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Adding Fuel to the Fire

North-South dynamics in the geographies of transport energy: the case of EU biofuels

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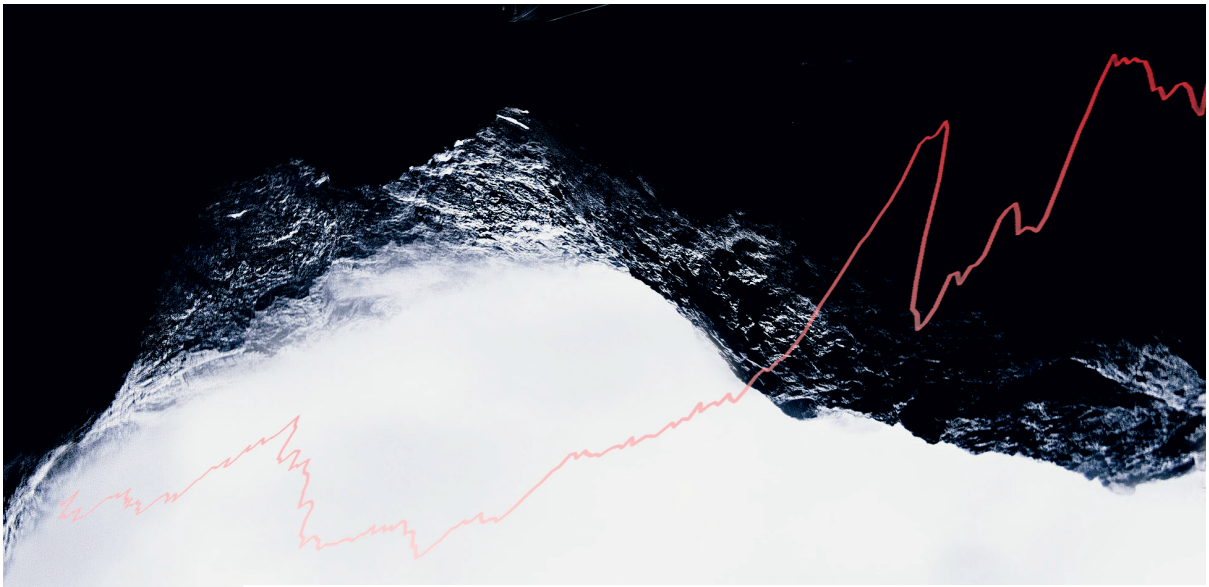

Adding Fuel to the Fire

North-South dynamics in the geographies of transport energy: the case of EU biofuels

DAVID HARNESK
LUCSUS | FACULTY OF SOCIAL SCIENCES | LUND UNIVERSITY

Since the 2000s, the European Union (EU) has promoted biofuels for transport to achieve climate change mitigation and rural development in the global South. Yet, intense debate suggests the opposite: that the promotion of biofuels in fact impedes more meaningful mitigation while also worsening rural livelihood conditions by dispossessing people from land and making local labour redundant. Why has the EU promoted biofuels for transport despite these doubts? Can its regulation assure the desired outcomes of significant greenhouse gas emission reductions in transport and positive social effects in rural areas? If not, what would constitute more viable alternatives for achieving the desired outcomes?

In this thesis I find plausible answers by examining the complex interdependencies of energy and geography. Specifically, I argue that the EU's promotion of biofuels for transport is a geopolitical process incapable of achieving its internal goals. Looking forward, I discuss more viable alternatives that can be promoted by exploiting the gaps and contradictions in the EU's support of biofuels that have now been identified within the geographies of transport energy.

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Adding Fuel to the Fire

North-South dynamics in the geographies of transport energy: the case of EU biofuels

David Harnesk

LUND UNIVERSITY

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Abstract

Since the 2000s, the European Union (EU) has promoted biofuels for transport to achieve climate change mitigation, and rural development in the global South. In contrast, critiques have argued that biofuel promotion impedes more meaningful mitigation while also resulting in dispossession of land and loss of labour opportunities in the global South. In this thesis, I study why the EU is promoting liquid biofuels for transport despite critique. I ask the following main questions: Can EU biofuel regulation assure the desired outcomes of significant mitigation of transport emissions and positive social effects in rural areas? If not, what would constitute more viable alternatives for achieving the desired outcomes?

Within a sustainability science frame, I draw on critical realism, emancipatory social science, and a mixed methods approach to examine the complex interdependencies of energy and geography across three interconnected analytical domains: 'geopolitics', 'energy markets' and 'energy landscapes'. For each domain there is a specific empirical focus and a corresponding theoretical body. The main structure of the thesis starts with a systematic 'diagnosis and critique' of EU biofuel regulation, then proceeds to discuss 'alternatives and transformation'.

My analysis unfolds in three major parts with respective findings. First, EU biofuel regulation impedes more meaningful mitigation of transport emissions. Its intrinsic mechanisms encourage firms to further expand intensified land-use practises for the production of energy commodities. This spills over to new land areas for increased production, and does not ensure substantial greenhouse gas emission reductions. Second, EU biofuel regulation has adverse social effects on the 'transnational rural precariat' especially in the global South where many states and governments accepted investments for the production of liquid biofuels as a means for development although it resulted in accumulation by dispossession. Together, these mechanisms tend to shift land and labour relations towards intensive agriculture with output designated for external regional markets, and without delivering ample social benefits to populations in these rural areas. Third, EU biofuel regulation is a response to (multiple) crises in capitalism: liquid biofuels have provided firms with new accumulation opportunities and the EU's regulatory mechanisms allow firms in pre-existing geographies of production and consumption to produce commodities in more 'flexible' ways. Importantly, I found that this 'flexing' is a defining feature of EU biofuel regulation wherein the ensuing geopolitical territorialisation reproduces the 'transport energy landscape' and its underlying social relations.

Finally, I discuss more viable alternatives for achieving the desired outcomes that can be promoted by exploiting the now identified gaps and contradictions inherent to the EU's support of liquid biofuels for transport. To conclude, I theorize the role of energy geographies in climate change mitigation, and delineate my contributions to the research agenda of sustainability science.

Key words: energy geography, geopolitics, territorialisation, climate change mitigation, transport, biofuel, agrofuel, European Union, certification, sustainability criteria, sustainability science

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Adding Fuel to the Fire

North-South dynamics in the geographies of transport energy: the case of EU biofuels

David Harnesk

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To the memory of my brother,

Tomas Axelsson, 1977 – 1999

Table of contents

1. Introduction 15

1.1 The frame: up against climate change and ecological modernization....15

1.1.1 The EU's support of liquid biofuels and the ensuing debate.....16

1.2 The issue: the dual problem of liquid biofuels 18

1.3 The aim and questions of the thesis 19

1.4 Thesis outline 19

2. Foundations.....21

2.1 The approach: from meta-theory to organizing principles 21

2.1.1 Meta-theoretical considerations from critical realism 21

2.1.2 Organizing principles from emancipatory social science 22

2.2 The setting: the argument and research focus 27

2.3 Three analytical domains of North-South dynamics 29

2.3.1 The analytical domain of geopolitics.....29

2.3.2 The analytical domain of energy markets.....32

2.3.3 The analytical domain of energy landscapes 33

2.3.4 Towards an interdisciplinary understanding.....34

2.4 The process: materials, methods, and analysis.....36

2.4.1 Two reflections on the process 37

3. EU biofuel regulation in the global North 41

3.1 The geopolitics of territorialisation and the structure of the proceeding arguments 41

3.2 A historical account of EU biofuel support.....43

3.2.1 A response to crises of energy and rural development? 43

3.2.2 A response to the climate crisis? 44

3.2.3 Managing crisis through self-regulation? 46

3.2.4 Neoliberal governance and ecological modernization.....49

3.3 EU biofuel regulation as containing mechanisms with effects 50

3.3.1 Four regulatory mechanisms with causal power 51

3.3.2 Effects on firm-level decision-making 57

3.3.3 Territorialisation through new economic flexibilities 59

3.4 A critique of EU biofuel regulation in Sweden 60
3.4.1 Internal limitations to EU biofuel regulation 60
3.4.2 Structural contradictions of EU biofuel regulation 62

4. EU biofuel regulation in the global South 67

4.1 Agrofuels as spatial fixes to crises 68

4.2 A historical account of agrofuels in Tanzania 71
4.2.1 The opening up of Tanzania to transnational capital 72
4.2.2 The shaping of neoliberal developmentalism in Tanzania 74
4.2.3 Attracting investments to agriculture via liquid biofuels 75

