "productivism" and the profit motive under capitalism. The solutions to the ecological crisis, as proposed by the greens are therefore ambiguous (Singh, 2009). Greens embrace small-scale industrialisation, "greening" of markets, elevating environment quality above profit motive within free markets and appealing to the individual consciousness and reasonableness of capitalist producers (Singh, 2009:

77) but they do not recognise that it is the logic of capital accumulation and profit motive which is incompatible with the goals of environmental protection. A number of studies from across the world have shown that even when environmental regulations imposed by state agencies, they have been unable to reconcile the goals of environmental prerogatives with continued capital accumulation. These studies show that whenever there is a trade off between environmental prerogatives and profitability, state regulations on environment are gradually eased[34] (Neumayer, 2001; Jorgensen, 2003; Bell, 2015). Thus, even while "greening" of capitalism is taking place in recent years, economic growth continues to hold precedence over environmental sustainability in this system.

Secondly, eco-socialists disagree with ecologists on their conception of nature. Ecologists have a mystical view of nature and believed that nature is an object of reverence (Dobson, 2007:122). Scholars like Morton (2007) criticise this view of "sacredness of nature" and consider "putting nature on a pedestal as a form of sadistic admiration comparable to what patriarchy does to women" (Morton, 2007:5). Many greens eulogise traditional societies and have an anti-urban, romantic vision of green development. For instance Goldsmith (1978) upheld the oppressive caste system in India as a social organisation, which promotes social unity and harmony with nature. Such forms of glamorisation of third world poverty and social inequities ignores the pain of poverty in the form of lack of proper housing, food, healthcare and education (Singh, 2010).

Thirdly, Eco-socialists believe that green thinking, unaccompanied by the socialist vision does not recognise that there are structural issues of class differences and class conflicts in a capitalist economy that have bearings on environmental issues (Singh, 2010). In contrast, eco-socialists recognise these structural issues in framing their understanding of environmental issues in a capitalist economy.

Lastly, greens believe that the ecological question is a universal one, as the destruction of the environment will impact everyone equally. But they do not recognise that ecologically challenges disproportionately impact the poor and vulnerable sections of the society. Hence, they fail to address the questions of

[34] These conflicts are discussed in detail in chapter 7.

exploitation of working class, poverty and gender discrimination, which are a fundamental aspect of the ecological crisis as well (Lowy, 2005: 16-17).

4.7 Eco-socialism: An integration of the Social, Economic and Ecological aspects of sustainability

The last two sections analysed how eco-socialism has taken a number of key perspectives from both ecology as well as the Marxism. At the same time eco-socialists recognise the essential limitations of both these perspectives. They have developed a third perspective on the concept of sustainable development, which represents an amalgamation of the two schools: Ecology and Marxism. It builds a concept of sustainable development, based on the integration of socio-economic and ecological aspects of sustainability. Table 4.2 summarises the eco-socialist paradigm of sustainability and makes a comparison between the green, Marxian and the eco-socialist perspective.

Table 4.2: Comparison of the Ecological, Marxian and Eco-Socialist paradigms on sustainable development

Criterion	Ecologists	Marxists	Eco-Socialists
Relationship between humans and the natural environment	Ecologists subscribe to the concept of biological egalitarianism. They regard all forms of nature as valuable for their own sake.	There is a dialectical relationship between humans and nature. As development takes place, humans transform both themselves and external nature through human intervention.	Same as Marxism
Motivation for preservation of environment	Nature should be protected for its intrinsic value.	The recognition of the dialectical link between humans and nature provides the motivation for preservation of the environment. Preservation of nature is essential for the very survival of humanity	Same as Marxism
Limits to growth	There are limits to the availability of natural resources in the economy. Therefore continuous economic	Does not recognise the concept of limits to growth and considers nature as a free gift to be used in the	Same as greens.

	and population growth cannot continue unabated, without depleting the critical natural resources.	production process.	
Root cause of ecological destruction	Large-scale industrial development and conspicuous energy intensive consumption in the western industrialised world	Capitalist relations of production create a "metabolic rift" between nature and humanity. These production relations are based on a one-sided, exploitative relations with nature and other humans and are the chief cause of ecological degradation	Same as Marxists.
Vision of sustainable development	No-growth community development, based on creation of decentralised local communities.	The ecological contradictions in capitalism will be overcome through development of socialism. Socialist society would be based on co-operation between humans and the natural environment and freedom from the oppression of ruling classes.	The transition to a sustainable society will take place gradually. The first phase of this process is the **Eco-Democratic Phase** where in green reforms within capitalism are made more people centric through decentralized institutions, community participation and grass root environmentalism. These reforms will lay the foundation of an eco-democratic society The second phase is the **Eco-Socialist Phase**, which is accompanied by structural changes in the socio-economic fabric of society. In this phase the development trajectory will be reoriented towards an ecologically benign development trajectory

			(ecologicallybenign refers to a development trajectory where in the ecological footprint of economic activities is minimised), rooted in socialist ideals of social justice
Source: Own Compilation			

As the above sections reveal, eco-socialism presents a new perspective of looking at the ecological question. Since 1970s a heterogeneous group of eco-socialist scholars have advocated a common theme in terms of addressing ecological degradation as a "systemic issue." These scholars have provided a critique of the two dominant socio-economic systems: capitalism and old style socialism for failure to address the problem of ecological degradation. These scholars believe that in old style socialist economies, ecological concerns have not been embedded in the central planning process. On the other hand, in capitalist economies capital accumulation and intensive use of resources have led to large-scale destruction of the environment. They recognise that there has been some progress on the environmental front in capitalist economies in recent years, with international agreements on climate change, market based environmental incentives as well as regulation and legislations on use of environmental resources and mainstreaming of renewable energy resources. However, these "green" capitalist economic reforms have only had limited impact and have proven to be inadequate to halt the process of environmental destruction. This is because even within "green" capitalism, continued economic growth holds precedence over environmental sustainability.

Eco-socialist authors have used the Marxian perspective and located the ecological problems within the social relations of production in society. They have been able to advance an explanation of how power structures in society (gender and class hierarchies) and issues of income distribution are interlinked with the problems of environmental degradation. Eco-socialists have moved beyond traditional Marxism, which saw industrial working class as the only agents of change. They believe that creating coalitions between ecologically conscious individuals, grass root environmental movements and community based decentralised institutions can play an important role in bringing a transformation to an ecologically friendly society (Singh, 2010). The first stage of eco-socialism in the form of eco-democratic reforms has advocated for "participatory democracy," for identification and evaluation of environmental needs and perspectives of different classes in society, and build consensus on environmental policy making.

Eco-socialism has helped us identify the limitations of the existing approaches (as highlighted in Chapter 2, section 2.7). However, a fully developed 'blueprint for transformation' to an ecologically sustainable societies, is in the process of being constructed. Eco-socialists believe that the fully developed blue print evolves in praxis. Globally, eco-socialism has not informed much of environmental policy making so far. In the case of policies that meet the goals of environmental sustainability within "green" capitalism[35], for example, the best practices got evolved historically, as the perspective informed the international and national policy making bodies. Eco socialism has yet to reach such acceptability. However, its best practices that address the nuts and bolts of the policy are slowly beginning to emerge.

Policy prescription within this perspective faces another challenge. Eco-socialism puts faith in grass root democracy to meet the twin objectives of economic development and environmental sustainability. Therefore, these policy prescriptions are likely to be far more context specific. As the institutions of participatory democracy get strengthened and respond to the challenges of environment in their contexts, policy practices will get established. The strengthening of these new forms of institutions, especially community based organisations, which are cognisant of environmental prerogatives will establish best practices for policy that help build sustainable environment. Within the eco-socialist literature, the exact forms of community based institutions is also quite open ended and will perhaps vary from context to context. However, grass root democracy that strengthens environmental objectives is the key criterion for attaining sustainable development. Eco socialists, by acknowledging caste, gender and class hierarchies raise the important question of gains from development and ecological justice in distribution of key natural

[35] These policies include emission taxes, subsidies, and tradable permits.

resources. Institutional structures of these community based organizations need to be designed in ways that facilitate the voice of deprived groups in decision making processes. Thus, the insights provided by eco-socialists also help us to identify goals for decentralized decision-making structures, so as to find common ground in development choices that bring both socially just and environmentally sustainable growth.

As suggested above, eco-socialism has moved beyond the concept of sustainability in mainstream economics by bringing in the socio-economic dimension of sustainability. In the absence of much empirical literature documenting the practice of this perspective, it is sometimes hard to discuss and generalize the exact modalities on the ground that reconcile the trade offs between the social, economic and ecological aspects of sustainability. However, there are few studies, which have applied an eco-socialist perspective to real world environmental issues, which help us to understand and appreciate the possibilities that open up when using this perspective. Karrouchi (2016), for instance, used the eco-socialist perspective to establish the socio-economic impacts of climate change on the poor and marginalized groups in Pakistan. Her findings showed that how within the green capitalist framework, the concerns of poor and marginalized groups with respect to equitable access to natural resources for the present and future generations have not been addressed. In contrast, these inter-relationships and inter-linkages between poverty and ecological degradation are one of the central fulcrum of the eco-socialist thought. Other scholars have attempted to provide an empirical basis to the eco-socialist critique of green capitalism. For instance, Delyse (2003) analysed "green industries" in New Zealand from an eco-socialist prism. His findings showed that within "green capitalism," the primary imperative is management of environment, without looking at the structural factors behind environmental degradation. Within this approach there is little attention on the institutional machinery that is necessary to implement the agenda of sustainable development. He concluded that these structural aspects can be addressed through replacement of asymmetric power held by business interests with participatory democracy in environmental decision making. In another study Budinsky (2011) studied environmental advertising in North America from an eco-socialist perspective through representative case studies.

The study concluded that environmental advertising is a “green-wash” and essentially reinforces stereotypes aligned with corporate interests.

However, none of these works deal with the question of trade offs between the social, economic and ecological parameters of sustainability. Given the emphasis on decentralized institutions in the eco-socialists framework, documenting the working experience of these institutions will perhaps be a good starting point for locating the principles to deal with trade offs. This thesis is a small attempt to advance the empirical basis for this theoretical framework. In this work, I have attempted to analyse the bioenergy projects in Punjab through an eco-socialist perspective. The framework for this research is informed by an initial review of literature on bioenergy as well as international sustainability assessment frameworks.

4.8 The Eco-Socialist perspective to inform sustainable bioenergy policies

By employing an eco-socialist perspective, I was able to unearth the political economy factors behind bioenergy projects in Punjab, which other schools like neo classical economics, institutional economics and development economics fail to identify and discuss. As established in the previous chapters, neoclassical economics simply considers humans to be “economic agents” without taking account of the social and political milieu in which they operate. Therefore, very often, the discussion of bio energy policies informed by this framework focus on infrastructural needs, capital inputs and technology (chapter 3, on the nature of bioenergy policies across the globe). As, we analysed in chapter 2, other schools like institutional and development economics have begun to recognise the reductionist nature of neoclassical environmental policies. These schools have brought in the role of formal and informal institutions in addressing the ecological question. In the bioenergy development discourse, the primacy of institutional factors has also been recognised by a number of international assessment frameworks in recent years. For bioenergy developments there are five international sustainability assessment frameworks, which are relevant for developing countries. These are RSB Principles and Criteria for Sustainable Biofuel Production (RSB, 2011); IDBI Biofuel Sustainability Scorecard (Inter-American Development Bank, 2011); International Sustainability and Carbon Certification (ISSC Association, 2010); Biofuel Environmental Analysis (BIAS) Analytical Framework (FAO, 2010) and World

Wildlife Fund Biofuels Environmental Sustainability Scorecard (WWF, 2008). These sustainability assessment frameworks have focused on the importance of accountability, transparency, comprehensiveness and stakeholder participation in the institutional structures of bioenergy policies. However, the theoretical literature on institutional/ development economics and international sustainability frameworks do not take account of the distribution of environmental gains and losses from bioenergy developments. Hence, class and gender divisions as key determinants of ecological degradation do not get captured, within the existing approaches.

In view of these weaknesses with the existing approaches, eco-socialism helped me to develop an alternative framework to capture the political economy factors behind bioenergy reforms in Punjab by creating a "chain of explanation," which went from the policy discourse on bioenergy to the institutional structure of bioenergy developments in Punjab, and finally to people's experiences of bioenergy developments at the ground level. This conceptual framework served as a "sensitizing" framework (Bowen, 2006), which laid the foundation for the field research. This framework provided me with guidelines to discover, understand and interpret data. It did not serve as a data classification template, to aid synthesis of data.[36] It provided a direction for "what to see" and (Bowen, 2006). However, this framework allowed room for using the field experience to incorporate emerging concepts/themes. In case of Punjab, these emergent themes included the role of religious organizations in creating trajectories of sustainable development. I was also able to locate how the historic caste trajectories in rural Punjab had led to differential outcomes of bioenergy developments for different caste groups in rural Punjab. The SCs (who predominantly comprised of agricultural labour households) had been largely excluded from the bioenergy policy discourse.

Figure 4.1: A Sustainable Bioenergy Framework, informed by eco-socialism

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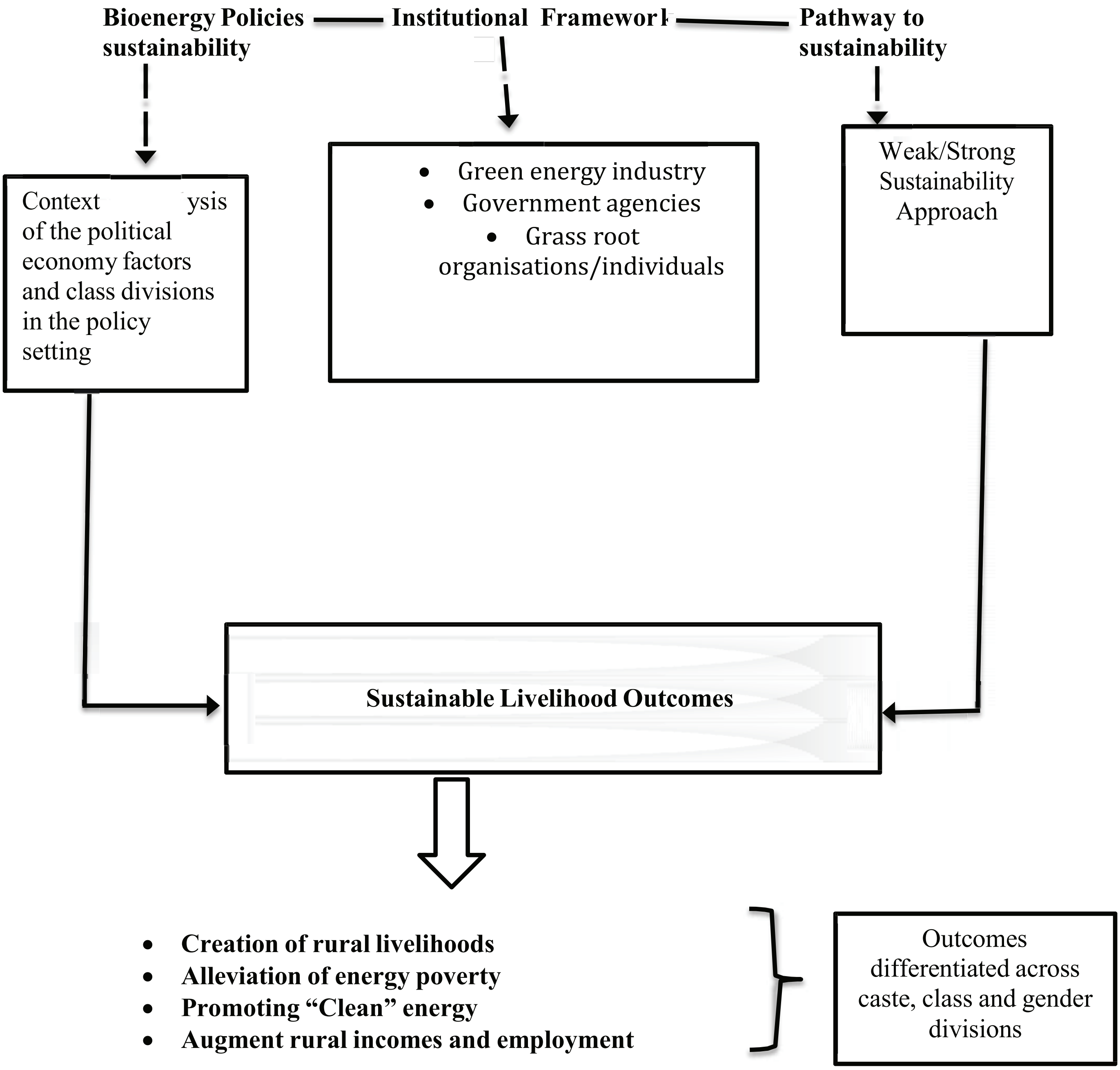
36 This distinction between frameworks has been made by Fisher et al (2013). They contend that within sustainability literature there are two traditions of frameworks. Some frameworks such as the socio-ecological framework proposed by Ostrom (1990), act as a toolkit to synthesize data. There are other frameworks such as the sustainable livelihood frameworks, which act as "thinking tools." They help to lay forth the key concepts as well as the relationship between concepts used in the research. They do not act as a toolkit to synthesize data.



Source: Own Compilation

The schematic view of the framework, as shown in Figure 4.1 is endeavoured at capturing the macro-structural aspects, which condition the outcomes of bioenergy developments for different socio-economic groups in society. I will first evaluate how bioenergy policies are rooted in the historic political economy factors and class divisions in the Punjabi society. This exercise will enable me to understand the socio-economic and ecological conditions, which are particular to the case study region. Following this, I will analyse the institutional framework of the current bioenergy policies, taking into account both formal institutions (green energy industry and government agencies) as well as grass root level organisations and individuals. As eco-socialism lays emphasis on grass root institutions and community based organisations, as a channel for eco-democratic and inclusive reforms, I will also evaluate these institutions in the context of case study region (besides the green energy industry and government agencies supporting green energy projects). The institutional and policy analysis will help me to inform the pathways to sustainable bioenergy development, which have been created in Punjab and how far these pathways have been conditioned to the historic political economy factors and class structures in Punjab. I will also attempt to see whether grass root institutions have created alternative pathways of sustainable energy (rooted in grass root environmentalism and participatory mechanisms), not picked up by the state and market based approaches.

From an eco-socialist perspective, I have categorised these pathways within a "strong" and "weak" sustainability paradigm. As my review of literature has established that bioenergy developments across many countries are associated with a number of adverse socio-economic impacts on vulnerable groups in society. However, the existing literature does not question how these adverse socio-economic outcomes are rooted in the prerogatives of the "green" growth agenda within a "weak" sustainability approach. An eco-socialist perspective allowed me to address this issue. I will evaluate what are the necessary trade offs between the socio-ecological aspects of sustainability and the prerogatives of "green" growth within a "weak" sustainability paradigm. Which dimensions and stakeholders are accorded primacy in a "green" capitalist framework?

The review of literature established that bioenergy developments have been instituted internationally as a means to develop "clean" energy sources, alleviate energy poverty, create rural livelihoods and employment and augment rural incomes through the creation of agro-industry. Hence, these are the primary parameters on which I will evaluate the outcomes of bioenergy developments in the case study region. Within an eco-socialist framework these outcomes will be evaluated for different socio-economic groups in society. I will evaluate whether green growth and agro-industrial development can be necessarily reconciled with the imperatives of rural development and alleviation of energy poverty.

An eco-socialist framework has thus enabled me to develop a historically grounded approach to assess the sustainability and outcomes of green energy developments in the region, by taking account of the historic political economy factors and class structures in rural Punjab. This framework will also provide a means to analyse the differentiated outcomes of bioenergy developments for differentiated socio-economic groups, as eco-socialism believes that class and gender divisions in society are the central explanatory parameters in the process of environmental degradation in society. This framework will serve as a basis for organizing the insights emerging from the field research.

4.9 Summing Up

This chapter summarised the evolution and the key theoretical constructs of eco-socialism. The analysis drew on the relationship as well as the key differences between the Eco-Socialist, Marxian and the Green perspective. Eco-socialists have espoused the key tenets of both these schools: Ecology and Marxism. They have adopted the Marxian critique of capitalism as a source of “metabolic rift” between individuals and society, created by capitalist production systems. However, they go beyond Marx and recognise that the replacement of capitalism with socialism will not automatically lead to the restoration of natural balance between nature and humanity, unless ecological goals are embedded in the basic tenets of socialism. From the ecological school, eco-socialists have adopted the ideas such as “natural limits to growth” imposed by capitalist production, and the concept of strong sustainability. However, eco-socialists critique the greens for not recognizing capitalist mode of production as the root cause of environmental destruction. Eco-Socialists view the transition to an eco-socialist society as a two phased process, where in the first stage comprises of implementing eco-democratic reforms within the existing capitalist societies and the second stage involves a transition to an eco-socialist society through radical changes in the production and consumption structures of capitalist societies. After developing the key tenets of eco-socialism paradigm, the final section of this chapter presented a framework of sustainable bioenergy imperatives, rooted in eco-socialism. This framework will be employed to analyse the sustainability of bioenergy policies in the Punjab, India in the subsequent chapters.

Following from this analysis, the next chapter presents the methodological framework, which was adopted to undertake empirical research on bioenergy imperatives in Punjab through an eco-socialist prism.

CHAPTER FIVE

RESEARCH METHODOLOGY

5.1 Introduction

Every research project is underpinned by assumptions on the nature of reality, the development of knowledge and the appropriate methodology, which needs to be employed for achieving the underlying objectives of a study. It is paramount to understand these philosophical assumptions informing the research design. This chapter discusses the research paradigm and the methodology, which was employed in this study in order to achieve the stated objectives of the research project, which is to locate bioenergy developments within the sustainability crisis facing developing countries, through in depth case study research.

The chapter is divided into four sections. The first section explains the research paradigm adopted in the study. The second section elaborates on case-study methodology and gives a justification for the multiple research tools used in this empirical investigation. The third section describes the data management and analysis procedures. The final section reflects on the criteria employed for maintaining the quality of the study and the role of the researcher in the research process.

5.2 Research Paradigms

A paradigm refers to a framework, comprising of a set of concepts and beliefs within which the researcher views the concept of knowledge (Farquhar, 2012). The researchers' paradigm constitutes their worldview and their approach to making sense of real world phenomena (Patton, 2015:89). There are three key concepts within a research paradigm that determine the overall research process (Farquhar, 2012). a) Ontology is a set of beliefs about the nature of reality. Reality may be perceived as objective and external to the individual or subjective and a product of the individual's beliefs. b) Epistemology is concerned with the study of nature of knowledge. A positivist epistemology is rooted in the idea that knowledge is objective and free from value judgments. An interpretivist epistemology is based on the premise that knowledge is essentially socially constructed. c) Methodology is a strategic plan of action, in consonance with the main objectives of the research. Positivists follow a quantitative methodology; based on the premise that the social world can be measured as a structured reality. Interpretivists rely on a qualitative methodology, aimed at understanding the complexity of the real world, on the basis of interaction with the research participants.

The concept of a paradigm was first given by Kuhn (1971). He contended that the development of knowledge relies upon a shared set of beliefs by the members of a particular scientific community (Hamersley, 2012). He defined this set of knowledge beliefs in terms of "paradigms". Kuhn propounded that scientists who shared the same paradigm have a common set of rules and standards of scientific practice that guide an individual researcher on the choice of research methods (Kuhn, 1971:10)

5.3 Nature of Social Reality and Social Research

The ontological and epistemological position of the researcher defines his worldview. These differences in worldviews have important implications on the researcher's perception of social reality and how research is conducted. Farquhar (2012) has classified paradigms into three categories viz. positivism, interpretivism and critical realism. I have adopted this classification in the study because my review of literature established that the existing research on sustainability of bioenergy projects is located in either a positivist or interpretivist framework. The positivist studies on bioenergy analysed the impacts of these developments on economic and ecological variables in the form of simple cause and effect relationships. Such an approach takes account of the socio-economic repercussions of these bioenergy developments without linking them with macro structures in society. On the other hand, the existing interpretivist studies analyzed the issues surrounding bioenergy developments such as land grabs by bioenergy producers and food insecurity purely as localized or individual problems, without unearthing the political economy processes and structures behind these issues. In contrast to these two approaches, in this research I attempted to evaluate how bioenergy projects in Punjab were rooted in the historic development trajectory in Punjab and how the political economy processes in the state influenced the outcomes of these projects for different socio-economic groups in society. Critical realism provided the necessary methodological fulcrum to the case study, as this paradigm locates the explanation of a phenomena in terms of the macro-structures in society. In the following sections, I discuss the different research paradigms and provide justification for my chosen research paradigm in the study:

Research Paradigm for this Research: Critical Realism

After reviewing the various research paradigms, I have situated the research in the critical realist paradigm. Critical realism emerged in the late 1970s' through the work of Roy Bhaskar (Bhaskar, 1978). Critical realism offered an alternative approach to both positivism and interpretivism (discussed subsequently). Critical realists criticize both interpretivism and positivism for equating ontology to epistemology and regard it as an "epistemic fallacy" (Bhaskar, 1978). In contrast to these approaches, critical realism views reality as a "multilayered, multi causal web of interacting force" (Oliver, 2012:75). Critical realists argue that the real world can be best understood by examining the interaction between human agency with the enabling and constraining effects of social structures (Craig and Bigby, 2017: 312). They recognise that knowledge of the real world is essentially filtered through the social context, but contend that our perception of reality can never be a true representation of the real world, which is essentially intransitive in character (Oliver, 2012:76). Hence, there is no one-to one relation between real world objects and our knowledge claims about these objects. Our claims to knowledge are essentially "fallible, open to criticism, testing and further improvement" (Carolan, 2005: 396).

Bhaskar (1978) contended that reality is not one-dimensional but comprises of three distinct domains. The first level of reality is "empirical." At this level, events or objects can be measured empirically and are always mediated through human experience and interpretation (Danermark et al., 2002: 20). The middle level consists of the *actual*. At this level, there is no filter of human experience. Events occur whether or not one experiences or interprets them, and these true occurrences are often different from those at the empirical level (Danermark et al., 2002: 20). The third domain is the *real/causal*. At this level causal structures, or "causal mechanisms", exist. These are the inherent properties in an object or structure that act as causal forces to produce events at the empirical level (Fletcher, 2017: 313).

Following from this ontological position, the epistemological position of critical realists is rooted in relativism. They recognise that events are essentially governed by power structures in society, hence knowledge can only be gained by analysing the structures and mechanisms behind actual events taking place in society and explaining the course of events in the form of "tendencies," rather than "laws" or "universal truths" or "generalisations," as claimed by positivists (Fleetwood, 2013). Realists believe that the "world is essentially theory-laden, though not theory driven" (Fletcher, 2017:182). Thus, they believe that knowledge can only be gained through critical construction of theories (Tsang and Kwang, 1999).

Critical realists contend that social reality cannot be based on inductive or deductive reasoning (Fleetwood, 2013). They subscribe to the concept of retroduction, which means moving from a given phenomena to the causal mechanism responsible for it (Fleetwood, 1999). Retroducion essentially involves "thinking backward" and moving from the conception of interest to the mechanism that generated the given phenomenon" (Lawson, 1997: 236). This technique is referred to as "causal-explanatory" because it believes that the objective of social science research is to provide a causal account of social phenomenon (Fleetwood, 2013).

Critical realists embrace "methodological pluralism" and postulate that the choice of research methods should be based on the object of the study and what one wishes to understand about a particular subject (Sayer, 2000). They believe that the failure of mainstream economics lies in the tendency to adopt the "closed system modelling methods to material for which it is essentially unsuited" (Lawson, 2003: 21). Mainstream economists limit their analysis to some restricted sectors within the economy and are unable to "generate meaningful social scientific results" (O'Boyle and McDonough, 2011: 9). Critical realists contend that the complexity of social reality may not be captured by a single method (Downward and Mearman, 2007). Different methods help to reveal different aspects of the social phenomenon as well as their structural characteristics and the inter relationship between them (Downward and Mearman, 2007).

This paradigm has strong roots in heterodox traditions in social sciences. Critical realism has a strong affinity with a number of alternative theories that fall outside the purview of empiricism (Nielsen, 2002:727). Roy Bhaskar, the father of critical realism was essentially Marxian in his political philosophy and described critical realism, as the “absent methodological fulcrum of Marx’s work” (Bhaskar, 1991:143-144). Although, Bhaskar’s conception of critical realism is rooted in Marxism, subsequent research by Lawson (1997), Forsyth (2001), Danermark et al (2002) and Fleetwood (2013) showed that critical realism is consistent with a broad range of heterodox traditions and helps to advance “a general methodological approach to theory, rather than subscribing to a particular substantive theory” (Henry, 2000:245). The critical realist approach helps in developing an alternative methodological framework in these disciplines, which goes beyond the neo-classical deductivist approach to creation of knowledge. It helps to explain the phenomena at a “deeper level by identifying the causal mechanisms responsible for it” and formulate empirically rich theories (Henry, 2000:245).

Critical realism provides the essential methodological pivot to this research. The process of “retroduction” in critical realism helps to create an explanation in terms of macro-structural factors and mechanisms that emerge over time. Critical realism thus helps to “understand the political construction of the environment” (Forsyth, 2001) and illustrate how seemingly apolitical, technocratic projects such as bioenergy are essentially conditioned by underlying historic, social and political structures in society (Forsyth, 2001). This methodological approach to understand ecological concerns has been supported by a number of scholars in recent years (Blaike, 1985; Forsyth, 2001; Carolan, 2005 and Forsyth, 2008). These scholars critique the positivist conception of ecology, which treats the environment as an isolated project, divorced from the larger socio-economic concerns of a society and describe it as “ecological orthodoxy” (Forsyth, 2001). They believe that such an approach neglects socio-economic repercussions and the issues of social injustice associated with ecological imperatives (Forsyth, 2001).

Paradigm, Prediction, falsification: Pointers for this Research

The history of methods in social science research reveals that till the early part of the 20^{th} century social science research was dominated by the positivist paradigm. Positivism believes that social sciences should be rooted in empiricism as favoured by the natural sciences (Firestone, 1987). The basic tenet of positivism is to discover a set of observable patterns in events and describe them in the form of causal laws in order to predict the general pattern of human behaviour (Farquhar, 2012). Positivism believes that the social world is essentially objective in character and that knowledge is value-free and objective (Esterberg, 2002). This essentially replicates the approach followed in natural sciences[37] and build an explanation of the social world through construction of causal relationships between the constituent elements (Burrell and Morgan, 1979) and rely on empirical methods to quantify variables and explore the precise relationships between them (Farquhar, 2012). Essentially, under this influence, social science modelled itself uncritically on modern natural science, emphasizing on the essential empirical basis of science and value free nature of scientific knowledge.

As a theory of knowledge empiricism limits itself to facts, to the experienced phenomena, to practical activity, without looking for general laws or explanatory theories. Empiricism has made a positive contribution to the debunking of political obscurantism, of 'truths' outside of experience, of knowledge through faith and mystic intuition, of anti-scientific thinking in general, and provides a useful critique of all transcendental, metaphysical speculation and of traditional prejudices and superstitions. But as a theory of knowledge, empiricism or positivism has failed to outgrow the limitations of the earlier period, when science in fact has long outgrown them. Modern science works entirely with theories, with explanatory hypothesis, with conceptual schemes, rational systems and laws, which lie behind data or empirical evidence they seek to explain. "The history of science demonstrates beyond a doubt that the really revolutionary and significant advances come not from empiricism but from new theories" (Conant, 1953:54). Bronowski also talks about the narrow view taken by the contemporary positivist philosophy, which would reduce science to "a mere description of facts" or of regularities in their occurrence and behaviour. Science is thus "not the blank record of facts, but the search for order within facts". And "the truth of science is not truth to fact, which can never be more

[37] The origins of the positivist tradition lie in the work of Comte (1971) who propounded that social science should be guided by the objective of, "generalising scientific conceptions and systematising the art of social life" (Comte, 1971:3). Comte's work was based on the premise that scientific knowledge is superior to other forms of knowledge and the only way that social science can develop is by giving a systematic character to it, like the natural sciences (Comte, 1971:12).

then approximate, but the truth to the laws which we must see within facts" (Brownowski, 1960: 135).

Focusing on "facts"' in opposition to traditional social theorizing, dismissive of the latter as 'value laden' and distrust of generalization or theory, the positivist approach failed to understand that "science, in its maturity, is not factual or descriptive statements but explanatory theory, a knitting together of the empirical and the rational" (Singh, 2017b). In the same essay Randhir Singh argues, "truth in natural science is by and large politically neutral, while in social sciences, with class divided societies, truth is essentially partisan and even dynamite. The description or explanation invariably has a value slope, even if the values remain unacknowledged, and the very use of language, given its inescapably value laden nature in social sciences, forbids any kind of ethical neutrality" (Singh, 2017b).

Popper proposed initial methodological rules of positivism, which have evolved since then. The key debates within positivism have been around paradigm, predictability and falsification. Maxwell (1972) critiqued Popper and stated that Popper does not provide any rationale for the methodological rules that he proposes. Maxwell (1972: 140) stated that there is no logical justification for proposing that the theories which have been subject to Popperian rules and experimental testing are superior to other forms of knowledge.

Popper said, "The "notion of the scientific ideal of absolute certainty is a mere idol" (Popper, 1959:280). He critiqued the notion of verification as the criteria for validity in positivist research. Instead, he advocated for the use of hypothetico-deductive method/ scientific method as the basis of scientific progress. This method is rooted in the criteria of "falsification" and is used to distinguish between scientific and non-scientific theories. According to this approach, a scientific inquiry proceeds by formulating a hypothesis on the basis of precise, testable predictions. These predictions may be falsified by tests on observable data. If the predictions are confirmed through stringent testing, the theory is provisionally accepted. If the predictions are not confirmed, the theory is then subject to further critical tests, until all anomalies are removed. When the predictions are still not confirmed after further critical testing, the theory is deemed to be falsified (Dhami, 2016).

The Popperian framework was later revised by Lakatos (1978). Lakatos contended that Popperian criteria was "too restrictive" and ruled out much of everyday practice as unscientific and irrational. He also showed that Popperian rules have not been followed in actual scientific practice and thus stand refuted by empirical evidence (Lakatos, 1968:115). This is because scientists often persist with theories that have been rejected based on falsified predictions. He proposed that instead of an individual falsifiable hypothesis, which stands rejected as soon as it is refuted by critical testing, one should consider a series of falsifiable theories (Lakatos, 1978: 31). These theories constitute a succession of theories and experimental techniques, developed over time and share a common "hard core" or central theses. He christened such a sequence of theories as a "research programme" (Lakatos, 1978:48). For Lakatos an individual theory within a research programme consist of a hard core and a set of auxiliary hypothesis. While the "hard core" is shielded from empirical testing, the auxiliary hypothesis entails empirical predictions, making the theory as a whole a falsifiable affair (Lakatos, 1978:48-49). Lakatos classified research programmes as "progressive" or "degenerative." A "progressive" research programme is marked by growth, novel facts and more precise predictions. On the other hand a "degenerative" research programme is marked by a lack of empirical growth, its auxiliary hypothesis does not lead to novel predictions (Lakatos, 1978:86).

Maxwell (1972) contended that Popperian rules were too restrictive and would impede the growth of science. *Firstly,* Popperian rules state that a new theory must always have greater empirical content than its predecessors. However, Maxwell (1972:134) contends that it may be in our larger interest to accept a new theory, which initially has less empirical content than its predecessor but with further development may lead to a theory of greater empirical content. *Secondly,* Popper believes that a new theory must be able to explain all the success of its predecessors. This assumption is too severe according to Maxwell (1972:134). A new theory may be able to explain several outstanding problems, even though it may not be able to explain all the success of its predecessors. *Thirdly,* Popperian rules state that the purpose of testing is invariably to falsify it. However, in actual practice the purpose of testing theories may be to develop the theory further and extend the range of its applications (Maxwell, 1972: 134-135).

Popperian rules were also critiqued by Kuhn (1971) who argued that scientific theories, do not develop linearly, but are situated within a particular “paradigm”. He contended that new theories are not extensions of old theories, but represent competing worldviews. Hence, it is not possible to construct a universal test of validity, as proposed by Popper in order to make comparisons between theories located in competing paradigms.

“Though each may hope to convert the other to his way of science and its problems, neither may hope to prove his case. The competition between paradigms is not the sort of battle that can be resolved by proofs” (Kuhn, 1971:148).