4.3 A critique of EU biofuel regulation in Tanzania 80
4.3.1 Tensions in the desirability of land in Tanzania for EU biofuels 81
4.3.2 Tensions in the desirability of labour in Tanzania for EU biofuels 84

5. The scope for change: a discussion on alternatives and transformation 87

5.1 Revisiting the key arguments and the critique 87

5.2 A theory of social reproduction (and gaps and contradictions) in Sweden 89
5.2.1 Complementarity between liquid biofuels and the fossil fuel landscape 91
5.2.2 The dynamic interconnections of material interests 97
5.2.3 Institutional constraints on reform space 101

5.3 Putting out the fire: a concluding discussion on viable alternatives 104
5.3.1 A desirable and viable transport energy landscape in Sweden? 105
5.3.2 A short remark on struggles against neoliberal developmentalism in Tanzania 106

6. Concluding remarks 109

6.1 Answering my research questions 109

6.2 Theorizing the energy geographies of climate change mitigation 112
6.2.1 Future research 113

6.3 Advancing an emancipatory sustainability science 114

References 117

Appendix I 135

Abstract

Since the 2000s, the European Union (EU) has promoted biofuels for transport to achieve climate change mitigation, and rural development in the global South. In contrast, critiques have argued that biofuel promotion impedes more meaningful mitigation while also resulting in dispossession of land and loss of labour opportunities in the global South. In this thesis, I study why the EU is promoting liquid biofuels for transport despite critique. I ask the following main questions: Can EU biofuel regulation assure the desired outcomes of significant mitigation of transport emissions and positive social effects in rural areas? If not, what would constitute more viable alternatives for achieving the desired outcomes? Within a sustainability science frame, I draw on critical realism, emancipatory social science, and a mixed methods approach to examine the complex interdependencies of energy and geography across three interconnected analytical domains: 'geopolitics', 'energy markets' and 'energy landscapes'. For each domain there is a specific empirical focus and a corresponding theoretical body. The main structure of the thesis starts with a systematic 'diagnosis and critique' of EU biofuel regulation, then proceeds to discuss 'alternatives and transformation'.

My analysis unfolds in three major parts with respective findings. First, EU biofuel regulation impedes more meaningful mitigation of transport emissions. Its intrinsic mechanisms encourage firms to further expand intensified land-use practises for the production of energy commodities. This spills over to new land areas for increased production, and does not ensure substantial greenhouse gas emission reductions. Second, EU biofuel regulation has adverse social effects on the 'transnational rural precariat' especially in the global South where many states and governments accepted investments for the production of liquid biofuels as a means for development although it resulted in accumulation by dispossession. Together, these mechanisms tend to shift land and labour relations towards intensive agriculture with output designated for external regional markets, and without delivering ample social benefits to populations in these rural areas. Third, EU biofuel regulation is a response to (multiple) crises in capitalism: liquid biofuels have provided firms with new accumulation opportunities and the EU's regulatory mechanisms allow firms in pre-existing geographies of production and consumption to produce commodities in more 'flexible' ways. Importantly, I found that this 'flexing' is a defining feature of EU biofuel regulation wherein the ensuing geopolitical territorialisation reproduces the 'transport energy landscape' and its underlying social relations. Finally, I discuss more viable alternatives for achieving the desired outcomes that can be promoted by exploiting the now identified gaps and contradictions inherent to the EU's support of liquid biofuels for transport. To conclude, I theorize the role of energy geographies in climate change mitigation, and delineate my contributions to the research agenda of sustainability science.

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List of articles

I. Harnesk D. Biomass-based Energy on the Move (under review) the Geographical Expansion of the European Union's Liquid Biofuel Regulation. *Submitted to peer-reviewed journal*.

II. Harnesk D & Brogaard S (2017) Social Dynamics of Renewable Energy – How the European Union's Renewable Energy Directive Triggers Land Pressure in Tanzania. *Journal of Environment and Development, 26*(2), 156-185.

III. Harnesk D, Brogaard S & Peck P (2017) Regulating a global value chain with the European Union's sustainability criteria – experiences from the Swedish liquid transport biofuel sector. *Journal of Cleaner Production, 153*(1), 580-591.

The work distribution in the co-authored papers was as follows:

Article II: David Harnesk conceived the idea for this article and outlined the argument based on data from joint fieldwork in Tanzania (2014). He also pursued most of the analysis and wrote the bulk of the paper with (continuous but) specific input from Sara Brogaard who suggested that the analysis should be framed in relation to ecological modernization.

Article III: The article is framed in correspondence with Sara Brogaard's research project 'The Renewable Energy Directive and Associated Sustainability Criteria – Sweden in a European and Global context'. David Harnesk developed the survey, gathered the data, selected the theory and performed the analysis with continual feedback from Sara Brogaard, Philip Peck and industry stakeholders. Philip Peck did the final editing.

List of figures and tables

Figures

Figures	Page
Figure 1: Road transport energy and liquid biofuel developments in the EU and Sweden, 1990-2015.	17
Figure 2: Liquid biofuel consumption and final energy consumption in transport in the EU (28 countries), 1990-2015.	45
Figure 3: Relative impact of factors behind food price spikes, 2007-2012	48
Figure 4: Comparison between the power densities (W/m^2) of crude oil and liquid biofuels	52
Figure 5: Retail price of petrol and diesel compared with tax exemptions provided for ethanol, FAME and HVO, 2000-2016.	53
Figure 6: Liquid biofuel consumption in, and biomass feedstock of liquid biofuels delivered to, Sweden, 2011-2016	63
Figure 7: Country of origin for biomass feedstock of liquid biofuels delivered to Sweden, 2011 - 2016, and biomass producers certified by the International Sustainability & Carbon Certification, 2011 - 2017.	64
Figure 8: Foreign direct investment, net inflows, Tanzania, 1990-2016	79
Figure 9: Road traffic infrastructure and types and amounts of liquid fuels in Sweden	93
Figure 10: Energy consumption and fuel consumption per vehicle type in road transport, Sweden, 1990-2016	94
Figure 11: Amount of passenger vehicles per 1000 capita over time for each county in Sweden	95
Figure 12: Amount of passenger vehicles per area, population density, and average driving distance of passenger vehicles, for each county in Sweden	95
Figure 13: Changes in population and land-based inland passenger transport in Sweden	96

Tables

Tables	Page
Table 1: The issue, the approach and the analytical domains	35
Table 2: What I followed, how I followed it, and where I have analyzed it	38
Table 3: A summary of liquid biofuel-related land deals in Tanzania	79
Table 4: Energy consumption in road transport of members of the Swedish Association of Local Authorities and Regions, and in Sweden, 2009-2014	99
Table 5: A summary of additions come EU Directive 2015/1513.	102

Acronyms

CR	Critical realism
EC	European Commission
ESS	Emancipatory social science
EU	European Union
FAME	Fatty acid methyl ester
GHG	Greenhouse gas
HGV	Heavy goods vehicles
HVO	Hydrotreated Vegetable Oil
ILUC	Indirect land-use change
ISCC	International Sustainability & Carbon Certification
LCV	Light commercial vehicles
NGO	Non-governmental organization
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SALAR	Swedish Association of Local Authorities and Regions
SEA	Swedish Energy Agency
SKL-K	SKL Kommentus
SPBI	Swedish Petroleum and Biofuel Institute
TIC	Tanzania Investment Centre
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
URT	United Republic of Tanzania
WWF	World Wide Fund for Nature

Note to the reader

Every morning on the bus from Malmö to Lund, we pass by a fuel station before we leave my neighbourhood. Most people do not pay much attention to this mundane aspect of everyday life, but for me the fuel station represents my thesis. This is the site where people refuel their vehicles with liquid biofuels. Surrounded by what over the years seem to be countless cars, buses, and trucks, always in motion, my mind have often wandered off to the question: how could this society ever move to reduce the impact of transports on the climate?

This research on the promises and promotion of liquid biofuels for transport took me far and wide, eventually pushing me to take a somewhat different path than I originally intended. Experienced readers know that a compilation thesis has an introduction – or 'kappa' in Swedish – to summarize and synthesize a collection of journal articles. However, in order to open up for a more comprehensive interpretation of what goes on beyond the fuel station, I do not quite follow this model. Instead, I ask the reader to think of the kappa as a fuller version of my findings that emerged through my research process.

Preparing and developing the articles were important steps towards this end, and they do indeed contain important parts of the story – not least more of the empirical findings and the presentation of specific methods. However, the kappa is what allowed me to truly develop my thoughts on wide reaching phenomenon of liquid biofuels for transport. I kindly ask the reader to keep this in mind while reading the text that I develop hereafter.