Popperian emphasis on the centrality of predictions has also been challenged by Sen (1989). He contended that although positivist economics has emphasized on the centrality of prediction in Economic theory, the other aspects of economic theory comprising of normative evaluation of a social phenomena or providing adequate description, have been ignored within this paradigm. In these cases, economic theory may be based on constructs that do not have predictive content and may not lend themselves to empirical testing, as supported by the traditional Popperian framework. Sen (1989) writes further that "...parts of economic theory are not open to testing" and this relates to the nature of "economics as a discipline and its internal diversity”

Furthermore, not only the notion of paradigm and predictability but the idea of falsification has also been debated in the literature. The application of falsification criteria in the realm of economic theory remains a contested subject. For a statement to be questioned using observation, it needs to be at least theoretically possible that it can come into conflict with observation. A key tenet of falsification is thus that a criterion of demarcation is needed to distinguish those statements that can come into conflict with observation and those that cannot (Caldwell, 1984). Popper chose falsifiability as the name of this criterion. In contrast to Positivism, which held that statements are meaningless if they cannot be verified or falsified, Popper claimed that falsifiability is merely a special case of the more general notion of “criticizability”, even though he admitted that empirical refutation is one of the most effective methods by which theories can be criticized. Caldwell (1984) has put forth three reasons for the limits of falsification in economic theory: *Firstly,* the laws in economics tend to be tendencies or patterns expressed in the form of empirical generalizations, rather than laws of universal validity in natural science. *Secondly,* true test of falsifiability can only occur if all exogenous variables are known, one is varied, while others are held constant. However, many economists believe that such controlled experiments lend a "degree of determinedness" to an economic model that does not exist in actual practice (Wilber and Harrison, 1978). In this context, Hutchinson (1977) gave the example of law of demand and stated that in the absence of initial conditions, regarding tastes, prices of other goods and expectations, the law is untestable. *Thirdly,* in order to "falsify" a theory in Economics, a model must be constructed. However, a number of models may be constructed to represent a single theory. Empirical falsification of a model does not imply falsification of a theory. Finally*,* as propounded by Hicks (1983) Economics is a broad discipline. There are many alternative/ heterodox research programmes in Economics, which are located outside the paradigm of empiricism and deductive logic. "Application of falsification criteria will not only eliminate all of alternative research programmes, Austrian, Institutionalism and Feminist Economics, but also much of standard economic theory" (Blaug, 1980:259). Starr (2014) conducted a survey of several studies in Economics the last ten years, which have been located in qualitative and mixed methods research. In these studies the researchers have rejected closed system modelling and treated the world as an open system, where in important insights emerge from interaction with research participants. These heterodox researchers contend that the objectivity of science can be improved by expanding the range of research methods used in economics and examining social problem from the perspective of ground level economic actors, rather than through a definitive set of variables, as practiced in standard economic theory. These heterodox economists contend that such insights not only improve scientific validity of economic knowledge, but also improve its social value (Starr, 2014).

To summarise, as is evident from the discussion above, positivism has been much debated and critically looked at by a large body of scholars on the grounds that positivist traditions fails to capture the complexity and multi-faceted character of the real world (Esterberg, 2002). Positivists treat the real word as a closed system, which is "cut off" or "isolated" from external influences and all disturbances are pre-empted (Esterberg, 2002). Thus, this approach fails to see that the social world is an open system where one mechanism will be affected by the operation of other mechanisms in society, so that "no unique relationships between variables will be possible" (Bhaskar, 1978: 53). 2006:49).

Interpretivisim: Pointers for this Research

As mentioned in the discussions on nature of social reality and social research the other contending paradigm besides positivism for critical realists is interpretivisim. Critical realist scholars also critique the interpretivists who treat environmental projects as "local level studies of environmental movements" and analyse them purely in the form of "discursively created local problems" (Forsyth, 2001). The interpretivist approach fails to recognise the complex political structures and economic processes behind issues of environmental degradation (Forsyth, 2001).

An Interpretivist paradigm is on the other end of the spectrum from positivism. Interpretivism is concerned with understanding the social world, based on the ontological position that the real world is socially constructed and can only be understood by occupying the frame of reference of the participants involved (Farquhar, 2012). The roots of interpretivism lie in the work of Weber (1947) who postulated that individual and social truths could only be grasped through human understanding. The interpretivist seeks to be an "active learner" in the research process in order to understand the social and cultural realities that shape the real world (O' Leary, 2004). The central premise of interpretivism is the interaction between the researcher and the subject. They employ qualitative techniques like interviews, focus groups and observations to construct complex meanings behind social phenomena (Ponterotto, 2005)

Though interpretivism helps to unearth the complexity of the social world, there are some limitations of this paradigm. *Firstly,* interpretivism as a philosophy does not have a foundational basis, as the notion of reality differs from person to person (Scotland, 2012). The researcher and the participants involved in the research process may not have the same notion of reality (Scotland, 2012). *Secondly,* interpretivist research yields qualitative, highly contextualised data and it is extremely difficult to unify it into a single coherent body to be employed for generalisations and policy purposes (Creswell, 1995). *Thirdly,* the manner in which interpretivist research is constructed favours the researcher's own ideology, which may not match that of the participants. The researcher chooses how to portray those being studied and filters the findings accordingly (Denzin and Lincoln, 1998).

In this project, interpretivism was not followed because the purpose of the research was not merely to capture people's ground level experiences of bioenergy developments in Punjab, but to situate the bioenergy projects within a larger political economy context; reflecting on the historic development trajectory of the region, the nature of policies being pursued on grounds and generating empirical evidence on the local level outcomes of these projects.

Based on detailed reasoning provided earlier in this discussion, in this research, scientific method, especially in the Popperain sense, was not followed because of a number of reasons already stated. One may then ask the question, is it possible to be scientific without being a positivist? Drawing from Bronowski (1953), discussed above, we can argue that claim to scientific method can only be in terms of what it has to offer as a critical science of society; scientific in its philosophical foundations and commitment to criticism and continuing verification and development of main principles, postulates and conclusions. "Doubt everything," Marx's famous dictum ought to be the favourite methodological principle, as Singh (2017b) suggests. He argues, that an approach that continuously interacts with the reality of the world around it and with the rest of contemporary thought, and grows with the growth of scientific and historical knowledge is a resilient approach. Scientific resilience, the openness to correction, is the real strength of a scientific method, not its weakness (Singh, 2017b).

This study is empirically grounded. The purpose of the empirical case study is to contribute to developing the theory of eco-socialism, and extend the range of its application further by adding empirical content to it. The intent of this research is not to falsify the theory for reasons propounded by Maxwell (1972). The main research objective of the empirical engagement in this project was to situate bioenergy in the sustainability crisis of the case study region and generate empirical evidence on the local level outcomes of these projects. In this research I followed the methodological approach put forth by Teddlie and Tashakori (2009), which states that the choice of paradigm/ methodology should be rooted in the research question.

This study relies on a range of qualitative and secondary data sources to explore the political economy factors behind green energy developments in Punjab and capture the lived experiences of ground level stakeholders from these bioenergy developments. The study is exploratory and descriptive and therefore does not set up clear tests of hypothesis, like in the case of close system modelling approach. We follow an "open" system, which leaves room for emergent themes to develop from the field.

Critical realist methodology, adopted in this study, helps to explain environmental issues through the "complex and contingent interconnections between nature and the social realms" (Stone-Jovicich, 2015). Such an approach is based on a realist ontology, which recognises the interconnections between human agency and social structures. The present study has adopted this methodological approach. I have analysed the political, and institutional structures that conditioned bioenergy developments in the region. Further I have evaluated how the outcomes of bioenergy projects have been mirrored in terms of the experiences/perspectives of stakeholders on the ground level. This approach helped to understand the complexity of bioenergy imperatives at a deeper level than the existing positivist explanations, and also bring in the voices of ground level stakeholders who are underrepresented in the bioenergy policy discourse.

The main research aim of this thesis was to locate bioenergy in the context of sustainability crisis of developing countries. In this research, as discussed in chapter 4, I adopted an eco-socialist lens to look at the sustainability crisis in Punjab. Eco-socialists contend that ecological problems are essentially rooted in the social relationships of production and the pattern/ process of capital accumulation and economic growth in society. In consonance with the eco-socialist framework, I have not treated bioenergy developments as mere technocratic developments in the empirical research. Instead I have attempted to analyse bioenergy projects in Punjab by looking at the historic development trajectory of Punjab, as a model of capitalist agricultural development. This analytical framework enabled me to evaluate the political and institutional factors that drive these bioenergy projects, as well as their socio-economic and ecological impacts on the various stakeholders in the community. The eco-socialist framework and critical realist paradigm work in synergy in this research to understand bio-energy in the context of sustainability crisis in a region within a developing country. Eco-Socialism and critical realism both compel the researcher to relate questions of environment within the larger context and not isolate or detach from the whole vast interconnection of things and helps see things in their motion. Simply put, we have adopted eco-socialist framework and critical realism as chosen approaches so that we do not miss seeing the wood for the trees.

The research methods adopted in the study are also in consonance with the critical realist paradigm. This paradigm contends that both extensive (statistical) and intensive (interpretive) data should be collected in a study in order to construct a complete picture of social reality (Fletcher, 2017:185). In this project I have analysed bioenergy developments at the empirical level through extensive field research, based on a combination of quantitative (official government data on bioenergy) and qualitative (document analysis, focus groups and interviews) data.

5.4 Research Strategy

The research strategy is defined as a logical sequence that provides a framework in order to link the study's initial research questions to its final conclusions (Yin, 2014: 26). It is a "blueprint" of the research process, which acts as a guide to the researcher on how to collect data, interpret findings and draw out conclusions (Easterby-Smith et al, 2008).

5.4.1 Case Study Research

In consonance with the main research question, I adopted case study strategy in this project. This method of inquiry is applicable when we want to understand "a contemporary phenomenon in depth, along with the contextual conditions responsible for its occurrence" (Yin, 2008:18). Such a method of investigation helps to answer questions pertaining to "how" or "why" a social phenomenon takes place and build an explanation for it (Yin, 2008:18). The case study involved an in-depth exploration of bioenergy projects in the region of Punjab, India, with a view to explore the opportunities and constraints of bioenergy as a sustainable energy alternative in the region. Single in-depth case studies have been employed as a "heuristic device" (Neville, 2012:37) to draw out theoretical conclusions by a number of scholars. For instance Scott (1985) conducted an in-depth case study of a rice farming community in a single village in Malaysia to build a general understanding of resistance and class struggles in agrarian societies, in the face of class structures that surround them. Evenden (2004) studied the Fraser River basin in Canada to trace out how local environmental concerns are shaped by transnational forces and international power lobbies. Single in-depth case studies help in the "systematic production of exemplars," which guides future research into the area (Flyvbjerg, 2006).

Though, this study does not make any claims of statistical generalisations, investigation of this single case provided insights into how regional economics, politics and institutions are located in the dynamics of bioenergy developments. Scott (1985:42) and Patton (2015:266) have convincingly advocated in depth case studies as a means to move away from a narrow "reductionist" approach to understanding the political economy concerns in developing nations and incorporate evidence based on human experience and interpretation of the phenomenon.

5.5 Research Design: A Sustainable bio-energy framework of Analysis in Punjab

From an eco-socialist perspective, the current challenges associated with bioenergy production essentially spring from the narrow technocratic approach to bioenergy developments without recognition of the local context in which these developments are taking place. In contrast, an eco-socialist perspective places these bioenergy developments within the historic developmental trajectory in a given region, in particular the forces and drivers of accumulation, and the power structures and mechanisms in society, which have emerged there in. This perspective thus helps to provide an understanding of the inter-linkages between the economic, social, and ecological aspects of green energy development. In order to evaluate the bioenergy projects in the case study region, Punjab, from an eco-socialist lens, I developed a framework of sustainable bioenergy projects to inform my ground level analysis In case study research, it is imperative that the researcher develops a preliminary conceptual framework, which will help to guide primary data collection (Yin, 2014: 38). This theoretical framework provides a guide on the data to be collected during the research process and how this data is to be analysed (Yin, 2014: 38). According to Patton (2015: 382) the conceptual framework ensures that the researcher goes into the field with purpose and “helps to organise the complex nature of social reality.” The framework for this research is informed by an initial review of literature on bioenergy as well as international sustainability assessment frameworks.

5.6 Research Methods Employed in the Field Study

Research methods are defined as the techniques of data collection and analysis to be employed in a particular study (Olsen and Morgan, 2005). Field studies are compatible with a wide range of both qualitative and quantitative research techniques (Yin, 2014). According to Merriam (1998) case studies do not prescribe to any specific techniques of data collection, as the focus of the research is to provide a detailed description and build a holistic explanation of the social phenomenon-taking place. By employing multiple sources of evidence filed studies are able to cover a broad range of issues and develop a complete picture of the topic to be investigated. The research methods employed in this field study are described in the following sections

Figure 5.1 Framework of the Fieldwork

Policy

Policy refers to official documents related to the energy and environmental sector and international climate change accords to which India is a signatory. The policy analysis has focused on the stated intentions on energy access, creation of livelihoods and sustainability solutions. It also analyses R&D solutions and the process of creation of green energy markets.

Secondary Data/ Document Analysis
Based on stated intention

Key Stakeholder Interviews
Stated intentions and experience with bioenergy

Implications for Livelihoods
Approach to Sustainability - Weak or Strong Sustainability
Experience with Green Energy Markets
Resource Planning

Bio Energy Projects

Industrial Projects

Documents

Interviews with Project Managers

Community Projects

Interviews

Focus Group Discussions with

Stakeholders

And Community Leaders

Source: Own Compilation

5.6.1 Official government data on bioenergy

This data was employed in order to develop a macro picture of the bioenergy sector in Punjab. The literature on methodology points out that the use of secondary data has some distinct advantages and is described as the "perfect complement to case study research" (Smith, 2007: 22). This method of investigation enables the researcher to access data on a scale that they cannot replicate themselves. Secondary data also provides opportunities for discovery of serendipitous relationships, not considered in primary research (Smith, 2007). Due to the large-scale nature of these data sets, they enable robust inferences, especially in the case of vulnerable sections of the population who often remain under-reported in a single survey carried out by the researcher (Brooks-Gunn et al., 1991, Sales et al, 2006).

In this study I used government survey data from two main sources. The *Energy Statistics of India,* compiled by the Central Statistical Office (CSO), Government of India was employed to evaluate the contribution of bioenergy to the total energy needs of Punjab. This data also enabled us to analyse the intertemporal changes in the bioenergy sector in Punjab in terms of installed capacity, reserves and potential for energy generation. The dataset is available from 2007-2016.

I also used data complied on household consumption of energy, gathered by the National Sample Survey Organization (NSSO), Government of India. The NSSO conducts a large-scale all India household survey on energy use and consumption in households, after every five years. This dataset contains detailed information on various energy sources used at the household level. I used unit-record household energy data of the NSSO for subsequent years (1987-88, 1999-2000 and 2010-11) to analyse the relationship between energy choices and household income across time. In addition to these sources, in chapter six I have used a number of official data sources such as the Statistical Abstract of Punjab, published by the Government of Punjab for subsequent years, Planning Commission data, released by the Government of India as well as the State Reports of the Reserve Bank of India in order to develop a macro perspective on the political economy of Punjab.

5.6.2 Key Stakeholders Identification / Interviews and Project Identification in the Bioenergy Sector

An interview is regarded as one of the most important sources of evidence in case study research (Yin, 2014: 110). It is a useful method for assessing an individual's views, interpretation and understanding of events. Interviews help to achieve depth and complexity in the analysis (Bryman et al.2008).

In this study I conducted semi-structured interviews with key stakeholders in the bioenergy sector in order to gather multiple perspectives on the development of the bioenergy sector in Punjab. The interviews were conducted in the form of guided conversations between the interviewee and interviewer. The interviewing did not follow a rigid guide and the phrasing and order of questions were adapted according to the interviewee's responses. According to Patton (2015:437) this form of interviewing helps the interviewer to build a conversation on a particular subject area and develop questions spontaneously as the interview progresses, while the focus remains squarely on the predetermined topic. This method helps to provide rich insights on the contextual dimensions of a phenomenon, which may not be adequately captured in a large-scale survey (Silverman, 2014: 72).

The sampling strategy for identification of bio energy stakeholders was based on purposive sampling. In this form of sampling the key participants are identified on the basis of their knowledge of the subject matter and the research question at hand (Yin, 2014:111). The bioenergy sector in Punjab comprises of a complex network of actors including government officials in the energy sector, biomass energy companies, NGOs, research organisations, farmers, community organisations and local residents. These key stakeholders were identified in accordance with the Global Principles and Criteria for Sustainable Biofuel Production developed by EPFL (2011) and an initial investigation of the field. The basic purpose of the sampling strategy was to ensure broad representation of all the key stakeholders concerned in the bioenergy sector in Punjab and garner multiple perspectives on the subject. Patton (2015) has advocated this sampling strategy and stated that "*key knowledgeables*" are crucial to an inquiry as the researcher is able to gain advantage of their knowledge, and expertise of the subject area (Patton, 2015:284). I conducted thirty semi-structured interviews with stakeholders in the bioenergy sector in Punjab. This is considered a requisite sample size in case study research when the sample is drawn from a heterogeneous population (Patton, 2015). The interviews with the bioenergy producers as well as the community and religious organisations engaged in bioenergy development in Punjab were conducted on site. This enabled me to visit the projects and garner additional evidence, based on my own observations on ground.

In accordance with the protocol of semi-structured interviews, I prepared a series of interview guides. These interview guides covered the main topics and themes to be covered in each interview. However, the actual pattern of questions depended on the responses of the interviewees. While the general topic of discussion remained the same, specific questions and themes were developed during the course of the interview to cover the issues and concerns specific to each interviewee. Some of the interviews were conducted in English, interspersed with Punjabi, others were conducted exclusively in Punjabi. Since I was a native Punjabi speaker, I did not require an interpreter and conducted the interviews myself. The interviews were recorded with the interviewees' permission as audiotapes provide a more accurate rendition of the interview than taking notes (Yin, 2014:110). Subsequent to the interviews, the recorded sessions were first translated from Punjabi to English and then transcribed and analysed. I also recorded my own observations from the interviews and the field visits, along with the interview transcripts.

Plate 5.1: Interview with a community leader in place, Village Seechewal, Jalandhar, Punjab

Source: Own Compilation, May 2016

Plate 5.2: Interview with an engineer of Laxmi Energy and Agro Foods Limited (LEAF), Khummano, Punjab

Source: Own compilation, May 2016

5.6.3 Document Analysis

The second major qualitative research method employed in the study comprised of document analysis. According to Yin (2014:107) documentary evidence, plays an explicit role in any data collection in doing case study research. Documents have three main uses in case study research as per Yin (2014:107-108)

- They help to confirm and build up on the evidence attained from other sources.
- They help to garner new and specific details about a given subject.
- These documents can help to develop inferences about a given topic and give clues about topics to be investigated further.

For the purpose of the present study I conducted a detailed review of national as well as state level policy documents and mandates related to the bioenergy sector along with the international accords on environment of which India is a signatory. This analysis enabled me to understand the key policy imperatives/ behind the development of the bioenergy sector.

During the course of the fieldwork, I also reviewed documents related to administrative and organisational aspects of bioenergy projects in Punjab, environmental and legal regulations for setting up bioenergy plants, norms for setting up tariff rates and tax subsidies on biofuels as well as the names of organisations and key individuals investing in bioenergy projects in the Punjab province. These primary source materials were obtained from Punjab Energy Development Agency (PEDA), which is the nodal agency for renewable energy development in Punjab.

5.6.4 Focus Group Meetings

Focus groups are defined as a form of planned discussion in which a number of individuals, who have a community of interest, are interviewed in a group setting, in the presence of a moderator (Goldman, 1962: 63-64). The basic purpose of a focus group discussion is to create an atmosphere where all participants feel comfortable in expressing their ideas and opinions on a given subject in the presence of a moderator/ facilitator (Stewart et al, 2007). A typical focus group comprises of 6-10 participants because larger groups are difficult to facilitate and create problems in transcription and analysis of data (Bloor et al, 2001, Litosseliti, 2005). The interviews are loosely structured on the basis of the topic guide, which covers the main areas of discussion (Litosseliti, 2005). However, there is still scope for unforeseen areas and discussions to emerge (Stokes and Bergin, 2006). Focus groups allow respondents to react to and build on the responses of other participants in the group and this synergistic effect of the group setting results in production of data and ideas, which are not possible in individual interviews (Litosseliti, 2005: 43). They generate a rich amount of data on different perspectives, beliefs, attitudes and experiences related to a particular subject, which enables the researcher to make important connections and identify subtle nuances in expression (Gibbs, 1997, Litosseliti, 2005: 18; Stewart et al, 2007: 42). Focus groups are considered useful in a multiple-method study as they help in collection group narratives on complex issues (Bloor et al., 2001).

Despite these distinct advantages, focus groups as a research strategy are criticised because the results obtained from focus groups are not generalisable due to the small number of participants, which may not be representative of the entire population (Gibbs, 1997; Bloor et al, 2001 and Stewart et al, 2007). However, other scholars believe that this criticism is unfair because the purpose of conducting focus groups is not generalisation, but illustration of a particular social phenomenon at hand (Litosseliti, 2005: 22). While the participants may not be representative of the entire population, they should be adequately representative of the phenomenon being explored. Bloor et al. (2001: 90) said that focus groups may not be the most suitable as a stand-alone research method, but these are particularly useful as an ancillary method. When focus group data is triangulated with data collected from other sources, it helps to clarify, qualify, extend or contest findings produced from other data sources (Bloor et al, 2001: 90).

In this research project I employed focus groups meetings as an ancillary method, along with document analysis and interviews with key stakeholders in the bioenergy sector. The number of focus groups to be employed in a research project is guided by the topic and the range of responses required in order to construct a holistic picture of the subject (Litosseliti, 2005). In this case four focus groups were conducted with local rural residents, who were end users of bioenergy. The primary objective of these focus group meetings was to gain feedback from village communities as stakeholders in Punjab's energy needs. The focus groups were centered on local energy issues and concerns, the key requirements of the community, people's experience of bioenergy programmes being implemented in the state and their expectations from the bioenergy policies of the state government.

Issues of energy access, proximity to the main town and the socio-economic profile of the villagers guided the selection of villages for the focus group meetings. The first two focus group meetings were conducted with residents of a relatively prosperous village Rauni, which was close to the near by town. The majority of the residents in the village were either farming/dairy households. These households had access to modern energy sources. A number of the interviewed households in this village were also beneficiaries of the biomass cooked stove initiative of the government. The other two focus group meetings were conducted in a remote village, Kotra Kaurewala, where a considerable section of the population still relied on traditional biomass. The interview participants comprised of men and women from agricultural labour households. These households formed the majority of the residents of this village. Agricultural labour households are the most deprived socio-economic group in Punjab's rural community. They are economically poor and socially marginalised. These households have been working as farm labour since generations. They do not have any land of their own and live in small mud houses outsides the main village. These households are the worst affected by issues of energy poverty and access. A large number of households do not have access to modern sources of energy and continue to rely on traditional biomass energy for their energy needs.

Plate 5.3: Focus group meeting with women belonging to agricultural labour households, Village Kotra Kaurewala, Rampur Phull, District Bathinda, Punjab

Source: Self compilation, June 2016

Within each village two focus groups were conducted-one with males and the other with female participants. Each focus group comprised of 8-10 participants. The basic objective of conducting separate focus group meetings was to get gender-disaggregated information on their experiences and key issues pertaining to energy use. Literature on focus groups advocates that there should be some homogeneity in the choice of focus group participants, as this affects participant's contribution and the degree of cohesiveness in the group (Litosseliti, 2005). The participants were homogeneous in terms of gender, geographical location, occupation types, caste groups and their understanding of bioenergy projects. However, in order to ensure some diversity in opinions and experiences, participants were selected from different age groups and educational backgrounds.

The focus group participants were recruited through two intermediaries, who were social activists working in the region and knew me through my previous work in the region. Stewart et al (2007) has advocated this form of recruitment of participants as it helps to save time and effort involved in recruitment and also ensures effective attendance. In order to ensure that none of the participants had been coerced into participating in the focus group meetings, they were provided with an information sheet and informed consent was taken from each of the participants. I prepared separate interview guides for conducting the focus group meetings with men and women in the two different villages. While the general topic of discussion remained focused on the resident's experience with bioenergy, each interview guide comprised of the specific set of issues and questions, which I wanted to address to the different group of the focus group participants. The focus group meetings in both the villages were conducted in an intermediary's house. The intermediaries played the host and were given a small amount of compensation for organising the meeting. This provided a comfortable and friendly atmosphere for the discussions to take place. I moderated the focus groups myself. An assistant was employed for recording the proceeds of the discussion and taking notes. The focus groups were conducted in Punjabi. Each focus group lasted for approximately sixty minutes. Immediately after conducting these focus group meetings, I transcribed the interviews by translating them from Punjabi to English.

5.7 Data Management

A large amount of data was accumulated from a number of sources in the present study in varied forms: numerical data, interview transcripts, policy documents and focus group transcripts. Once the raw data was accumulated, data management procedures were put in place in order to create a case study database. A case study database is defined as a separate and orderly combination of all the data collected from a case study (Yin, 2014: 123). The creation of such a database helps to create a "chain of evidence" so that the case study reader may follow the derivation of evidence from the initial research questions to the final conclusions (Yin, 2014: 124). The quantitative data derived from the Energy Statistics of India for subsequent years 2007-2015 was stored in an Excel database and individual data files were created. These data files were arranged chronologically. Similarly the unit record household energy data from the National Sample Survey organization for subsequent years:

1987-88, 1999-2000 and 2011-12 was first extracted from the NSSO database and then stored in SPSS data files.

The documentary evidence comprised of reports, feasibility studies, policy documents as well names and location of biofuel projects. I made copies of these documents and then organised them according to the topic and the chronology of events related to bioenergy developments in the state of Punjab. The stakeholder interviews and the focus group meetings were audio recorded, then translated from Punjabi to English and subsequently transcribed. I transcribed the focus groups and interviews myself. This approach of transcribing provides an opportunity to immerse yourself in data, get a feel of the cumulative data and generate important insights Patton (2015:525). After all the interviews and focus group meetings were transcribed, these were stored in separate files for further analysis.

5.8 Data Analysis

After putting the data management procedures in place, the first phase of the analysis concentrated on analysis of quantitative data comprising of energy statistics of India relating to the periods 2007-2015. This was a logical step to build a macro understanding of the bioenergy sector in the region of Punjab, in terms of the overall contribution of bioenergy to the total energy needs of the state, the sector wise contribution of bioenergy and the changes in this sector over time. This was followed by analysis of NSSO household consumption expenditure data to evaluate the energy choices of households on the basis of cross tabulating variables like household income, monthly per capita expenditure income and occupation types with household energy choices. The quantitative data analysis was undertaken prior to the fieldwork.

The qualitative data analysis was an iterative process. During the course of fieldwork in Punjab, I constantly analysed policy documents and interview transcripts to inform subsequent interviews and focus group meetings. I decided to use manual coding in this project. The first phase of this process involved rigorous reading of the documents, interviews and focus group transcripts, which enabled me to “immerse” myself in the data (Braun and Clarke, 2006). Thereafter I began coding the data. A code is defined as a label that assigns a particular attribute to a portion of the text

(Saldana, 2009: 3). Indexing and classification of data through the use of codes helps to arrange things in a systematic order for further analysis (Saldana, 2009:4). Coding of data was based on thematic analysis, which is defined as the process of identifying categories, patterns and themes in the data (Patton, 2015: 541). The coding process in thematic analysis can be of two types viz. theoretical codes (themes are identified on the basis of the conceptual model) and inductive coding (themes are identified on the basis of events taking place on ground) (Braun and Clarke, 2006). In this research I relied on a combination of the two approaches. Some themes were developed on the basis of the concepts and categories in the conceptual model, while others emerged inductively from the data. As the analysis progressed, I was able to draw out the inter-relationships and inter-connections between the different themes more clearly. This facilitated interpretation and writing up in the later stages.

In the writing up stage, I triangulated the results obtained from different sources of evidence. I made extensive use of illustrative quotations from the interviews/ focus groups and the policy documents to illustrate the main arguments in the text. At many places these quotations were corroborated with quantitative government data, to strengthen the validity of the findings and construct a coherent picture of the bioenergy projects in Punjab. Teddlie and Tashakkori (2009) have advocated this method of drawing out inferences on the basis of qualitative and quantitative strands of the study separately and then drawing out final conclusions across the qualitative and quantitative strands as meta-inferences. They contend that the two approaches together help us to improve upon the quality of the analysis (Teddlie and Tashakkori, 2009).

5.9 Quality of the research

The criteria for measuring the quality of a research project is intimately connected to the context of the study as well as the chosen theoretical and methodological framework. For the purpose of this research project I adopted “Tracy’s eight tent criteria” as a measure of the quality and trustworthiness of the study (Tracy, 2010). The various criteria of quality and trustworthiness under this “pedagogical model” are summarised in table 5.1 below.

Table 5.1: The criteria for maintaining the quality of the study under "Tracy's eight tent" approach	
Criteria	**How the criteria was maintained in the research**
Worthy topic	The project is relevant in light of the fact that there is much debate on the sustainability of bioenergy imperatives across developing countries. This research will provide timely insights into the opportunities as well as limitations of bioenergy policies.
Rigour	• ***High Quality Data:*** The study was based on authoritative and high quality primary and secondary data. • ***Purposive Sampling:*** The use of purposive sampling enabled the researcher to choose interviewees based on their expertise and knowledge in the bioenergy sector. • ***Prolonged Engagement:*** The research is based on prolonged periods of fieldwork in Punjab in two rounds. The first round was conducted between June-August, 2015 and the second round of fieldwork was conducted between May-August, 2016. • ***Descriptive data****:* I collected detailed descriptive quality data through interviews, focus groups as well policy documents on bioenergy in the state. • ***Recording of Interviews****:* The choice to audio record interviews as well as focus group meetings ensured that I have dependable data. • ***Data Management:*** I built a case study database comprising of transcribed interviews and focus groups, quantitative data and policy documents on bioenergy. This helped to preserve the data and ensure systematic access to the data.

Credibility	• ***Thick description***: I have provided a detailed description of the research methods, the data collection processes, contexts and assumptions, which were employed to construct meaning of the phenomena. • ***Triangulation:*** Data collected from multiple sources were corroborated and converged, which lend validity to the research findings. By using multiple sources of evidence, inadequacies of one data source were overcome with the advantage of the other data source • ***Multivocality:*** I considered multiple viewpoints and varied voices of the different stakeholders in the bioenergy sector to lend credibility to the research process. • ***Member checks:*** Formal checks took place through discussions with the supervisors and seeking their comments and guidance on data collection, management and analysis, which helped in refining the quality of the analysis. I also had the opportunity to present my findings at various seminars and conferences, which provided another way to gain insights from experts and sharpen the analysis of the data.
Sincerity	In order to provide a sincere and a transparent account of the study, I reflect on the researcher's role in the process through "self reflexivity"
Ethics	I gained ethics approval for the conduct of the study from the University Research Ethics Committee, Oxford Brookes University. It was ensured that research ethics were strictly adhered to in terms of taking informed consent from the participants, maintaining their anonymity and ensuring that the data collected during fieldwork is stored securely
Coherence	This research project was based on systematic conduct to ensure that the stated objectives of the study may be achieved. Prior to data collection, I developed a research design to provide a framework for actual data collection. I also developed a coherent procedure for data management and analysis in order to ensure that the final research findings are integrated with the data as well as the literature on bioenergy.
Resonance	The study generated theoretical/empirical findings on the opportunities and limitations bioenergy projects as a sustainable energy alternative. These findings will be transferable to other contexts as well and provide valuable insights for future research on bioenergy projects in other parts of the developing world.
Contribution to	The research project aims to provide a theoretical as well as practical contribution to knowledge. This study develops a

knowledge	theoretical framework, based on participatory field based research to understand the opportunities and limitations for implementation of sustainable bioenergy policies in Punjab. This framework will serve as a guiding model for assessment and implementation of bioenergy policies in other parts of India and across the developing world.
Source: Own Compilation	

5.10 Self Reflexivity: Incorporating the researcher's role in the research process

In the present study, I was a native resident of the case study region and had some prior experience of conducting research in the area. I went to the field with some experience as well as perceptions of the bioenergy developments taking place in Punjab. My pre-existing knowledge, fluency in the language as well as an understanding of the socio-economic constructs of the region was useful during the conduct of the fieldwork. This research project warranted that the methodological framework should be appropriately designed and the researcher should have some knowledge and sensitivity towards the socio-economic realities of the region, which helped to provide a coherent understanding of the multipronged aspects of bioenergy developments in the region. My previous research experience and the fact that I was a native of the region helped me to identify, forge contacts and gain access to the key stakeholders in the field. In addition to this, I was able to gain easy access to official government documents, government survey data and records pertaining to bioenergy developments.

However, I recognised from the outset that my previous knowledge, perceptions and experience might lead to some personal biases and pre-conceptions. My pre-existing concepts and knowledge of the field may prevent me from going into the field with an open mind and being responsive to important details or taking some things for granted. This research bias may threaten the reliability of the study. Lincoln and Guba (1985: 300) advocate that the researcher should go into the field with a stance of "neutrality" in order to ensure the reliability and validity of the study. In this project I attempted to adopt the stance of neutrality by following standard procedures of data collection, data management and analysis, as outlined in the previous sections. Reliable statistical and policy data was collected during the course of the study, to provide a rich account of the bioenergy development in the region of Punjab. My past research experience in Punjab proved fruitful in identifying and collecting rich and reliable primary data from varied sources. I was aware that in case of interviews and focus group meetings, I will have a direct impact on the interviewees, since they would be would be essentially communicating with me as a respondent in the research process. In order to minimise the researcher bias in interviews and adopt the stance of neutrality, I adopted standard interview practices such as developing interview guides, taking informed consent from the participants and asking neutral non-leading questions. I designed a systematic research design to ensure rigour in the process of data collection and analysis. I audio recorded all the interviews and focus groups and took copious notes during the interview/focus group proceedings. I feel that along with these standard protocols, my pre-existing knowledge and experience enabled me to develop sensitivity towards the socio-economic and political factors that influenced bioenergy developments in the region.

In the writing up stage of the thesis, I had to revisit the data and my experiences in Punjab and make decisions on how to present complex themes and issues, which emerged in the field. This process involved immersing myself in the data, continuously reading through the transcripts and drawing out the core themes. While the research is essentially my own interpretation of the events on the field, an attempt has been made to stay as true to events on the ground as possible.

5.11 Summing up

This chapter presented the research methodology employed in the study. In Section 1, through an extensive review of literature, I reasoned why I have chosen critical realist paradigm for this research, and why this research does not follow an interpretivist or positivist approach. Following this, I elaborated upon the various research methods used in the process of data collection, and discussed their relative strengths and weaknesses. The use of multiple methods enabled me to balance the weakness of one method with the corresponding strength of the other. The methodology is essentially rooted in a participatory stakeholder perspective, which enabled me to capture multiple voices and viewpoints on bioenergy developments. The chosen methodological framework enabled me to bring in issues of poverty, energy access, rural livelihoods and household energy choices, which form an important part of the sustainable energy discourse. In the final section I reflected on the criteria for maintaining research quality, and reflected upon the researcher's own impact on the process. I recognise that an important methodological limitation of this study is that due to temporal constraints I was only able to evaluate the sustainability of bioenergy developments in Punjab at a particular point of time. Sustainability is a long-run, multi-dimensional process, which must be evaluated across time. However, it is hoped that this study will provide some insights to policymakers and bioenergy developers in the region and pave way for further research in the coming years.

After presenting the methodological framework of the research, in the next chapter I will provide a detailed analysis of the political economy of the case study region, Punjab. This chapter will provide the necessary context for the evaluation of the current bioenergy projects taking place in the region.

CHAPTER SIX
POLITICAL ECONOMY OF PUNJAB' S DEVELOPMENT: A CRITICAL ANALYSIS FROM A SUSTAINABILITY PERSPECTIVE

6.1 Introduction

This chapter presents a systematic evaluation of the political economy of the region of the case study, Punjab, India. The analysis will provide an in depth understanding of the manifestations of the capitalist mode of agricultural development in a region of the developing world. I have analysed Punjab's development model from the time of conception of modern day Punjab in 1966 to present and evaluated its socio-economic and environmental policies, in order to understand how these may impact the future development trajectory of the province. This critical investigation will provide insights into the political economy factors, which have shaped Punjab's socio-economic and ecological policies and set the stage for the presentation of the main findings from this research in the subsequent chapters.

Punjab represents a particular model of capitalist agricultural development, which was initiated in the state in the early 1960s. It was the epicentre of the green revolution in India, where in dissemination of industrial agriculture took place through development of High Yielding Varieties (HYV) of seeds and intensive irrigation techniques (Newman, 2007:1). As a result of this, the agrarian sector in Punjab was transformed from traditional agriculture to a "package of agrochemical and mechanical inputs" during the next two decades (Newman: 2007:1-2). This is evident from the fact that between 1965-66 to 1982-83, fertiliser consumption in Punjab increased fifteen times, consumption of electricity in agriculture increased six times and area under irrigation trebled (Singh, 1989). Agricultural yields quadrupled in the initial years of the Green Revolution, with average crop production increasing at the rate of 7 per cent per annum between 1960-1980 (Singh, 2016 a; Murgai et al, 2001). This elevated Punjab to the status of one of the most developed states of the Indian subcontinent; characterised by high levels of per capita income, developed infrastructure and low levels of poverty (Singh, 2008). With rising food grain production, the province began to be touted as the "food granary of India" (Newman, 2007:5). However, after the initial success of this development model, it backfired by the 1980s (Newman, 2007:5). This agrarian model of development was based on "targeting the best and leaving the rest" (Newman, 2007:5). While the rich farmers could afford to invest in this highly mechanised agricultural model, the cost of production for small and medium farmers rose dramatically over the years (Singh, 1989). They found it increasingly difficult to continue farming. By the early 1990s many small farmers were forced to either resort to borrowings to finance their cost of production or to sell their land, triggering the phenomena of "reverse tenancy"[38] (Kaur, 2010).