1. Introduction

1.1 The frame: up against climate change and ecological modernization

The science is certain about the significant dangers of climate change. It further confirms that climate change drivers, impacts, and responses are multiple, diverse, and unevenly distributed (Edenhofer et al., 2014; Field et al., 2014). The impact on poor rural areas is disproportionately high, especially in the global South where more people than in the global North depend on access to land, water and food to maintain their livelihoods (Dasgupta et al., 2014). To mitigate the dangerous impacts of climate change, massive reductions of carbon emissions from road transport are necessary, especially in the OECD-1990 countries[1] that emitted more than half of these in 2010 (Sims et al., 2014).

The dominant approach to climate change mitigation, with the ultimate goal of saving us from an ecological crises, particularly in the European Union (EU), is to pursue ecological modernization. The logic of ecological modernization is to green the economy through environmental regulation that stimulates technological solutions and eco-innovations. It has been promoted by states, environmental movements, and expert organizations who want to decrease the damage caused by polluting industries by punishing environmentally degrading activities, while at the same time creating market-based incentives for clean(er) production (Mol, 2010; Spaargaren & Mol, 2009; Buttel, 2009; Jänicke, 2008; Baker, 2007; Hajer, 1995).

However, the ecological modernization position, along with its key assumption that it is possible to decouple economic growth from environmental degradation, is not delivering the desired outcomes. This becomes particularly apparent when one rejects the false assumptions that environmental impacts are contained within national borders and that efficiency gains will lead to reduced consumption (Dietz, Rosa & York, 2012; Krausmann, et al. 2009; Moore, Cranston, Reed & Gali, 2012). Instead, the globalization of commodity production has escalated, along with an

[1] Australia, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Japan, Canada, Luxembourg, the Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States of America.

increase in the use of global material from 22 billion tonnes in 1970 to 70 billion tonnes in 2010 (Schandl et al., 2016: p. 35). Further, global emissions continue to increase, while the annual rate of reduction required to meet climate targets is growing exponentially if there are no absolute cuts in total global greenhouse gas (GHG) emissions (Stocker, 2013). The political-economic critique suggests that regulation thus far has been largely ornamental and served to pacify the public, since firms must still produce more goods at a lower cost to survive in a profit-driven and growth-oriented economic system (see Rudel, Roberts & Carmin, 2011).

After these conditions had piqued my interest, I started to look for the 'alternatives' that the EU promotes to reduce transport emissions from the production and consumption of fossil fuels in road traffic. More importantly, if these aforementioned alternatives were not viable for achieving the desired goal of climate change mitigation, I wanted to understand why they were so persistently pursued, as well as what could constitute a better alternative.

1.1.1 The EU's support of liquid biofuels and the ensuing debate

The EU, a supranational authority, has put much political faith in substituting the energy from oil-based fuels used in internal combustion engines with that of liquid biofuels[2] produced from land-based resources, such as sugar-, starch- and oil-based agricultural crops, forestry residues, and animal fat. Since the 2000s, the EU has supported liquid biofuels by developing directives that include a suite of biofuel-friendly regulation like: mandatory renewable energy targets, biofuel blending obligations, standards, and tax exemptions. The EU's position implies that this regulation can ensure: (1) that the market will deliver liquid biofuels to reduce carbon emissions in transport, and (2) that adverse social effects, caused by increased demand of liquid biofuels in the EU, will not occur in the global South (see Franco et al., 2010). This support has resulted in a substantial increase in the consumption of liquid biofuels (see Figure 1). Sweden stands out, with its reported 24 per cent share of renewable energy in transport for 2015 (EC, 2017a); achieved primarily through increased consumption of liquid biofuels (see Figure 1).

[2] Liquid biofuels refers to biofuels delivered in liquid form as *alternatives* to petrol and diesel used in internal combustion engines. As we will see later, these represent the dominant share of biofuels delivered to the market, and mainly come in low-admixture forms. For example, ethanol from sugar cane is blended together with conventional petrol, or biodiesel from canola is blended together with conventional diesel.

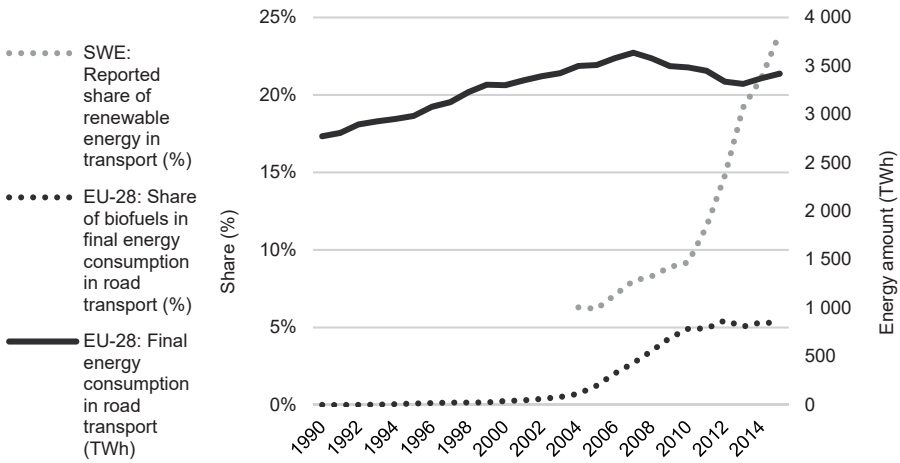

Figure 1 Road transport energy and liquid biofuel developments in the EU and Sweden, 1990-2015. Final energy consumption, and share of biofuels in road transport, in the European Union 28 countries (EU-28), 1990-2015. Reported share of renewable energy in transport, Sweden, 2004-2015. Sources: Eurostat (2017a; 2017b; 2017c).

The first critique suggests that emissions caused by feedstock and fuel production impede possible GHG savings. This is due energy conversion rates and, not least, to the fact that liquid biofuels – especially from food-based crops – compete with other land-uses. Hence, increased liquid biofuel production could move, for example, food production to previously un-cultivated land; thereby releasing GHG into the atmosphere through land-use change. The debate concerns the specific conditions under which, if ever, liquid biofuel production could actually deliver climate- and environment-friendly alternatives to fossil fuels in transport (e.g. Prade, Börjesson, Lantz & Ahlgren, 2017; Lapola et al., 2010; Dijkman & Benders, 2010; Searchinger et al., 2008; Danielsen et al., 2009; Börjesson, 2009).

The second critique (more often associated with the term 'agrofuels') suggests that the support of liquid biofuels adds economic pressure to land and land-based resources; which in turn harms 'food security'[3] and increases conflicts over scarce resources in rural areas, especially in the global South (see German, Schoneveld & Pacheco, 2011). Here arguments are based on to the adverse effects that rising/volatile food prices have on people in rural areas in the global South, not least on small-scale farmers who depend on secure access to food and agricultural incomes for their livelihoods (McMichael, 2010; 2012; Conceição & Mendoza, 2009; Dauvergne & Neville, 2010). Others have studied how land acquisitions

[3] According to the FAO and IPCC, 'food security' refers to a "state that prevails when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development, and an active and healthy life." (Agard & Shipper, 2014: p. 1765). The "three components underpinning food security (i.e., access to food, utilization of food, and food availability), […] need to be stable over time" (ibid.).

change land-tenure relations and often result in loss of access to land and natural resources for local populations without any (or ample) gains or social benefits through employment (Borras, McMichael & Scoones, 2010; Nalepa & Bauer, 2012; Vermeulen & Cotula, 2010; Cotula & Vermeulen, 2011). Reference here is made to the many land deals that are (or at least were) tied to the emerging markets for EU biofuels (Grain, 2016; Land Matrix, 2017, Johansson, Fader, Seaquist & Nicholas, 2016).

1.2 The issue: the dual problem of liquid biofuels

Having now described the broader context within which this thesis is situated, I proceed to the crux of the scientific matter and thus wish to welcome you to this thesis in *sustainability science*. Sustainability science is an emerging, interdisciplinary, problem-driven, and solutions-oriented scientific field (Clark, 2007) that addresses issues that are predominately rooted in nature-society interactions (Kates, 2012). Although problem definitions vary within sustainability science, their causes are acknowledged as complex and interdependent, meaning that what some may perceive as solutions may actually generate other or more complex problems (Jerneck et al., 2011). To produce robust knowledge for 'better solutions', researchers in sustainability science must draw on several disciplines (Kates et al, 2001).

In this thesis, as alluded to in the debate described above, the EU's support of liquid biofuels for transport is understood as constituting a dual problem. First, it is problematic that liquid biofuels, despite dubious environmental claims, are persistently pursued as a means to mitigate climate change; especially since this impedes the introduction and implementation of more meaningful alternatives. Second, it is also problematic that the growth of liquid biofuel markets for transport has adverse social effects on rural populations, especially in the global South. If this indeed is the case, what would be able to resolve this dual problem?