The situation worsened with the structural transformation of the Indian economy in 1991 and the launching of the regime of liberalisation and privatisation, in conformity with the World Bank and IMF perspective (Singh, 2008:3). This transformation of the Indian economy resulted in a decline in importance of the agrarian sector in India's national income, a decrease in public investment in agriculture and a cut down on farm subsidies (Ahluwalia, 2002). This had grave consequences for a primarily agricultural province like Punjab (Singh, 2017). There was little industrial development in the region, and a majority of the population continued to practice this unsustainable model of agricultural development as their only source of livelihood (Singh, 2017). Farm incomes began to dwindle rapidly and in the absence of any alternative source of employment and income, the Punjabi economy began to plunge into a crisis like situation (Singh et al, 2016: 15).

Punjab's development model has also been characterised by a number of socio-economic and ecological contradictions. The original architects of this model did not consider the issues of land distribution, ecological sustainability and the long-term consequences of input oriented capitalist development (Newman, 2007:6). Over the years, with extensive use of chemical fertilisers and pesticides, the soils were diseased, the water was polluted and the fertility of the land was compromised

[38] Small and marginal farmers in Punjab started leasing out land on cash terms to medium and large farmers, who had sufficient capital and family labour and could make investments in machinery and agriculture infrastructure. This phenomenon came to be known as reverse tenancy (Singh, 2000: 1889).

(Ghuman, 2017 and Ghuman and Ramona, 2010). From the lens of social sustainability, Punjab remains a "rich but not developed province" (Singh, 2017 a). Though the state has achieved high levels of per capita income, it lags behind other Indian provinces in indicators of health, education and sustainable development (Centre for Development Finance, 2011).

As a result of these challenges, it is being recognised that the Green Revolution strategy is not a holistic model of development. Therefore, in consonance with the reorientation of the capitalist development model in other parts of the world, the development strategy in Punjab has begun to be re-oriented towards a strategy of green capitalist reforms (Singh, 2017). These reforms are aimed at reviving the growth process in Punjab, and simultaneously achieve protection of the natural environment (Wanner, 2015:16). These green policy reforms are being hailed as a "second green revolution" and comprise of a move towards a more environmentally friendly development trajectory (Bajpai, 2015). A major plank of these reforms is the development of Punjab as a "green power" economy with a greater impetus on non-renewable sources of energy (Business Standard, 2015). The former deputy Chief Minister of Punjab, Mr. Sukhbir Badal remarked in this context:

"Punjab has moved from green revolution to green power revolution; which would benefit both farmers and entrepreneurs in the state, boost rural incomes, besides supplementing income on farmlands" (Press Trust of India, 2015).

In view of these developments, this chapter critically traces out the development trajectory of Punjab over the years and analyses the essential contradictions in the green revolution model of agricultural development. The first section presents the political history of Punjab from the colonial times and analyses the colonial model of agricultural development, which was a precursor to the Green Revolution model in Punjab. The second section focuses on the initiation of the Green Revolution model in the province and how it transformed the economic, ecological and the social fabric of Punjab. The third section elucidates the ecological and socio-economic ramifications of the Green Revolution model. The fourth section reflects on the impact of India's structural adjustment programme on the Punjabi economy, in the face of the continued "ruralisation" and lack of industrial development in the province. The concluding section traces out the state's move towards ecological reforms, as a potential solution to the continuing socio-economic and ecological crisis in the Punjab and the implications of these reforms for the future development of the state.

6.2 Political History of Modern Day Punjab

6.2.1 Historical underpinnings of Punjab's development model

The Sikhs rose to political power by launching an armed campaign against the Mughal rule under the tenth Sikh guru, Gobind Singh (Singh, 2008: 24). After the death of Guru Gobind Singh in 1708, his chief general, Banda Singh Bahadur continued to lead the community's armed political struggle against the Mughals (Singh, 2004:116-117). He annexed a number of feudal princely states and established a programme of land redistribution among peasants, which eventually took the form of an "agrarian uprising" that tilted agrarian relations in favour of the actual cultivators in the annexed territories (Singh, 2004:117). Banda Bahadur changed the class structure of land holdings in Punjab by liquidating many of the big land-owning families. The large feudal estates controlled by these families were systematically broken up into smaller land holdings and the proprietary rights on these holdings were transferred to the farmers' cultivating them (Singh, 2008: 25-26).

Sikhs continued to engage in guerrilla warfare with the Mughal rulers over the years, which finally led to the establishment of a Sikh kingdom under the leadership of Maharaja Ranjit Singh in 1799 (Singh, 2004:120-22). With the establishment of the Sikh kingdom, the hold of traditional proprietary families was weakened and the position of the tiller was strengthened (Singh, 2001)

The British annexed the Sikh kingdom in 1848, after the defeat of the Sikh army in the Anglo Sikh wars (Sidhu and Jaijee, 2011). Following this the colonial government launched paternalistic efforts to win over Punjab peasantry and rally support for the British rule[39] (Singh, 2001:22).

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[39] The British government had three main motivations to develop Punjab as an agrarian province and create a loyal political base among the Punjabi community. *Firstly,* to increase agricultural output and maximise land revenue returns to the colonial government. *Secondly,* to facilitate military recruitment from among the peasantry and make military service a route to

6.2.2 Colonial model of agricultural development in Punjab

The British government significantly altered the agrarian system in the province. The mainstay of the British agricultural policy in Punjab was the development of canal colonies (Kaur, 2010: 41). The British recognised an untapped irrigation source in Punjab, in the form of its five rivers. It sought to exploit these rivers, by constructing a network of canal systems, in order to better cultivate the dry state (Newman, 2007:21).

With the launching of these massive irrigation works, twenty million acres of land, comprising of 52 per cent of the total cropped area in the state was brought under cultivation (Sohal, 2013: 244). The development of these canals established Punjab as a "new agrarian frontier" (Sohal, 2013: 244). There was a tremendous improvement in the proportion of irrigated land in the state, from 5.8 million acres of irrigated land in 1916-17 to 12.5 million acres of irrigated land in 1943-44 (Josh, 1979: 43). It represented a "stupendous engineering feat", which transformed six million acres of desert area into one of the richest agricultural areas (Talbot, 2007:13). It is regarded as one of the colonial state's greatest strengths (Talbot, 2007:13). At this time the British also introduced new agricultural technologies in Punjab through establishment of research facilities at Lyallpur University (Singh, 2001:31). Genetically modified hybrid varieties of wheat were introduced in the state (Singh, 2001:31). There were also technological innovations in agriculture through introduction of equipment such as sugar crushers, Persian wheels, iron ploughs and drills (Singh, 2001:31). As a result of these developments, land value and agricultural prices in the state began to rise rapidly (Singh, 2001:31). A number of cash crops such as wheat, tobacco, sugarcane and cotton began to be cultivated in the state and Punjab emerged as the "pace setter of agricultural development in India" (Talbot, 2007:5). These developments in agriculture during the British time are referred to as the "first green revolution" in Punjab (Baker, 1984:40). They succeeded in introducing a substantial monetised and market oriented agrarian economy in Punjab (Singh, 2001:21). This politico-economy strategy of

land acquirement. *Thirdly,* to create a loyal political base in the countryside for British rule (Singh, 2008:28-29).

development under the colonial rule laid the foundation for an agriculturally oriented path of development in Punjab, which continues till the present times (Talbot, 2007: 7; Singh, 2008:28-29). This was in sharp contrast to other provinces like the Bombay presidency, the Madras presidency and Bengal where the state policy was heavily tilted towards intensive industrial development (Singh, 2008:29).

This strategy of development yielded immense economic, political and military dividends to the British government (D'Souza, 2006:621). However, it was characterised by a large number of inconsistencies, due to which Punjab experienced a "contradictory pattern of development, in which growth was closely paralleled by underdevelopment" (D'Souza, 2006:622). The colonial policy of developing Punjab merely as a model of capitalist agricultural development led to a paradoxical situation where in Punjab experienced rapid economic growth as a result of this colonial policy and yet remained backward (Ali, 1989: VII).

While agricultural production in Punjab continued to rise, farmers' experienced increasing indebtedness due to increased land revenue burden and the need to invest in modern agricultural techniques (Singh, 2008:28). Increased indebtedness among farmers led to growing grievances against the British rule (Singh, 2008:29). Darling (1925) conducted an in depth analysis on the conditions of Punjabi peasants in the canal colonies on the basis of administrative records and his own observations on the field. He concluded that 80 per cent of peasants in canal colonies were in debt (Darling, 1947:5).

The commercialisation of agriculture also had an adverse impact on Punjab's ecology. The colonial policies of clearing up fallow lands and forests for agricultural production, introduction of commercial crops and double cropping, accompanied by canal irrigation "reoriented ecological relations between land and water" (D'Souza, 2006:625). Whitcombe (1972) analysed the environmental impact of construction of canal colonies under the British rule. The principal conclusion from her work was that canal irrigation eliminated traditional methods of irrigation such as wells and resulted in increased drainage problems and widespread incidence of malaria in the province.

The economic returns from this model of agricultural development also began to dwindle towards the end of 1930s (Parayil, 1992:740). At this time the growth rate of agricultural production decreased to 0.3 per cent per annum and was outstripped by the growth rate of population at 2.2 per cent per annum (Parayil, 1992:740). This period also coincided with the Great Bengal Famine of 1943 (Islam, 2007:421). The famine induced epidemic led to 3 million deaths across the country (Islam, 2007:421). As a result of this crisis Punjab became a major supply zone within India. However, at this time agricultural production in Punjab had begun to stagnate (Sohal, 2013). With increasing exports and pressure to be the “food bowl of the entire Indian subcontinent”, Punjab was pushed into a socio-economic crisis, characterised by severe food shortages, inflation and deprivation, which led to famine like conditions in south east Punjab in early 1940s (Sohal, 2013).

Thus, at the time of independence Punjab was plagued by a host of problems comprising of declining farm yields, increasing indebtedness of farmers, as well as deteriorating quality of the natural environment. These challenges carried forward into the post-independence period as well and had a profound influence on the future development trajectory of the province.

6.3 Initiation of the Green Revolution Strategy

After a prolonged political struggle in the post-independence era, Punjab acquired its distinct political and geographical identity on November 1, 1966 (Singh, 2008:3). This period coincided with the implementation of the Green Revolution model in India. The Green Revolution was a techno-political strategy of development, designed to create material wealth in third world countries by overcoming natural “limits to growth” through implementation of modern agricultural technologies and uprooting of the traditional methods of cultivation (Parayil, 1992:737). Norman Borlaug, the “father of green revolution” in his noble prize winning speech in 1970 remarked that the Green Revolution was comparable to the Industrial Revolution in the western world and would charter a new course of development in third world countries, unconstrained by natural limits to growth (Borlaug, 1970)

The Green Revolution strategy in India was launched in the form of Intensive Agricultural Development Programme (IADP), on the recommendation of thirteen agro-economists of the Ford Foundation (Newman, 2007:10). The central premise of this strategy was to integrate the agricultural sector in India into the world capitalist market through the adoption of a new technology package (Cleaver, 1982: 179). The IADP was a strategy of capitalist agricultural development, selectively "building on the best" and "building on the strongest" (Newman, 2007:10). This strategy aimed to target the well-endowed agricultural regions in India and the largest farmers in terms of acreage (Newman, 2007:10).

6.3.1 Motivation for the green revolution strategy

Four main players initiated this agricultural model in the Indian sub-continent: The Indian capitalist state, international agricultural institutes, multilateral and bilateral agencies and the US government (Parayil, 1992:744). At the time of independence, agriculture in India was stagnating and there was a decrease in overall food production. This manifested itself in the form of high level of hunger and food security in the sub-continent (Dasgupta, 1977:241). India was heavily dependent on food imports from the United States under the PL-480 (Peace for Lunch)[40] programme (Dasgupta, 1977:241). Hence, the resurrection of the agriculture became a primary strategy of the central government at this time. It was believed that achieving food self-sufficiency would give legitimacy to the newly formed government at the centre (Newman, 2007:7). Initially the central facet of this strategy involved introduction of "progressive agriculture" through land reforms and development of village co-operatives (Newman, 2007:7). However, land reforms were severely constrained and slow to take off due to widespread opposition from within the ruling Congress government, many of whose ministers comprised of big landowners (Newman, 2007:7). By the 1960s, the stagnation in Indian agriculture

[40] The US government had been providing food aid to a number of developing nations under the PL-480 programme launched in 1952. During the post-World War II period, surplus food grains had accumulated in US due to a dramatic rise in its food grain production. The US government did not want to sell these surplus food grains in the US/ world market for the fear of crashing them. Therefore it developed a national policy of PL-480 to supply these surplus grains to food deficit countries in the form of food aid. The PL-480 programme was expanded in the 1960s. In India food aid was tied to a number of conditions in the form of devaluation of Indian rupee by 37.5 per cent, import liberalisation and opening up the market for foreign investment in fertiliser industry. Finally, the Lyndon Johnson government refused to give food aid to India for more than a month, unless it adopted the conditions of the Green Revolution package (Newman, 2007:9).

culminated into a series of famines and widespread agricultural distress in different parts of the country (Parayil, 1992:740). This crisis was attributed to the "backward nature of traditional Indian agriculture" by a number of agricultural experts (Blaug, 1970).

At this time the Indian government began to recognise that the only way to achieve food self-sufficiency in India was to increase agricultural productivity by modernising traditional Indian agriculture (Newman, 2007:8). It acknowledged that the survival of Indian nationhood depends on increased agricultural output through technical progress (Singh, 2008:116). It was contended that Green Revolution presented the possibility of a "spectacular breakthrough in grain production for India" (Doyle, 1985:256), which would help the country to achieve self-reliance in food grain production and free the country from the humiliating conditions of accepting food aid from USA (Singh, 2008: 115).

The USA government had its own agenda for promoting the Green Revolution in India. With the formulation of the communist regime in China in 1949, there was an increasing threat of a Pan-Asian communist revolution. They feared that Indian peasants like their counterparts in China were disillusioned with the system and there was an increasing threat of a communist peasant revolution in India (Newman, 2007:9). These western powers began to employ food as a political power to thwart peasant movements in Asia (Cleaver, 1982:286). The US government decided to counter the threat of communist insurgency by introducing the Green Revolution strategy of agricultural development in India and other developing nations (Anderson et al, 1982:3).

This strategy sought to replicate the American model of capitalist agricultural development in India by bringing in foreign capital and western techniques of agricultural production. It was seen as a means to stabilise the countryside by "mobilising science and technology in the service of counter-revolution" (Anderson et al, 1982: 3). Another motivation for the US government to promote the Green Revolution in developing countries was to create a profitable market for chemical fertilisers in third world developing countries, as there was an abundant supply of chemical fertilisers in USA in the post-world war II period[41] (Doyle, 1985:259). The factories engaged during the Great War in the fixation of atmospheric nitrogen for the manufacture of explosives had to find other markets for their products. This led to a rapid rise in the use of NPK fertilisers in agriculture (Howard, 1940:25).

The Congress government in India too was threatened by the prospect of agricultural revolts taking place in various parts of India, such as the *Telangana* uprising and hailed the Green Revolution as a model for meeting the revolutionary threat from left wing peasant movements who were demanding social reforms in agriculture (Newman, 2007:9). The government promoted the Green Revolution as "a means towards a peaceful revolution" (Newman, 2007:9).

6.3.2 Punjab: The epicentre of green revolution strategy

Punjab "was singled out as ground zero for the implementation of this largest agricultural experiment in the history of India" (Newman, 2007:2). It was considered the most suitable region for this experiment because of its rich soils and historically developed irrigation system, in the form of canal colonies (Singh, 2008:116). Punjab also had a number of large-scale farms, due to the land reforms, which had been carried out in the state in 1947 (Randhawa, 1977:657). These land reforms led to consolidation of land-holdings in the state and created a class of large landowners who had sufficient capital to make necessary investments in the new technologies and inputs (Randhawa, 1977:657). The "human factor," was also a major contributing factor to the choice of Punjab as the epicentre of Green Revolution technologies. Traditionally Punjabi farmers are believed to be endowed with a "high degree of entrepreneurial ability" and the "capability to adopt new innovations" (Singh et al, 2014; Corsi, 2006).

6.3.3 Transformation of rural economy of Punjab and the green revolution

[41] In the course of developing agents of chemical warfare during World War II, some of the chemicals created in the laboratory experiments were found to be lethal to insects. This led to a rapid development of new chemical fertilisers and pesticides in USA. There was a five-fold increase in fertiliser production in USA from 124,259,000 tons in 1947 to 637,666,000 tons in 1960 (Carson, 1965:25-27).

The initiation of Green Revolution brought about a number of changes in the nature of agricultural practices in Punjab. These changes were meant to transform traditional agriculture in Punjab into a model of capitalist agricultural development, characterised by mono-cropping patterns of cultivation, intensive irrigation as well as indiscriminate use of chemical inputs. In order to bring about these changes a key strategy of the government involved setting up of the Punjab Agricultural University (PAU), Ludhiana to modify the agro economic practices in Punjab as per the requirements of the Green Revolution in terms of cropping patterns, fertiliser and insecticide use, water usage and adoption of new HYV seeds (Singh, 2008: 116).

Scientists at the PAU selected some strains of imported seeds from Mexico and developed two new varieties of wheat, *Sonalika* and *Kalyanson* in 1968 (Singh, 2014 a). These were based on Mexican HYV seeds, modified for cultivation within Punjab (Singh, 2014 a). These developments led to two main changes in the agrarian structure of Punjab. Firstly, rice and wheat varieties began to be produced from a narrow genetic base, compared to the high genetic variability in traditional wheat/rice varieties. After the introduction of Mexican dwarf HYV seeds, within a span of three years, by 1971, HYV seeds began to account for 70 per cent of the total rice and wheat production in the state (McGuirk and Mudlak, 1991:23). As shown in table 6.1 below, the proportion of major crops under HYV seeds in Punjab has been rising rapidly. As per the latest estimates, HYV seeds form almost 100 per cent of the area under cultivation of major crops.

Table 6.1: Percentage of cropped area under HYV seeds, 1966-67 to 2012-13

Year	Rice	Wheat	Maize
1966-67	5.4	7.5	
1970-71	33.33	69.12	8.83
1980-81	92.56	98.04	41.78
1990-91	94.59	99.94	85.11
2000-01	95.94	100	93.33
2008-09	100	100	94.16
2010-11	100	100	96.99
2012-13	100	100	97.8

Source: Adapted from Government of Punjab (2014)

Rotation of diverse crops like wheat, rice, millets, pulses and oilseeds was replaced by mono-cropping pattern of wheat and rice cultivation (Sidhu, 2005:200; Mann, 2017:30). Between 1960-61 to 2013-14, the percentage of area under wheat production rose from 29.58 per cent to 47.9 per cent, while the area under other crops like pulses, maize, oilseeds, cotton and sugarcane fell dramatically (as shown in table 6.2 below). In 1960-61 only 4.8 percentage of the cropped area in the state was under rice production. After the introduction of semi-dwarf varieties of seeds the area under rice production increased dramatically and by the year 2013-14 the total area under rice production rose to 37.23 per cent (Table 6.2). 95 per cent of this area is under semi-dwarf varieties HYV seeds (Sidhu and Singh, 2014). The change in cropping pattern in the state has been accompanied by a rapid rise in cropping intensity, from 126 per cent in 1960-61 to 189 per cent in 2014-15 (Government of Punjab, 2015). As a result of this increase in cropping intensity, forests, pastures and common grazing lands in Punjab were systematically brought under crop cultivation. Today, 83 per cent of the total area in Punjab is under cultivation, which is the highest in the country (Sidhu and Singh, 2014:118-119).

Table 6.2: Cropping patterns in Punjab: 1960-61 to 2013-14

Year	Wheat	Rice	Maize	Pulses	Oilseeds	Cotton	Sugarcane
1960-61	1400 (29.58)	227 (4.80)	327 (6.91)	903 (19.08)	185 (3.91)	447 (9.45)	133 (2.81)
1970-71	2299 (40.48)	390 (6.87)	555 (9.7)	414 (7.29)	295 (5.19)	397 (6.19)	128 (2.25)
1980-81	2439 (38.99)	567 (9.07)	577 (9.22)	441 (7.05)	122 (1.95)	649 (9.59)	71 (1.05)
1990-91	3273 (43.63)	2015 (26.86)	188 (2.51)	143 (1.91)	104 (1.39)	701 (9.34)	101 (1.35)
2000-01	3408 (42.95)	2612 (32.93)	164 (2.07)	55 (0.69)	86 (1.08)	473 (5.69)	121 (1.52)
2009-10	3522 (45.51)	2801 (35.41)	139 (1.76)	19 (0.24)	62 (0.78)	511 (6.46)	60 (0.76)
2013-14	3512 (47.9)	2851 (37.23)	125 (1.43)	8.4 (0.11)	59.8 (0.65)	438 (4.22)	89 (0.83)

Source: Government of Punjab (2015)
Note: Figures in Parentheses indicate percentages

Prior to the Green Revolution, fertiliser and pesticide use in Punjabi agriculture was negligible (McGuirk and Mundalk, 1991:35-36). However, the HYV seeds required high doses of fertilisers in order to bring about a rise in productivity. As a result fertiliser use in Punjab rose from 1.33 kg/hectare in 1960 to 105 kg/hectare in 1979 to 404.32 kg/hectare in 2005-06 (Singh et al, 2016). This constitutes a 304-time rise in total fertiliser use in the state (McGuirk and Mundalk, 1991:35-36; Murgai et al, 2001).

There was also a rapid rise in the intensity of irrigation in the post-green revolution period. The intensity of irrigation in agricultural production rose rapidly from 54 per cent in 1960-61 to 97.5 per cent in 2006-07 to 98.45 per cent in 2013-14, with the result that Punjab is today the most irrigated state in the Indian sub-continent (GOP, 2014 b). There was a rapid rise in both surface and groundwater irrigation, in order to fulfil the higher water demands of HYV seeds (McGuirk and Mundalk, 1991:33). Surface water irrigation was expanded with the construction of large dams such as *Bhakra Nangal* Dam (1963*), Pong* Dam and *Pandoh* dams (1977) (McGuirk and Mundalk, 1991: 33). Along with the construction of these dams there was a rapid rise in construction of tube wells. The number of tube wells rose rapidly from 5000 in 1959-1960 to 610,000 by 1981-82 (McGuirk and Mundalk, 1991: 33). The rapid expansions of tube wells led to high level of energy and electricity demand for agriculture. These tubewells were either electricity or diesel operated (Sidhu, 2005). Between 1960-61 and 1983-85 the per capita consumption of electricity was highest in Punjab among all other states of India (Singh and Kohli, 2005). The fastest growing demand for electricity was in the agricultural sector (Singh and Kohli, 2005). Between 1960-61 to 1979-80 total electricity consumption in agriculture as a percentage of the total electricity consumption in the state increased from 14.5 per cent in 1960-61 to 38 per cent in 1970-71 to 47 per cent in 1979-80 (McGuirk and Mundalk, 1991: 34). Around 43 per cent of this increase in consumption was attributed to the rise in installation of tube wells between the two sub-periods (McGuirk and Mundalk, 1991: 34). This phase was also marked by a high degree of mechanisation in agriculture. The total number of tractors in Punjab in the state rose from 169/100,000 hectares of land in 1961 to 2570/100,000 hectares in 1969-70 to 4642/100,000 hectares in 1984-85 to 10756 in 1985-86 (Singh and Kohli, 2005). At present one in every third household in Punjab owns a tractor and a third of the tractors in India are owned by Punjabi farmers (Singh et al, 2016:25). These tractors are run on diesel and have further contributed to high-energy usage in the state (Singh and Kohli, 2005).

These technical reforms were accompanied by high level of institutional support for agriculture in the period following the Green Revolution (McGuirk and Mundlak, 1991:39-40). The Agricultural Price Commission was set up in 1960, which set remunerative prices for agricultural products and provided a guaranteed market for food grain production across India, without relying heavily on market driven demand (McGuirk and Mundlak, 1991:39-40). The Punjab government further augmented support for farmers and set its own prices above those recommended by the Agricultural Price Commission in order to enable farmers to recover the cost of production, rent for leased land and cost of labour (Chadha, 1986:54). There was also expansion of credit for purchase of agricultural inputs, through setting up of agricultural co-operative societies and availability of greater loans to farmers by nationalised banks for purchase of HYV seeds and other farm inputs (Corsi, 2006: 89). Easily available financial credit facilitated rapid expansion in the use of production inputs. Credit was much more easily available in Punjab than any other part of India (Westley, 1986:88). There were a number of other infrastructural reforms in the form of construction of all-weather roads, expansion of power and electricity generation in Punjab and electrification of villages (Chadha, 1986:55; McGuirk and Mundlak, 1991: 34).

6.3.4 Punjab: The Breadbasket of India

These technocratic reforms initially led to tremendous productivity gains in agriculture in Punjab. It became a "symbol of economic prosperity" (McGuirk and Mundlak, 1991: 15). Between 1960-1980 agriculture in Punjab grew at a compound rate of 4.4 per cent annum, which was more than double the growth rate of agriculture in India as a whole, estimated at only 2 per cent per annum (McGuirk and Mundlak, 1991: 15). The average yield of wheat increased by 8.7 per cent between 1968-69 to 1973-74 while the average yield of rice increased by 5.17 per cent during the same period (Gill, 2005: 225). The productivity of major crops was increasing at a rapid pace, while the total cost of production remained stagnant during this period. (Gill, 2005:225-227). This led to massive income gains in the province. In the period immediately following the green revolution (1970-71), Punjab was able to achieve the highest per capita income among all other states of the Indian sub-continent in the early years of the Green Revolution (Singh, 2005). High agricultural growth elevated Punjab to the fastest growing state in the Indian sub-continent (Singh, 2005). By 1970-71 the average per capita income in Punjab was INR 1070 compared to the national average of INR 633 (Singh, 2008: 120).

Between the years 1960-1979, yields of staple food grains, rice and wheat increased by 124 per cent and 175 per cent respectively (McGuirk and Mundlak, 1991: 19). At this time agriculture became the dominant sector of Punjab's economy, contributing to 73 per cent of the net domestic price and employing 63 per cent of the labour force (McGuirk and Mundlak, 1991: 19). Punjab began to contribute to over 50 per cent of the total food grain production in India, earning it the reputation of the breadbasket of India (Kaur, 2010). In the initial years of the Green Revolution, this increase in income manifested itself in the form of increased income among all sections of the Punjabi peasantry (small, medium and large farmers as well as agricultural labour), though unequally (Bhalla and Chadha, 1982 b). Both farm income and agricultural wages began to rise rapidly (Bhalla and Chadha, 1982 b). The Green Revolution period also coincided with a rapid decline in overall levels of poverty of the state (Bhalla and Chadha, 1982b).

Thus, the initial period of green revolution model of agrarian development led to an agrarian transformation in Punjab and brought about overall prosperity to the Punjabi society.

6.4 The Socio-Economic and Ecological Contradictions of Punjab's Development Model

The gains from the Green Revolution model were very short lived and after its initial success, this strategy led to a number of social, economic and ecological contradictions in Punjabi society.

6.4.1 Declining economic returns

The economic returns from the Green Revolution began to dwindle rapidly by the 1980s. The cost of production rose rapidly, while agricultural productivity began to dwindle (Singh, 2016). The dwindling crop productivity during this period has been largely attributed to the deteriorating quality of Punjab's rich alluvial soils due to intensive use of chemical inputs and predominance of a cropping pattern dominated by wheat-paddy rotation (Singh, 2016).

Up to 1971-72 the returns on cultivation were estimated to be 27 per cent. However, by 1978-79 the returns on investment had fallen to less than 2 per cent for the cultivators (Kaur, 2010:43). According to estimates, the annual growth rate of per hectare return on wheat and rice, after accounting for variable costs declined to -2.18 per cent during the 1990s and for cotton the per hectare productivity declined to -14.24 per cent per annum (Ghuman, 2008:12).

As shown in table 6.3 below, the annual yield of all the principal food crops in Punjab-rice, wheat and maize has progressively slowed down over the years

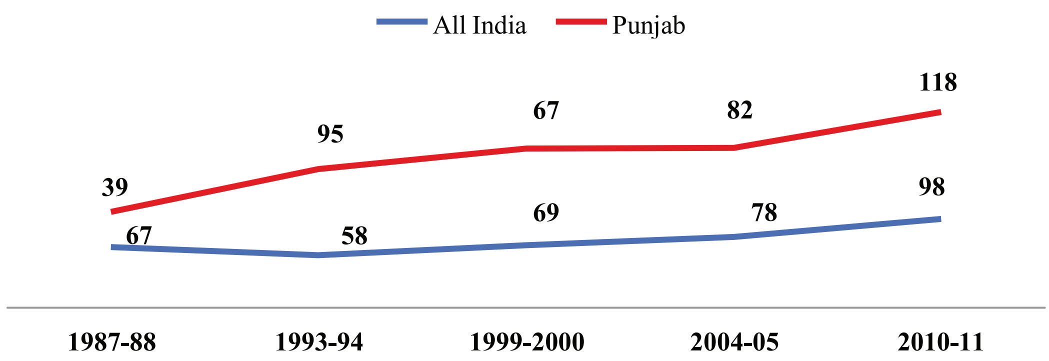
Table 6.3: Average annual growth rate of yield in major crops (percent per annum)

	1960-70	1970-80	1980-90	1990-2000	2000-2010
Rice	2.2	6.95	1.3	1.1	1.77
Maize	5.11	-0.08	1.3	3.1	4.85
Wheat	3.17	2.4	3	0.3	0.19
Cotton	3	0.12	8.6	1.5	2.3
Sugarcane	-1.32	4.31	0.64	0.3	-0.04

Source: Adapted from Singh (2014 a:71)

With declining productivity of agriculture, the increase in rural wages shrank over time. Bhalla (1979) conducted a detailed analysis of agricultural wages in Punjab during the Green Revolution period. Her analysis showed that real agricultural wages in Punjab increased up to the year 1967 and in the following period between1969-1977; real agricultural wages began to decline rapidly. The real rural wages in Punjab have grown very slowly as compared to the real rural wages at the all India level since the 1980s. It is only in the most recent surveys conducted by the National Sample Survey Organisation (NSSO) in the years 2004-05 and 2009-10 that the situation has been reversed (Figure 6.1). The real agricultural wages in Punjab in these years have been estimated to be higher, in comparison to the real agricultural wages at the all India level (Figure 6.1).

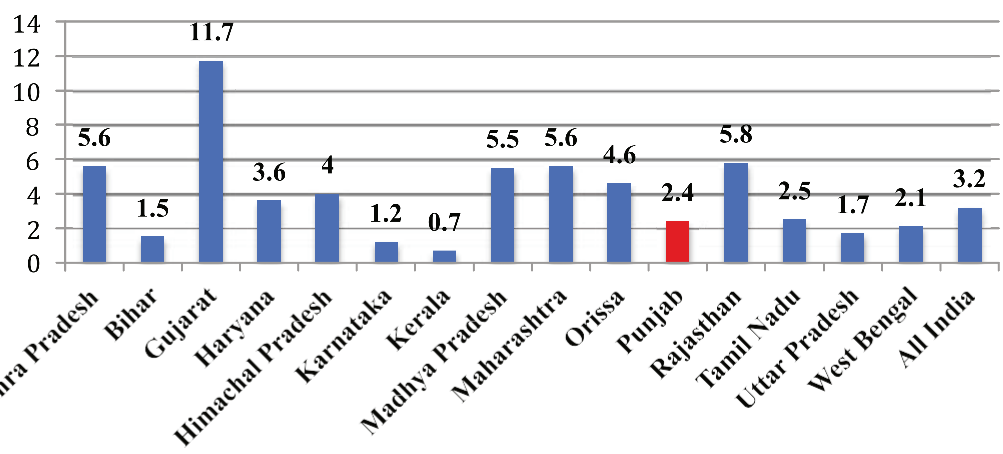
Figure 6.1: Real wage trends in rural areas, All India and Punjab (2004-05 prices)



Source: Adapted from Singh et al, 2016: 25-26

The stagnation of the agricultural sector led to a systematic slowdown in agricultural GSDP (Gross State Domestic Product), especially since early 2000. Between the sub-period 2000-2010 agricultural GSDP in Punjab grew at merely 2.4 per cent per annum in Punjab, as against 3.2 per cent at the all India level. It also lagged behind all other major states of India (Figure 6.2).

Figure 6.2: State wise agricultural GSDP growth rates (2000-2010)



Source: Adapted from Sidhu and Singh (2014)

As agriculture is the main stay of the Punjabi economy, the slowdown in the agrarian sector led to the stagnation of Punjabi economy as a whole (Sidhu and Singh, 2014).

As table 6.4 below shows, in the decades of 1960s Punjab achieved the highest growth rate of per capita state domestic product (SDP) among all other major Indian states at 5.6 per cent. The growth rate of per capita SDP declined to 5.4 per cent in 1970s and further to 3.2 per cent in 1980s and 2 per cent in 1990s before recovering to 4.9 per cent since early 2000s.

Table 6.4: Growth rate of per capita state domestic product among major Indian States

Major States	1960-61 to 1969-70	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-'00	2001-2010
Andhra Pradesh	1.5	3.2	2.6	4.3	5.4
Bihar	0.7	2.8	3	1.4	3.6
Gujarat	5.1	4.5	3.6	3.4	5.7
Haryana	5.5	4.8	4.1	3.5	5.2
Himachal Pradesh	5.6	2.4	4.4	5.2	5.2
Karnataka	3.4	4.3	4	4	4.8
Kerala	3.8	1.7	3	4	5.8
Madhya Pradesh	1.5	1.3	2.7	2.1	2.8
Maharashtra	2.9	5.7	3.6	2.4	5.3
Orissa	0.7	2.3	4	2.1	6.6
Punjab	**5.6**	**5.4**	**3.2**	**2**	**4.9**
Rajasthan	1.3	3	4.4	4.3	3.8
Tamil Nadu	1.5	3.4	4.8	3.9	6.7
Uttar Pradesh	1.6	2.6	3.5	1.3	3.8
West Bengal	2.5	2.9	3	5	5
All India	3	3.6	3.4	3.3	5.9

Source: Adapted from Planning Commission (2015)

Punjab's relative position in terms of per capita income also declined over time, from being the number one state in terms of per capita income in 1970-71 to number eight in 2013-14, among all other major states of India (Table 6.5).

Table 6.5: Comparison of per capita income (current prices) of major Indian States 1970-71 and 2013-14				
Column 1 States	Column 2 1970-71	Colum 3 Rank	Column 4 2013-14	Column 5 Rank
Andhra Pradesh	585	9	74062	9
Bihar	402	14	23497	15
Gujarat	829	3	101525	5
Haryana	877	2	116543	1
Himachal Pradesh	651	6	98141	7
Karnataka	641	7	98812	6
Kerala	594	8	108147	3
Madhya Pradesh	484	12	39296	13
Maharashtra	783	4	108915	2
Orissa	478	13	49908	12
Punjab	**1070**	**1**	**93555**	**8**
Rajasthan	651	6	61175	11
Tamil Nadu	581	10	105568	4
Uttar Pradesh	486	11	33567	14
West Bengal	722	5	68867	10
All India	633			
Source: Column 2 and 3 adapted from Singh (2008:121), column 4 and 5 from Government of Punjab (2015)				

6.4.2 Rising socio-economic inequities and agrarian indebtedness

The Green Revolution exacerbated the existing socio-economic inequities in Punjab. "Capital intensive technological change by its very nature was bound to benefit only the upper strata of peasantry, leading to accentuation of tension in the countryside" (Bhalla and Chadha, 1982a: 826). This model created a "class of gentlemen farmers" with a political and social clout (Singh, 2016 a). These were a class of capitalist farmers who possessed large land landholdings, capital assets and governed over the political institutions-the state legislative assemblies as well as the village councils[42]. They also had access to information, credit and other benefits from the new technologies (Gill, 1988).

On the other hand small and medium farmers found it increasingly difficult to get

[42] A recent study found that 48.2 percent of the members of the legislative assembly in Punjab belong to large land owning families and only 9 percent of the members of the legislative assembly come from landless households (Rani, 2013).

access to fixed and working capital needed to participate in the Green Revolution (Newman, 2007:16). A large proportion of these farmers were forced to resort to borrowings at this time, in order to purchase farm inputs and equipment, leading to widespread indebtedness in the agrarian sector (Singh, 2016). The proportion of outstanding loans in Punjab has been rising systematically over the years. According to an all India survey on rural indebtedness conducted by the National Sample Survey Organisation (2005), the proportion of indebted farmers in Punjab was 65.4 per cent, as compared to only 48.5 per cent at the all India level. The average outstanding loan per farm household is highest (INR 41, 576) in Punjab compared to the all India average (INR 12,585) as well as other major states of India. An intertemporal study on farmer indebtedness in Punjab concluded that debt per household tripled in Punjab in the last decade from INR 52,000 in 1997 to INR 139,000 in 2006 (IDC, 2006). This study concluded that nearly 72 per cent of Punjabi farmers are in debt, while 17 per cent farmers are in a debt trap and cannot even afford to pay the annual interest payments on loans from their given income (IDC, 2006). The average debt to income ratio in Punjab is 3:6, which implies that debt burden is double the annual income (Bharti, 2011:38). Singh et al (2016) conducted an in depth analysis on indebtedness in rural Punjab. Their estimates revealed that there is an inverse relationship between per hectare indebtedness and the size of land holdings in Punjab, showing that the highest proportion of debt is borne by small and medium farmers in the state. A recent study, based on All India debt and indebtedness survey has shown that the debt to income ratio of an average sized farm[43] in Punjab is 1.49; while the debt to income ratio of a small farm household is 1.57, and the debt to income ratio of a marginal farm household is 2.47 (Singh, 2018).

The largest sources of debt comprised of non-institutional lenders[44], who are highly exploitative towards farmers (Singh et al, 2016). They not only charge higher rate of interest, but also charge differential interest rates from different group of farmers. Small farmers are charged higher interest rates, as compared to large farmers (Singh

[43] The author has categorized a household with 5-10 hectares as an average farm household. A household with up to 5 hectares is categorized as a small farm household, and a household with 1-2 hectares of land is categorized as a marginal farm household (Singh, 2018).

[44] Non-institutional lenders or commission agents own 50 per cent of total agrarian debt in Punjab. They charge extravagant rate of interest at 24-36 per cent per annum (Singh, 2000:1891).

et al, 2016: 51). There is also a growing incidence of interlinking the financing with input, consumption goods and output markets. These lending practices are counter-intuitive and are leading to growing debt burden on farmers on one hand and reduction of farm surpluses on the other hand (Singh et al, 2016:51).

Due to falling agricultural productivity and rising indebtedness, one-third of small farmers (with an average landholdings of less than 5 hectares) and one-fourth of medium farmers, with an average land holdings (between 4 to 10 hectares) were plunged into poverty during the 1970s (Bhalla and Chadha, 1982b: 875). By the 1980s these small and marginal farmers were increasingly unable to meet their basic household consumption needs on farming income as they suffered from severe diseconomies of scale (Bhalla, 1983:60). "The mechanization process that has started taking place at a massive place in Punjab has reduced the scale neutrality of technology and small and marginal farms started turning non-viable" (Singh et al, 2016:43).

A large number of small and medium farmers found it increasingly difficult to perform farming operations and began to lease out their land to large holders who had the necessary resources and linkages for modern farming/agri-business[45] (Singh, 2012:51). As table 6.6, shows that between 1970-71 to 2010-11, the proportion of marginal and smallholdings in the state has declined from 56.54 per cent to 30.2 per cent, while the proportion of large farmers increased from 5 per cent in 1970-71 to 8.65 per cent in 2010-11. Small and marginal land holdings in the state fell by 200,000 since early 1990s as a majority of small and marginal farmers quit farming due to low incomes and small size of landholdings (Singh, 2012:51). This process triggered a dual process of "pauperization and proletarianisation" for a large proportion of small and marginal farmers in Punjab, who lost agriculture as their chief source of livelihood and had no other alternative sources of employment (Newman, 2007:14). This is evident from the fact that by the 1980s the proportion of the cultivators declined by 2.7 per cent, while the proportion of agricultural labour increased by 2.2 per cent at this time, relative to the 1970s (Singh, 2000:1889).

[45] "Reverse Tenancy" is a peculiar feature of Punjab's economy. While, landholdings are getting fragmented in other parts of India, in Punjab there is increasing concentration of land among a few big farmers. Between 2000-2010, 128000 farmers leased out their land to large farmers, while 72000 farmers sold their land to large land holders and opted out of farming (Singh, 2012:51).

Table 6.6: Distribution of Average Land Holdings in Punjab: 1970-71 to 2010-11							
Farm Category	1970-71	1980-81	1990-91	1995-96	2000-01	2005-06	2010-11
Marginal and Small (1-2 hectares)	56.54	38.62	44.73	35.43	29.7	31.64	30.2
Semi-Medium (2-4 hectares)	20.44	27.99	25.85	29.31	32.9	31.85	30.89
Medium (4-10 hectares)	18.02	26.2	23.41	27.98	30.2	29.45	28.33
Large (10 hectares)	5	7.19	6.01	7.28	7.2	7.06	8.65
Source: Adapted from Government of Punjab (2012)							

This model thus exacerbated income inequities in the state, by directly relating the gains from mechanised agriculture with the initial size of landholdings and "making profits exclusively dependent on the employment of costly farm inputs" (Kaur, 2010:41). It has been estimated that the share of large farmers in total income of Punjab has risen to 56 per cent, while the share of agricultural labour and small farmers has fallen to merely 10.5 per cent (Bharti, 2011:36).

These rising inequities are also reflected by the Monthly Per Capita Consumption Expenditure data (MPCE)[46], collected through subsequent rounds of household consumption expenditure survey of the National Sample Survey Organization (NSSO).

Table 6.6a: MPCE by size of landholdings in Punjab			
1993-94			
	Landless	>10 hectares land	Gap
Punjab	400	556	156
All India	383	410	27
2011-12			
Punjab	3272	4608	1336
All India	2827	3374	547
Source: NSSO 1993-94 and 2011-12			

46 MPCE is used in India by government agencies like NSSO as an indicator of the economic status of the household.

Table 6.6a reveals that there are stark inequalities in consumption expenditure between landless (agricultural labour) households and large land-owing households (those households with more than 10 hectares land). The difference in MPCE between these two groups has widened from Rs 156 (27)[47] in 1993-94 to Rs 1336 (547) in 2011-12. NSSO Household Consumption Expenditure data also reveals that the income of all labour households (i.e. agricultural and non-agricultural labour households combined) in rural Punjab increased by 3.9 times between the years 1993-94 and 2011-12, while the overall income of the land owning households in rural Punjab increased by more than 5 times during this period (NSSO, 1993-94 and 2011-12). Thus, one can conclude that the Green Revolution model reinforced the existing class and income inequities in Punjabi society. The marginalized groups have been made worse off over the years.

A tragic ramification of increasing agrarian distress, rising inequities and indebtedness has been the rising incidence of farmer suicides in Punjab (IDC, 2006:23). According to a state level study by the Punjab Agricultural University, 2890 farmers committed suicides between the years 2000-2008 (Punjab Agricultural University, 2009). Movement against State Repression (MASR), an NGO working in Southern Punjab, since the late 1980s estimated that there have been a total of 1798 farmer suicides in Southern Punjab in the two decades between 1988-2008 (Sidhu and Jaijee, 2011: 171-72). A census survey conducted in the two most suicide affected districts of Punjab in 2011 revealed that these suicides have a direct relation with the economic position of farmers. This survey revealed that 1757 farmers had committed suicide in the region between 2000-2011. Out of these 79 per cent were small farmers, while 44 per cent were marginal farmers. Out of the 1757 affected families, 1288 (73.3 per cent) listed indebtedness as the principal cause of suicide (Bharti, 2011).

Green Revolution heightened consumerism and worsened the existing social and gender inequities in Punjabi society. Rich farmers in the state began to spend their increased income on luxury goods, expensive cars and large houses, while only ploughing back a fraction of the increased capital in the form of investment in

[47] The figures in brackets indicate all India averages.

agriculture (Bhalla, 1983:160). On the other hand the small and marginal farmers found it increasingly difficult to fulfil even their basic needs (Bhalla, 1983:162). The Green Revolution also exacerbated the existing gendered vulnerabilities in Punjab. On one hand, increased consumerism propagated the custom of dowry in Punjabi society (Kaur, 2010:43). On the other hand, new technology replaced the traditional labour that women contributed to in agriculture. With increased incomes, large land holding families began to confine women to the household, as a sign of their improved social standing (Kaur, 2010:44). This is evident from the fact that by the 1980s the unemployment levels among rural women in Punjab was 7.4 per cent, while in the nation as a whole the level of unemployment among rural women stood at only 3.5 per cent[48] (Singh, 2000:1890).

The Green Revolution also exacerbated the existing caste inequities in the region and deprivation among vulnerable groups like scheduled castes (SC). Punjab has the highest proportion of Scheduled Caste (SC) communities. They constitute 28 per cent of Punjab's population at present (Census of India, 2011). However, their ownership of agricultural land is the lowest in the country (Jodhka, 2007). Over 77 per cent of the SC population in rural areas is employed as casual labour in the agricultural sector (Sood et al, 2014). Poverty in Punjab is concentrated disproportionately among the SC population in both rural and urban areas. On the basis of estimates of monthly per capita consumption expenditure (MPCE), 27.2 per cent of the SC population in rural areas and 35.3 per cent of the population in urban areas in Punjab are estimated to be below the poverty line, as compared to only 1.5 per cent of the general population in rural areas and 7.1 per cent of the population in urban areas (Table 6.7). They also continue to lag behind other communities in terms of indicators of health, education and social development (Sood, 2014).

Table 6.7: Rural and urban poverty by social groups in Punjab, 2012-13

Social Group	Rural	Urban
Scheduled Caste	27.2	35.3
Other Backward Caste	11.4	24.7

48 Calculations have been made by the author on the basis of NSSO Employment/Unemployment Data (1979-80).

General	1.5	7.1
Punjab	14.6	18.1
Source: (Sood, 2014)		

Table 6.7a: MPCE by social groups in Punjab, 1993-94 and 2011-12			
1993-94			
	SC	Average of all other groups	Gap
Punjab	365	455	80
All India	257	325	68
2011-12			
Punjab	1710	2356	646
All India	1291	1627	336
Source: NSSO 1993-94 and 2011-12			

The inequities between SCs and other groups are also reflected through the trends in MPCE (Table 6.7a). In 1993-94, the gap between the MPCE of SC households and non SC households was Rs 80 (68)[49] less as compared to the general category of households. By 2011-12 the gap between the MPCE of SC households and non-SC households had widened to Rs 646 (336). The table reveals that consumption inequalities between SC households and others are very stark and have worsened in the last decade. The consumption inequalities between SC households and non-SC households are higher in Punjab as compared to the consumption inequalities between SC households and non-SC households at the national level.

6.4.3 Ecological ramifications of the green revolution model

Over time, the Green Revolution model led to irreversible damage to Punjab's natural environment. According to the Environmental Sustainability Index[50], Punjab ranks among the states with the lowest levels of sustainability. This reflects the state's deteriorating quality of the environment, high level of pollution and vulnerability to environmental catastrophes (Centre for Development Finance, 2011).

[49] The figures in brackets indicates all India averages.

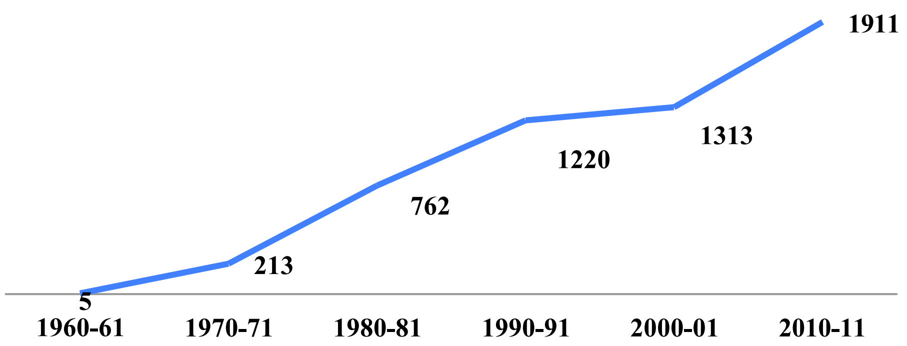
[50] Environmental Sustainability Index (ESI) is a relative measure of sustainability that ranks Indian states according to the pressure they face in managing their natural resources. Higher, the ESI value for a state, lesser the ecological challenges it faces (Centre for Development Finance 2011: 12).

This model wrecked the genetic diversity of Punjab's agriculture. Diversity in indigenous agriculture, based on cultivation of wheat, maize, millets, pulses and oil seeds was replaced with a mono-cropping pattern based on wheat and rice cultivation (Table 6.2). Wheat and rice cultivation now accounts for 90 per cent of the total cropped area in the state, where as the area under all other crops has been reduced to less than 10 per cent (Mann, 2017). These wheat and rice varieties come from a very narrow genetic base as compared to the high genetic variability in traditional wheat and rice varieties (Parayil, 1992:747). These HYV seeds are highly susceptible to disease (Parayil, 1992:747). They also require massive amounts of fertilisers, in the form of a "nitrogen steroid" to enable plants to grow as large and as quickly as possible (Parayil, 1992:747)

In Punjab, fertiliser use increased 304 times between 1960-61 to 2010-11[51] (as shown in figure 6.3 below). The average fertiliser consumption in Punjab is 235 kg/hectare, which is 1.84 times the all India level of 128 kg/hectare (GOP, 2014b). The extensive application of these fertilisers has increased soil toxicity on one hand and made Punjabi soils deficient in essential nutrients such as zinc, magnesium and phosphorus on the other hand (Ghuman and Ramona, 2010). Increased use of NPK fertilisers has also polluted water bodies in the province. Fertiliser residues have been found in surface and ground water bodies in the state (GOP, 2014b).

[51] The recommended level of NPK (Nitrogen Phosphorus Potassium) ratio stands at 4:2:1 (TERI, 2015:5). In Punjab NPK consumption ratio in 1990s was drastically high at 58:22:1(TERI, 2015:5). It has been subsequently brought down and in 2014-15 the NPK consumption ratio was estimated to be 36:9:1 (Mann, 2017:32).

Figure 6.3: Fertiliser use in Punjab (In '000 nutrient tonnes), 2013-14



Source: Adapted from TERI (2015:5)

Pesticide use in Punjab is 923 gram/hectare, compared to the national average of 381 gram/hectare (GOP, 2014 b). "Pesticide retailing is a free for all trade" (Singh and Aggarwal, 2010:192-194). There is no formal training given to farmers on pesticide use, storage, health and safety guidelines as well as the recommended level of fertilisers. As a result many farmers end up using higher than the recommended levels of fertilisers (Singh and Aggarwal, 2010:192-194).

High levels of pesticide use in Punjab have led to serious health issues. Farmers in the province have reported health concerns such as eye irritation, skin problems, difficulty in breathing, dizziness and presence of persistent organic pollutants (POPs) in their blood samples (Singh and Aggarwal, 2010:195). Since the late 1990s, there has been an alarming increase in the incidents of cancer in Punjab (Singh et al, 2014). The Malwa region of Punjab, which accounts for 75 per cent of the total pesticide use in the state, has won the dubious distinction of being "the cancer belt of Punjab." There has been a ten-fold increase in the number of cancer cases in this region between 1990-2005 (Mittal et. al, 2010: 366). Direct exposure to pesticides has been associated with increasing incidents of brain, blood, throat and liver cancers, while indirect exposure to pesticides has been linked with increased incident of breast, uterus and food pipe related cancers, especially among women (Singh and Aggarwal, 2010). According to the estimates of the Directorate of Health and Family Welfare, Punjab the prevalence of cancer in Punjab is 1089/100,000 population as compared to 881/100,000 at the national level (Department of Health and Family Welfare, 2010).

Another adverse consequence of the mono cropping pattern of cultivation and excessive fertiliser use was depletion of micronutrients in the top soils in Punjab (Newman, 2007:18). One of the watermarks of the Green Revolution technology was the "pumping of NPK fertilisers into the soils, as a nitrogen steroid to make them as large, as quickly as possible" (Newman, 2007:18). Though, the use of these chemical fertilisers initially help to increase productivity, in the long- run it "de-fertilizes" soils as plants began to absorb micronutrients from the soils (Newman, 2007:18-19; Paul and Steinbrecher, 2003:8-9).

In Punjab, the prolonged use of fertilisers has created a soil nutrients imbalance in 70 per cent of the total geographical area in the state (TERI, 2015:5). The decline in soil fertility, in turn led to decreased productivity of major crops such as wheat, rice and maize (Singh, 2014:69).

The Green Revolution model also intensified the water crisis in the state (Ghuman, 2017). Punjab traditionally had a well-developed system of canal irrigation. However, these canals were insufficient to fulfil the high water demands of the Green Revolution technologies (Gill, 2016). With the introduction of water-intensive crops such as rice, wheat and sugarcane, there was a growing mismatch between the demand and supply of water, as HYV seeds require three-four times more water than traditional varieties (Gill, 2016:39; Newman, 2007:21). The Human Development Report of the Punjab government stated in this context, "This cropping pattern, based on wheat and rice rotation has increased the demand for water for irrigation to such an extent that it simply cannot be met in the years to come" (GOP, 2004: 41). According to the estimates provided by the Punjab Agricultural University, the current demand for water for irrigation purposes is estimated to be 95 MAF (Million Acre Feet) while the supply is only 34.8 MAF (Gill, 2016:37-39).

The water use efficiency of the canal network is very poor. The "canal network is inefficient due to heavy stilting, erosion of banks and embankments" (GOP, 2014b: 63). This is due to the fact that canals, which carry water from the fields and their distributaries are not cleaned regularly, resulting in damage to the crops by flooding of fields. A lot of water is wasted in this process and the tail end farmers often do not get the requisite amount of water from the fields.” (Gill, 2016:41).

According to the estimates of the Planning Commission (2015:185) “The overall water use efficiency of canals in Punjab is only 33 per cent, as against the overall efficiency of 52 per cent at the All India level. Some ground reports have revealed that there has been no repair and maintenance of the canal system, since 1992, when technically it should happen every two years. As a result cracks have surfaced and cement has fallen off at many places (Sidhu and Jaijee, 2011:92).

To fulfil the high irrigation requirements, there was extensive development of groundwater resources in Punjab (Ghuman, 2017). In the Green Revolution decades of 1960s and 1970s, the use of wells for irrigation purposes increased by 80 per cent (Ghuman, 2017). Today, there are 28 tube wells per square kilometre of net sown area in Punjab, which fulfil 75 per cent of Punjab’s irrigation needs (Newman, 2007: 21). Since 1990 farmers are provided electricity free of charge and encouraged to construct tube wells (Gill, 2016:39). With the advent of this policy, there was a 65 per cent increase in the total number of tube wells in the state between 1990-91 to 2010- 11 (Gill, 2016: 39). As a result of this ground water resources in the state have become seriously overexploited.

Another major factor, which has contributed to the severe groundwater depletion in Punjab is attributed to the ten time increase in area under rice cultivation (a water intensive crop) during the decades of 1966-2015 (Singh and Singh, 2017 a). In a recent study, Singh and Mann (2017) compared the total quantity of water available in Punjab from all major sources to the total quantity of water required for rice cultivation in the state and concluded that there is an aggregate deficit in water available for rice cultivation in Punjab, which is likely to worsen in the coming years. Their study also revealed that rice cultivation alone takes up 50 per cent of the ground water available in the state (Singh and Mann, 2017).

The stage of groundwater development in Punjab is 170 per cent (Kulkarni and Shah, 2013:66). It tops the list of Indian states, facing the risk of dangerous exploitation of groundwater resources (Kulkarni and Shah, 2013:66). Scientists at the Punjab Agricultural University (PAU) published a report in 2004 stating that the water table in Punjab is retreating by 2 metres annually. The report warned that in subsequent years water table may go down to such an extent that lifting water to the surface would require heavy capital investment in the form of high power electric motors or submersible pumps (The Tribune, 2004). Another aspect of Punjab's water crisis is that the ground water availability for future irrigation use in the state is now negative and estimated at (-)14.83 billion cubic metre (Singh and Singh, 2017 a).

Out of the 138 administrative blocks in Punjab, 110 are overexploited, 11 are critical while 13 are semi-critical and only 25 blocks are safe zones (Sidhu and Jaijee, 2011:90; TERI, 2015). These safe zones ironically comprise of those areas where the sub-soil water is unfit both for drinking and irrigation purposes (Sidhu and Jaijee, 2011:90). At the other end of the spectrum, south- west Punjab has emerged as a "white zone." In this zone, intensive canal irrigation has water logged large stretches of cultivable agricultural land. This has in turn lead to "salt poisoning"[52]

Thus, from the above sections one may conclude that the Green Revolution model brought about multiple ecological, social and economic crises in Punjab. Over the years, these dangerous trends became embedded in the agriculture and ecology of Punjab. This model treated both humans and natural resources as mere inputs in the production process. However, continuous application of laboratory created seeds, pesticides and fertilisers and intensive irrigation destroyed the very natural conditions, which made Punjab an epitome of agricultural growth and the most favoured site for the Green Revolution model.

These crises have today manifested in the form of the falling water table, diseased and dying soils, mounting irrigation costs, increased economic inequality, falling agricultural productivity, rising farm debt, failing health of the population and farmer's suicides. The Green Revolution model has not only destroyed the

[52] "Salt poisoning" refers to a process, through which salt is leeched into the rising water table and then into the sub-soils. This process permanently erodes the fertility of top soils and its ability to effectively grow crops. In addition, the fertilisers and pesticides, which had sunk into the aquifers are drawn back up into ground level drinking water. This represents a great hazard to human health and drinking water (Newman, 2007: 22).

ecological and social fabric of the state, but also resulted in stagnation of agricultural productivity and declining economic growth in the region. Today the crisis has reached such a level that this intensive agricultural model threatens not only the quality and possibility of future harvests in Punjab, but also threatens the health and dignity of a great many of its citizens (Newman, 2007:25).

6.5 Continued "Ruralisation" of the Punjabi Economy

The previous section highlighted how the Green Revolution model of technologically enhanced agricultural development played havoc on the Punjabi economy over the years. The second element of the crisis in Punjab comprises of the continued "ruralisation" of the Punjabi economy. This thesis was proposed by Singh (2008) in his seminal research on the economy of Punjab. He analysed the political economy of Punjab from a historic prism. His analysis shows that since the colonial times, Punjab has been developed primarily as a rural based politico-economy. Industrial and urban development in the province was highly constrained. This pattern of development continued in the post-independent era as well. Both the colonial government and the Indian national government imposed their own development agenda on Punjab, without considering its economic priorities, stage of development and resource endowments. These historic developments have led to the continued "ruralisation" of the Punjab economy and a lopsided development pattern, with a developed agricultural sector and a backward industrial sector (Singh, 1994 and Singh 2008).

Due to the colonial government's policy of developing Punjab as primarily an agrarian province, it remained an industrially backward region at the time of independence and mostly comprised of small-scale cottage industries (Singh, 2008:137). The partition of India in 1947 further disrupted this limited industrial set up and most of the existing factories, small and cottage industries closed down. The banking facilities were disrupted and there was little financial capital available for industrial development (Singh, 2008:138). In the post-independent era, the central government further reinforced this agenda of agrarian oriented development and initiated the Green Revolution model, with a singular focus on the development of the agricultural sector (Singh, 2008:138). This model was motivated with a twopronged agenda of achieving food self-sufficiency at the national level and achieving balanced regional development in the Indian sub-continent. However, these two objectives had very conflicting implications for the Punjabi economy. The pursuance of goal of food self-sufficiency helped Punjab to achieve tremendous gains in food output and become a "model state for agricultural development" (Singh, 2017a). However, the goal of balanced regional development strategy at the national level meant that since Punjab was achieving more resources for agricultural development, the central government funds for industrial development began to be channelled to other states under the central government's politico-economic strategy of reducing regional income inequalities (Singh, 2008:138). The proportion of public sector investment in industries in Punjab remained very low and stagnated over the years, (Singh, 2008:139).

In the early years of the initiation of Green Revolution, in 1960s and 1970s, Punjab was able to achieve high levels of economic growth and per capita income and became one of the fastest growing states in the Indian sub-continent due to its impressive performance in the agricultural sector (elaborated in section 6.3.4). However, due to the development agenda imposed by the central government, it remained locked in a "rural development trajectory" and was not able to make the transition from a traditional rural economy, to a modern industrial urban economy, as suggested by traditional Economics literature (Kuznets, 1966)[53]. With the ushering in of the Green Revolution, Punjabi economy was able to produce the desired levels of savings and create work force surpluses; however the economy was not able to transition from agriculture to industry and gained very little in terms of industrial development (Singh et al, 2016:33).

Under the federal structure of India, the central government plays an "all-encompassing role in industrial development and the role of the state government in the field of industry is extremely limited" (Singh, 2008: 132-33). Due to Punjab's favourable position in the agricultural sector, it attracted very low levels of public sector investment in industry. In developing economies public sector investment

[53] An economy transitions from a traditional rural economy to a modern industrial economy at a mature stage of economic development. This transition entails the transfer of surplus from agricultural sector to the industrial sector, in terms of both savings and workforce (Kuznets, 1966)

plays a crucial role in developing the necessary pre-conditions for attracting private capital subsequently (Singh, 2008:132). In Punjab, since these pre-conditions for developing a modern industrial sector remained lacking, it was unable to attract private capital in subsequent years and remained primarily a rural based economy (Singh, 2008: 132-33).

Table 6.8 reveals that this lopsided pattern of development in Punjab continues even today. A comparison of the sectoral composition of the Net Domestic Product (NDP) at the all India level and the Net State Domestic Product of Punjab shows that between 1960-61 and 2013-14, the Indian economy as a whole has made an impressive structural transformation in the last four decade. The share of the agricultural sector in the NDP has been drastically reduced from 42.6 per cent (1960-61) to 17.5 per cent (2011-12). For India, the share of the industrial sector has risen from 19.9 per cent (1960-61) to 28.7 per cent (2011-12), while the share of service sector has risen from 38.3 per cent (1960-61) to 53.9 per cent (2011-12). On the other hand in Punjab, the structural transformation is much less impressive, as agriculture continues to contribute more than 30 per cent of the Punjab's economy. The share of industrial sector in Punjab's NSDP is 25.6 per cent (broadly comparable to the all India level of 28.7 per cent). However, while the industrial sector at the all India level comprises of large manufacturing concerns, in Punjab it remains dominated by cottage and small-scale industries (Singh (2008:148; Singh et al, 2016:45) In Punjab the service sector contributes to merely 41.4 per cent of the NSDP (as compared to 53.9 per cent) at the all India level.

Table 6.8: Sectoral composition of NDP, India and NSDP, Punjab (at current prices)			
	All India		
	Agriculture	Industry	Services
1960-61	42.6	19.9	38.3
1970-71	47.8	19.7	32.4
1980-81	41.3	23	35.7
1990-91	35.3	25.2	39.5
2000-01	21.1	27.9	53.7
2013-12	17.5	28.7	53.9
	Punjab		

	Agriculture	Industry	Services
1960-61	54	15.6	30.4
1970-71	60.3	13.4	26.3
1980-81	49.5	18.5	32
1990-91	44	23.8	32.2
2000-01	32.9	23	40.2
2011-12	30.6	25.6	41.4
Source: Adapted from Singh et al, 2016: 45-46			

Thus, while the Indian economy as a whole, made an impressive transition away from the agricultural sector, Punjab remains locked in an agriculturally oriented development trajectory, even after the gains from this development model have been exhausted. Since the industrial and service sector in Punjab failed to take off, more than one- third of the Punjabi population continues to rely on this unsustainable agricultural model as its sole source of livelihood (Sood, 2014).

6.6 Structural Adjustment Programme (SAP) in India and Punjabi Economy

The continued "ruralisation" of the Punjabi economy had very grave consequences for Punjab, with the launching of the Structural Adjustment Programme (SAP) in the Indian economy in 1991 (Singh, 2017). This strategy was essentially rooted in a radical overhaul of the Indian economy through reduced role for the state and rapid industrialisation and urbanisation in order to bring about a rapid increase in gross domestic product of the Indian economy (Ahluwalia, 2002). The SAP brought about policy changes in several major areas of the Indian economy: industry and trade, agriculture, infrastructure, finance, privatisation and social sector reforms (Ahluwalia, 2002). The salient features of the SAP in India are summarised in Table 6.9 below:

Table 6.9: Salient features of SAP in India	
Industrial Policy	• List of industries reserved for public sector was reduced from 18 to 3 • Industrial licensing was abolished for all, except a few hazardous and environmentally unsafe industries. • List of industries reserved

	for the small- scale industry was drastically cut down. • Investment ceiling on small-scale industries was raised to \$10 million. • Limits on production capacity of industries abolished.
Trade Policy	• Import licensing was abolished on capital and intermediate goods. • Switch to flexible exchange rate regime. • Progressive reduction in tariff protection, import duty and import of foreign technology. • Equity limit on foreign direct investment was raised from 49 per cent to 100 per cent.
Privatisation	• Progressive disinvestment in public sector enterprises.
Fiscal Policy	• Imposition of greater fiscal discipline by both the central and state governments. • Cut down on fertilisers and food subsidies • Rationalisation of custom and excise duties. • Income and Corporate tax cuts.
Financial Sector Reforms	• Dismantling of control on interest rates. • Reduction in statutory liquidity ratio • Reduction of statutory investments to invest in government securities. • Reducing requirement to invest in priority sectors of the economy. • Progressive disinvestment of commercial banks in rural credit.
Source: Own compilation based on Ahluwalia (2002); Singh, (2005) and Singh (2008)	

These measures have a profound impact on the economy of Punjab. Punjab's economic position in terms of growth rate of GDP per capita Punjab's position has deteriorated to the bottom among all other major Indian states, according to the latest data (Table 6.10)

Table 6.10: Ranking of major states on the basis of growth rate of per capita income (PCI), 2014-15		
State	**Growth Rate of PCI (%)**	**Ranking**
Andhra Pradesh	7.9	3
Bihar	5.6	12
Gujarat	7.7	5
Haryana	8	2
Himachal Pradesh	7.5	6
Karnataka	7.8	4
Kerala	6.7	8
Madhya Pradesh	6.8	7
Maharashtra	5.8	11
Orissa	6.2	9
Punjab	4.9	13
Rajasthan	6.1	10
Tamil Nadu	8.7	1
Uttar Pradesh	6.2	9
West Bengal	N/A	
Source: Adapted from Singh et al 2016: 22		

This deceleration of Punjab's economy in the post reform period is attributed to two main reasons. Firstly, in the post liberalisation period, there was a decreasing importance of agriculture in India's economy (Singh, 2017a and Singh, 2008). The priority attached to achieving food self-sufficiency in the Indian sub-continent was downgraded in the post-reform period (Krishnaswamy, 1994:A66). After the liberalisation regime, there was systematic withdrawal of public sector investment in agriculture by the Government of India at the centre. The minimum support price on agricultural goods was frozen. The gross fixed capital formation of the public sector in agriculture declined from 21.74 per cent in 1980s to 11.91 per cent in 2000-01 to 7.85 per cent in 2010- 11 (Singh et al, 2016:35). These factors made agriculture an increasingly unprofitable source of income, especially for small and marginal farmers in the region (Singh et al, 2016:35). The agricultural sector grew at a very low rate of 1.9 per cent per annum in the period following the reforms, growth rate of the agricultural sector declined further to 1.6 per cent per annum during the second sub-period 2001-2012 (Singh et al, 2016:39). As this sector contributes to over 30 per cent of Punjab's economy and employs more than 39 per cent of the workforce, the decline in this sector, led to the overall deceleration of the Punjabi economy (Singh et al, 2016:39).

As for the industrial sector, the SAP in 1991 progressively reduced the protection accorded to small-scale industry and led to increased competition in this industry (Singh, 2014). The opening up of the economy through reduction on imports and tariff duties further increased competition for small-scale industry (Singh, 2014). This put substantial pressure on the small-scale industry in Punjab (Singh, 2014). Singh (2005) conducted a systematic analysis of the trend growth rate of the Indian economy in the pre and the post reform period. His analysis shows that in the pre-reform period (1970s and 1980s) the growth rate of the manufacturing sector in Punjab was 9.32 per cent per annum, while in the post reform period it decelerated to 5.74 per cent per annum. His analysis also showed that in post-reform period, there was a decline in all the major indicators of industrial development i.e. net value added, fixed capital, value of output and share of emoluments. This stagnation of the industrial sector in Punjab can be gauged from table 6.11 below which shows that in the post liberalisation period, the investment-GDP ratio in Punjab has been declining rapidly and there is a growing gap between the investment-GDP ratio in Punjab and at the all India level. Presently the Investment-GDP ratio in Punjab is two and a half times less than the all India level. According to an in depth study by Singh (2010b) on the pattern of foreign direct investment in India, Punjab remained a low priority state in terms of attracting foreign direct investment throughout the period 1991-2004. The latest data on foreign direct investment in Indian states reiterates this trend. Table 6.12 below shows the data on cumulative FDI flows in regional headquarters of the Reserve Bank India (RBI). Chandigarh, which represents the headquarters of the three north Indian provinces of Punjab, Haryana and Himachal Pradesh could attract only 0.2 per cent of the cumulative FDI flows into India as a whole between the sub-period 2000-2016.

Table 6.11: Comparison of investment-GDP Ratio, Punjab and All India, 2014-15

	Investment-GDP ratio	Investment-GDP ratio	Gap
	India	Punjab	India-

			Punjab
1980-81	15.2	15.6	-0.4
1990-91	27.1	23.1	4
1999-00	25.9	16.9	9
2010-11	38.2	15.1	23.1
Source: Government of Punjab, 2015			

Table 6.12: Cumulative FDI flows, Indian States, 2000-2016

RBI Headquarters	States Represented	Cumulative Flows (2000-2016)	% Inflows
Mumbai	Maharashtra, Dadra and	4,15,753	29%
	Nagar Haveli		
New Delhi	Delhi	3,32,312	22%
Chennai	Tamil Nadu, Pondicherry	1,18,547	7%
Banglore	Karnataka	1,08,912	7%
Ahmdabad	Gujarat	68,464	5%
Hyderabad	Andhra Pradesh	59,556	4%
Kolkata	West Bengal, Sikkim	20,847	1%
Chandigarh	Chandigarh, Himachal Pradesh, Haryana, Punjab	6,538	0.50%
Jaipur	Rajasthan	7,126	0.50%
Source: Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, GOI (2015-16) (Available online at http://dipp.nic.in/English/Publications/FDI_Statistics/2016/FDI_FactSheet_April_Sep_2016.pdf) [Accessed on 12/6/2017].			

Another major factor contributing to the worsening state of the economy of Punjab, post the implementation of the NEP (New Economic Policy) was the deteriorating fiscal health of the state. The fiscal deficit in Punjab had been highest among the fifteen major states of India, throughout the 1980s (Singh, 2010 b). This fiscal deficit was financed through borrowings from the central government. With these increased borrowings, public debt mounted over the years and a substantial portion of the total tax revenue of the state began to go towards interest payments to the central government. According to the estimates made by Singh (2010b) due to high debt burden of the state government, the development expenditure, as a percentage of NSDP declined from 10.9 per cent to 8.4 per cent between 1990-95 and 2000-2008, while the non-development expenditure increased from 5.9 per cent to 9.8 per cent during the same time period. Out of the total development expenditure in the state, social sector expenditure as a percentage of total state expenditure has remained consistently low over the years and has manifested itself in the form of poor health, education and nutritional outcomes in the state, as well as glaring caste and socio-economic inequities (Table 6.13).

Table 6.13: Social sector expenditure as a % of total expenditure

	1993-94	2004-05	2013-14
Andhra Pradesh	37.2	29.3	35.6
Bihar	38.3	30.5	41.8
Gujarat	33.8	29	38.4
Haryana	26.4	24.2	41
Karnataka	37.9	33.4	39.6
Kerala	41	35.6	34.9
Madhya Pradesh	39.5	32.5	39
Maharashtra	38.8	24.7	39
Orissa	39.2	28.9	41
Punjab	**25.6**	**19.8**	**22.7**
Rajasthan	37.7	35.7	40.2
Tamil Nadu	40.3	37	40.2
West Bengal	41.3	34.1	41.9
All India	37.3	35.1	39

Source: Own Calculations based on state reports of Reserve Bank of India (RBI 1993-94, 2004-05 and 2013-14)

Thus, from this section one can conclude that in the post reform period Punjabi economy suffered from a number of setbacks. The Green Revolution model, which had been the main stay of Punjab's economy proved to be unsustainable from the angles of socio-economic and ecological sustainability by the 1990s. On top of this, there was decreasing importance of agriculture and small-scale industries in the nationalist development discourse. Both of these i.e. agriculture and small-scale industry formed the life-blood of Punjab's economy. The central government policies eroded the Punjabi economy of its wealth, led to mounting debt burden on the state government and squeezed its ability to invest for development purposes and human capital formation. These factors have in turn hampered Punjab's capacity to revive its income and growth and trapped the economy in a vicious cycle of low economic growth and poor human development.