I argue that novel answers to this dual problem can be found by examining the complex interdependencies between energy and geography. To incorporate the inescapable materiality of energy into research, while also fulfilling the aspirations of sustainability science, I will develop a research approach that draws on *critical realism* (CR) (Bhaskar, 2013a; 2013b; 2010; 1986; Bhaskar, Danermark & Leigh, 2018; Sayer, 2000) and *emancipatory social science* (ESS) (Wright, 2010; 2013). I employ CR as a meta-theory to guide me through a set of questions that I ask in research, and to help me both interpret how several theoretical and empirical bodies speak to each other and navigate between them. I structure my research with the help of an ESS approach. Firstly, I am inspired by how it seeks to identify, explain,

and eventually contest, how institutions and social structures generate social harm and oppression. Secondly, I draw on its 'theory of transformation'. I apply a mixed-methods approach to conduct research across three empirically connected analytical domains of North-South dynamics – 'geopolitics', 'energy markets', and 'energy landscapes'. As we will see later, each analytical domain has a corresponding theoretical body and empirical focus, which I will tie together through the use of CR and ESS.

1.3 The aim and questions of the thesis

The aim of this thesis is to understand internal limitations and structural contradictions in the EU's support of liquid biofuels for transport, and to locate the scope for change within these. My research questions are accordingly:

1. Why did the EU pursue liquid biofuels for transport through regulation?
2. Can EU biofuel regulation:
    a. assure that GHG emission reductions in transport will be delivered?
    b. safeguard against adverse social effects in the global South that may arise because of increased demand of liquid biofuels in the EU?
3. If not, why has EU biofuel regulation failed?
4. What might constitute better alternatives for delivering the desired outcomes of EU biofuel regulation?

For fulfilling the overall aim of the thesis through answering these research questions, I adjust the overall methodology of the ESS approach (see Section 2.1.2), and by doing so I seek to also contribute to the critical problem-solving research agenda of sustainability science. The aim and the approach will be clarified when I explain my meta-theory and organizing principles the chapter that follows.

1.4 Thesis outline

In this introductory chapter, I introduced the contextual frame, the key issues, the overall aim, and the research questions that guide this thesis. In chapter two, I will explain my research approach: covering meta-theoretical considerations from CR and organizing principles developed from ESS. After that, I will specify the research setting, my argument, my theoretical bodies and their empirical focus, and my research process (including materials and methods).

The rest of the thesis is structured according to the ESS framework articulated by Erik Olin Wright (2010): starting with a systematic 'diagnosis and critique', then proceeding to 'alternatives and transformation'. This means that in chapters three and four, I start by presenting my 'diagnosis and critique' of EU biofuel regulation before proceeding to 'alternatives and transformation'.

In chapter three, by drawing on my research on the EU and Sweden, I build the foundation for my analysis of EU biofuel regulation by explaining the geo-historical context and the regulatory mechanisms (including their effects on firm-level decision-making) through which the EU promoted the economic pursuit of land-based resources for liquid biofuel production designated for transport. The chapter concludes with a critique of EU biofuel regulation, mainly by focusing on the EU's claim that the market will deliver liquid biofuels that can reduce GHG emissions caused by transport.

In chapter four, I seek to understand how mechanisms rooted in EU biofuel regulation affect land and labour relations, directly and indirectly, in the global South. Drawing on my research in Tanzania, I will explain the emergent properties of liquid biofuel markets. The chapter concludes with a critique of EU biofuel regulation, mainly focusing on the EU's claim that its regulation can safeguard against adverse social effects from increased demand of liquid biofuels in the EU.

In chapter five, I proceed with ESS by turning to alternatives and transformation. I start by revisiting the argument presented thus far, and then suggest a theory of social reproduction that may explain the persistence of the EU's support of liquid biofuels for transport – including some of its gaps and contradictions. The chapter concludes with a discussion of potential viable alternatives to resolve the dual problem of liquid biofuels.

In chapter six, I conclude by answering my research questions. I also define my theoretical and methodological contributions, including their wider implications for energy geographies in changing climate mitigation, and for sustainability science more generally.

It should be noted that each of the three articles, which are printed after the kappa, provide further detailed information on methods, empirical material, findings and arguments, parts of which are woven into each chapter. The first article is more explanatory in style and thus closer to the synthesis presented in this kappa, while the latter two are more exploratory and descriptive.

2. Foundations

2.1 The approach: from meta-theory to organizing principles

Here I present my approach to sustainability science. Meta-theoretically I am guided by CR, while methodologically I structure my analysis in line with the organizing principles of ESS articulated by Erik Olin Wright (2010). Below I clarify how I relate CR and ESS to one another both broadly and within the context of this thesis.

2.1.1 Meta-theoretical considerations from critical realism

Within CR, knowledge about the world is theory-laden but parts of the world exist independently of our theoretical thoughts about it.[4] Since our knowledge is conceptually-mediated, this becomes a challenge for science, especially as "there are always a multiplicity of causes and mechanisms required to explain an event or concrete phenomenon" (Bhaskar et al., 2018: p. 257). CR suggests that researchers face this challenge head on through interdisciplinarity, which, in turn, is desirable for finding fuller explanations, achievable through meta-theoretical unity, methodological specificity, and theoretical pluralism (ibid.).

CR suggests a '*stratified ontology*' comprising three levels: *the real*, *the actual,* and *the empirical* (Sayer, 2010). *Real objects* and *structures* that have causal power exist, as do *mechanisms* that originate in their existence that (may) generate *effects*. Since here science deals with complex and open systems, where causality occurs in specific *geo-historical contexts*, there are of course *multiple mechanisms* that interact with each other to create different *actual* effects across time and space (Sayer, 2010). Moreover, *real* objects can exist without their causal power being

[4] For example, the abandonment of the flat earth theory did change the shape of the earth itself, and when social scientists change their mind about a phenomenon they study, it will for the most part not change the phenomenon.

activated, consequently not generating any *actual* effects.[5] What researchers experience and the way they observe *empirical* phenomenon may relate to the objects, structures, and/or mechanisms in the *real* or the *actual* events that play out in front of them. This ontology provides the foundation for my approach to critical problem-solving science, which will be clarified below when I present my adjustment of ESS.

Furthermore, according to CR, a phenomenon can be *emergent* if: the properties of two or more objects can interact with each other to generate it and if a particular phenomenon has properties that are not predictable from the properties found at the level of the objects that generate it (Sayer, 2010).[6] The existence of an *emergent phenomenon* depends on the existence of the objects that generate it, and once emergent phenomena have been brought into existence further/new mechanisms may arise. As a result, CR explanations of causality not only involve the identification of mechanisms and how these (may) affect reality, but also if, how, and under what conditions they have been activated. For my research, these assumptions allow me to examine how land-use and tenure relations in the global South could be affected by decisions made in the EU even without observable material flows between two.

Not only does CR's stratified ontology and notion of emergence underpin my work, but CR also structures my method of presentation. Proceeding with CR, I start by developing accounts of the invisible and intangible domain of the *real* in order to access the *actual* through the *empirical*. Therefore, my chapters and sections often start with abstract/conceptual arguments (about *the real*) before proceeding to their more concrete implications (the *mechanisms* and *effects*), eventually showing their outcomes (in the *empirical*).

2.1.2 Organizing principles from emancipatory social science

As a meta-theory, CR allows us to speak about processes in terms of effects that are generated by mechanisms rooted in nature-society interactions; while also suggesting that we can assess the scientific validity of different claims and arguments, and thus identify better alternatives (Porpora, 2013). Bhaskar (1986) argued that the identification of *real* causal powers is crucial for fulfilling the transformative and potentially emancipatory role he saw in social science. This

[5] For example, the physical and mental capacity of people to work may be *real* (i.e. labour power), while this power and its effects are activated only when people *actually* exercise this capacity (i.e. labour).

[6] For example, if you solely focus on individual behaviour you will miss the properties of society that emerge from people, or if you study hydrogen and oxygen separately you will fail to explain the properties of water.

potential to be emancipating would depend on successful conceptualization of the powerful 'objects'.

However, Sayer (2010) argues that the limits of a critical approach in social science lie "in justifying the standpoints of its critique and of finding alternative social forms which generate fewer problems than those they replace, and hence lead to net improvement" (p. 168). This is exactly what I seek to do with the help of sociologist Erik Olin Wright's overarching framework for ESS.