6.7 Reorientation of Punjab's Development Strategy and Initiation of Green Capitalist Reforms

By the beginning of the 21st century it was increasingly felt that the current development model in Punjab is unsustainable from the lens of economic, social as well as ecological sustainability. The structural transformation of the Indian economy and decreasing importance of agriculture in India's national economy further put the Punjabi economy into crisis. As a result of these developments, the policymakers in Punjab are now moving towards a green growth trajectory. This is to some extent in consonance with the changes taking places in the global capitalist economy and the reorientation of the capitalist countries towards "green capitalism." Many global institutions such as OECD, World Bank and UN have welcomed a green growth platform, especially in developing countries. It is believed that such a development platform represents a win-win situation for developing nations as it will help to achieve higher economic growth, along with reduced carbon emissions and pollution, enhance energy security and resource efficiency and prevent loss of biodiversity (Babier, 2016).

In Punjab, the green growth platform is focused on three key areas viz. sustainable agriculture, energy efficiency and water conservation (TERI, 2015). Since Punjab remains primarily an agrarian economy, it is believed that radical policy changes in agriculture and a move towards a sustainable agriculture pathway will be a key pathway to achieving sustainable development in the state. The state, with the support of the central government launched the National Mission for Sustainable Agriculture (2014), which focuses on "enhancing agricultural productivity and farm incomes through sustainable use of key natural resources" (TERI, 2015). This mission has several components and focuses on crop diversification, improvement of soil health and productivity, promotion of organic farming and horticulture. The Punjab government, in recent years has also introduced the State Water Policy (2008) to overcome the problems of "availability, overexploitation and deteriorating quality of surface and ground water resources" (TERI, 2015:16). The third key policy imperative of green growth is to promote renewable energy. The state government passed the New and Renewable Sources of Energy Policy (2007), which was later modified in 2012 (NRSEP, 2012). It is believed that bioenergy development will help Punjab to move towards clean energy, by utilising its agricultural endowments, create a new industry in Punjab and benefit both farmers and entrepreneurs (Business Standard, 2015). Another advantage of renewable energy development is that it would help farmers earn additional remuneration from selling wheat and paddy straw as biomass feedstock to plantations, instead of burning it as crop residue on site.[54] It is believed that the increasing impetus towards renewable energy will help bring a "green power" revolution in the state. The thrust areas of green economic reforms by the Punjab government are summarised in Table 6.14 below.

Table 6.14: Sustainable development policies in Punjab: A review		
	Sustainable Agriculture	
Policy	**Areas Covered**	**Policy Measures**
Agricultural Policy, 2013	Crop Diversification, Water conservation and improvement in soil health	• Reduce the area under rice cultivation from 28 million hectares at present to 16 million hectares and increase the area under other crops from 13 million hectares to 26.8 million hectares during the sub-period 2012-2020. • Utilisation of soil cards and integrated nutrient management to improve soil health • On farm water management, water harvesting and regulations for improving water use efficiency.
Crop Diversification Program 2013-14	Improving production technique for alternative crops and enhancement of soil fertility through cultivation of legumes.	• Diversification of 5% land under paddy cultivation to maize, oilseeds and agro-forestry products. • Cluster demonstration of alternative crops such as basmati, maize, cotton and agro-forestry products. • Subsidy on adoption of water conservation techniques. • Subsidy on inputs/equipment for maize cultivation.

[54] Punjab generates 18 million tons of wheat straw and 20 million tons of paddy straw each year. Almost eighty per cent of the straw generated is burnt. This leads to loss of nitrogen, phosphorus, sulphur and potassium present in the straw and erodes the soil of its microbial population. Pollutants in the atmosphere are a health hazard and trigger a range of respiratory problems (TERI, 2015:15).

		• Promotion of soil testing for site-specific nutrient management. • Subsidy on green manure
National Project on Management of Soil Health and Fertility, 2008	Promote integrated nutrient management and improve soil health and fertility	• Create a location specific database of balanced use of fertilisers. • Provision of soil testing kits to extension officers. • Strengthening of soil testing and fertiliser quality control labs. • On farm water management.
Energy Efficiency and Conservation		
New and Renewable Sources of Energy Policy, 2012	Promotion of renewable energy technologies-solar energy and bioenergy, based on wheat, paddy straw and cotton husk and increase the contribution of renewable energy in Punjab's energy matrix.	• Maximise share of renewable energy to 10 per cent of installed capacity by 2022. • Target of 600 MW of decentralised power generation through biofuels. • Application of solar PV pump sets. • 25 per cent subsidy on biogas cooked stoves.
SPV Water Pumping Programme, 2014	Installation of 500 SPV water pumping systems in the state.	• 30 per cent subsidy on installation of solar water pumping systems.
Water Conservation and Management		
State Water Policy, 2008	Improvement in water use efficiency, conservation and equitable distribution and management.	• Fixed target of agricultural pump sets released by Punjab State Power Corporation. • Prohibition on sowing nursery of paddy before May 10. • 45 per cent subsidy on micro-irrigation projects for small and marginal farmers and 35 per cent for other farmers. • 50 per cent subsidy on underground pipeline systems on individual fields and 90 per cent subsidy for community underground pipeline projects.
Source: Own Compilation based on Agricultural Policy for Punjab (2013); GOI (2014 b); GOI (2014a); GOI (2008 a); NRSEP (2012) and GOP (2008)		

As table 6.14 above shows that there have been a number of green policy reforms by the state government in the last decade. However, there has been little research on the outcome of these green reforms, their impact on the lives of people concerned and their long-term sustainability. In view of this gap in literature, the following chapters will explore the sustainability of these green economic reforms in Punjab, with a focus on the renewable energy sector through in depth field based research in Punjab.

6.8 Summing Up

This chapter explored in detail, the political economy of Punjab, through the colonial times to the present ages. Through the analysis I found that due to Punjab's favourable climate, rich natural resources and human capital, it was chosen by colonial rulers as a site for the development of canal colonies and by the Indian national government as "ground zero for the Green Revolution experiment" (Newman, 2007:4). There was singular emphasis on technologically enhanced agricultural development in the region, with little focus on industry and service sector growth. Initially the Green Revolution model yielded rich dividends to the state and Punjab became one of the most developed states of the Indian sub-continent. However, the gains from the Green Revolution waned off quickly and this technocratic model of development exploited and destroyed Punjab's natural assets.

Over the years agricultural yields declined, soils were diseased and water bodies were polluted. With little development in the industrial and service sector, a large section of the population continued to depend on agriculture for their livelihood. With the launching of the SAP (1991) the importance of agriculture in India's national development strategy declined further and there was progressive withdrawal for institutional support for agriculture. This led to further decline in agricultural income and the livelihood of small and medium farmers was put in peril. As this model of development has now proven to be increasingly unsustainable, Punjab is moving towards a more sustainable development trajectory, with a leading role of the bioenergy sector in promoting both green agriculture and industrial development. However, there has been little ground level research on the sustainability of these green energy imperatives and their lives of the rural population of Punjab, especially those living in the marginalised communities.

Following from this analysis on the political history of Punjab, in the subsequent chapters, I will explore in detail the bioenergy developments in Punjab and analyse their sustainability from the eco-socialist prism.

CHAPTER SEVEN
THE OPPORTUNITIES AND CONSTRAINTS OF BIOENERGY DEVELOPMENTS IN PUNJAB: FINDGINGS FROM THE FIELD

7.1 Introduction

In the previous chapter I presented the historical context of the political economy of Punjab and traced its development trajectory over the last fifty years. This region was developed as a model of capitalist agricultural development (Singh et al, 2014: 65). However, this development model proved to be increasingly unsustainable over the years and Punjab is now trapped in a deep sustainability crisis (Singh, 2017). In response to this crisis, the state is now forced to think about a more ecologically friendly development trajectory, mirroring somewhat the international developments where major developed as well as developing capitalist economies are exploring options in “green capitalism” (Wanner, 2015:23).

A major plank of the green capitalist agenda is to move away from fossil fuels to green energy sources (Wanner, 2015:30). In Punjab too, a significant part of the green reforms is focused on developing the province as a “green power” economy with a leading role of the alternative energy sector (Singh, 2017). It is in this context that I carried out a field investigation in Punjab in 2015-2016 and explored how green energy initiatives were playing out on the field at multiple levels. The exploratory case study research focused on creating a “chain of explanation,” which went from the policy discourse on bioenergy to the commercial green energy projects being pursued in Punjab and finally to the impact of these developments on the rural community of Punjab. The field based research was based on discursive analysis of policy texts, in-depth interviews with bioenergy producers, managers, researchers and community leaders, as well as focus group discussions with the rural community in two villages.

The experience of bioenergy projects on the ground is evaluated from the eco-socialist lens, described in chapter four. Eco-socialism approaches ecological degradation as a "systemic issue," historically embedded in the process of capital accumulation (Pepper, 1998). Punjab provided an ideal case study for analysing the sustainability of bioenergy developments through an eco-socialist prism. This region is an exemplar of the eco-socialist critique of capitalist development. Punjab was chosen as the epicentre of green revolution model in India. Over the years, this technocratic agricultural model destroyed the ecological fabric of the Punjabi society, strengthened the existing power structures in society and created new forms of exclusion and marginalisation along caste and gender lines. The development trajectory in Punjab is an epitome of how capitalism creates a "metabolic rift" between humans and their natural environment in its insatiable desire for higher and higher profits (Foster et al, 2010). It mirrors the "second contradiction of capitalism" [55] wherein capitalist development destroys the very social and environmental conditions that are necessary for development to take place in the future: the viability of the ecosystem, health and well-being of workers as well as the social capital and environment of the communities in which workers live (O'Connor, 1988).

In the face of this ecological crisis, capitalist agricultural development in Punjab is now attempting to move towards "green" capitalist reforms, with a key role of the renewable energy sector (Singh, 2017). The eco-socialist perspective allowed me to analyse these bioenergy reforms as they played out in a class-based hierarchal context in Punjab. It also enabled me to see how solutions could be explored through decentralized institutions and grass root environmentalism. The perspective was very helpful in understanding and interpreting the fieldwork.

This chapter is divided into four main sections. The first section lays down the overall context of bioenergy developments, rationale and policy prerogatives behind bioenergy developments in Punjab and examines the extent to which these policies create an enabling environment for sustainable development in the state. The second section identifies the institutional framework for intervention in the bio energy sector in the state and the main actors in the bio energy sector. This section lays the

[55] The first contradiction of capitalism takes place, when individual capitalists attempt to restore profits by increasing labour productivity through increase in working hours or cutting wages. The unintended impact of these measures is a decline in demand for consumer goods, which leads to a further decline in profitability (O'Connor, 1988).

groundwork for identifying the stakeholders and respondents in the field study. The third section appraises how these policies are playing out on the ground through representative case studies of three major types of bioenergy projects in the state. The fourth section assesses community green energy initiatives and deliberates on the role of bioenergy at the levels of the community and households in rural Punjab to assess its contribution in alleviating rural energy poverty. The final section sums up the findings from the fieldwork and presents the key conclusions.

7.2 Bioenergy Policy Context and Prerogatives in Punjab

The bioenergy developments in Punjab have their foundation in the larger energy crisis facing the Indian subcontinent. India is one of the fastest growing countries in the global economy, yet it is plagued with a number of challenges in the energy sector. India faces extensive energy poverty (IEA, 2015), increasing shortage of energy due to the growing mismatch between supply and demand in the face of higher economic growth (Krishna et al, 2015:9) and high dependence on fossil fuels, making the country extremely vulnerable to ecological catastrophes (Mengpin et al, 2014). It is in the context of these challenges that renewable energy developments are being promoted as a potential solution to India's multipronged energy crisis. It is believed that these developments can enable the country to make a transition to a clean energy pathway (Natranjan, et al, 2015), improve energy security in rural areas (Patil et al, 2013), reduce import dependence and honour its climate change obligations (Tompsett, 2010).

In the face of these energy challenges facing the Indian subcontinent, Punjab was chosen as ground zero for bioenergy developments in India, due to its historic advantage as an agriculturally developed province. It has been estimated that Punjab has the highest potential for biomass based electricity generation among all other states of India (Table 7.1 below).

Table 7.1: Bioenergy potential of Indian states (Mega Watts) and % distribution of biomass reserves, Indian states						
State	**Biomass**	**Co-generation**	**Waste to Energy**	**Total**	**% Distribution ***	**Rank ***
Andhra Pradesh	578	300	123	1001	3.99	11
Bihar	619	300	73	992	3.95	12
Gujarat	1221	350	112	1683	6.71	5
Haryana	1333	350	24	1707	6.80	4
Himachal Pradesh	142	N/A	2	144	0.57	15
Karnataka	1131	450	36	1617	6.44	8
Kerala	1044		78	1122	4.47	9
Madhya Pradesh	1364	N/A	287	1651	6.58	7
Maharashtra	1887	1250	2	3139	12.51	2
Odisha	246		22	268	1.07	14
Punjab	**3172**	**300**	**45**	**3517**	**14.02**	1
Rajasthan	1039		62	1101	4.39	10
Tamil Nadu	1072	450	151	1673	6.67	6
Uttar Pradesh	1617	1250	176	3043	12.13	3
West Bengal	396		148	544	2.17	13
All India	17538	5000	2556	25094	100	

Source: Compiled from Energy Statistics of India (2016)
*Own Calculations.
Note: These 15 major states of India together account for 92.47 per cent of the total bioenergy potential of India. The remaining 7.53 per cent is accounted for by smaller states.

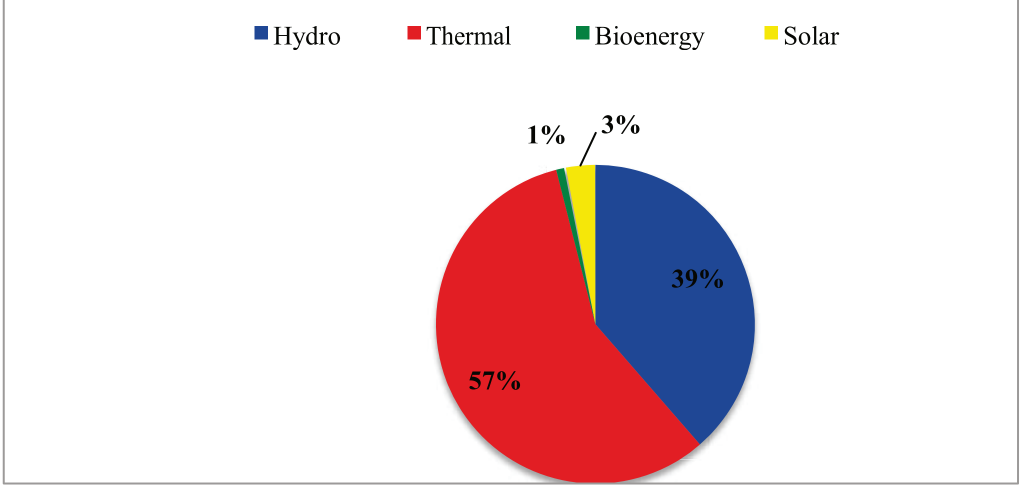
It was contended that Punjab's traditional advantage in agriculture could be tapped to generate biogas for both commercial and household use. This model of biomass development has been hailed as a "key source of locally produced energy" for agrarian economies in the future (Bluemling et al, 2013). The biomass energy potential of Punjab for power generation has been identified by a number of scholars. According to some estimates, Punjab can potentially produce up to 5000 MW per year by utilising residues of major crops: rice, maize, wheat, cotton and sugarcane grown in the province (Jenkins, 1991; Singh et al, 2003; Singh et al, 2008 and Chauhan, 2012). Bioenergy can potentially contribute to 15-20 per cent of the state's total energy needs (Singh and Chauhan, 2014). Despite this high potential, bioenergy was on the fringes of Punjab's energy sector until recently. It is only after 2007-08 that power generation through bioenergy and its contribution to the state's energy matrix began to rise.

A textual review of documents reveal that between the year 2007-08 and 2014-15 a number of renewable energy projects were initiated in the state, as a result of which the bioenergy production in the province has doubled (India Energy Statistics, 2016). Bioenergy developments in the state are being promoted through government agencies, industrial projects as well as community based initiatives, making Punjab the epicentre of bioenergy developments within the Indian sub-continent. Punjab was awarded as the "Best Performing State in Renewable Energy Capacity" at the National Renewable Energy Summit, 2015 (The Tribune, 2015).

Figures 7.1 and 7.2 compare Punjab's energy matrix in 2007-08 and 2015- 2016. Between these years, the contribution of bioenergy increased from 1 per cent to 6 per cent of Punjab's energy matrix. The percentage change in installed capacity of bioenergy in the state between 2007-08 and 2015-16 is higher than any other major state of India (Figure 7.3). In the past few years there has been widespread euphoria about bioenergy in the province. A high-level government official in the renewable energy department of the state government made the following claims, when questioned about the scale of these developments in Punjab:

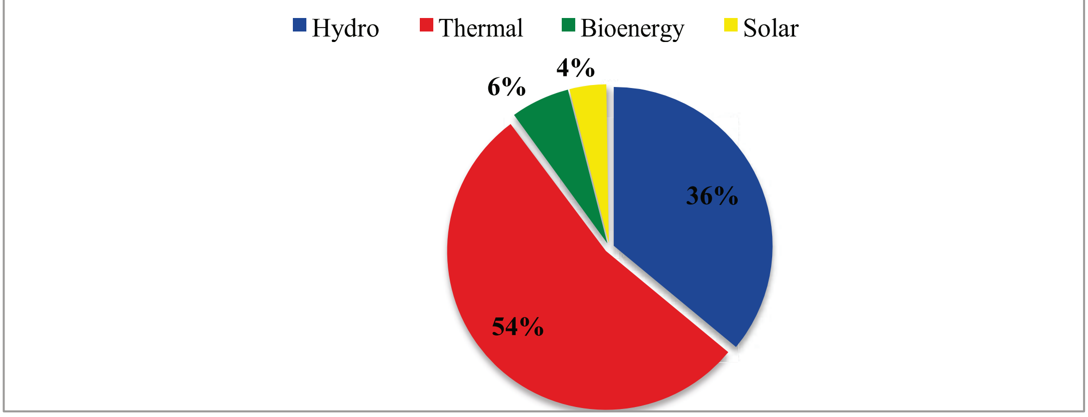
"It is the start of a new green revolution in Punjab. These projects will set the course for an alternative development model that will boost both agriculture and industry" (Interviewee Government Official 1, Punjab Energy Development Agency, Government of Punjab, Chandigarh, June 2, 2015).

Figure 7.1 Punjab's energy matrix, 2007-08



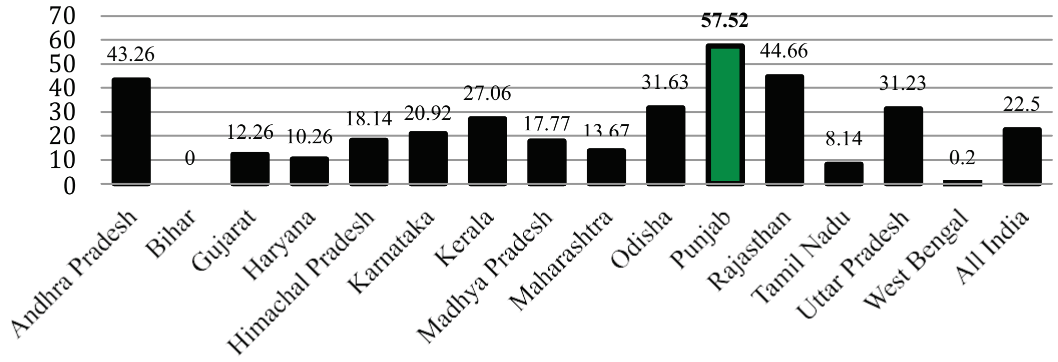
Source: Energy Statistics of India, 2007-08.

Figure 7.2: Punjab's energy matrix, 2015-2016



Source: Energy Statistics of India, 2015-16

Figure 7.3: Percentage change in bioenergy power generation, major Indian states, 2007-08 to 2015-16



Source: Own calculations based on Energy Statistics of India (2007-08 and 2015-16)

It is significant to note that the model of bioenergy development in Punjab is distinct from the projects being implemented in other parts of India and a large part of the developing world. The bioenergy developments across the globe are currently dominated by first generation biofuels and suffer from a host of socio-economic and environmental challenges (Chapter 3, Section 3.5). The same model of bioenergy developments is being pursued in other Indian states: Rajasthan, Karnataka and Tamil Nadu (HLPE, 2013). These states are promoting biofuels through development of jatropha plantations on wastelands and village commons in order to generate biodiesel (Baka, 2014). Evidence on the socio-economic and ecological impacts of these plantations however reveals that these projects have been associated with land use change (Baka and Bailis, 2013), loss of property and grazing rights over village commons (2014), increasing debt burden of small and marginal farmers (Pradhan and Ruysenaar, 2014) and increased incidence of soil erosion and ground water depletion (Gmunder et al, 2012).

In contrast, the Punjab government has not invested in new biofuel crops. Instead, the state is utilising its comparative advantage in biomass[56] and employing residues from existing crops (wheat, rice, cotton and sugarcane) to generate bioenergy for power generation for commercial and household use. As energy expert 1 said:

"Our bioenergy production is aimed at making efficient and productive use of biomass, which is abundant in the state. We are developing projects through which

[56] Agricultural waste products like wheat husk, paddy husk and cow dung.

solid biomass is collected from various sources and converted into producer gas through the process of gasification. This gas can be employed for electricity generation as well as heating and cooking purposes within the household" (Interviewee Energy Expert 1, August 8, 2015).

The state government is also extensively promoting the use of bioenergy as a domestic fuel for household cooking and lighting purposes under the National Biomass Cooked Stove Initiative (MNRE, 2009). The strategy offers a number of potential ecological and socio-economic benefits and overcomes the weaknesses associated with first generation biofuels, according to the interviewed experts and government officials in the energy sector:

"This strategy of biomass development overcomes the problems associated with land use change, as there is no change in cropping pattern and replacement of land grown for food crops into fuel crops. It is also inclusive in nature. All farmers in the region can participate in these projects. This strategy of bioenergy development does not require any additional resources to be invested by farmers (Interviewee Energy Researcher 2, July 27, 2015).

Top government officials in the energy sector in Punjab claim that a major strength of this strategy is that it is rooted within the indigenous economy and is based entirely on local resources and technologies:

"The use of locally available biomass is the cornerstone of our policy. We are attempting to develop a strategy for clean and efficient use of biomass energy for both household use and decentralised power generation within rural industries such as sugar and rice mills" (Interviewee Government Official 3, June 6, 2015).

Another major advantage of this form of bioenergy generation, as is being claimed is that it gives farmers the opportunity to dispose agricultural waste in an ecological friendly manner and at the same time augment household income through sale of crop residues to bioenergy companies[57] (Interviewees Renewable Energy Experts 1 and 2, August 9-12, 2015).

To sum up the discussion in this section we see that Punjab provides a potentially very promising case. Punjab has significant advantages and enabling conditions, which provide a positive push for conditioning the bioenergy policy in the state. Punjab is an example of how the movement from traditional environmentally destructive capitalism to green capitalism is emerging in a regional setting. The state

[57] Burning of agricultural waste products is one of the primary causes of air pollution in Punjab (TERI, 2015).

is pro-active state, willing to acknowledge the failure of the dominant growth strategy and experiment with various projects.

7.3 The Instititutional Framework of Bioenergy in Punjab: A Stakeholder Approach

In order to discern the institutional framework and identify the types of bio energy interventions adopted in the state I have used a multiple stakeholder approach. Following this, we identify "wide range of public and private actors, who operate at different spatial and jurisdiction levels" (Termeer et al, 2010: 29). Through this, I was able to identify multiple stakeholders and capture their perception and experiences on the ground: those who were setting the policy context (government departments), those in a relative position of power (the owners and managers of bioenergy projects), those expected to lead the R&D in the sector (Universities and Research Centres), those who were at the margins of the policy making process (the farmers/ workers in bioenergy plantations and rural residents as end users of bioenergy) as well as those who were promoting these developments outside the mainstream (community players engaged in green energy developments). By adopting the frame of reference of multiple stakeholders on the ground level and capturing their lived experience of bioenergy projects, we hope to unearth both the opportunities offered by these projects, as well as the contestations surrounding them in the subsequent sections.

Based on the multiple stakeholder approach, the desk review of key policy documents, and interviews with informed respondents, we identified a range of stakeholders as described below:

a) Government agencies: The Ministry of New and Renewable Energy (MNRE) was set up in 1996 by the Government of India at the centre and acts as the nodal agency for the development and implementation of renewable energy projects across the country through close co-ordination with the state governments. In Punjab, the department of renewable agency is christened as Punjab Energy Development Agency (PEDA). It has been in operation since 1991. This state agency has a major role in implementing the policies set up by the MNRE at the centre, designing and implementing its own bioenergy policies and co-ordinating with the individual projects at the local level. The PEDA works closely with other state agencies: Punjab State Power Corporation Limited (PSPCL), which is responsible for generation of electricity in the state; Punjab State Transmission Corporation Limited (PSTCL) which is responsible for transmission and distribution of power and Punjab State Electricity Regulation Company (PSERC), which is responsible for setting tariff rates. The bioenergy companies in the state sell power to PSPCL through long-term power purchase agreements, fixed for a period of 25 years.

Interestingly, PEDA doesn't work with the Commission for Agricultural Costs and Prices (CACP), which is an attached office of the Ministry of Agriculture and Farmers Welfare. This goes on to show that the PEDA has no direct interface with farmers in its ambit. The consequence of this as we will see in the following discussion is that PEDA remains a "top down" bureaucratic institution which is not organically linked to stakeholders from below.

b) Private Biomass Companies: The second major stakeholder is the private biomass companies. A number of private biomass companies have set up operation in the region in recent years. Along with these biomass companies, some existing companies, primarily sugar and rice mills have set up co-generation power plants.[58] These power plants generate energy by utilising the waste products of the industry. These co-generation projects are intended to make the industry self- sustaining in their electricity needs. A second objective of these projects is to develop biomass industries as a model of industrial development, based on renewable energy generation. Bioenergy producers have organised themselves into an association called the Biomass Energy Producers of Punjab since 2004. This association collectively bargains with the state government on issues such as subsidies and grants given to them, as well as the per unit price of electricity they receive from the state electricity board. As we will see in the subsequent discussion in this chapter, the bio-energy producers of Punjab have obtained a large number of fiscal subsidies including exemption from VAT, stamp duty etc. but more crucially, the permission for land use change, whereby land under agricultural has been diverted to set up operations by the private companies.

[58] The existing rice/ sugar mills in the state are using the by-products of the industry such as bagasse and rice husk to generate captive steam and power by installing captive power plants in the mills (Interviewee Government Official 1, Renewable Energy Department, Government of Punjab, June 2, 2015).

c) Research Organisations/ Universities: The other stakeholder is institutions entrusted with local R&D. There are two state level organisations, the Punjab Agricultural University (PAU) and the Chandigarh Renewable Energy and Science and Technology Promotion Society (CREST), which conduct research on renewable energy deployment in the province, and provide technical assistance to PEDA by developing demonstration projects on renewable energy for potential bidders. Agricultural experts and economists in the state also provide key inputs on sustainable energy development in the region to the state government. But our interviews with technical experts and engineers working in CREST/ PAU and PEDA, as well as a review of official literature published by these organizations did not bring out a proactive role of these institutions or any big innovation in bioenergy technologies credited to them.

d) Community Organisations promoting bioenergy: Some community leaders, religious organisations as well individuals are promoting bioenergy projects in the state through voluntary initiative. [59] Their main motivations include creating environmental consciousness among the local communities and awareness about bioenergy to make their own villages and communities ecologically sustainable and to leave a better planet for the next generation. Besides these community-based initiatives, small farmer's organisations/collectives in the state can also play an important role in mobilising support for green energy among farmers, as well as negotiating with bioenergy companies with respect to feedstock prices to be paid to the farmers and conditions for employment in the bioenergy companies. Despite the fact that these farm leaders showed keen awareness for ecological and energy issues surrounding agriculture and the rural community at large, they had been left out of the mainstream environmental policy discourse in Punjab.

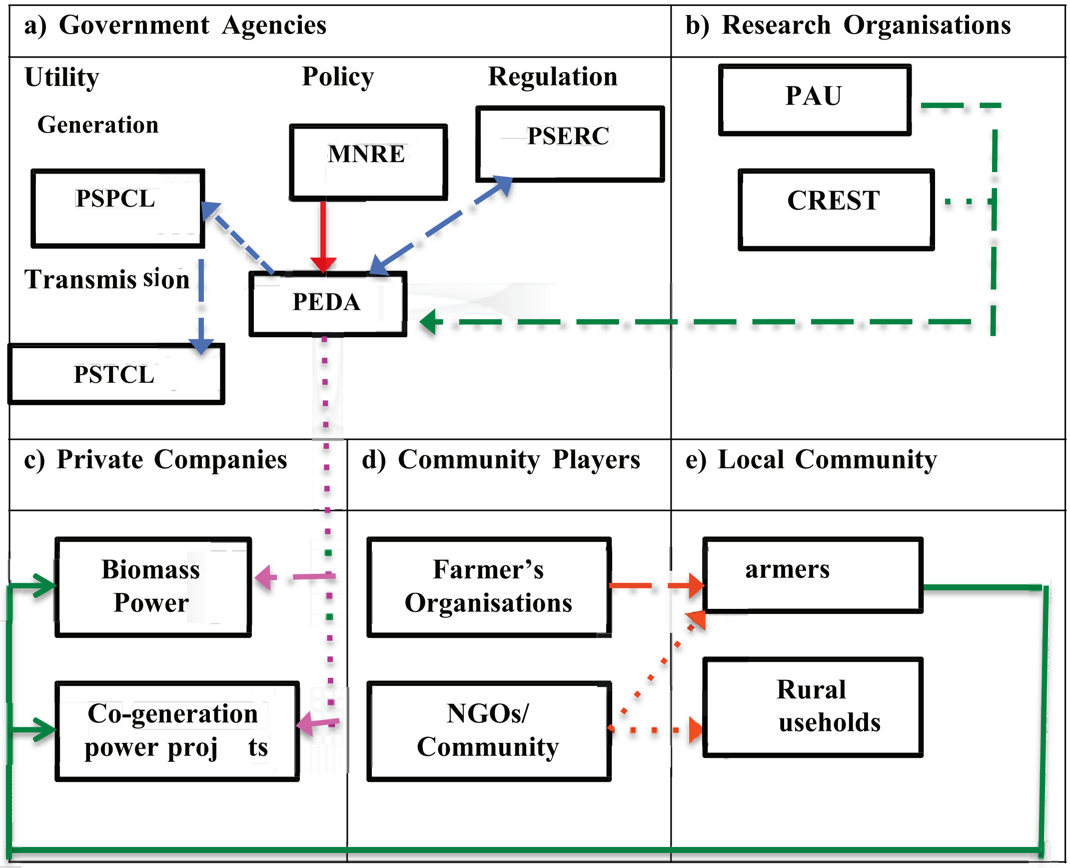
e) Local Rural Communities: Local rural communities are both suppliers as well as end users of bioenergy. The bio energy plants crucially depend on the supply of biomass by the farming communities and local farmers, which include female and

[59] Among the most influential in this field in Sant Balbir Singh Seechewal, a religious community leader but also an eminent environmentalist who initiated a campaign for generating awareness amongst different sections of the society to solve the problem of desilting the water body following the failure of the government body, Punjab Pollution Control Board (PPCB) and local industries to comply to environmental standards. He single-handedly cleaned and restored Kali Bein river, a 160 km long tributary of river Beas in Doaba region of Punjab.

male farmers. They sell various biomasses such as paddy straw, cane trash, maize cob, bagasse, and cotton stalk to the biomass power companies, and provide raw materials for co-generation mills operating in the state. Farmers and agricultural labour also provide the pool of cheap, unskilled labour to the biomass companies. As consumers, local rural residents (both farming and non-farming households) use bioenergy for their end use and are also beneficiaries of household bioenergy schemes of the state government. They have a crucial place in the energy matrix because many poor households are reeling under energy poverty in Punjab due to shrinking forest cover and access to commons. These were the traditional sources for fuel wood for the poor households. They are thus key to the success of bioenergy initiatives.

In the field analysis of the bioenergy projects in Punjab in the subsequent sections I have taken into account the roles and the perspective of these multiple stakeholders at different levels, along with my own observations on the ground to construct a holistic picture of bio energy developments. Figure 7.4 below provides a schematic view of the major stakeholders in the bioenergy matrix in Punjab, which shows that D and E are neither connected to policy nor to research.

Figure 7.4: Major Stakeholders in the bioenergy sector in Punjab: a schematic view



Source: Own Compilation

Symbol	Meaning
	Biogas Policy Design
	Policy Implementation
	Awareness and mobilisation of support
	Biomass Production
	Research
	Project implementation

As the subsequent sections reveal, in the current policy discourse, bioenergy policies as well as their ground level implementation are solely dictated by the government and industry interests. The overriding policy prerogative of both these parties emerged as the creation of a profitable green energy industry in Punjab, which was being supported by a range of fiscal concessions. The other stakeholders like the farmers, farm organizations, community players and the rural communities (especially the more economically marginalised like SCs and women) are left out of the development discourse.

7.4 Key Policy Imperatives of Bioenergy Developments

Government and industry emerge as the two significant actors in the bio energy sector in the state. In order to evaluate the main prerogatives behind bioenergy developments of the government in Punjab, I conducted a desk review of nine major policy documents of the central and the state government of Punjab related to the energy and environmental sector. These included documents starting from 1981-82 along with three international climate change and sustainable development accords to which India is a signatory.[60] These are listed in Table 7.2 below.

Table 7.2: Key policy imperatives on bioenergy in selected documents on energy, environment and sustainable development in India	
Year	**Programme**
1981-82	National Project on Biogas Development
1994	National Programme on Bagasse Based Cogeneration
2003	Electricity Act
2003	National Biofuel Policy
2004	Village Energy Security Programme
2005	Integrated Energy Policy
2008-17	National Action Plan on Climate Change
2009	National Biomass Cooked Stove Initiative
2012	New and Renewable Energy Policy[61]
International Climate Change Accords to which India is a signatory	

[60] In the federal structure of the Indian economy, the renewable energy sector falls under the purview of both the central and the state government. The Ministry of the New and Renewable Energy (MNRE) of the Government of India formulates the main policies related to the renewable energy sector and these are implemented by the state nodal agencies (Krishna et al, 2015: 15). In case of Punjab, the state agency PEDA (Punjab Energy Development Agency) has also implemented its own New and Renewable Energy Policy (NRSEP, 2007) and modified it in 2012 (NRSEP, 2012), besides the renewable energy policies of the central government, which are currently being effected in the state.

[61] This is a policy of the government of Punjab, while the others are All India policies.

1992	United Nations Framework Convention on Climate Change
1998	Kyoto Protocol
2015	United Nations Framework Convention on Climate Change
Source: Own Compilation based on review of policy documents taken from Planning Commission (2002); GOI (1994); CERC (2003); GOI (2003); MNRE (2008); GOI (2005); GOI (2008b); MNRE (2009); NRSEP (2012); UN (1992); UN (1998) and UN (2015)	

In addition to the review of documents I also brought insights through interviews with a number of key stakeholders: government officials, academics/ researchers, NGOs and farm leaders on their perspective of the bioenergy policies of the government to construct a coherent picture of the direction and focus of bioenergy policies of the government. This analysis reinforced and enriched some key insights into the bioenergy strategy of the government discerned from the policy documents. The insights that emerged from the document analysis as well as the stakeholder interviews are presented below in four sub heads:

a) Alignment with international climate change accords

It is quite clear that bioenergy policies in India have been developed by aligning them with the priorities of sustainable energy development laid down by international development agencies and climate change accords. The National Policy of Biofuels (GOI, 2003), for example, clearly states:

"In the context of international perspectives and national imperatives, it is the endeavour of policy to facilitate and bring about optimal development and utilization of indigenous biomass for production of bioenergy" (GOI, 2003:4).

Also,

"Biofuels are environment friendly fuels and their utilization would address global concerns about containment of carbon emissions in India" (GOI, 2003:3).

This alignment may be attributed to the fact that India is the fourth largest emitter of GHGs, due to the country's high dependence on fossil fuel energy[62] (Mengpin et al, 2014). There is increasing pressure on India from international agencies to move towards a cleaner energy pathway. However, a deeper analysis of policies reveal that it is a 'cut and paste' policy which doesn't build on the analysis of local

[62] Fossil fuels currently contribute to 74 per cent of the total energy needs of the country (India Energy Statistics, 2016).

conditions. Rather the documents quote extensively from the three International Climate Accords to which India is a signatory, namely, United Nations Framework Convention on Climate Change (1992), Kyoto Protocol (1998) and the United Nations Framework Convention on Climate Change (2015).

b) Creation of a Green Energy Market[63]

In all the major policy documents, there is an underlying theme of mainstreaming of bioenergy, to create a viable "green energy market" through large-scale concessions and subsidies for capacity building and research in green energy initiatives.

"Investments and joint ventures in the biofuel sector are proposed to be encouraged. Biofuel technologies and projects would be allowed 100% foreign equity through automatic approval route to attract Foreign Direct Investment" (GOI, 2003: 11)

"Financial incentives, including subsidies and grants, will be considered for advanced technologies and conversion processes; and, production units based on biomass feedstock. If it becomes necessary, a National Biofuel Fund could be considered for providing such financial incentives" (GOI, 2003:11)

The international agreements on which the bioenergy policies of the Indian/Punjab government are based on, are themselves oriented solely towards creation of green energy markets in partnership with private sector.

"For innovations in the green energy sector to spread - we need partnerships with the private sector, the global engine of growth and the primary source of new investments" (Sustainable Energy for All, 2012).

Similarly, the commitment to the creation of green energy markets is quite evident from the following statements in key policy documents pertaining to bioenergy over the years:

"To create a level playing field for accelerated development of bioenergy, appropriate fiscal and financial measures will be considered. Research, development and demonstration will be supported to cover all aspects from feedstock production to processing" (GOI, 2003:6-7).

63 In the policy documents of the Indian/ Punjab government, green energy markets are defined as the development of a viable green energy industry in the state, through a range of fiscal subsidies and concessions to green energy producers. These fiscal subsidies and concessions are intended to make the green energy industry competitive (NRSEP, 2012:2). This is in contrast to the commonly understood definition of creation of a green energy market through market-based instruments like quotas, marketable permits and cap and trade solutions.

"To encourage private/ community players to invest in biogas plants, they will be provided with subsidies on land/capital" (GOI, 2005: 97-98).

"Create a market based mechanism to enhance cost effectiveness of renewable energy projects and develop fiscal instruments to promote energy efficiency" (GOI, 2008: 3).

"Creation of conducive conditions for attracting private sector investments in bioenergy to improve the quality of power in rural areas; give support to specific projects and support R&D, commercialization and demonstration of new and emerging technologies (NRSEP, 2012:2).

This policy focus on creation of a green energy market was reiterated by a number of government officials and policy experts in Punjab in my field interviews as well.

"*The principal role of PEDA is to provide an enabling environment for the creation of a viable renewable energy market in the state" (Interviewee Government Official 2, Chandigarh, June 5, 2015).*

Some experts also believed that creation of green energy market offered a potential pathway to the state government to create its own agro-industry, given the deep linkages between the agricultural sector and the bioenergy sector. The crisis of Punjab's agricultural economy, lack of avenues for diversification of agrarian capital, and the energy crisis, all created push towards creating "green energy market". The director of a leading policy research institute, Institute of Development and Communication (IDC) made the following observations about the linkages between agriculture and bioenergy development in the state:

"Since the last decade and a half, Punjab is trapped in a deep crisis in the agricultural sector. While agriculture is stagnating, there is no alternative source of employment in the region, due to the absence of industrial development. Bioenergy projects offer an opportunity to the state to develop its agro-industry and revive the rural economy. Also, these projects are highly labour intensive and could create skilled and unskilled work in rural Punjab" (Interviewee Academic 1, Chandigarh, May 20, 2015).

This brings out very clearly the policy orientation towards creating a green energy market by incentivising private business investment in the bio energy sector. The other important insight which emerges from the analysis is a complete absence of an analysis of local socio-economic conditions in the policy framework.

c) Absence of socio-economic analytical framework

The socio-ecological aspects of bioenergy projects in the form of tackling energy poverty and supporting rural livelihood and employment have been given only lip service in these documents. These policy prerogatives find no mention in the New and Renewable Energy Policy (NRSEP, 2012), which was instituted by the state government. A careful analysis of the policy document reveals that there has been no systematic attempt to address issue like marginalisation, livelihood creation, rural development, environmental best practices, and protection of land rights of farmers in the bioenergy discourse. Several academics and NGOs working on Punjab also echoed this view:

"Bioenergy policies have been instituted, without putting into place institutions and mechanisms that are necessary to make them pro-people. Ambitious targets have been set without considering the available infrastructure, government machinery, technological potential and available resources. These policies have put agro-industry as the key focus of the policy, rather than the energy needs of the poor population" (Interviewee Academic 2, September 14, 2015)

"*These policies are being promoted purely for economic reasons, which may be attractive for industry; however they offer no assurance for either social development or environmental protection" (Interiewee NGO 1, May 2, 2016).*

Interestingly, while a number of fiscal subsidies and concessions have been given to private sector bioenergy producers in Punjab in the form of 100% exemption of VAT, electricity duty, stamp duty, change of land use and external development fund (NRSEP, 2012), the only incentive given to end users of energy in rural areas is a meagre 33 percent subsidy on installation of a household biogas stove (MNRE, 2009). However, this subsidy is insufficient as the installation cost is quite prohibitive as described in the subsequent sections. Consequently, a large section of the rural population get exculded from the scheme because of the high costs.

"A medium sized biogas stove, for meeting household energy needs costs 50,000 rupees; after the subsidy the price comes to 33500 rupess. This amount is too high for a large mass of the rural population who can only afford to pay 4000-5000 rupees and no more for the stove" (Interviewee NGO 2, June 14, 2015).

d) Absence of local level stakeholder participation

Bioenergy policies are top-down and leave out any local stakeholder involvement in policy formulation and implementation. Although there are a number of individuals and community based organisations promoting bioenergy projects in the state at the ground level, they have been largely excluded from the bioenergy policy discourse. This fact was admitted by officials of PEDA as well.

"We do not have a mechanism for involvement of either panchayats [village

councils] or farmer's organisations, labour unions and NGOs in bioenergy projects and negotiations with developers" (Interviewee Government Official 2, June 5, 2015).

The absence of stakeholder participation emerged as a major weakness of these policies, in the course of the interviews with experts. One economist made the following comment, when asked about the nature of bioenergy developments in the province:

"These policies have been formulated within a very weak governance framework, without any involvement of people on the ground. As a result there is high chance for exploitation of locals with respect to payment of wages, fair price of agricultural produce and protection of land rights. There are no checks and balances on bioenergy producers to uphold ethical practices in their operations" (Interviewee Academic 3, May 10, 2016).

The lack of representation and integration within the rural communities emerged as a key factor, due to which labour and farmer's organisations remain apprehensive about these projects. The representatives of farmer's organisations mentioned that they had been largely left out of bioenergy negotiations, although these policies were closely aligned with farmer's welfare and employment issues.

"We welcome bioenergy projects in the state. But farmers are highly uncertain about the agreements to be signed with bioenergy producers. They have been given no information about the terms and conditions, but are being asked to sign a number of documents. We need a series of meeting between the farmers and companies to receive impartial information on land tenure agreements, prices of produce and conditions of employment and then enter into formalised partnerships with them" (Farmer Organisation Representative 1, May 18, 2016).

Clearly, the policy prerogatives of the state government are geared towards creation of a green energy market. The policy prerogatives appear to be dominated by business interests, rather than the concerns of ground level stakeholders. This also suggests that bioenergy policies have been instituted within the "weak" sustainability framework. This is the dominant paradigm underlying green capitalism where in green reforms are instituted as technocractic developments to keep the growth process in the economy intact (Garmendia et al, 2010:97). Within such a framework the socio-economic and ecological dimensions of these projects fail to take primacy in policy discourse. The primary objective remains business viability. Socio-ecological dimensions such as the energy needs of the people and ecological sustainability do not form part of the policy discourse. The discussion points to the missing parameters of 'strong sustainability', which advocates for the maintenance of critical natural capital and integration of socio-economic and ecological aspects of development. Eco-socialists subscribe to a strong sustainability paradigm.

The policy analysis revealed that business interests have appopriated the policy discourse, on "green energy" developments in Punjab. The existing legislations on bioenergy in Punjab (NRSEP 2007, 2012) have been formulated to facilitate creation of agro-industry, rather than environmental sustainability and clean energy. The legislations are not geared to monitor whether businesses are following environmnetal best practices, technological and labour norms. These purely private profit-oriented trends were identified by academics and NGOs alike.

Interestingly, this form of "regulatory capture" is pervasive in all areas of green capitalism; where in business interests have come to dominate environmental regulation (Vlachou, 2005). Our review of literature in chapter three established clearly that in case of biofuels, regulatory capture by biofuel companies and weak governance frameworks contributed to the undermining of the socio-economic aspects of bioenergy developments and created a host of challenges such as infringement of labour rights, land grabs and environmentally unfriendly practices across many developing regions. Applying an eco-socialist lens, we are able to see this as a far deeper problem than mere capture of regulation by vested business interests. As eco-socialist authors have pointed out, market regulation is an external barrier, which is essentially shaped on capital's terms (Kovel, 2002). Thus, environmental regulation cannot interfere with the process of capital accumulation, as this is unacceptable in a growth oriented system (Kovel, 2002). This phenomena has been referred to as "regulatory chills" and has been empirically examined by some studies. For instance Neumayer (2001) gathered evidence on how toughest environmental regulations and energy taxes in Germany and US were gradually diluted in order to maintain "competitiveness" of tobacco and mineral processing industries. In another study, Bell (2015) analysed how in the wake of the 2007/08 financial crisis in UK, environmental legislations were systematically eased and it was explicitly stated by the UK government that removing these regulations would save businesses 1 billion pounds. In India, since 2012 environmental regulations on use of forests for setting up industries, conditions for expansion of mining activities and monitoring of pollution levels by industries have been gradually dismantled in the name of “ease of doing business” by successive governments at the centre (Business Standard, 2015a). This insight that the policy prerogatives on bioenergy have been systematically formulated to attract capital in the bioenergy sector, favour business interests and competitiveness, rather than address socio-environmental concerns is consistent with the eco socialist understandings on the environment question. For other schools of thought, the domination of business interests to address socio-environment concerns is considered an abberation which can be addressed through more strict regulation. The challenges of domination of business interest in the environmental policy discourse is not seen as a systemic concern.

The other aspect of bioenergy policy is that policy prerogatives have been formulated by aligning them with international climate change accords, without considering the environmental concerns particular to Punjab such as unsustainable agricultural practices, absence of waste disposal mechansisms for agricultural wastes, high degree of energy poverty among certain socio-economic groups and the respiratory diseases associated with indoor pollution. These socio-ecological concerns have failed to be included in policy. PEDA officials admitted that there is no mechanism for involvement of panchayats, labour unions and NGOs in the designing of policy framework, which points to a top down approach to policy making. Within the institutional and development paradigms, decentralized institutions are considered useful to help implement those policies that are designed by international agencies or at the national level. However, in Punjab, the policy priorities are not rooted in the localized specificities and experiences. The role of local level institutions has not been identified in the policy discourse. Once again, it is only the eco-socialists paradigm that opens up the possibility of a “bottoms up” approach so that the prerogatives of green energy policies are defined by the community themselves through participatory democratic processes and decentralised institutions. Green capitalism or other market based paradigms do not acknowledge the differential environmental needs of different classes. On the contrary, they are treated homogenously as economic actors. How agricultrual waste acquires different meaning to castes/classes who are historically conditioned to “clean” waste vis-à-vis those whose economic activities produce this waste, is not something that can be incorporated within the universalist framing of markets and purely market based solutions. The eco-socialist prespective acknowledges that caste and gender hierarchies are linked with power structures in economic process like land ownership patterns or occupational divides rooted in ascriptive identities. Just to make a comparison, in Cuba, for instance, which is following a model of participatory descision making in its environmental discourse, the necessity for community participation in environmental decision making and right to environmental information has been enshrined by law (Bell, 2015).

It is well acknowldeged that the lack of stakeholder participation is pervasive in capitalist economies and redistributive social policies and welfare states are mechanisms to overcome this. However, in India the 'welfare state' is more a story of failure, than it is of success. In a significant study based on indepth data analysis of poverty, inequality and growth rates in the post-reform period, Balakrishnan (2018) concluded, "25 years since [economic reforms], India continues to have an unacceptable level of poverty according to international standards. The progress made on this front is disappointing given the claim that the reforms mark a sea change in India. … The spread of opportunity is uneven going by the fact that the sector containing the largest number of workers (agriculture) has been the one growing the slowest."

Two issues emerge clearly from the evidence provided by Balakrishnan a) the failure of redistribution and, b) the uneven spread of opportunity (Balakrishnan, 2018). Both these factors are related to the embedded nature of capitalism in India. Capitalism in India is firmly embedded in its social and political institutions. On the other hand, the Indian state is embedded in a tradition of highly uneven distribution of resources, wealth and income as a result of the formation of particular classes within the context of caste system (Harris-White, 2003; Harris-White and Prakash, 2010).

The economics of the caste system has ensured a clear hierarchy of classes. The upper castes enjoy a higher economic status and lower castes a lower status as reflected in the evidence drawn from the All-India Debt and Investment Survey (AIDIS) data, which shows an extremely high concentration of wealth among top 10 per cent of the households, while SCs remain on the bottom of the asset ladder. Data also shows that the gap between SCs and upper castes in terms of asset ownership has been increasing over time.[64]

Furthermore, if we look at Punjab, land is a key determinant of socio-economic power relations. The historical subjugations of SCs in the pattern of land ownership in Punjab is extreme. While at the all India level, 58.4 per cent of SC households are landless, in Punjab the percentage of landless SC households is a staggering 86.6 per cent (Anand, 2016)[65]. The Gini coefficient of land in Punjab is 0.85, compared to 0.76 at the national level (Anand, 2016). SCs constitute 35 per cent of the total population of Punjab, but they own just 2.8 per cent of the total land holdings in the state. The average size of land holdings for SC households is 0.4 hectares compared to 0.88 hectares for non-SC households in Punjab (Anand, 2016). This story of SCs being at the lowest rung of the social and economic ladder is also repeated for the levels of representation in the governance institutions[66] and the unequal distribution of resources. Discrimination in terms of access to resources and equality of opportunity is further exacerbated if gender is added to this equation.[67] It is not a mere chance that in recent years horrific forms of caste based violence has been witnessed in the state, especially against SC women. There is a strong correlation

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64 An analysis of the trends in wealth ownership and its inequality in India between 1991 and 2012 using three rounds of All-India Debt and Investment Survey data reveals that between 2000 and 2012 there is a greater concentration of wealth at the top 10 percent households in comparison with the period 1991-2002. Calculations based on the AIDIS survey show that between 1991 and 2012, the ranking of the social groups in terms of average per capita assets has remained unchanged. During both 1991 and 2012, SCs were at the bottom of the ladder in terms of average per capita asset ownership. The STs were better off than the SCs and the OBCs were better off than the STs in terms of average per capita asset ownership. The gap in the per capita asset ownership between the SC households and the general category households has widened over the years, so much so that the average per capita wealth of general category households is now more than four times that of the SC category. The rates of growth suggest that the general category has accumulated wealth faster than the other social groups. In sum, the levels of average wealth indicate that the historically deprived groups continue to be behind; the rates of growth indicate that these inequities are worsening over time.

65 These calculations have been made by the author on the basis of 70th round of Land and Livestock holding survey of National Sample Survey Organisation (2013).

66 A recent study evaluated the caste and occupational profile of the Punjab legislature. This study found that between 1997-2014, 76.1 percent of the members of the legislative assembly belong to middle and higher income groups and only 24.9 percent of the members belong to lower income groups. The study also found that 48.2 percent of the members of the legislative assembly in Punjab belong to large land owning families and only 9 percent of the members of the legislative assembly come from landless households (Rani, 2013).

67 The 15th Lok Sabha had a total of 84 Dalit MPs of which 72 were men and 12 were women. Data on Elected Women Representatives from 1951 to 2014 in the lower house of the Parliament (*Lok Sabha*) suggests over these years, the average of women in Lok Sabha is only 7% (Lal et al, 2015).

between socio-economic and political marginalisation of SCs and violence inflicted against them (Singh, 2016a).

However, none of these class and gender dimension and widening social and economic power relations have been considered, while formulating the environmental policies in Punjab and the redistributive schemes to address energy poverty. In the policy documents, the rural community has been treated as a homogenous unit. The only incentive given to end users of bioenergy is a 33 per cent subsidy on the installation of a household biogas stove (MNRE, 2009). This policy has not taken into account the income and wealth inequities in rural Punjab and whether households have the capacity to pay for the remaining 67 per cent amount. An eco-socialist lens allows me to see the problems in this approach and identify the specific failures that could potentially be minimised by making policy which acknowledges the reality of exising land ownership structure, the socio economic power structures associated with it, the occupational profiles of the households, the inequalities of wealth and so on.

Thus, from this section one can conclude that bioenergy policies have been primarily formulated in the interests of business and creating profitable green energy market. The policy documents, as well as the interviews with government officials and policy experts revealed that the focus of green energy developments is primarily focussed on creating a viable green energy markets. It is believed that creation of such a green energy market will automatically lead to a greener energy pathway in the state. However, within this policy framework, the structural factors behind the prevelance of energy poverty and the energy use patterns in the state have not been recognised in policy. These policies have been formulated in a "top down" fashion, and the everyday realities of poor and the marginalized communities have been relegated to the margin. Due to the absence of participatory mechanisms and provisions, the critical voices from trade unions and NGOs, as well as contentions surrounding green energy developments have not even been considered in the policy process. Within this larger context in Punjab, in the next section I will analyse how bioenergy projects are playing out on ground.

7.5 Types of Bioenergy Projects in Punjab

In Punjab, currently there are three major types of bioenergy developments taking place. These are Biomass power project, Co-generation power projects and Biomass cooking stove initiative, as described in table 7.3 below:

Table 7.3: Types of Bioenergy Projects in Punjab

Project Type	**Focus of the Project**	**Description**	**Development Status/ Targets**
Biomass Power Project	Industrial biomass production	Biomass energy is generated through collection and processing of agricultural waste products: cotton stalk, paddy straw, wheat straw and paddy husk. The electricity generated is sold by biomass power companies to the state electricity corporation through long-term power purchase agreements.	Number of projects implemented: 7 Number of projects in the pipeline: 16
Co-generation Power Projects	Industrial biomass production	The existing sugar and rice mills in the state are using bagasse (the by-product of sugar industry) and paddy husk (the by-product of rice mills) to generate captive steam and power by installing captive power plants in the sugar and rice mills. The purpose of this project is to make these industries self-sufficient in power generation, so that they move away from traditional fossil fuel energy to decentralised power based on local resources.	Number of projects implemented: 42 Number of projects in the pipeline: 90

Biomass Cooking Stove Initiative	Household biomass production	Family type biogas plants, using organic manure and cow dung as feedstock are installed in rural households across the state at a subsidised rate in order to enable rural households to make a transition from burning of traditional biomass resources such as firewood and cow dung to modern bioenergy sources	Number of installed stoves: 160,000 Targeted Number of Stoves: 450,000
Source: Compiled on the basis of information gathered from PEDA (2016) and interviews with officials in PEDA.			

As table 7.3 above shows, in Punjab biomass energy is being promoted for both industrial and household use. The household projects comprise of setting up of family type biogas stoves in rural households. There are two types of industrial imperatives in biomass energy. The biomass power projects comprise of biofuel plants, which are being set up in rural areas to produce electricity through solid biomass. These biomass companies purchase agricultural residues from farmers in the vicinity, use these agricultural wastes to generate electricity and then sell the electricity generated to the Punjab State Power Corporation, while also using some of it for their own operations. The second type of industrial biomass energy projects are the co-generation projects, where in existing sugar and rice mills in the state are making use of the mills' own waste products (paddy husk and bagasse) to generate biogas. These mills are setting up biomass power plants in their factory premises. The mills themselves use the electricity generated, while the surpluses are sold to Punjab State Power Cooperation. The primary difference between these two projects is that while the biomass power companies are sourcing agricultural waste products from farmers and providing an additional market for their produce; the co-generation projects are utilising the existing waste materials produced by the mills themselves.

In this section I will first evaluate the viability and economic sustainability of commercial bioenergy projects being implemented in the state on the basis of empirical evidence collected from three major bioenergy projects in Punjab. Each chosen project was representative of the typical bioenergy development taking place in the region- biomass power generation, co-generation rice mills and co-generation sugar mills. The projects were selected on the basis of the review of the PEDA website, which lists the names, addresses and the production capacity of various bionenergy projects operative in the state, as well interviews with officials in the renewable energy sector. The general description of the three chosen projects namely, Luxmi Energy and Agro Foods Ltd (LEAF); Morinda Co-operative Sugar Mill (MCSM) and Punjab Biomass Power Ltd. (PBPL), is displayed in Table 7.4 below:

Table 7.4 General characteristics of the researched bioenergy projects in Punjab

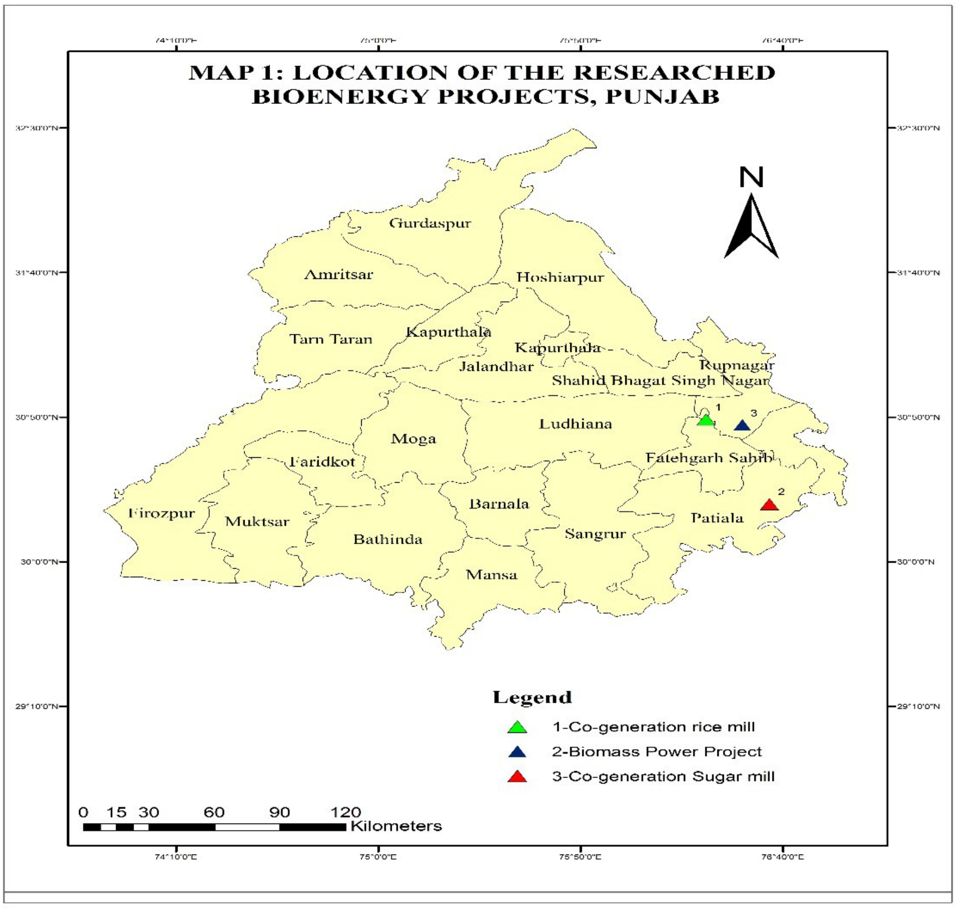
Name of the Project	Luxmi Energy and Agro Foods Ltd (LEAF) (Ltd)	Morinda Co-operative Sugar Mill (MCSM) (Commissioned byA2Z Infrastructure Pvt. Ltd.)	Punjab Biomass Power Ltd. (PBPL)
Project Type	Co-generation rice mill project	Co-generation sugar mill project	Biomass based power project
Project Location	Khamano, District Fatehgarh Sahib	Morinda, District Mohali	Rajpura, District Patiala
Project Capacity (MW)	30	14	14.5
Stated Objectives	Economic/Social	Economic/Social	Economic/Social
Scale of Operation	Large	Medium	Small-Medium
Project Description	LEAF is one of the largest agro-industry concerns in Punjab, set up in 1981. It purchases rice from 30,000 farmers across the state. This mill set up a rice husk (a by product of the rice industry) based biomass power project in 2011. Rice husk is converted into energy through boilers installed in the mill.	Morinda Co-operative sugar mill is the oldest sugar mills in Punjab, set up in 1964. In 2011 this mill set up a bagasse (a by product of the sugar industry) based power project in the mill. This project has an installed capacity of 15 MW	This was the first biomass power plant, set up in the state in 2004. This biomass power plant can employ a range of feedstocks-rice straw, wheat straw, cotton straw and bagasse. These are collected from farmers in the neighbouring villages and used as feedstock.

Development Area	Set up over 100 acre of land. The land has been allocated to the mill by the state government.	Set up over 20 acres of land in the premises of the mill. The land has been with the mill since it started functioning in 1964	Set up over 10 acres of land. The land was privately acquired by the mill after negotiating with the local village council.
Initial Capital Outlay	INR 250,000,000	INR 50,000,000	INR 30,000,000
Nature of Technical Organisation	Set up a technical collaboration with Wilcox, a UK based company. Installed two 15.75 MW husk based biomass plants in 2011	Commissioned A to Z infrastructure Ltd., a Delhi based coropration, specialising in renewable energy to set up a 14 MW baggase based biomass power project	Commissioned Gammon Pvt Ltd, a Delhi based renewable energy company to set up a 14.5 MW biomass power plant in 2004. This biomass plant can be run on an amalgamation of feedstock- wheat husk, paddy husk, cotton stalk and saffron.
Energy production	30 MW, out of which 24-25 MW are sold to the Punjab Power Corporation and 4-5 MW are used to meet the energy needs in the mill. The mill has become self sufficient in its energy needs.	14 MW, however the company is currently not producing any electricity.	The project has a capacity of 15 MW. 2 MW energy are consumed by the plant itself and the rest is sold to the Punjab State Electricity Board.
Profitability	a) Initial cost of production was recovered in 3 years time by 2014 b) The project is profitable as per unit cost of electricity comes out to be INR 3 per unit while the state power co-operation pays INR 5.75 per unit.	The project is currently unsustainable as the company is not producing any electricity, due to a number of technical reasons.	a) The company received a number of capital subidies from the government and was able to recover its initial capital outlay by 2010-11. b) The daily operations of the plant are not profitable as the cost of production comes out to be INR 6.5-INR 7.5 per unit, while the state power corporation purchases it at INR 5.75 per unit.

Source: Own compilation based on field observations and interviews

The location of the bioenergy projects are presented in Map 1. The bioenergy plantations are concentrated in the Malwa region of Punjab. This region has become the "hub of bioenergy" developments in the state in recent years (own observations and field interviews).

Map 1: Location of the Researched Bioenergy Projects, Punjab



Source: Self Compilation, 2016 using Arc-GIS software

These projects were evaluated on the basis of my observations on the field as well as interviews with industry experts, project administrators, local farmers and farm leaders. This exercise enabled me to identify the key strengths as well as the limitations of these projects on the ground level.

a) Economic Viability

The field data revealed that there is large-scale variation in the performance of the three projects. LEAF is the only one of the three bioenergy projects, which is currently making profits. The other two projects: Morinda Co-operative Sugar Mills and Punjab Biomass Power Ltd projects have not proven to be financially viable so far.

"Day to day operations of the plant are unprofitable. We are currently operating at only 16 percent PUF (plant utilisation factor[68]). Sometimes the plant is operative only for 5-7 days in a month because of technical faults" (Interviewee Chief Engineer, Punjab Biomass Power Ltd, April 5, 2015)

"The biomass plant has not been in operation for several months now" (Interviewee Chief Engineer, Morinda Co-operative Sugar Mills, July 8, 2015).

A number of reasons emerged for the lack of viability of these projects. Apparently, all the three projects either commissioned foreign or pan-Indian companies to set up the plant, which resulted in huge capital outlay and investment in the project. I discovered that most bioenergy projects in the state are operating in a similar fashion because of technical failures. Most are dependent on outside technical support and no indigenous technology or skill is used.

"There has been negligible research on bioenergy technologies in Punjab. Much of the equipment and machinery has to be sourced from outside. This leads to substantial costs in setting up the plant. These high production costs are preventing projects from taking off in a big way" (Energy Expert Interviewee 4, May 5, 2016).

There are no maintenance networks in the region for the foreign companies and very few suppliers of spare parts in case of a fault in the plant.

"If there is a breakdown, it takes a number of days to rectify the fault and the plant becomes non-operational in the meanwhile. We have to employ local mechanics for

[68] It is assumed by government agencies that these plants operate with a plant utilisation factor of 33 percent and the price per unit of electricity is fixed accordingly (Patil et al, 2013). The PUF was also confirmed by my own interview data (Interviewee Government Official 1, June 6, 2015).

repairs but they are not experts. There are no spare part suppliers in Punjab. If a part needs to be replaced, we have to wait for the company from Delhi to source it and the project closes down in the meanwhile" (Interviewee Chief Engineer, Punjab Biomass Power Ltd; April 5, 2015).

Furhtermore, no local skills have been built and the operations remain dependent on outside experts. This point was also put forth by a NGO representative.

"One of the principal reasons for the limited reach of renewable energy projects in Punjab is the poor quality of the technical staff. There are no specialised programmes to promote local skill development in renewable energy projects. Unless skill development and entrepeneurship in renewable energy projects is encouraged, the state will fail to meet its renewable energy targets" (Interviewee NGO 1, May 2, 2016).

LEAF was able to overcome this by giving training to its own technical staff.

"We have a total of twelve mechanical engineers employed in the mill. Post installation we got three experts from our partner firm Wilcox to give training and run workshops in plant repairs and maintenance. Since then we have had no problems, if there are any technical faults they are resolved by our technical staff" (Interviewee General Manager, LEAF, May 8, 2016).

However, the other two plants did not have such technical support and maintenance networks. In case of Morinda Co-operative Sugar Mill, the chief engineer of the project stated:

"A to Z infrastructure Limited installed inferior equipment and boilers in the plant due to which the plant experienced a number of breakdowns in the first few months. The plant is completely non-operational since the last few months and we are waiting for new equipment to be installed. A similar fate met other co-operative sugar mills in Nakodar and Fazilka, which had initiated bioenergy projects and installed equipment from the same company. Both these projects are functioning only partially, due to the faulty equipment installed by A to Z infrastructure limited (Interviewee Operations and Maintenance Engineer, Morinda Co-operative Sugar Mill, August 4, 2015).

Additionally, the viability of these was affected by inadequate planning and management related to the availability of feedstock in the region, logistics and storage. LEAF, being an established agro-industrial firm in the region had a well-established transport network and warehousing facilities. It was able to source feedstock from farmers throughout the province.

"We have 50 trucks and contracts with 200 grain agents in the state. Our warehousing capacity is 300,000 tones, spread out across 50 warehouses in the region. We are able to procure rice from remote parts of the state as well, due to the

large scale of our operations" (Interviewee Operations Manager, LEAF Co-operation; May 8, 2016).

On the other hand Punjab Biomass Power Ltd and Morinda Co-operative Sugar Mill did not have such well developed warehousing and transport networks and therefore had to depend on farmers in the vicinity for supply of feedstocks. In the absence of any warehousing facilities to store the feedstock, they had to utilise it on the same day. These factors have negatively affected the operational efficiency of both these projects.

The project administrators in both Punjab Biomass Power Ltd and Morinda Co-operative Sugar Mill also admitted that they did not evaluate the availability of local feedstock before setting up the plant. This lack of planning has resulted in difficulty in ensuring a smooth supply of feedstocks on a daily basis from the farmers in the vicinity:

"The main reason that the project has failed to take off is the lack of adequate assessment of the biofuel feedstock in the region. We set up a 14 MW power project, which was too ambitious. Thereafter the feasibility study we conducted showed that only 8-9 MW power plant will be feasible here" (Interviewee Chief Engineer, Morinda Co-operative Sugar Mills, August 5, 2015).

In sum, from the evaluation on the financial viability of these projects it is evident that the industrial bioenergy projects were ill conceived. They lacked backward forward linkages in terms of raw material, technical expertise, institutional support and a well-developed network of transport and storage facilities. The experience of both Morinda Co-operative Sugar Mills and Punjab Biomass Power Limited suggests that in the absence of these conditions, the projects will fail to be viable. The financial viability of these projects was further compromised by their lack of adequate planning and assessment of local conditions such as supplies of biofuels, storage and technical expertise. Such failures have been reported in other projects across the state as well.

Another important reason for the failure of these projects is that there has not been any development of indigenous bioenergy technologies despite the tall claims made by the government officials in the renewable energy sector. As the previous discussion on stakeholders pointed out, the regional R&D institutes were not found to be dynamic or pro-active in developing indigenous technologies or local skills. The state continues to rely on technical experts from outside the region for the installation of plants and post installation maintenance. These factors have greatly compromised on the viability and operational efficiency of these projects.

Plate 7.1: Farmers loading trolleys for supplying sugarcane to Morinda Co-operative Sugar Mill

Source: Own Compilation, August 2015

b) Social and Ecological Sustainability

The mission statement of all the three bioenergy projects state their commitment to sustainable development, creation of rural livelihoods and development of a clean energy pathway in Punjab (Lakshmi Energy and Foods Ltd, not dated; Gammon, not dated and A 2 Z infrastructure not dated). They profess to have both an economic and a social motive in their operations. However, my fieldwork showed that these projects have demonstrated little societal and ecological benefits so far as described below on account of supplementary income generation, employment opportunities, women's employment creation, and environmental sustainability.

i) Supplementary Income Generation: These companies claim to be creating supplementary income for farmers through selling agricultural residue (wheat straw, paddy husk and bagasse) as feedstock to the company, instead of burning them as waste products. The rice and sugar mill co-generation projects can also potentially create a viable market for farmers in their vicinity. The interviewed farmers in the nearby villages, adjoining the biomass projects welcomed the additional income opportunities created by biofuel companies:

"Selling agricultural waste to the mill helps to earn some cash before the new harvest comes through" (Interviewee Tarlochan Singh, village Khammanon, June 17, 2016)

"The sugar mill has helped to create a market for sugarcane farmers. We do not have to travel far to sell our crop. We prefer to grow sugarcane, if there is a market for the crop in the region. It is a perennial crop and is not affected by cold or rain. It also does not require large doses of fertilisers for its cultivation, unlike wheat and rice" (Interviewee Jarnail Singh, Village Rauni, June 20, 2016).

However, the lack of fair payment for feedstock is one of the factors due to which many local farmers were reluctant to participate in these projects. The government agencies do not fix the price of biomass feedstock. In fact, a significant point to note is that the central government and the state government policies are opposed to each other regarding the minimum price of feedstock. There is no provision for fixing the minimum price of feedstock in the renewable energy policy set up by the Punjab government (NRSEP, 2012). On the other hand the National Policy on Biofuels (2003) set up by the central government states, "A major instrument of this policy is that a minimum support price (MSP) for feedstock should be announced and implemented with a provision for its periodic revision so as to ensure a fair price to the farmers" (GOI, 2003: 7). The interviewed government officials in PEDA admitted that so far there has been no provision of setting up minimum price for feedstock sold to biomass energy companies (Government Official 3, June 6, 2015).

The companies arbitrarily decide on these prices. The going price for feedstock is 1000-1500 rupees/tonne (Field interviews, project administrators, May-June, 2016). However, many farmers supplying feedstock to the companies seemed dissatisfied with the price they were paid and deemed it unfair:

"We have to travel 25-30 kilometres to supply the feedstock to the company. Our diesel cost adds up to 300-500 rupees. The company does not cover our transport cost. After accounting for fuel costs, we are barely able to make anything. On top of this many times they do not accept our produce and deem its quality to be unsatisfactory. The entire trip goes waste" (Interviewee Beant Singh, Rice farmer, June 16, 2015).

Clearly, as pointed in the previous sections, the biofuel policy is inclined towards private business interests and its profitability. The local communities are mobilised to fulfil the business interests.

ii) Creation of Employment Opportunities in Rural Areas: Bioenergy projects are intensive in use of labour and claim to augment rural livelihoods through creation of additional employment opportunities in rural areas. Farmers in the region welcomed the subsidiary employment generation potential through biomass companies.

"Farming is becoming increasingly difficult due to uncertain weather and high cost of machinery, fertilisers and pesticides. We prefer jobs to farming to provide for our families, but jobs are difficult to find in the vicinity. These bioenergy developments may help us by providing jobs in the village itself" (Interviewee Sukhwinder Singh, Farmer, May 21, 2016).

However, the bulk of the employment in all the three companies was casual, unskilled and daily wage labour, which was subject to unfair and exploitative work conditions. LEAF especially had a reputation of being exploitative towards its workers and many local residents did not want to work in the mill. Three farmers, who had worked in LEAF in 2014 on a casual basis, complained that their wages were not paid to them for over a year (Farmer interviews, Morinda, 2016). A past project manager of LEAF reaffirmed this:

"The company is exploitative of locals in the region. While the prices they receive from the state power corporation for electricity are revised yearly, the feedstock prices for farmers remain fixed. Many farmers' dues are not cleared for over months. All the company is interested in is expanding profits. I left the company due to its unethical practices" (Former General Manager and Project Administrator, LEAF, May 28, 2016).