In his "*Envisioning Real Utopias*" (2010), Wright explains the rationale for an ESS that works to uncover the causes of *social harm and oppression* (which he defines in relation to moral principles), as well as support social change for alleviating them. He starts from two foundational propositions: (1) many forms of social harm and oppression are caused by existing institutions and social structures, and (2) these adverse effects can be (substantially) alleviated by transforming institutions and social structures into new forms that would better ensure *human flourishing*[7] (Wright, 2013, 2010). Importantly, social harm and oppression, and their potential alleviation, are not seen as rooted in human nature but in social relations.[8]

Drawing on the vibrant theoretical flora on social change and transformation in critical theory and sociology, Wright (2010) presents an overarching framework through which the production of scientific knowledge can challenge various forms of oppression. This framework suggests that science should start by developing a systematic *diagnosis and critique*[9] to show how social harm and oppression is

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[7] Departing from a *radical democratic egalitarian* understanding of justice, Wright (2010) defines *human flourishing* as: "the absence of deficits that undermine ordinary human functioning. This includes things like hunger and other material deprivations, ill health, social isolation, and the psychological harms of social stigma. This is a heterogeneous list – some elements refer to bodily impairments, others to social and cultural impairments. But they all, through different mechanisms, undermine basic human functioning. A just society is one in which all people have unconditional access to the necessary means to flourish in this restrictive sense of the satisfaction of needs for basic human flourishing." (p. 13).

[8] This overarching theoretical position contrast that of much sustainability science research. I expand on this in a forthcoming paper that will be presented at the Association of American Geographer's conference in New Orleans, LA, in April 2018, alongside my co-author Eliinor Isgren. In the paper, we argue that some sustainability science research has implicit/incoherent assumptions about social change that lead to scientific disconnect between levels of analysis and choices of theory. For example, we point to how the subject matter of research deals with structural problems rooted in social relations, yet researchers turn to theories on individual behaviour, cognitive science, or resilience theory for ideas on social change (see also Olsson, Jerneck, Thorén, Persson & O'Byrne, 2015).

[9] Wright's approach to critique relies on a Kantian, analytical epistemology, in which science first specifies moral principles for judging the mode of institutions and social structures (Wright, 2010). Even though *sustainability* has been incorporated as a moral principle into the ESS framework (Wright, 2013: pp. 5-6), exactly how nature-society interactions are to be brought into

generated in society. Research should then develop a scientific account of *viable alternatives* that can lead to (substantial) net improvements. In the pursuit of *achievable* alternatives, ESS also seeks the scope for change in relation to *structural obstacles and possibilities of transformation*, and with this as a basis, it proposes a *theory of transformation* for achieving alternatives.[10] All these tasks are necessary for a comprehensive approach to ESS, but one or the other may be more pressing than others depending on the particular time and place (Wright, 2010: p. 10).

Two aspects of how I rely on, and adjust, this 'theory of transformation' need to be further elaborated: the approach to critique, and the role of social reproduction in conditioning the scope for change.

First, although the purpose of my diagnosis and critique is the same as in ESS (i.e. to identify root causes in social relations), my approach is closer to that of *immanent criticism* often found in CR. While Wright (2010) starts by defining a baseline against which he judges whether or not institutions and social structures are generating social harm and oppression, my approach to critique instead starts from within the position of what is being criticized (Bhaskar, 2013b: p. 12). This means that my initial task is not to explain what criteria I decided to use for evaluating different alternatives, but rather to understand what societal actors within their specific contexts are seeking to achieve. Here, if one could show how the mechanisms of EU biofuel regulation is incapable of achieving its internal goals, this makes for a more convincing argument for the implementation of more viable alternatives (rather than if one shows that the regulation fails to achieve goals it has never purported to achieve in the first place). Thus, the underpinning logic being that knowledge attained through immanent critique is more convincing than that of external critiques, thus offering greater possibilities for change when used by actors in emancipatory struggles (see Antonio, 1981).

Second, ESS suggests that a variety of interconnected mechanisms of active *social reproduction* allow for the harmful causal power of institutions and social structures to remain unchallenged (Wright, 2010: p. 16). Broadly, social reproduction here refers to "the processes that reproduce the underlying structure of social relations and institutions of a society" (ibid.: p. 274). For example, this could be both through

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the production of scientific knowledge in ESS remains unspoken. Thus, in using Wright's framework, I instead start from CR and engage with sustainability science methodology.

[10] As suggested by the title "Envisioning Real Utopias", Wright is cognisant of the significant challenges of *achieving* alternative social structures and institutions. For Wright (2010), the agency for implementing any given alternative to social structures and institutions sometime in the future depends on two kinds of processes: (1) "the *consciously pursued strategies* and the *relative power* of social actors who support and oppose the alternatives in question" (pp. 24-25), and how (2) "the probability of any given alternative being implemented depends upon the trajectory over time of a wide range of *social structural conditions* that affect the possibilities of success of these strategies" (p. 25).

processes "anchored in the mundane routines and activities of everyday life" and through institutions partly designed to serve the purpose of social reproduction – such as the police, the courts, the state administration, education, the media, churches and so forth (ibid. pp. 274-275). Furthermore, as disruptions to ecosystems are (or may be) irreversible, one may add a sustainability science perspective to this point on social reproduction, since certain forms of social reproduction can be further reinforced through nature-society interactions.[11]

However, following ESS theory of transformation, Wright suggests that research:

> […] should not simply map the mechanisms of social reproduction, but should also identify the processes that generate cracks and openings in the system of reproduction. (Wright, 2010: pp. 290-291)

ESS posits that social reproduction is *not* entirely consistent, and thus prone to failure. These *'gaps and limitations'* internal to the mechanisms of social reproduction open up possibilities for *collective action* aimed at structural change. Most importantly, the possibilities for agents to utilize these inconsistencies for their purposes depend on the progress of scientific knowledge about them (Wright, 2010: p. 17). Adding a sustainability science argument, these gaps and contradictions can also be found in how society interacts with nature, as ecological limits may also (eventually) undermine mechanisms of social reproduction. Therefore, I seek to identify and explain the active mechanisms that reproduce the conditions that allow the EU's support of liquid biofuels for transport to prevail (i.e. the mechanisms within social reproduction), and the possible spaces wherein these mechanisms can be challenged (i.e. gaps and contradictions internal to the social reproduction).

To summarize, drawing on CR and taking inspiration from parts of the ESS theory of transformation (for more elaboration see Wright, 2010), I seek to: (1) diagnose and critique the root causes of the dual problem of liquid biofuels (2) discuss what may constitute *desirable and viable alternatives* that resolve these problems by relying on an immanent critique of EU biofuel regulation, while also identifying additional gaps and contradictions in its underlying social reproduction. Although within ESS reasoning it is important to consider the great challenge of

[11] For example, 'energy' is both biophysical processes (e.g. gusts of wind blowing or flows of water flowing) and social phenomenon that require space (e.g. land for windmills or manufactured dams) for doing something (e.g. mechanical work for grinding, or providing the grid with electricity). Say a river has been dammed by a nation-state that seeks to provide cheap electricity for capitalist development through hydropower production in an area historically inhabited by an indigenous population. Any attempts by local indigenous communities, who have lost access to land, water, and other resources, will face even stronger mechanisms of social reproduction that impede their struggle for restoring values they saw as in this specific place as the change of the biophysical reality, including ecosystems, is difficult (if at all possible) to retract.

achievability[12], in this case that endeavour falls outside of the scope of my Ph.D. thesis. That said, in the articulation of an *achievable alternative*, a corresponding critique together with a convincing theory of social reproduction and the identification of gaps and contradictions inherent to this social reproduction play a crucial role in actually being able to conceive an achievable alternative. Illuminating these qualities helps to demonstrate how current approaches within EU biofuel regulation undermines its own goals and may provide a convincing rationale for mobilizing agents towards viable alternatives.

Finally, to energize this interdisciplinary approach with the nature-society dynamics at play, I will unpack the multifaceted and complex nature of how the materiality of energy relates to space. Here, Mathew Huber's article "*Theorizing Energy Geographies*" (in which he engages with critical theory) provides important insights on the complex interdependencies between energy and geography. Huber (2015) argues that energy can be reasserted as a central concept when understanding the social production of space by conceptualizing: (1) energy extraction as part of geopolitical imaginaries, (2) the role of energy infrastructure and urbanization, and (3) how energy consumption relates to geographies of globalization (ibid.). I will elaborate on how I use these three aspects in Section 2.3, where I describe my three analytical domains. Here, I emphasize that the materiality of energy and its relation to social phenomena are ever-present in my research, but, in line with my method of presentation, I only bring it in when needed to conceptualize the problem at hand.