Even in the case of other two companies, the Punjab Biomass Power Corporation and the Morinda Sugar Mills, the wages paid were less than the minimum wages stipulated in rural areas under the National Rural Employment Guarantee Act (MGNREGA).[69] The Punjab Biomass Power Ltd. paid workers INR 120 per day, while the Morinda Co-operative Sugar Mills paid workers INR 140 per day, when the stipulated minimum wage is INR 218. The project administrators in both these projects stated that they could not afford to pay more, as the project would not be viable (Interviews, Project Administrators, May-June, 2016). However, the lack of fair compensation and exploitative work conditions has made local agricultural labour wary of working in these projects. Also, these projects have failed to create any skilled employment in the region. Both LEAF and Morinda Co-operative Sugar Mill used their existing technical and administrative staff in the mill to run the biomass project. Punjab Biomass Power Ltd. had employed five engineers and three administrators in 2004 when it was set up. Since then there has been no new employment in the company (Field Interviews, Project Managers).

iii) Gender Concerns: Employment in all the three biomass plants was concentrated exclusively among males. There was not a single woman employee/ worker in any of the three biomass projects. These agro-industrial enterprises could offer a potential avenue for jobs and paid employment for women. This could be a potential societal contribution of bioenergy companies in Punjab. Gender inequity and the inferior status of women is an important concern in Punjabi society (Singh and Singh, 2017). Lack of employment opportunities for women are a major source of their economic vulnerability and low societal status. The labour force participation rate of rural women in Punjab is the lowest among all other states of India (NSSO, 2014). A large proportion of women do not even register themselves as employed, even though they work in the family farms, tend to cattle, and see to household chores as well. Their work gets discounted as "family labour" (John et al, 2008) and it remains invisible and unpaid. A woman peasnt leader shared her perspective about the condition of women in Punjab:

[69] MGNREGA is an act of the Indian parliament, which provides guaranteed wage employment to workers in rural areas for 100 days in a year at a stipulated minimum wage rate. The wage rate is revised every year, on the basis of cost of living index for agricultural labour, calculated by the Central Statistical Office of the Indian government (Kaur and Randhawa, 2016). The current wage rate is fixed at INR 218 per day in Punjab (Economic Times, 2016 a).

"Rural women are in a precarious situation. The work performed by them does not get counted as labour; even though they work hard in fields and at home. Many women are educated upto secondary school but fail to find employment because there are no avenues in the region. Bioenergy projects could help in this regard but so far there has been no progress" (Interviewee Woman Peasant Leader, July 7, 2016).

The managers of the bioenergy companies admitted to this fact. This statement by the general manager of LEAF illustrates the typical response put forth by the represntatives of biomass energy companies, when questioned about the participation of women in the biomass energy projects.

"We have been so focussed on making the project take off that we have not been able to concentrate on empowerment of local women. However, this is something we need to look into more carefully in future" (Operations Manager, LEAF Co-operation, May 28, 2016).

iv)Environmental Sustainability: Bioenergy is widely seen as a green energy alternative to the dirty fossil fuel system. However, my field observations and interviews revealed that currently these policies are offering little ecological benefits. Geared as they are to the imperatives of growth, environmental considerations are only secondary. It is evident from the fact that there is no provision of monitoring of the environmental practices of the bioenergy producers by the state agencies (Field Interviews). As a result, all the three researched projects failed to adhere to environmental best practices. My field observations revealed huge wafts of thick black smoke emerging from two of the bioenergy projects-LEAF and Punjab Biomass Power Ltd. But it did not appear to be a problem or a concern. An expert at Punjab State Power Co-operation casually admitted:

"The digesters used in the biomass plants are currently employing the same technology as thermal power plants. After the machines have been in place for 4-5 years the smoke generated increases gradually (Renewable Energy Expert 3, August 2, 2016).

This negative environmental impact of biomass energy generation has been documented in literature as well. Biomass energy generation is associated with increase in nitrogen and methane emissions, in the range of 15.3 % to 33.6 %. (DeMeester et al, 2012). After new post-digester technology emerged recently, emissions from biomass projects have gone down considerably as these digesters absorb fifty per cent of the dust and particulate matter (DeMeester et al, 2012). However, the project administrators of the researched projects stated that they had not heard of the technology or employed it in their projects (Field Interviews, Project Administrators, May-June, 2016). Another adverse impact of these biomass plants is that they generate a large amount of ash, which is disbursed in the nearby fields and harms the productivity of crops. Newspaper reports have revealed that despite repeated complaints by farmers, biomass companies or PEDA have done little to amend the situation (Punjabi Tribune, 2018).

Plate 7.2: Thick smoke emerging from LEAF biomass power plant, Khummaon

Source: Own Compilation, July 2016

Also, these projects are not at all contributing to improving agricultural practices in the region and making them more sustainable as part of a larger sustainability goal. It has been argued that bioenergy production would have only limited environmental gains, unless an integrated approach is developed and green energy production is combined with initiation of sustainable agriculture practices in terms of land, water and resource use (Saeed and Kaveh, 2015). This is especially true in case of Punjab, as Punjabi agriculture is currently dominated by unsustainable cultivation practices, which have rapidly destroyed the natural resource base of the economy, as illustrated in Chapter 6. Many farmers appeared to be disillusioned with the current agronomic practices but did not have an alternative.

"The fertilisers and pesticides sold in the market are sub-standard. Over the years they have made our soils infertile. I have to apply fertilisers in large quantities to make crops grow. I do not have much knowledge about the exact amount of fertilisers the crops needs and I often just follow my neighbour. I want to move towards natural inputs but don't have any information on how to go about it" (Interviewee Nirmal Singh, Rauni, Ropar, July 3, 2015).

To sum up the section, green energy projects have initiated the development of a new form of agro-industry in the state and also opened up opportunities to existing rice and sugar mills to capitalise on these developments. They represent a positive development for a province like Punjab, which has been trapped in an unsustainable rural development trajectory. However, the field investigation and interviews point to major weaknesses in the policy initiatives, its design and conceptualisation. The outcome is that overall the projects suffer both on account of weak sustainability approach to bioenergy projects and the absence of a supportive institutional framework. At the firm level, we find that projects fail to be economically viable due to four main reasons 1) lack of indigenous technology 2) lack of planning and needs assessment 3) lack of in-house training and 4) lack of back-end support and maintenance networks in bioenergy developments. Some firms, for example, agro company LEAF, has overcome these constraints by relying on foreign experts and technology, the other two case study projects (new entrants in the field) continue to suffer the internal mismanagement and larger policy related disadvantages. As the fieldwork revealed, they struggled with the supply of inferior technology and lack of institutional support. The interviewees revealed that the same fate had met a number of other bioenergy projects in the state as well.

In mainstream analysis, some of these problems are treated as a case of corporate fraud, mismanagement, and misuse of resources. However, an eco-socialist perspective enabled me to work from the "chain of evidence" established in the research, to demonstrate that the 'top down' policy framework had been set without considering the local resource conditions, including the availability of local technical expertise, infrastructure and technological and R&D potential. The policy was implemented by assigning a lead role to private industry through heavy subsidies, tax concessions and other favourable policy sops such as land use change permissions.[70] The private industry was also allowed to operate without environmental regulations as the fieldwork revealed. The state decided to look the other way as the firms were left free to let out polluting smoke in the environment while producing 'green energy'. There has been no state attempt to develop and encourage indigenous bioenergy technologies despite the euphoria created around green energy projects. The state continues to rely on technical experts from outside for the installation of plants and post installation maintenance. These factors have greatly compromised the viability and operational efficiency of the projects.

Most importantly, the bioenergy developments are taking place as stand-alone projects, without developing the necessary inter linkages between the bioenergy sector and the agricultural sector. But in this context the experience in Punjab is not unique. Many other countries' experienced similar limitations. Literature suggests that a large number of bioenergy projects in developing regions across Asia and Africa have failed due to similar reasons, namely, linking the projects with the development model, and inadequate planning and assessment of local conditions, where these are to be set up (Ariza-Montobbio et al, 2010; Baka, 2014). Eco-socialism provides a lens to look at these projects, as systemic failures, where in the macro development aspects with respect to policy, resource availability and technology use in the regional economy have failed to be considered in bioenergy developments.

Secondly, it was demonstrated that on social and ecological sustainability, the outcomes are at best fair or poor. The concerns of farmers with respect to minimum support price for feed stock, a fair payment cycle, wages and employment opportunities for women have not been addressed by these green energy projects. These outcomes reinforce the findings from document analysis i.e. the policy framework on bioenergy has been systematically designed as a business proposition to favour business interests and create a green energy market, without any

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[70] According to Punjab government's own laws, irrigated, fertile, multi-crop yielding land cannot be acquired for industrial purposes without the consent of the farmers and social impact assessments. This has proven to be a major cause of conflict between industry and farmers and often lead to stalling of projects because the farmers are not willing to let their land go. So far, if the government gives permission for "land use change", it is a major concession for the industry.

consideration for the vulnerable sections of the rural community. The nature of green energy policies is top down, which does not incorporate the voices of the vulnerable communities.

Further, the poor working conditions and poor wages in bioenergy projects in Punjab are reflective of the larger changes in the Indian industry, where labour laws and regulations are being systematically diluted in order to increase industrial competitiveness. This phenomena has been termed as "reforms by stealth" (Sood et al, 2014). These reforms have manifested in the form of increasing casualization of labour, a weak labour welfare regime and reduced collective bargaining power of trade unions to negotiate on wages and employment conditions in the industrial sector (Sood et al, 2014).

Thirdly, the failure of biomass companies to adhere to environmental best practices and adopt environmentally friendly technology as described in the previous section is rooted in the phenomena of "regulatory chills". There has been increasing deregulation of environmental regulations to favour business interests, especially with respect to monitoring of pollution levels by industry. The evidence from the fieldwork reinforced the analysis from the policy documents. These green energy initiatives are primarily aimed at reviving growth through creation of a profitable green market in Punjab. Environment and social and economic sustainability are being treated in separate silos. As a result there has been no attempt to integrate the social, economic and ecological aspects of green energy developments. The policy prerogative of both the government and the bioenergy producers in the state is profitability, although they claim to have ecological and societal motives as well. Due to increasing deregulation of the Indian industrial sector, with respect to environmental and labour norms, these projects have failed to follow environmental best practices and labour norms. On the contrary they have exhibited exploitative tendencies towards local people and adopted environmentally harmful techniques of production.

The empirical evidence gathered through the fieldwork thus raises serious questions on the "pro-poor" and "pro-environment" focus of green energy projects as is claimed in the policy documents (NRSEP, 2012). The findings echo the concerns raised by eco-socialists that the imperatives of profitability of green capitalist bioenergy reforms are essentially at odds with the prerogatives of poverty reduction, rural development and environmental protection, as is being claimed. A green capitalist strategy fails to see that renewable energy development is not removed from other socio-economic and ecological concerns afflicting the region. Such a reductionist approach to green energy developments in Punjab has also affected the viability and long-term sustainability of these projects while undermining the confidence and support of the local community in these initiatives.

7.6 Bioenergy Initiatives in Punjab's Rural Community

Besides the mainstream bioenergy projects, a number of community and religious organisations in the state are promoting renewables through small-scale local level initiatives but which have not been studied systematically. Although the size of these initiatives is small, these reflect communities' awareness about deteriorating environmental conditions with consequent health, nutrition and livelihoods concerns, the energy poverty as well as their desire for a more sustainable living.

7.6.1 Community based bioenergy initiatives in Punjab

A major part of these developments comprises of the initiatives by religious, especially Sikh religious institutions, which point to the rising environmental consciousness within Sikhism, the dominant religion in Punjab.[71] Interestingly, this green turn within Sikhism is in consonance with global developments where in major religions of the world are increasingly engaging in the ecological discourse by reinterpreting religious texts in the light of the current ecological crisis (Bauman et al, 2011: 59). In 2003, *Akal Takht,* the highest temporal authority of the Sikh religion joined the Alliance for Religion and Conservation (ARC), created by the World Bank (Prill, 2015). The ARC brought together leaders from eleven major world religions as partners in developing global environment programmes

Following this, many Sikh temples launched a grass root level "Green *Gurudwara*"

[71] 57.69 percent of the population of Punjab identify themselves as Sikh (Census of India, 2011).

movement to reduce their environmental footprint, through preparation of organic food in the community kitchens, planting trees, recycling waste and participating in renewable energy projects (Own observations and field interviews). Green energy initiatives are a major focus of this programme. Since 2012, the Golden Temple in Amritsar, the holiest shrine of the Sikhs has begun to be powered through solar energy for cooking in the community kitchen (Hindustan Times, 2012). The Temple feeds upto a 100,000 every day[72]

A number of smaller *gurudwaras* in the state are also taking part in these imperatives. Baba Deep Singh *Gurudwara,* located on the Chandigarh-Ropar highway, one of the busiest roads in the state runs a 24-hour community kitchen, which serves food to about 5000 people per day (own field observations and interviews). Since 2013, this *Gurudwara* is running its community kitchen through solar energy by installing a 2.5-kilowatt solar photovoltaic panel (SPV):

"We installed a solar power plant in March 2013 on the rooftop of the langar hall (community kitchen). Since then we completely depend upon solar energy to meet our cooking needs in summers, while in winter we use a mix of LPG stoves, fuel wood and solar energy. Solar energy has brought down our fuel costs by almost 500,000 rupees per year and enabled us to cut down on smoke and emissions from burning wood" (Interviewee Baba Saroop Singh, patron of the Baba Deep Singh Gurudwara, July 8, 2015).

Plate 7.3: Solar photovoltaic plant installed at Baba Deep Singh *Gurudwara*, Village Solakhian, Chandigarh-Ropar Highway

72 https://www.aljazeera.com/indepth/inpictures/2013/11/pictures-kitchen-feeds-100000-daily-2013111712423829339 6.html

Source: Own compilation, July 2015

However, solar energy is still in the burgeoning stage of development across India. Numerous problems have been identified with solar energy projects operating in different parts of India-high costs, inadequate post-maintenance provisions, lack of incentives, insufficient provision of use subsidies and lack of affordability characterise solar energy projects, operating in different parts of India (Kapoor and Dwivedi, 2017; Kasturi, 2017). The *Gurudwara* management echoed similar concerns as well

"We had to spend 650,000 rupees on the solar power plant. We received a subsidy of only 10,000 rupees from the government after a year. The plant requires frequent maintenance, which the company Azure power does not provide. Mostly, we have to depend on local mechanics in case of any repairs. There are very few suppliers in the region. Whenever there is a fault in the plant, it takes a long time to rectify" (Interviewee Mr Dharamveer Singh, Adminstrator, Baba Deep Singh Gurudwara, July 8, 2015).

So while there is awareness and commitment to clean energy, cutting down smoke, the constraints of lack of institutional support and technology are debilitating for community initiatives as well.

Sant Balbir Singh Seechewal, one of the icons of environmental advocacy in India[73] launched a novel bioenergy initiative in the Seechewal Gurudwara in 2007. This initiative began to shape when the *Gurudwara* was faced with the problem of waste disposal in the community kitchen, as well as rising fuel costs. The project was

[73] In 2008, Time Magazine named Sant Seechewal as one of the "Heroes of the Environment" for his work in cleaning up a river through voluntary service.

designed and implemented entirely by Sant Seechewal himself, without the help of any external/ government institutions (field interviews, May 2016).

"We designed a 13 cubic metre biogas stove, employing kitchen wastes and scraps as feedstock. The biogas stove has pipelines connected to the main kitchen and the gas generated is used for cooking and heating purposes in the kitchen. This biogas stove fulfils all the cooking needs in the community kitchen in the Gurudwara and we do not have to depend on any other energy sources such as LPG cylinder or wood fuel" (Interviewee Sant Sukhjit Singh, May 26, 2016).

Plate 7.4: Biogas stove based on kitchen scraps, Village Seechewal, Jalandhar

Source: Own Compilation, May 2016

Taking example from Sant Seechewal, other major *Gurudwaras* in the state, such as the Golden Temple have also introduced plans to set up biogas stoves, based on vegetable scraps to run the community kitchen (The Tribune, 2016). My field visit to the Golden Temple revealed that efforts are underway to set up a large biogas plant in the *langar* hall of the *Gurudwara.* This project will be one of the largest community biogas initiatives in the state. It is being set up with a capital expenditure of INR 80,00,000. The biogas stove will help to fulfil the cooking needs of over 100,000 pilgrims who eat *langar* in the *Gurudwara* everyday (Own observations and field interviews, July 2016).

Similarly, *Pingalwara*[74], the well-known destitute home in the city of Amritsar, which is home to over a thousand destitutes, also installed a community biogas stove

[74] *Pingalwara* was set up in 1957 by Bhagat Puran Singh in Amritsar and is known for its work with the poor and individuals with mental/physical disabilities. The organisation also has a strong environmental advocacy focus. The *Pingalwara* has set up an organic farm in Dhirekot near Amritsar. The organisation also launches tree plantation drives every year and educates local farmers in natural farming practices.

in 2007. However, the project did not take off successfully.

"We installed a biogas stove. The stove was donated to us by a private individual in charity. However, the biogas stove was too small and could not fulfil the cooking needs in our community kitchen. Also we did not have enough infrastructure and personnel for regular maintenance and cleaning up of the stove. We also tried to experiment with solar energy and installed a SPV panel. Here, again the project failed due to lack of maintenance and repair networks in the region. We are very keen to invest in renewable energy, but so far are efforts have not borne fruit." (Interviewee Dr. Inderjit Kaur, Director, All India Pingalwara Charitable Society, July 30, 3016).

However, the community initiatives are not limited to religious organisations only. There are also some other examples of promoting renewable energy initiatives in the state where the motivation is community betterment and progress. One of the most prominent of these initiatives, which received widespread media attention (Hindustan Times, 2015a; The Tribune, 2016 a) is a community biogas stove, installed by a large private dairy, RS farms, in their native village Bahadurpur in Ropar district of Punjab. This community initiative provides free biogas to 75 households in this small village. This biomass-stove project provides free biogas to both upper caste farming households as well as the lower caste agricultural labour households within the village. Mr Balvir Singh, the owner of the dairy stated that the motivation for the project came to him from the belief that "we should all be stakeholders and work for the greater good of the community." He also gave a detailed description of his initiative:

"We have a large dairy comprising of 150 milking cows. Disposing off cow dung was a huge problem for us. At the same time many villagers faced difficulty in obtaining fuel and had to travel nearly 20 miles to the nearest town to purchase subsidized LPG cylinders from the nearby town. To solve both these problems, we designed a large 20 cubic meter biogas stove in the dairy with a capital outlay of 50,000 rupees. This stove was connected to all the households in the village through stainless steel pipelines. The villagers were each asked to pay 100 rupees to maintain the pipeline. Since then biogas is being supplied 24 hours in the villages and contributes to all the cooking needs of the village households" (Interviewee Balvir Singh, Owner RS Farms, May 16, 2016).

Plate 7.5: Community biogas stove installed by the RS farms, Bahadurpur, Ropar

Source: Own Compilation, May 2016

These community initiatives for promotion of renewable energy in the state illustrate the aspirations of the Punjabi community for sustainable living, and their capacity to adopt new innovations, which has been widely documented in literature (Singh et al, 2014:4). All these organisations and individuals are promoting renewable energy through an innovative approach, based on community awareness, common ownership, fairer distribution, the use of local resources and sustainability. From an eco-socialist perspective, these initiatives point to significant, nascent trends in Punjab. They point to the possibility of forming coalitions between environmentally conscious individuals, grass-root level organisations and community leaders for decentralised sustainable solutions. Eco-socialists believe that such coalitions are possible and fundamental for creating a sustainable development discourse, rooted in participatory democracy and equitable distribution of natural resources.

If we look at literature, some studies have previously investigated how environmental consciousness in society can be altered by drawing on the notions of “altruism” and “fairness” exhibited by some individuals such as the owners of RS farms (Fehr and Schmidt, 2005). These studies have analysed how differences in the notions of “fairness” and collective risk from environmental damage influence how individuals co-ordinate and prevent environmental damage (Milinski et al, 2008; Brekke and Johanson-Strenmen, 2008). According to OECD (2012), the insights from behavioural economics were also instructive in looking in to alternative policy designs in environmental policy. This literature has shown how small "nudges" such as provision of incentives can work to ensure formation of voluntary stakeholder groups so that broad support can be created in areas pertaining to management of natural resources. The literature has contributed to the debates on understanding of 'what works' to change norms for better environmental consciousness.

Behavioural economic literature has thus contributed to expanding the environmental discourse, beyond the neo-classical paradigm of "rationality." Insights from these studies are crucial in understanding the behavioural motivation behind individual and collective action in support of environmental projects. Eco-socialist recognise the role of individuals in environmental prerogatives. However, they believe that these individuals/ community based initiatives also display an alternative macro-structural approach to environmental imperatives, which need to be factored in. In this thesis we have looked at individual/community initiatives from a macro-structural perspective, where in the questions of environmental justice are crucial to understanding the initiatives. Sant Seechewal's initiative for example, can be seen as an example of individual initiative but if we look at the history of his initiative, we will see it also has a macro/legal context. Seechewal's initiative built on a legal case in the Punjab Haryana High Court[75], seeking intervention of the Court to save the Budha Nullah from environmental pollution created by industries in Ludhiana and ensure public health and safety by stopping the contamination of water. The High Court passed an order asking the Punjab Pollution Control Board's (PPCB) to intervene to stop the industries from polluting the *nullah*. However, the PPCB failed to act or reign-in the powerful industry lobby in Ludhiana at which point Seechewal initiated a campaign for justice for local people, generating awareness to solve the problem of desilting the water body for the sake of common people's health.

Eco-socialists believe that considerations of environmental justice (inequity in resource distribution and voice in environmental decision making processes) and how certain socio-economic groups have historically had access to better choice

[75] http://www.ppcb.gov.in/Attachments/Legal%20Matters/BudhaNallahNirbhai.pdf

architecture[76] as compared to other socio-economic groups need to be factored in individual environmental decision making (Demeritt and Hoff, 2018). For instance a recent study, based on World Bank data drawn from 38 countries showed that individual environmental values are correlated with the overall economic development in the nation. The study found evidence of greater ecological consciousness in developed nations, as compared to developing countries (Givens and Jorgensen, 2011). Thus, these studies show that environmental decision-making is attributed both to individual behaviour as well as the social context. In this context, Demeritt and Hoff (2018) conclude, "If the choice architecture embedded in our institutions systematically advances privileged groups over the poor and socially excluded, we must consider not only whether or not to nudge, but whether nudges are fairly allocated." Additionally, there also remains difficulty in aggregating behaviour insights from individuals belonging to different socio-economic groups and seeing how they come to define common social norms.

The environmental justice consideration emerged as one of the central explanatory variables for failure of bioenergy policies in Punjab in my research. All the community players interviewed in the course of the project stated that they have been unable to mobilise wider support for renewable energy, primarily because it requires huge investment and is unaffordable by a large section of the population and the state support and incentives are few and far between. Resource constraint also emerged as a primary reason for the failure of the household bioenergy stove scheme of the state government as described in the next section. In contrast, individuals like RS farms, and big gurudwaras like Golden Temple have created inclusive green energy projects in the state. These projects have shown that egalitarian institutional structures and community ownership practices, based on local inputs and technology can be created in rural Punjab. For instance Sant Seechewal's model of bioenergy development based on kitchen scraps (also being replicated by a number of other Gurudwaras), or the RS farm's model of large dairy farmers developing community green energy projects can be adapted by village councils. Recently, the RS Farms model has begun to be adapted by some other villages as well. For instance, the Lambra Co-operative Society in village Lambra in Hoshiarpur district of Punjab recently secured

[76] A social and institutional context that encourages individuals to make better environmental decisions.

a financial grant of Rs 200,000 from the Ministry of New and Renewable Energy, New Delhi and set up a community biogas plant in the village commons through technical support from Punjab State Agricultural University, Ludhiana (Pal, 2018) Other village councils in Channuwal and Badhni Kalan have also put forth proposals to set up community based biogas initiatives in their villages (Pal, 2018).

Such community based projects can help us to think through new and innovative decentralised models to transition to clean energy alternative in the state. It is also clear that while some of the bigger initiatives have been able to overcome the various constraints because of their access to large resources, the resource-strapped Pingalwara failed to take off, pointing to the need for state institutional support. Also, within a green capitalist framework, these projects, though significant remain small, stand-alone efforts by community organisations and individuals being led purely on their own initiative with limited amount of resources. They are not recognised as stakeholders by the government. In contrast, eco-socialism provided me a window to analyse that if the state policy recognises the importance of stakeholders on the ground, develops appropriate incentives and a “bottoms up” policy design with an active partnerships with individuals and communities, there is a better chance of developing sustainable options and overcoming problems of energy poverty widely prevalent among vulnerable groups in rural Punjab.

The other major aspect of the community experience is the use of bioenergy in the rural households. This is discussed below in the second part of this section. The fieldwork involved assessing how the clean energy needs of the poor rural community were met through household biogas initiatives of the state government. This was done through focus group discussions with men and women in two different villages of Punjab.

7.6.2 Bioenergy and household energy aspirations in rural Punjab

A major prerogative of bioenergy policies in Punjab is to enable rural households in the state to make a transformation to “clean” bioenergy sources. Punjab is one of the few states of India, which is fully electrified and even the remotest of villages have access to electricity[77] (NFHS-4). Despite these factors, a large section of the rural population continues to depend on biomass energy sources such as firewood, biogas and cow dung for their household energy needs, as shown in table 7.7 below. While the proportion of households using LPG for cooking has increased slowly from merely 10.63 per cent in 1987-88 per cent to 47.35 per cent in 2011-12, the proportion of households using traditional biomass sources such as firewood (24.45 per cent), cow dung (22.12 per cent), biogas (2.97 per cent), and kerosene (2.31 per cent) still remains substantial. This phenomenon has been documented in literature as "fuel stacking" (Heltberg, 2004). Instead of climbing up the "energy ladder"[78] and switching to modern sources of energy, households continue to rely on a mix of modern and traditional sources of energy (Pachauri and Ziang, 2008; Bhide and Monroy, 2011).

Table 7.5 : Primary sources of energy employed in rural househols (%) in Punjab across time						
Year	**Coal**	**Firewood**	**LPG**	**Biogas**	**Cow dung**	**Kerosene**
1987-88	1.15	35.48	10.63	0.29	40.08	10.80
1993-94	2	34.70	17.50	0.10	34.80	8.30
1999-2000	0.22	27.84	27.29	0.54	29.07	10.19
2004-05	0.13	27.50	38.50	2.60	28.60	6.70
2011-2012	0.07	24.45	47.35	2.97	22.12	2.31
Source: Compiled from NSSO (1993-94, 1999-2000, 2004-05 and 2011-12)						

Some studies propose that with high rates of electrification and higher income levels, households move to cleaner energy sources (Srivastava et al, 2012; Lambe and Atteridge, 2013). This also holds true in the case of Punjab. The analysis reveals that the richer households in the income quartiles Q4 and Q5 have progressively switched over to the LPG as their main source of fuel and their reliance on traditional biomass sources (coal, firewood, dung cakes and kerosene) has systematically declined over the years (Table 7.8 below). On the other hand a majority of poorer

[77] The percentage of electrified households in Punjab is estimated at 99.4 percent (NFHS-4).

[78] The energy ladder hypothesis states that rural households transition to modern sources of energy in 3 phases. In the first phase households rely on traditional biomass. In the second phase they transition to fuels such as kerosene, coal and charcoal and in the final phase they move to fuels such as LPG and electricity for household use (Heltberg, 2004: 870).

households in the income quartiles (Q1 and Q2) still continue to rely on traditional biomass resources (firewood, dung cake and biogas). These poor households have transitioned to modern sources of energy to a much smaller extent, as compared to the households in the higher income groups. This table thus shows that energy poverty in rural Punjab is staked against the poorer households.

Table 7.6: Household energy consumption by income groups

1987-88					
Fuel	Q1	Q2	Q3	Q4	Q5
Coal	0.28	0.28	1.02	1.68	1.06
Firewood	41.89	36.13	40.85	37.66	31.29
LPG		0.64	2.76	8.68	17.81
Biogas		0.47	0.17	0.12	0.43
Dung Cake	48.11	55.79	46.77	39.58	34.09
Kerosene	5.57	5.62	6.15	11.18	13.76
1999-2000					
Fuel	Q1	Q2	Q3	Q4	Q5
Coal	-	0.11		0.11	0.29
Firewood	57.01	36.48	31.93	29.82	21.77
LPG	3.57	6.96	11.02	18.66	44.61
Biogas		0.56	0.44	0.56	0.59
Dung Cake	26.42	41.13	36.67	32.27	21.14
Kerosene	8.57	7.27	13.14	11.73	8.57
2011-12					
Fuel	Q1	Q2	Q3	Q4	Q5
Coal			0.13	0.16	
Firewood	52.77	41.95	31.10	22.45	11.93
LPG	10.39	24.03	33.23	53.16	64.73
Biogas			0.07	1.05	1.97
Dung Cake	31.76	27.29	28.67	19.08	17.32
Kerosene	1	3.57	3.08	2.76	1.18

Source: Self- Compiled from unit record data of NSSO Energy Sources of Indian Households for Cooking and Lighting, 2011-12, 1999-2000 and 1987-88

Biomass use within the household is associated with a number of health and ecological hazards (Lambe and Atteridge, 2013). In view of this, the Punjab government is promising to help rural households to transition to modern bioenergy through installation of bioenergy stoves across the state under the National Biomass Cooked Stove Initiative (MNRE, 2009). A senior official of PEDA made the following remarks, when questioned about the state's strategy to transition to clean sources of energy for household use:

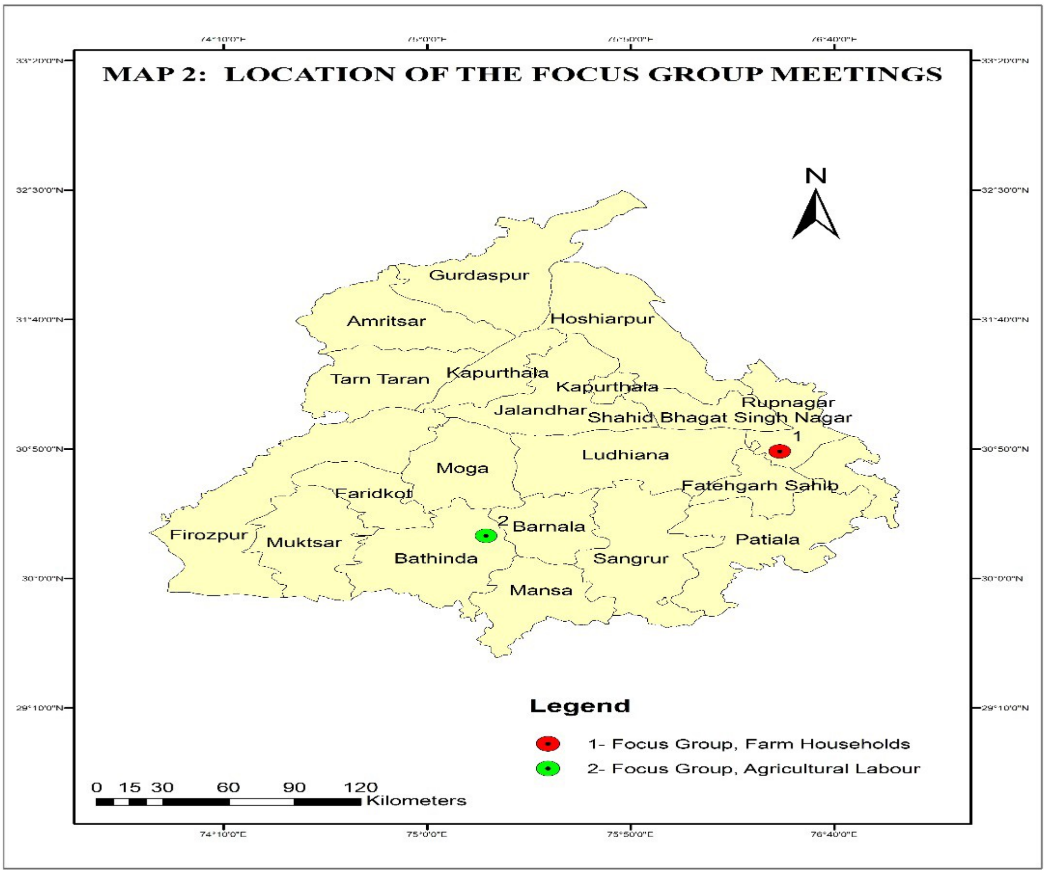
"We recognise that a large section of rural Punjab burns traditional biomass in the household, and will continue to do so in future. Instead of using biomass in the currently inefficient and environmentally damaging way we are attempting to help households to transition to more clean and efficient use of bioenergy through installation of biomass cooking stoves. These cooking stoves provide both economic benefits and saving in fuel wood. These are provided at a highly subsidised rate so that they are affordable by all sections. So far 160, 000 stoves have been installed across the state" (Interviewee Government Official 3, June 2, 2016).

This model of installing bioenergy stoves, as a means to shift to clean energy sources is being implemented across different regions of India. However, these stoves have had only limited penetration in rural India so far (Srivastava et al, 2010). There has been no systematic evaluation of outcomes of the scheme. The few studies that have been conducted are based on large scale government survey data. These studies have evaluated the efficacy of this biogas scheme on purely technical grounds, on the basis of their energy efficiency and energy returns to the household (Kishore and Ramana, 2002; TERI, 2010, Shrimali et al, 2011, Lambe and Atteridge, 2013; Khandelwala et al, 2017). But there continues to be a gap in terms of understanding of the social and economic factors which influence a household's energy choices and how far does bioenergy fulfil aspirations of rural households as end users of energy, especially for those at the bottom of the energy ladder. In this research I have attempted to fulfil this gap in knowledge by gauging the perspective of rural residents on the issue, focussing on their household energy requirements, their perceptions, the trade-offs they face in their decision making process and factors that compel them to make their household energy choices. I used focus group discussions in two villages to obtain insights on these questions. The description and composition of the focus groups have been elaborated upon in the methodology chapter. I conducted four focus groups across two villages in Punjab - Rauni and Kotra Kaurewala among different socio-economic groups (Map 2, below). This exercise enabled me to understand both the common challenges and the caste, class and gender differentiated experience of the communities about their energy choices, needs and aspirations.

Plate 7.6: A focus group meeting in place with male participants in village Rauni

Source: Self-Compilation, January 2016

Map 2: Location of the Focus Group Meetings



Source: Self Compilation based on Arc-GIS software

Main Findings from the Focus Groups

i) Energy Choices of the Farmer Households

Participants in both the villages- Rauni and Kotra Kaurewala used a mix of energy sources for their household fuel use. However, the pattern of fuel consumption in the two villages differed. In Rauni the middle income farming households employed a mix of LPG and biogas cooking stoves for meeting household energy needs. These households previously used a mix of cow dung cakes and fuelwood for cooking in the household. However, a majority of the participants stated that they rarely used these traditional sources of biomass energy now. When asked to elucidate on the factors which compelled them to move away from traditional biomass, the key factors which emerged from the discussion were that it was time consuming to gather cowdung and prepare dung cakes at home, difficult to collect fuelwood, generated indoor smoke and was inconvenient to burn as a fuel at home. Some of the key insights from the discussion are presented in Table 7.9.

Table 7.7 Key factors which prompted households to move away from biomass energy	
Key factor	**Illustrative Quotations**
Time consuming	*"It took five to ten days to prepare cow dung cakes every month. The wet dung had to be gathered, shaped into cakes and then left to dry for five to seven days before it could be used"* *"Cooking roti (flat bread) on open fire used to take a long time"*
Difficult to collect	*"We used to cut branches of trees from the village common land and burn them. But lately forest officials have become stricter. A fine may be imposed if caught cutting a tree."*
Pollution/ Inconvenience to use	*"Burning cow dung cake on an open fire, generated huge amount of smoke. I used to cough all the time"* *"When cooking with fuelwood on open fire heat fell directly on my face"* *"Soot accumulated on the utensils when these were burned on an open fire."*
Source: Self Compilation	

ii) Bioenergy in the Household Energy Matrix of Farm Households

Six out of the eight households had a biomass cooking stove installed in the household between the years 2010-11. Peer reference and word of mouth had been the primary motivating factor behind households installing these stoves. All the women participants unanimously expressed satisfaction with the current fuel combination based on biogas and LPG cooking stove. This also reflects how time poverty, as a result of inefficient and hazardous fuel combinations for cooking is a real issue for women but remains an unrecognised element in dominant policy discourse. Some of the insights from women participants are presented below:

"I do not have to spend time, preparing cow dung cakes for items which require slow cooking such as spinach"

"Biogas stove is connected through a pipeline to our two-burner cook stove, we can increase or decrease flame as required"

"I do not have to cook with smoke around me"

"Time spent collecting wood and preparing cow dung cake is reduced sufficiently"

While most women regarded biogas and LPG as equally good in terms of ease of cooking, bioenergy was preferred because it led to considerable saving in household fuel costs.