An epistemological consideration on the scalar issues of emancipation

The monumental challenge of mitigating human-induced global warming creates dilemmas on how to allocate the costs and benefits of scarce energy resources. Although one could apply this research approach within a nation-state, Nancy Fraser, one of few within critical theory who has explicitly theorized justice in such a globalizing world (see Fraser, 2013: pp. 189-208), has argued that injustices can arise at different scales (Fraser, 2009).

In my research, the main scalar issues of social harm and oppression revolve around what Fraser refers to as the 'social exclusion of the transnational precariat' (Fraser, 2010). Fraser argues that most struggles today operate in a way that conceptualises sovereign nation-states as relatively independent from one another, which may thus deny the causal responsibilities of actors, processes, and mechanisms that operate on a transnational scale (Fraser, 2010; 2013). So, in this case, because we 'misframe' struggles as contained within nation-states, we may miss the opportunity

[12] For an alternative to be *achievable* it would have to mobilize agents to formulate "coherent, compelling strategies which both help create the potential to mobilize the necessary social forces to support the alternative" (Wright, 2010: p. 24).

to understand the reality and claims of vulnerable formal/informal/unpaid workers in the global South in relation to practices that happen in the global North.

To overcome this scientific challenge when adopting the ESS framework, I adjust the terminology proposed by Nancy Fraser (2010) slightly and conceptualize a '*transnational rural precariat*' as a group of vulnerable formal/informal/unpaid workers, who are mostly located in the global South, and may easily slip into disfavoured livelihood conditions when "global economic structures intersect with local status hierarchies and national political structures" (Fraser, 2010: p. 370). While Fraser does not emphasize the rural, I will argue that the mechanisms that I approach in this thesis are more likely to affect rural livelihoods than urban livelihoods. Importantly, political ecologists have shown that, while livelihoods of rural communities in particular are dependent on local ecologies and broader landscape dynamics, state and international law and regulation can introduce, or impose, other uses; resulting not only in the loss of access to natural resources amongst this land-dependent population, but also the loss of non-economic values that they see in nature (see Robbins, 2011; Bryant, 1998). Following Fraser's scientific advice on emancipatory struggles, and acknowledging the academic debate on agrofuels, the analysis hereafter incorporates the effects EU biofuel regulation on the transnational rural precariat.

2.2 The setting: the argument and research focus

With an analytical focus on the underlying capitalist social relations of production and exchange that characterise the expansion of the EU's liquid biofuel market for transport (clarified in Section 2.3), this thesis presents an argument that consists of three major parts.

First, I argue that EU biofuel regulation impedes more meaningful mitigation of GHG emissions in transport. Its intrinsic mechanisms encourage firms to further expand intensified land-use practises for the production of energy commodities. This spills over to new land areas for increased production, while regulation is incapable of assuring that these energy commodities deliver actual (and substantial) GHG emission reductions.

Second, EU biofuel regulation has had (and continues to have) adverse social effects on the transnational rural precariat, especially in the global South. This because many states in the global South pursue(d) liquid biofuels as a neoliberal approach to development; resulting in accumulation by dispossession. Together, these mechanism (in this case, propagated by the EU and the Tanzanian state) tend to shift land and labour relations towards intensive agriculture designated for external

regional markets without delivering ample social benefits to the local population of these rural areas.

Third, EU biofuel regulation is a response to (multiple) crises in capitalism: liquid biofuels have provided firms with new accumulation opportunities and the EU's regulatory mechanisms allow firms in pre-existing geographies of production and consumption to produce commodities in more 'flexible' ways. Importantly, I found that this 'flexing' is a defining feature of EU biofuel regulation wherein the ensuing geopolitical territorialisation reproduces the 'transport energy landscape' and its underlying social relations. Importantly, in this specific geo-historical context, particularly given prevailing North-South dynamics, the underlying capitalist social relations of production and exchange will almost certainly be unable to resolve the dual problem of liquid biofuels.

Finally, by exposing the weakest links within the structural contradictions inherent to EU biofuel regulation – through immanent critique and by identifying the gaps and contradictions within its social reproduction – I will elaborate on the scope for change under current structural conditions.

The analytical focus here is on the geographically expanding process of commodity production and regulatory development resulting from EU biofuel regulation. More specifically, I stress the material processes generated by the regulatory mode institutionalized in the EU's renewable energy and fuel quality directives (EC, 2009a; 2009b); directives that opened up to fiscal policies to be used for achieving a mandatory 10 per cent 'renewable energy' target for transport by 2020 and established a mandatory hybrid regulatory system. While the expansion of the EU's liquid biofuel market for transport is directed, guided, and led by the EC, it is the market that supplies goods (i.e. liquid biofuels), services (i.e. certification systems), and technological development (i.e. GHG emission reductions) that must abide to regulation. The core mechanism is that EU biofuel regulation defines what commodities are allowed within the subsidized market, and that firms organize commodity production in accordance with regulation (given that there are opportunities for profit-making on these regionally regulated markets). As a result, the development of regulation necessary for liquid biofuels to compete with fossil fuels, and the agency and activities of firms (with agential self-interests) within this structure, are the main objects of study for following this expansion.

The geographically expanding process of commodity production and regulatory development resulting from EU biofuel regulation, including the problems it exacerbates and how it may be challenged through its internal gaps and contradictions, is examined in three ways: by unpacking the mechanisms of EU directives, by closely studying the activities of firms that produce and exchange liquid biofuels for the EU's transport fuel market, and by tracing the appropriation of land-based resources for its associated commodity production in the periphery.

Indeed, echoing Neil Smith's interpretation of Karl Marx's concluding chapter on colonization in *Capital*, "the social relations of capitalism are more clearly and sharply observable at the periphery of the system than at the centre" (Smith, 2003: p. 235). Therefore, I set out to follow the power of EU biofuel regulation in the social relations of production and exchange all the way to the global South to gain a deeper understanding of the nature-society interactions in energy regulation under current global conditions.

2.3 Three analytical domains of North-South dynamics

My research is conducted across three interconnected analytical domains of North-South interactions – each associated with its own guiding question. Analytically, albeit intertwined practically, each of the domains has a corresponding theoretical body and empirical focus.

2.3.1 The analytical domain of geopolitics

Throughout history the extraction of energy sources has generated geopolitical processes that are often linked to issues of state power and territoriality (Bouzarovski & Bassin, 2011; Labban, 2011; Le Billon & El Khatib, 2004). Matthew Huber (2015) argued that energy's link to geopolitical imaginaries can be identified by tracing energy from the point of consumption to the source of extraction (pp. 3-5), a point that I agree with. This endeavour can help explain how energy extraction is shaped not only by political forces but also by how the materiality of energy relates to space.

Some initial conceptual clarifications on political economy of land is necessary. Land is a valuable economic resource of limited supply, and its availability, use, and productivity have bearings on the capacity for economic growth. While land-based resources (from which the energy for liquid biofuels is sourced) carry such materiality, they also carry complex, and evolving, social constructs filled with other (non-economic) meaning. Therefore, land is affected by capitalist social relations of production and exchange, and I understand land-use as the result of actors' continual struggle to re-negotiate its terms.

David Harvey (2003: pp. 183-211) has stressed that numerous and ongoing social struggles are part of (larger) accumulation processes, and that these struggles are place-specific rather than occurring in a homogeneous and pre-determined set way. Although place-specific, a critical approach to these struggles must increasingly relate to the greater economic reach of contemporary capitalism. Nancy Fraser refers

to how the cracks, or the demise, of the 'Keynesian-Westphalian frame'[13] that has come with the neoliberal era has blurred the line between domestic and international space in ways that affect these struggles (Fraser, 2013). Simply put, many observe how social processes shaping the lives of people in one territory relate to decisions made in another, but fewer actively seek to understand the complex causalities involved.

What I refer to as geopolitics has to do with territorial struggles that revolve around the capture of benefits, and control over land and land-based resources. For Huber (2015), understanding energy as an object of geopolitics implies that energy "is, an object of concern in not only state formation, but forms of conflict and cooperation between states" (p. 4). Therefore, in the context of globalisation and the geopolitics of capitalism (Harvey, 2006a; 2006b), I suggest that the expansion of the EU's liquid biofuel market for transport is part of an ongoing 'territorialisation process' (Brenner, 1999; Brenner, Jessop, Jones and MacLeod, 2003; Sheppard, 2011).

Territorialisation has been theorized as a dialectical process of de- and re-territorialisation (see Brenner, 1999). On the one hand, capitalism has an expansionary drive to eliminate all territorial barriers for finding cheaper raw materials, new sources of labour, new markets for goods/services, and profitable investments. On the other hand, capitalism also requires stable territorial organizations, not least in order to ensure the necessary physical infrastructures for production, exchange, distribution, consumption, and transportation to facilitate accumulation. I understand the formation and continued development of the EU as part of a re-territorialisation of the state onto a supranational scale. This European re-territorialisation is partly geopolitical and serves "to enforce regional structural competitiveness and as protective barriers to global competition" (Brenner, 1999: p. 66).

When explaining his view on the geopolitics of capitalism, Harvey (2006a: pp. 107-109) specifically points to the intimate, and contradictory, relationship between a territorial logic wherein nation-states or larger regional blocks try to protect their own interests through political strategies such as regulation, and a capitalist logic wherein capitalist firms try to protect their own interest by moving their capital to where most profit can be made. In this process, regional 'alliances' of territorial and

[13] The phrase Keynesian-Westphalian frame "is meant to signal the national-territorial underpinnings of justice disputes in the heyday of the postwar democratic welfare state […]. In this period, struggles over distribution […] were premised on assumptions of state steering of national economies. And national Keynesianism, in turn, was premised on the assumption of an international state system that recognized territorial state sovereignty over domestic affairs […] I invoke 'Westphalia' as a political imaginary that mapped the world as a system of mutually recognizing sovereign territorial states. My claim is that this imaginary undergirded the postwar framing of debates about justice in the First world." (Fraser, 2013: p. 190)

capitalist interests collaborate and/or compete against each other as they seek control of land and land-based resources.

The geopolitics of capitalism will assume a territorial aspect due to the 'history of geographically uneven development' and the 'variegated nature of capitalism' (Harvey, 2006a; 2006b). The history of geographical uneven develop implies that throughout history, economic development has been geographically uneven, and that the world is characterised by diverse labour and nature productivity across time and space (Harvey, 2006b). Uneven development is largely caused by processes and outcomes that are characteristic of, and functional to, capitalist development (Gregory, Johnston, Pratt, Watts & Whatmore, 2011). Consequently, capitalism is 'variegated', implying that it takes different concrete shapes and forms all over the world – much due to how struggles between labour and capital have proceeded in each locality (see Peck & Theodore, 2007).

To illuminate the social relations involved in this accumulation process (i.e. the EU's pursuit and extraction of energy sources), my objective in this analytical domain is to answer:

> In what geo-historical context and through what mechanisms did the EU promote, and the state in Tanzania facilitate, the appropriation of land-based resources for liquid biofuel production?

Tanzania, a country in eastern sub-Saharan Africa, will help illustrate the emergent properties of the expansion of liquid biofuel markets. Tanzania specifically helps illustrate these emergent properties for several reasons. The Tanzanian government welcomed foreign direct investments for developing liquid biofuel production (Coulson, 2013; Sulle & Nelson, 2009), while not producing any liquid biofuel nor having any specific domestic interest in its production prior to policy-stimulated growth in the 2000s (Appendix I.1). Up to 25 liquid biofuel-related land deals are currently classified as (potentially) ongoing, a number that does not include those that are classified as ceased or having not formally started the land deal process at all (Locher and Sulle, 2014; Locher and Sulle, 2013). There is also a large amount of peer-reviewed academic literature available on liquid biofuel projects specifically, and land-use and tenure relations more broadly (see Chapter 4).

The scope of my research in Tanzania is limited primarily to the national level. The analytical focus is on the state and the national bureaucracy, and how they facilitated foreign direct investments, targeting those related to liquid biofuel production. I chose this scale, as I see agency and power in political strategies aimed at attracting foreign direct investments as mainly residing in the Tanzanian state and among its bureaucrats (see Coulson, 2013).

2.3.2 The analytical domain of energy markets

In a capitalist economic system, the competition-enforced dynamics of accumulation tend to steer social relations towards profit maximization. This capital accumulation is "the process by which capital is reproduced on an expanding scale through the reinvestment of surplus value" (Gregory et al., 2011: p. 3). Competition in the quest for new profit opportunities tends to drive investment towards intensifying production and consumption in locations where profits can be made. This contributes to shaping the uneven geography of capitalist development and transforming other social relations in ways that facilitate the expansion (Harvey, 2006b).

The 'energy commodities' studied in this thesis, i.e. liquid biofuels for transport, are delivered to and through physical infrastructure that condition the production and exchange of commodities (see L. Harvey, 2010). Here, territorialisation has made certain energy commodities (and physical infrastructure) cheaper, while natural processes (made observable through the laws of thermodynamics) make it more expensive to overcome the biophysical limitations of commodity production. Furthermore, firms also act within pre-existing geographies of production and consumption, as they produce these commodities and exchange them on markets. Hence, the activities of firms that produce, distribute, and/or exchange 'energy commodities' are conditioned by pre-existing physical infrastructure, as well as by the laws of thermodynamics and pre-existing geographies of production.

Furthermore, market dynamics are also subject to institutions, such as regulation. Specific modes of regulation are historically contingent, and can also only target "a definite consumption, distribution, and exchange, as well as definite relations between these different moments" (Jessop, 2000: p. 324). Consequently, regionally regulated markets exist, through which states can affect the social relations of consumption, distribution and exchange of specific goods and services. As an ontological starting-point, I view regulation as containing mechanisms (such as targets, fiscal policy, and standards) that can stimulate production of specific commodities.

To access the more precise capitalist social relations involved in the EU's liquid biofuel market for transport, my objective in this analytical domain is to answer:

> How, through what geographies of production and consumption, and within what physical infrastructure, do firms produce and exchange commodities for the EU's liquid biofuel markets for transport?

This focus on economic geography and regulation is justified with reference to three empirical phenomena. First, liquid biofuels for transport are commodities produced by private firms that act on a transnational-to-local scale. Second, current production methods require land-based resources such as agricultural crops, forestry residues,

and animal fat. Third, firms are not only conditioned by their profit-driven nature, but also by the fact that access to the subsidised EU market also requires them to demonstrate compliance to EU biofuel regulation.

2.3.3 The analytical domain of energy landscapes

The geographies of transport energy are conditioned by material aspects: such as the dominance of the internal combustion engine, the scale of energy consumption in road transport, and the sunk costs of road transport infrastructure, including distribution systems for liquid fuel such as fuel stations and the oil-based commodity chains beyond. To keep transport running requires a steady input of energy commodities, the production and consumption of which is also subject to regulation (e.g. energy targets, subsidies, and standards).

The land-use dynamics for the production of liquid fuels analysed in this thesis are immediately affected by the materiality of energy. Drawing on the laws of thermodynamics, at least two biophysical conditions that impose specific material relations onto the land-use dynamics involved can be distilled. First, the form and quality of energy matters for the amount of mechanical work that can be converted from it, which conditions the land-use dynamics associated with the production of energy commodities in society. Second, land, on which plants are cultivated, also has important biophysical limitations that affect the size of the land area required to convert energy into a form that is useful to perform mechanical work, which then further conditions land-use dynamics. Taken together, I understand energy commodities produced from land-based resources (e.g. oil-based or starch-based agricultural crops) through different production systems as embodying different total amounts of energy that has been derived from economic and ecosystem-based processes (see Odum, 1971; 1996). By making these kinds of substantive qualifications, the spatial relations involved in the substitution of fossil fuels with other energy sources in terms of land-use can start to be revealed (Pasqualetti & Stemke, 2017, Smil, 2015).

To elucidate the spatial relations of liquid biofuels in the geographies of transport energy, I draw on literature on ‘energy landscapes’ (Pasqualetti & Stremke, in press; Carton, 2017; 2016) and ‘energy geography’ (Huber, 2015, 2013; Bridge, Bouzarovski, Bradshaw & Eyre, 2013). I proceed to conceptualize a ‘transport energy landscape’ that I describe and analyse in ‘spatial’ terms (by explaining the physical appearance of this energy landscape), ‘substantive’ terms (by showing what energy resources are being used in this energy landscape), and ‘temporal’ terms (by showing how this energy landscape changes over time) (see Pasqualetti & Stremke, in press).

To assess the outcomes of these processes that are both material and social, my objective in this analytical domain is to answer:

> Which material outcomes has EU biofuel regulation generated in the Swedish transport energy landscape in terms of: the types and amounts of liquid biofuels delivered, the types and amounts of land-based resources used, and the origins of those land-based resources?