"Earlier we used to purchase LPG cylinder every month at 500 rupees. Since installing the biomass stove our fuel costs have almost come down to zero. We keep a spare cylinder but do not have to purchase a cylinder every month"

The male focus group participants also regarded saving in fuel costs and time as the main advantage behind installation of the biogas stove. Since there is no gas agency in the village, an LPG cylinder cannot be purchased in the village. Rural residents had to spend many hours in travelling 20-25 miles to the nearby town every month for purchasing the cylinder.

"I had to travel every month to Chandigarh to purchase the stove and stand in queue all day at the ration shop."

"I save 500 rupees per month on LPG cylinder plus 100 rupees on diesel costs every month."

However, some of the male participants also shared important insights on the viability about the biomass stove for different socio-economic segments of society. One participant stated that it was a viable option for only those households which had at least 5-6 cattle head as it required about 50 kg cow dung to operate daily. This was also confirmed by the description of the scheme on the PEDA website, which states that:

"A medium sized biogas stove, suitable for a family of six necessitates 45-50 kg of organic matter daily, which requires the household to possess at least 4-6 cattle" (PEDA, 2016).

Another participant stated that after he sold off two of his cattle the feedstock became increasingly insufficient for the stove and he had to now purchase cow dung from other farmers in the village, which comes up to 200-250 rupees per month. Two of the participants also complained that biogas stoves took away from competitive uses of cow dung, such as organic manure in the fields for which they employed it earlier. Another major complaint of men was that they had to spend considerable amount of time in operating the stove and keeping it functional

"I have to wheel the stove for two hours every day to ensure that sufficient gas is generated for using at home"

"The plant has to be plastered every couple of years"

"The gas pipeline has to be cleaned regularly or else it will clog."

My own observations of these biogas stoves found that biomass stoves were far from environmentally friendly, as is being claimed. They were dug in open pits and were frequented by flies, especially during the hot summer months. They generated foul smell and generated huge quantity of churned out cow dung. Most people are therefore forced to install it in their fields or land adjoining the house. Also the person operating the stove had to operate it manually and was highly exposed to a number of water borne diseases and infections (Plate 7.7 below).

Plate 7.7: A farmer operating a biogas stove outside his house

Source: Self Compilation, June 2015

iii) Cost Comparisons: Biomass stoves and other alternatives

All the focus group participants unanimously agreed that it was a big investment to install the biogas stove. While the initial cost came out to 40,000 rupees for participants who had installed it in 2010-11, households who had recently installed the stove had paid as much as 50,000 rupees. Most of these participants however, indicated their willingness to pay for the stove. This was reiterated by my own observations of the living conditions of the participants. They considered it a useful purchase as it helped to generate lifetime savings in fuel costs, in comparison to both LPG and traditional biomass energy sources.

Although, the government claims to give a subsidy on the biogas stove; many participants expressed dissatisfaction with the subsidy scheme of the government

"The subsidy amount is only 7000 rupees which contributes to almost nothing"

"I had to wait for almost a year to get the subsidy."

"There are a number of conditions involved. I had to get a certificate from the panchayat [village council], get a receipt signed from the local mason installing the stove, take photos of the stove as proof and have a witness sign. On top of this I had to travel to the town to get the paperwork authorised. After all this the subsidy amount is nothing. It is simply not worth the effort."

Thus, from my own observations and focus group meetings I was able to gauge that the biogas stove scheme of the government has enabled comparatively well off farmers to make a transition to modern bioenergy, away from the traditional biomass they burned earlier. These stoves offer considerable advantage in terms of time, reducing the drudgery of rural woman in fuel collection and preparation and helped to curb indoor pollution and smoke as well. However, the nature of the scheme is such that it excludes a large section of the population, who does not have sufficient number of cattle or resources to get the stove installed.

iv) Energy Choices of Farm Labour Households

The farm labour households were completely dependent upon traditional biomass for their household energy needs. Their main source of energy was cow dung, followed by burning of twigs and fuel wood. Many participants revealed dissatisfaction with these energy choices and said that it was becoming more and more difficult to procure firewood recently.

"Earlier farmers for whom I work allowed me to cut branches and twigs from trees grown in their fields but not anymore."

"The government has made it illegal to cut trees grown in village commons. The guard chases us away"

"It is not possible to cut large branches of the tree. We can only get small twigs"

"We have only been able to cut wood from pahari kikkar (a locally grown, thorny tree). It is full of thorns and it's very difficult to separate branches from it for pruning"

As for cow dung, none of these households had any cattle of their own. So they had to purchase cow dung pads from dairy owners in the village. They had to spend 200-300 rupees on dung pads every month. One participant stated

"I work with a dairy farmer. Earlier he used to give me cow dung for free in return for working with him. But it is not so now. I make dung cakes for him. He keeps half of them and sells the other half to me at 5 rupees per cake."

A couple of participants stated that earlier cotton straw was the main fuel, which they burnt at home but due to the widespread cotton crop failure in the past years, with the whitefly infestation, this is no longer available to them.

"We used to get work for 15-20 days in the field of cotton farmers every month and collect cotton straw from the fields. We used to burn it as fuel in the household. Since the past few years cotton crop has failed. Not only has our main livelihood suffered, we have also lost our main source of fuel"

Plate 7.8 : A young farm labourer preparing cow dung cakes

Source: Own Compilation, July 2016

v) Perceptions about biomass energy among farm labour households

The focus group participants in this group too did not consider burning biomass as an ideal source of energy. They were aware of the ill effects of burning biomass and desired to burn a fuel which produced less smoke. Many participants also complained of a number of health ailments, which they linked to burning biomass at home:

"My son coughs a lot when I burn the stove"

"I have been suffering from headaches and my eyes water while cooking"

Another major concern for this group was the safety of women, especially young girls when they venture out to collect fuelwood. For instance one male participant stated

"There have been a number of incidents of abduction and rape in the region in the past year. I fear for my daughters' safety and I go with them to collect fuelwood, even though it compromises on my work time."

Poor women's sexual safety and bodily integrity in rural areas has been a neglected issue in policy and dominant discussions which is only beginning to be recognised now (Singh 2016). In my field discussions this topic came up several times especially in relation to collecting fuelwood.

Plate 7.9: Farm labour women burning twigs and wood on an open fire

Source: Self Compilation, May 2015

vi) **Use of modern energy in the household energy mix**

All the focus group participants in this group had heard of the biomass energy stoves. However, it was not a viable energy alternative for them, given the high cost of the stove and the operational expenses.

"We cannot afford to pay 50000 rupees, just for a stove."

"My house is not large enough to install the stove in. I do not have any land of my own"

"I do not have any cattle of my own. I will have to purchase cow dung from farmers in the village. This will add up to the costs."

Almost all the participants had an LPG gas connection and occasionally purchased a gas cylinder from the nearby town. But LPG was not used regularly in the household.

"There is no gas agency in the village. I have to travel 25 miles to the nearby town to purchase a gas cylinder."

"The cost of the cylinder is 560 rupees. It is not always possible to purchase it. I only purchase it if I have made sufficient money in the past month."

A couple of participants also admitted that they had resorted to power theft during cash shortages.

"Work is hard to find and sometimes I get employed for only 8-10 days in a month. During such times we hook on to the main line through kundis. [79]This tides us for about a week."

Plate 7.10 : A household using a *kundi* (hook) **connection at home**

Source: Own Compilation, June 2016

In sum, the focus group discussions were revealing and exposed many fault lines of the bioenergy debate along class, caste and gender lines. From the two sets of focus groups one may conclude that as per the policy claim, the installation of biomass stoves is a positive step in enabling rural households to transition to more efficient use of bioenergy. It enables rural households to save on fuel costs, reduces the time associated with collecting fuel and preparing food, minimises the harmful effects on

[79] *Kundi* is a colloquial word for power theft in Punjab. Households hook on to the main electricity line in the village and steal electricity.

health and significantly addresses the ecological hazards associated with burning traditional biomass. On the surface, this scheme also seems to fulfil the objective in terms of "mitigating the drudgery of rural women in fuel collection."

However, an eco-socialist lens enabled me to analyse these policies at a deeper level and see the class bias was inherent in the design of biogas stove initiatives. This policy was essentially targeted at the better endowed sections of the rural population, while leaving out the vulnerable groups. Although, the scheme has helped middle income farmers to transition to modern bioenergy, it has failed to consider the resource constraint faced by small farmers and landless who do not own adequate cattle or capital. Within a green capitalist debate, the caste based inequities and the fact 86 percent of SC (agricultural households) are landless and therefore are excluded from the biomass stoves has not even been considered. With stagnation in agriculture in Punjab, access to traditional biomass sources of energy of the rural landless is dwindling rapidly, while the modern sources of energy are not affordable by them. As a result this group is trapped in a vicious cycle of energy poverty, alongside the resource poverty. The gender dimensions of energy poverty are not even being considered by the policy making process as poor women's drudgery and their long hours of labour to collect fuel wood continues.

The second major weakness of this policy is its flawed design and poor implementation with regard to the incentives, especially the subsidies. The policy promises to cover 50 per cent of the installation costs, however, the field reports suggest that costs of installation are undervalued in government documents, making the size of subsidy smaller (33 percent) and even this amount is difficult to get because of the winding bureaucratic processes. This weak subsidy regime seems to function as a major discouragement for households to install the stove. Again, the subsidy regime has considered rural Punjab to be a homogenous entity and have not taken account of the fact that different groups in rural Punjab (agricultural labour versus landed households) have differential capacity to pay.

The third major concern with the biogas stove initiative is that even though biogas is being promoted as a "clean" fuel, this is not entirely true. While it helps to reduce pollution associated with burning solid biomass at home, the design of the stove is such that it exposes the users to a number of health risks caused by standing water, flies and mosquitoes.

As regards fuel usage by households, I overwhelmingly found that households across socio-economic groups were aware of the ill effects of traditional biomass energy, in terms of health hazards and ecological costs. This is contrary to commonly held view that rural families have an inherent preference for burning biomass energy. It is very evident that households are forced to use biomass because of resource and income constraints which leave them with no other alternatives. It was quite remarkable to come across such clarity on the part of ordinary, poor men and women on the links between biomass burning and environmental degradation. Overwhelming they aspired to use clean energy and more sustainable options.

Based on my field work and perceptions gathered through interviews and focus group discussion, a major policy lesson which can be drawn pertains to people's preparedness for making the transition to clean energy sources through bioenergy stoves. However, the essential flaws of this policy design related to the failure to incorporate caste and gender dimensions of energy poverty in the policy discourse. In this context eco-socialism provided a new lens to bring in these dimensions into the design of biogas initiative.

From an eco-socialist lens, the current constraints faced by users of bioenergy with respect to inadequate subsidies, lack of affordability, and poor hygiene of stoves essentially spring from "top down" nature of these policies. Within green capitalist approach, there are no mechanisms and institutions for ground level stakeholders to ensure their participation, so that the weaknesses of these schemes may be addressed. From the aspect of technology too, the state government has not endeavoured to create models based on indigenous resources, which is suitable to address the energy poverty of the poor and the landless SC households.

7.7 Summing Up

Based on the textual reading of the bioenergy policy and the interviews with the members of the policy community, the case studies of the commercial bioenergy projects, the analysis of well-known green community imperatives, and examination of the energy aspirations of rural households, it is possible to make some general observations and conclusions on the complex issues surrounding bioenergy developments in Punjab.

The policy regime in Punjab is largely geared towards a green capitalist framework. The policy commitments, the incentive mechanism for the industry, the private sector partnerships all point to this direction. The policy is oriented to creation of a profitable green energy market by utilising the region's comparative advantage in agricultural production. This is a positive development as green reforms within capitalism are a useful starting point towards transition to an ecologically sustainable development model. The policy push has led to initiation of a number of bioenergy projects in the state and fostered a new form of agro-industry in the region. This is again welcome because Punjab has huge potential and a dire need for such initiatives.

However, using the eco-socialist framework, I was able to see from the fieldwork that the policy is being pursued within a 'weak sustainability' framework and ecological as well as socio-economic concerns which are fundamental parameters of sustainable development are essentially appropriated by business interest. The transition to an ecologically sustainable development in the long run requires putting socio economic and ecological reforms at the centre and not on the margin. The impact of green capitalist reforms is therefore limited as it is rooted in a weak sustainability paradigm, to only keep the growth process intact, and not consider the socio-economic embeddedness of ecological concerns. We found that there were no mechanisms for participatory democracy and stakeholder involvement in the design of environmental policies.

Another crucial aspect of the bioenergy policy is absence of a regulatory framework. Within the existing policy, there is no attempt to regulate the environmental and labour practices of green energy producers. On the contrary, these regulations are constantly been dismantled to attract more capital in the green energy sector. Climate change commitments and socio-economic aspects pertaining to alleviation of energy poverty, creation of rural livelihoods, and equitable resource distribution remain marginal aspects for policy.

The third aspect is lack of stakeholder engagement. The policy approach is largely "monocentric[80]" and top down. The absence of effective stakeholder participation emerges as a principle flaw of the state's bioenergy policies. Stakeholders other than the private sector, such as community leaders, farmers and rural residents are largely excluded from incentives, claims and benefits. Also, these projects are disconnected from livelihood, employment and energy security concerns of the rural communities. On the contrary they display exploitative tendencies towards locals with respect to working conditions and payment of wages.

The role of religious organisations, farmer's collectives, as well as individual households who are developing communal projects to support renewable energy on the basis of indigenous technologies and resources have been excluded from institutional support or representation in the mainstream renewable energy projects in the state. Their initiatives are not being studied systematically for their motivation, viability or replicability. Their crucial role in demonstrating innovative models of clean energy through the participation of local community is ignored. The lack of stakeholder engagement has also produced challenges for the success of the industry – the lack of adequate raw material, skilled manpower for operations, the absence of biomass pricing policy and non-existence of an incentive structure for the community have all contributed to its limited success.

The fieldwork also pointed to the deep sustainability aspirations of the community. The community is aware of the health implications of poor quality fuels and aspire for clean and better fuels. At the level of household bioenergy initiatives, the biomass cooking stove policy is a welcome initiative which could potentially enable rural households to make a transition to clean energy. However, the fieldwork revealed that the biomass cooking stove policy has been formulated largely within a

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[80] A monocentric approach to policy making implies that policy prerogatives have been set solely on government and industry interests. This is in contrast to a multiple stakeholder approach, where in the interests of multiple ground level stakeholders are considered while setting the policy prerogatives (Termeer et al, 2010).

"one size fits all" framework. It did not account for differences in the income and socio-economic status in the communities. As a result the policy has been successful in providing benefits to comparatively better off households and womenfolk from these households have been clear beneficiaries. However, the poor and vulnerable groups in society who are at the bottom of the energy ladder remain outside the purview of benefits.

Similarly, the experience of the community based green energy imperatives in Punjab illustrate how alternative, indigenously developed models of green energy can be created within the existing structure of agrarian capitalist economies. The focus groups with the rural community highlighted that rural households in Punjab display ecological consciousness and are ready to embrace clean, green energy alternatives, provided that they are affordable. The research highlighted how ecologically responsible citizens and organisations can mobilise popular support for green energy imperatives and provide a model for instituting more eco-democratic, inclusive and people centric green energy reforms.

Finally, eco-socialism has provided a lens to look at the ecological question through the prerogatives of different ground level stakeholders. Eco-socialists recognise that given the complex nature of projects like bioenergy there will be conflicts between different stakeholders in bioenergy developments. For instance the overriding concern of bioenergy producers emerged as profitability of biofuel projects; while the rural community aspired to use these projects as a means to create sustainable livelihoods and get out of the cycle of poverty. Within the rural community also, there was considerable heterogeneity between the energy concerns and livelihood constraints of farming and non-farming households. These perspectives and conflicting priorities have not been recognised by the state government of Punjab due to the absence of mechanisms and structures within the green capitalist framework which make participation and stakeholder negotiations possible.

In this context eco-socialists prescribe eco-democratic reforms as a way forward where in the needs and prerogatives of green energy projects are defined by the community itself through means of decentralised institutions (such as village councils) as well as community based organisations and farmer's unions. They believe that environmental projects should be rooted in participatory decision making, where in all trade-offs and compromises are identified, openly discusses and deliberated upon and then justified (Kovel, 2008). This process of discussion, deliberation and collective bargaining within the community will help to create consensus and garner popular support for the long-term sustainability for these projects, which is lacking in the “green capitalist” framework of bioenergy reforms. Eco-socialists contend that in the long- run any trade-off decisions must not compromise on the fundamental objective of environmental sustainability and decisions should be based through consultation with all relevant stakeholders (Haywood et al, 2009).

However, the codification of these policy prescriptions within this analytical framework, as well as the necessary tools for assisting stakeholders in understanding and resolving these conflicts can only be developed through application of this perspective on actual green energy projects (Haywood et al, 2009). As this perspective matures and develops further through generation of empirical evidence, new and innovative policy instruments and prescriptions may be created to further augment the process of creating participatory approaches to green energy developments.

In the following chapter I will discuss the larger implications of these findings for informing sustainable bioenergy developments within an eco-socialist paradigm.

CHAPTER EIGHT
SUMMARY AND CONCLUSION

This thesis traced out the multi-dimensional energy challenges in the global economy, and located the contestations in the energy sector within the overall crisis of the capitalist system. Over the years, the capitalist model of development based on relentless pursuit of wealth and capital accumulation has put immense pressure on the natural resource base of the global economy. In the last few years, many capitalist economies have instituted environmental regulations in order to overcome the process of environmental degradation. However, these regulations have had only a limited impact. We have reached a “tipping point” as far as carbon emissions, and exhaustion of key natural resources is concerned. In response to this crisis, many developing as well as developed economies are adopting the reformist agenda of “green” capitalism, to bring about an “ecological restructuring” of the existing capitalist societies. “Green” capitalism aspires to reconcile the aims of economic development and environmental protection, under the existing institutional structures of capitalist economies. “Green” capitalism is based on the twin planks of creation of green markets and mainstreaming renewable energy sources. “Green” capitalist reforms are rooted in neoclassical environmental economics. This school of economics considers environmental degradation to be an “externality” which may be corrected through market-based instruments like taxes, subsidies and permits or direct state regulation.

The neo-classical approach to environmental protection has been critiqued by other schools like institutional and development economics. These schools regard mainstream neoclassical economics as a “reductionist” approach to environmental protection, as it does not consider formal and informal institutions, and the role of communities in the environmental discourse. Institutional economists like Ostrom

(1990) have demonstrated the importance of decentralised community based institutions in creating alternatives "beyond market and state" for protecting the natural resource base of the economy. Development economics have also critiqued neoclassical environmental policies because they have primarily been designed to tackle ecological problems in the developed industrial economies. They have not systematically taken into account the specificities of environmental problems in developing countries; particularly issues of energy poverty, marginalisation and loss of common pool natural resources. Unlike the neo-classical approach, which concentrates only on the "hardware" of development, such as technology, infrastructure and capital inputs; development/institutional economics has laid emphasis on the "software" of development, including institutions, social capital and human capabilities.

These schools have helped to broaden the environmental discourse, bringing in the role of decentralized institutions and communities, as well as specificities of environmental problems in developing countries. However, none of these schools have systematically addressed the questions of ecological justice, in terms of inequitable access to resources among different classes in society and the inequitable costs and benefits of environmental protection. In view of these limitations of the existing approaches, this thesis adopted an eco-socialist paradigm, which considers environmental degradation to be a "systemic issue." Eco-socialism agrees with the basic tenets of institutional and development economics in terms of creating decentralized institutions and a "bottoms up" participatory approaches in the environmental discourse. However, unlike other schools, eco-socialism considers the power and class structures in society as the central explanatory parameters in explaining the process of environmental degradation in society. Eco-socialism provides a vision of a new development trajectory, where in the socialist ideals of equality/ social justice are integrated with environmental concerns. In an eco-socialist perspective, a primary objective of sustainable development is environmental justice.

In this research an eco-socialist perspective was used to analyse the strengths and limitations of bioenergy projects, in the case study region. An eco-socialist perspective was used to evaluate the essential prerogatives of sustainable development, in a region pursuing "green" capitalist reforms in the bioenergy sector and also how the outcomes of these projects played out for different class and gender divisions in society.

8.1 Research Questions and Conceptual Framework

As chapter 2 and 3 established, one of the major planks of "green" capitalism is mainstreaming renewable energy sources. In this context bioenergy was extensively promoted as the "fuel of the future" in recent years. It was touted as a pathway to promote energy security, give a boost to rural agrarian economies and create the necessary synergy between energy and agricultural markets. However, our review of literature established that these bioenergy reforms have been associated with limited ecological and socio-economic gains. There has been very little research on the socio-economic and livelihood impacts of green energy reforms in developing nations in terms of supporting energy access, increasing affordability of modern energy sources and creating rural livelihoods and employment. Although, these were the key objectives with which bioenergy was promoted in the context of developing agrarian economies (HLPE, 2013). In this context many scholars have advocated the need for more locally grounded research to "demystify the complex issues" surrounding bioenergy imperatives in developing nations" (Esterees, 2013).

In order to contribute to this critical area pertaining to the sustainability of bioenergy projects in developing nations, this doctoral research attempted to develop an alternative eco-socialist framework to inform sustainable bioenergy production in developing countries. Eco-socialism is based on the idea that ecological concerns should be embedded within the socialist ideals of equality and social justice, in order to create a development pathway that is both ecologically and socially sustainable. Eco-socialists subscribe to a framework of "eco-democratic" reforms as a rational starting point for the creation of sustainable development pathway. This essentially implies that ecological reforms should be rooted in participatory decision making and be cognizant of the socio-economic concerns in a given region. Eco-socialism advocates an approach to sustainability, rooted in the inter linkages between the social, economic and institution parameters of sustainability.

The conception of “eco-democratic” reforms was used to develop a framework of sustainable bioenergy production in chapter four. This framework enabled me to develop a historically grounded approach to evaluate the bioenergy projects in Punjab. I evaluated the political economy factors, which have shaped the class structures and environmental constraints in Punjabi society, and how these factors are conditioning the outcomes of bioenergy developments. Within an eco-socialist paradigm, I analysed the role of both state and market based bioenergy reforms, as well as community based organisations who were creating more inclusive and participatory institutional structures in the environmental discourse. Finally, I analysed how these institutions and policy framework on bioenergy were playing out in terms of ground level outcomes in Punjab’s rural community. Unlike, other approaches eco-socialism enabled me to treat the rural community of Punjab, as a “heterogeneous” structure distinguished along historically created class and gender divisions in society.

The eco-socialist framework was supported by a critical realist approach. This approach was instructive in developing the theoretical constructs of the research. It enabled me to create a “chain of explanation” in order to discern the global, regional and local power structures and mechanisms, which had important implications for the development of the green energy sector. Relying on a critical realist approach, I was able to analyse the macro-structural factors that have conditioned bioenergy developments in Punjab, as well as the outcomes of these developments for different socio-economic groups in rural Punjab. For instance while exploring the state and community based projects on green energy in Punjab through a critical realist paradigm, I was able to identify the differences in the conception of sustainable development in a mainstream “green” capitalist policy approach and the prerogatives of sustainable development in Punjab’s rural community. This approach thus enabled me to go beyond simplistic explanation of green energy projects as “good” and “bad” and unearth the complexities associated with bioenergy developments at a deeper level, while presenting the main findings from the primary research in Chapter seven.

A critical realist approach enabled me to embrace “methodological pluralism” in my research design. I was able to rely upon a range of research methods such as stakeholder interviews, focus groups, document analysis and quantitative government data, during the course of the primary research in Chapter seven. This plurality of research methods enabled me to capture different aspects of bioenergy developments and their inter-connections with other major sectors of the regional economy of Punjab such as agriculture and electricity. I was also able to bring in the voices of multiple ground level actors, including the vulnerable groups in society such as women and landless agricultural labour whose concerns have been relegated to the margins in the mainstream bioenergy policy discourse.

8.2 Case Study Findings

The theoretical framework was employed to analyse the bioenergy projects in Punjab, India, on the basis of participatory field research. The Punjab region of India provided an ideal case study to analyse the efficacy of green energy reforms within the existing institutional framework of an agrarian capitalist economy. After the failure of the Green Revolution strategy, resulting in widespread agrarian distress and mounting socio-ecological tensions, the state government is proactively pursuing an agenda of "green capitalist" reforms. These reforms have a strong economic motive. They are primarily intended to break free from the cycle of "ruralisation" in Punjab and foster a new form of agro-industry in the province through setting up of bio-refineries and biomass industry in rural Punjab. Another important prerogative of these reforms was to alleviate the problems of energy poverty in rural Punjabi community, through household biomass initiatives.

I analysed these initiatives through an eco-socialist lens, which enabled me to create a "chain of evidence," going from the policy discourse, to ground level projects and finally people's experiences with bioenergy at the ground level. The first important finding from the research was that bioenergy reforms of the state government have been initiated by aligning them with the Government of India's interests and interpretations of international commitments to sustainable energy development. In this centralized policy process, the energy and ecological discourse have been developed with very poor understanding of the regional specificities of these projects. There has been little focus on the development of indigenous technologies, supply chain linkages, institutional structures, enforcement and monitoring mechanisms, as well technical and skill development at the regional level. Also these projects had been developed as isolated projects, without linking them with other programmes of sustainable agriculture, water use and resource conservation in the context of Punjab.

In the absence of these enabling conditions many bioenergy projects have failed to be economically viable. Also grass root level organizations and individuals, who were developing models of bioenergy development rooted in indigenous technology and resources were excluded from the policy discourse. This has resulted in massive project failure and poor outcomes of bioenergy projects in the state. Only very well endowed companies, who have means to create their own technical and institutional support have succeeded have been successful. Many new biofuel companies have failed to take off because of inadequate planning of local conditions and indigenous technologies. Punjab is not an isolated case. A number of countries across Asia and Africa have developed their bioenergy policies by embedding them in the sustainability frameworks developed by international agencies (Faveretto, 2014; Jumbe et al, 2009). However, evidence shows that this approach to biofuel development is extremely limiting in the context of developing countries. It merely "rubberstamps sustainability concerns" (Tomei and Helliwell, 2017) but fails to embed the social, economic, political and ecological complexities of regional economies in the policy discourse (Mol, 2013; Brown, 2009). This was confirmed by the analysis on the sustainability of these projects in Punjab as well. In this context eco-socialism enabled me to see the failure of commercial bioenergy projects as a "systemic issue," rooted in a "one size fits all" approach. In mainstream economic theory, these failures have been treated simply as cases of mismanagement of resources and corporate fraud by technology suppliers. Eco-socialism, on the other hand enabled me to see how these "market failures" are essentially rooted in the bioenergy policy framework of the state government.

The second important finding was that bioenergy reforms privileged business, agro-industry and comparatively better-endowed farmers in the region. While a large number of fiscal concessions and subsidies were instituted to promote industry, the concerns of local farmers/residents with respect to feedstock prices, employment conditions and energy affordability found no mention. An eco-socialist lens enabled me to see that this issue was largely than mere “regulatory capture” by the industry. I systematically evaluated the empirical evidence generated in the study, as well as literature on regulatory regime in India and other parts of the world. This exercise enabled me to see that there has been a systematic case of “regulatory chills” in Punjab where environmental and labour regulations have been diluted for the sake of “ease” of doing business and attracting investment in the bioenergy sector. This phenomena resulted in bioenergy companies using environmentally destructive technologies, failing to adhere to environmental best practices and adopting exploitative labour practices. An eco-socialist lens enabled me to see that this was not mere regulatory failure. It was a case of systematic deregulation by the state agency. Within a “green” capitalist agenda in Punjab, economic growth and creation of green industry held primary importance. The socio-economic and environmental parameters of sustainability had been ignored.

The other major implication of the centralised “top down” nature of green capitalist reforms in Punjab was that there was no involvement or recognition of local stakeholders in the policy framework. The eco-socialist lens enabled me to capture the alternative trajectories of sustainable development, which had been created by community organizations, individuals and religious institutions in the state. These grassroot organisations had created participatory communal institutional structures for bioenergy developments, rooted in indigenous technologies and resources. However, there have been no efforts on the part of the state governments in Punjab to forge alliances with individuals and community actors. As a result these community-based initiatives have remained local level, isolated projects, and their projects have not been amplified. Also, due to the absence of any stakeholder participation, the concerns raised by NGOs and labour unions have not even been considered by the policy makers.

With respect to the household bioenergy initiatives, I found that in the household cooking stove initiatives of the state government the rural community had been treated as a homogenous entity. The class and gender dimensions of energy poverty had not been picked upon within the green capitalist policy framework in Punjab. On the other hand eco-socialists regard class, caste and gender divisions in society, as central explanatory parameters in explaining issues of energy poverty. An eco-socialist enabled me to analyse the differential impact of the scheme on different socio-economic groups. The state government had instituted a uniform subsidy on bioenergy stoves, without considering the class divisions in terms of land and asset ownership and occupational patterns (agricultural labour versus land owners). As a result this scheme had helped comparatively better off households. On the other hand the historically vulnerable and marginalized caste (SC) and occupational groups (agricultural labour) had been excluded from this scheme.

The case of Punjab thus, shows that when green reforms are implemented as a “technical fix” without taking into account the historic political economy factors and power structures of the region, they have a differentiated impact on different socio-groups within the regional economy. The class structure of the agrarian society of Punjab has imposed limits on the outreach as well as the efficacy of the green capitalist reforms. The existing socio-economic and gendered inequities in rural Punjab have manifested in unequal costs and benefits from the current green energy projects taking place in the province. While the better-endowed sections of the rural society of Punjab have been able to gain from these developments to some extent, the vulnerable groups in society were largely excluded from the ecological discourse. An eco-socialist lens enabled me to effectively capture these limitations of mainstream “green” capitalist reforms in Punjab.

An eco-socialist vision of eco-democratic reforms also provides a way forward in the case of Punjab. The main limitations of green energy reforms in Punjab lie in absence of effective stakeholder participation, and a sustainability discourse, where in business interests and a green growth agenda are accorded primacy over other socio-economic and ecological parameters of sustainable development. The energy needs and expectations of Punjab’s rural community can be effectively addressed by creating a polycentric governance framework, where in the needs and prerogatives of green energy projects are defined by the community itself through means of decentralised institutions (village councils) as well as community based organisations and farmer’s unions. As, the case study of Punjab demonstrates that long-run sustainable development can only succeed through participatory decision making, especially bringing in the voices of marginalized groups in society. All trade-offs and compromises between social, economic and ecological aspects of sustainable development should be identified, openly discussed and deliberated upon. This process of discussion, deliberation and collective bargaining within the community will help to create consensus and garner popular support for the long-term sustainability for these projects, which is lacking in the "green capitalist" framework of bioenergy reforms. Eco-socialists unlike the green capitalist approach regard environmental project as the ultimate "bottom line." Therefore, they contend that in the long-run economic growth should not be at the cost of environmental sustainability.

The codification of the policy prescriptions within eco-socialism, as well as the necessary tools for assisting stakeholders in understanding and resolving these conflicts can be strengthened through application of this perspective on actual green energy projects. In the case of Punjab the empirical evidence shows how involvement of community based organisations, labour unions and environmentally conscious individuals can create alternative trajectories of participatory and inclusive sustainable development. As these participatory processes evolve and mature, more innovative policy instruments and mechanisms may be created.

8.3 Scope, Limitations and Way Forward

The work has been able to contribute to the understanding of the livelihood and socio-economic impacts of bioenergy, and how in turn these outcomes are conditioned by the historic political economy and class structures in a regional economy. This is an under researched area in the current discourse on bioenergy developments (Hodbod and Tomei, 2013). The findings from this research have helped to identify the potentiality of green energy developments in Punjab and the factors, which are preventing these projects from reaching their purported economic, ecological and social objectives. This research is a timely contribution, given that bioenergy projects are an on going development in Punjab and are affecting the local rural communities in the province through a number of channels illustrated in the previous chapter.

The in depth case study research was able to generate empirical evidence on the opportunities and contestations of green energy developments in the context of developing agrarian economies. The focus on creating a "chain of explanation" helped to unearth the global, national as well as the regional factors, which have influenced these projects. On the other hand, the multiple-stakeholder framework helped me to analyse bioenergy projects in Punjab on the basis of the perspective and lived experience of various ground level stakeholders. As elaborated upon in the methodology chapter, case study research is criticised for the lack of generalisability. I admit that some of the field-based findings from the research are particular to Punjab. However, many other aspects of bioenergy developments such as the issues of power and marginalisation, which have led to inequitable distribution of costs and benefits of bioenergy projects, as well as issues of energy poverty and inequitable access to modern energy sources across different socio-economic groups may find resonance in other regions of the developing world as well.

Locating the current research within an eco-socialist framework had important theoretical implications as well. In this work I drew on the theoretical arguments surrounding the sustainability discourse and the fundamental contestations between the weak and strong versions of sustainability. I was able to unearth the limitations of a "weak sustainability" paradigm in informing renewable energy developments in the context of a developing agrarian economy and was able to establish that "weak sustainability" is essentially a reductionist approach to sustainable development and leaves out important socio-economic and ecological concerns in the framing of environment policies.

The experience of Punjab suggested that implementation of green reforms as a technocratic solution to existing ecological problems is essentially flawed. The empirical research was able to establish that there is no "positive sum relationship between environmental gains and economic growth" (Tomei, 2014:240), as is advocated by green capitalist reforms. Rather, the outcomes of these developments are influenced by complex non-linear processes and socio-political structures of a given economy. In the case of Punjab the weaknesses of the current bioenergy developments had their roots in the deep-seated issues of the regional economy-income inequities, unsustainable agricultural practices, environmental degradation, exploitative conditions of employment, non-remunerative price for crops, insufficient development of indigenous technologies and widespread gender inequities, which have not been recognised in a green capitalist approach.

In this research I took forward the ideas of some eco-socialist scholars through empirical research (Singh, 2014; Harris, 2014; Harris, 2010; Singh, 2010 and Lowy, 2007). The case of Punjab showed how projects rooted in a “weak” sustainability approach (the commercial bioenergy projects) and the “strong” sustainability approach (the community based bioenergy imperatives in rural Punjab) were operating in a parallel manner. The research demonstrated that instead of treating “weak” and “strong” sustainability paradigms as contested approaches, the dominant “weak” sustainability paradigm could be transcended into the “stronger” version of sustainability. This can be accomplished by forging effective partnerships with grass root individuals and organisations, which are promoting these developments at the community level. The lived experiences of the rural community in Punjab demonstrated that people’s needs and aspirations are more aligned with eco-democratic reforms that are egalitarian and participatory in nature and address the existing socio-economic vulnerabilities and questions of ecological justice in the green energy policy discourse.

To sum up, this work has taken the debate on bioenergy forward. The project was able to elucidate the key challenges that are acting as stumbling blocks in the success of bioenergy projects within a green capitalist framework and also explore the possibilities offered by alternative models, located in community based solutions and common pool resources. The research was also able to offer some contributions towards more effective implementation of alternative energy policies in the future. However, this research does not constitute an end point in our understanding of bioenergy developments. The work needs to be supplemented with parallel research in life sciences, agriculture and environmental sciences in order to develop more progressive, locally centred models of renewable energy production.

Another area of potential research is with respect to the behavioural motivations underlying environmental projects. We demonstrated that behavioural economics has provided rich insights on the factors such as individual perception of risk, uncertainty fairness and altruism, which influence environmental decision-making. Insights from these studies are crucial in understanding the behavioural motivation behind individual and collective action in support of environmental projects. While behavioural economics has broadened the understanding of the “micro” factors in environmental decision making; eco-socialism helped to analyse the macro-structural approach to environmental decision-making. Eco-socialists believe that the macro-structural approach is crucial to take account of the considerations of environmental justice (inequity in resource distribution and voice in environmental decision making processes) in the environmental discourse. Thus, when insights from behavioural economics are combined with an eco-socialist perspective, they can create greater possibilities for securing environmental justice. Acknowledging the differential motivations of various classes, gender and groups will enrich and deepen the contributions from behavioural approaches to environmental decision-making.

I aim to disseminate the findings from this research through publication of newspaper op-eds, journal articles and conference papers and hope that my research outputs will help to inform more progressive outcomes of renewable energy policies, particularly with respect to improving stakeholder participation and representation of vulnerable groups such as women and agricultural labour in defining the policy prerogatives related to renewable energy. The other area where more research is required is with respect to the role of progressive social movements in the green energy policy discourse. My empirical findings revealed that women’s, farmer’s as well as worker’s organisations favoured the need for a sustainable development discourse in Punjab. The coalition of these social movements can potentially become a vehicle for change and foster the province towards a green energy pathway that is socially, economically and ecologically sustainable.

From the theoretical prism, this thesis has applied the eco-socialist conception of sustainable development to bioenergy projects. This framework can be used to inform other policy issues pertaining to natural resource management, energy policy and ecological imperatives. There is a need to explore this area further, on how the eco-socialist perspective can be used to analyse policy prerogatives and influence progressive outcomes in terms of embedding social justice and democratic planning in the policy discourse on sustainable development.

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