Here, Sweden is viewed as the "most likely case" (Flyvbjerg, 2006: pp. 229-233) for successfully operationalizing the EU's regulatory mode. There are five reasons for this: Sweden was among the first member states to successfully transpose the EU's regulatory framework (Hamelinck et al., 2013); among all member states it has the highest share of renewable energy in the transport sector (European Commission, 2015); it has a long history of promoting liquid biofuels (Eklöf, Ekerhom & Mårald, 2012); and it has a political target to have a vehicle fleet that is independent of fossil fuels by 2030 (Government Office in Sweden, 2016). Furthermore, the degree of commitment to develop a biofuel market is larger in Sweden than in other member states of the EU (see Di Lucia & Kronsell, 2010). This decreases the institutional uncertainty of the territory's commitment to liquid biofuels for transport, though it must still abide by the rules of the supranational authority that is the EU.

2.3.4 Towards an interdisciplinary understanding

How then do all these theories fit together? As a meta-theory, I rely on CR to help me interpret how theories speak to/against each other (see Alvesson & Sköldberg, 2009: pp. 271-274). ESS offers not only a research approach, but also an overarching theory of transformation that relates to the aim of this thesis. Through an iterative research process across the three analytical domains of North-South dynamics, I explain the mechanisms of the geographical expansion of commodity production and regulatory development resulting from EU biofuel regulation, and relate these mechanisms to the overarching theory of transformation.

An overview of the issue, the approach and the analytical domains is presented in Table 1 (see Table 1). My approach to sustainability science also hinges on a reflexive stance towards empirical research. This brings me to my research process, materials, and methods.

Table 1 The issue, the approach and the analytical domains.

The dual problem of liquid biofuels

1. Liquid biofuels for transport are persistently pursued by the EU as a means for climate change mitigation in transport despite contested claims around their environmental performance
2. The growth of liquid biofuel markets has adverse social effects on rural populations, particularly communities in the global South (i.e. the group I have conceptualized as the transnational rural precariat).

Research aim and research questions

- To understand internal limitations and structural contradictions in the EU's support of liquid biofuels for transport, and to locate the scope for change.

1. Why did the EU pursue liquid biofuels for transport through regulation?
2. Can EU biofuel regulation:
    a. assure that GHG emission reductions in transport will be delivered?
    b. safeguard against adverse social effects in the global South that may arise because of increased demand of liquid biofuels in the EU?
3. If not, why has EU biofuel regulation failed?
4. What might constitute better alternatives for delivering the desired outcomes of EU biofuel regulation?

Meta-theory and organizing principles

- **Critical realism**:
  Effects are generated by mechanisms rooted in nature-society interactions. We can assess the scientific validity of different claims and identify better alternatives through interdisciplinary research.
- **Emancipatory social science**:
  Develop a diagnosis and critique, an account of viable alternatives, and a theory of transformation (given the structural obstacles and possibilities of transformation)
- **Theory of transformation**:
  Expose the weakest links within the structural contradictions inherent to what is being criticized – through immanent critique and by identifying the gaps and contradictions within its social reproduction – to elaborate on the scope for change under current structural conditions.

The analytical domains of North-South dynamics and their objectives

Analytical domain of geopolitics	Analytical domain of energy markets	Analytical domain of energy landscapes
In what geo-historical context and through what mechanisms did the EU promote, and the state in Tanzania facilitate, the appropriation of land-based resources for liquid biofuel production?	How, through what geographies of production and consumption, and within what physical infrastructure, do firms produce and exchange commodities for the EU's liquid biofuel markets for transport?	Which material outcomes has EU biofuel regulation generated in the Swedish transport energy landscape in terms of: the types and amounts of liquid biofuels delivered, the types and amounts of land-based resources used, and the origins of those land-based resources?

2.4 The process: materials, methods, and analysis

In order to identify emergent phenomena in this vast world characterised by multiple mechanisms, my research applies a mixed-methods approach (Creswell & Clark, 2007), wherein I draw on 'follow the thing' methods in particular (Bair & Werner, 2011; Freidberg, 2001; Hughes & Reimer, 2004). My research strategy employs a 'distended case study' approach (Peck & Theodore, 2015; 2012). In this spirit, I affirm that (in some research settings) the borders that researchers define may not be as precise or ideal as wished for in a case study (ibid.). Instead, in these cases, we turn to theory and concepts to "distend the case" (i.e. allow it to swell), and thus capture more of 'what is going on' (Peck & Theodore, 2015; 2012; see also Burawoy, 1998).

Peck and Theodore (2015, 2012) suggest that in a critical analysis of transnational-to-local processes, one can follow a particular object of study by way of a relational analysis spanning across multiple research sites. Borrowing from Burawoy (2001), they see certain *movement* across different sites that can be observed in the locality (p. 149). Therefore, trends like the decentralization of nation-states, the mushrooming of multilateral agencies, or the expansion of transnational expert networks are not "mere precursors to global homogenization, but rather as complex and contradictory spaces ripe for critical interrogation" (Peck & Theodore, 2012: p. 21). Since actors, processes, and mechanisms across these sites are highly dynamic, researchers are forced into more exploratory modes of research rather than pre-formulated ones. Thus, in order to find or build concepts that successfully explain what is occurring in the *movement*, researchers must adopt stronger forms of *reflexivity* and methodological experimentation as they follow objects that travel across multiple sites (Peck & Theodore, 2012).

This may seem challenging or even chaotic. In response, Peck & Theodore (2012) suggested a procedural logic for studying objects (in their case, policies) not as fixed but as complex, mobile, and evolving social constructs that shape and re-shape social relations between distant places (p. 23). As such, objects (e.g. policies and regulation) enter socially structured and constituted fields marked by institutional heterogeneity and contending social forces (p. 23). The task is therefore to follow them through these fast-changing and relational research settings, while keeping track of their 'unscripted deviations' (Peck & Theodore, 2012: p. 29).

As suggested by Alvesson and Sköldberg (2009: p. 274) the trick is then to control many theories without letting them control you, and to use meta-theoretical insights to stimulate alternative points of departure for thinking about what you can produce through empirical work. In this dynamic research process, my analysis has benefitted greatly from continual reflections on how empirical material is affected by my interpretative repertoire (theories) and by using my meta-theory (CR) to

problematize and stimulate alternative views and theories (see Alvesson & Sköldberg, 2009: pp. 274-278). For example, land that EU-based firms may view as suitable for production of ethanol feedstock – given that it is supported by EU biofuel regulation – could be viewed by Tanzanian government officials as an asset necessary to attract investments for agricultural modernization. At the same time, smallholders in subsistence farming may see this land as imbued with cultural meaning and gendered livelihood practises. Any scholarly interpretation of a highly dynamic reality where actors have varying perspectives, must therefore endeavour to be fair and nuanced.

In more concrete terms: what have I followed in my research? Broadly defined, I set out to 'follow the energy' via routes of both the commodity production of liquid biofuels for transport and regulatory development for EU biofuel regulation. On this expedition, I applied the above-described mixed-methods approach in order to gain access to the actors, processes, and mechanisms that participate in the expansion of the EU's liquid biofuel markets for transport; both in terms of commodity production and regulatory development. Observations, interviews, and workshops with actors in Tanzania and Sweden (identified through scoping exercises as in some way related to liquid biofuels) were important tools that helped me gain access to sites where powerful actors and institutions reside, as well as knowledge of these actors (see Wedel et al., 2005: p. 41). Further, spatio-temporal analysis of quantitative data was an important tool for following the growth of the EU market for liquid biofuels, and document analysis helped provide a deeper understanding of the regulatory development that allowed liquid biofuels to compete with conventional liquid fuels on energy markets (in the EU, Sweden, and Tanzania). In Table 2, I have summarized: (i) what empirical phenomena I have followed and at what sites, (ii) how I followed more concrete objects of study including methods and types of data, and (iii) where/how I interpreted findings (see Table 1). In Appendix I, I have listed (and described) the meetings and workshops I organized, and the different observation sites I visited throughout my Ph.D. project.

2.4.1 Two reflections on the process

Two aspects of this research process were particularly important to the development of this thesis.

First, during the initial stages of my Ph.D. education and research, I approached many 'incumbents' (Fligstein & McAdam, 2011) – actors whose interests and views tend to reflect those of prevailing institutions and social structures. Thus, in preparation of productive fieldwork and interviews with decision-makers at government organizations and firms, I had to expand my knowledge of how the EU's market of liquid biofuels for transport affects the day-to-day practices of these

Table 2: What I followed, how I followed it, and where I have analyzed it. A summary of the objects that were studied, and the methods that were applied, throughout the research process. Data marked with * refers to data treated as quantitative data.

What have I followed?		**How have I followed it?**			**Where have I analyzed it?**	
Phenomenon	**Site**	**Object of study**	**Method**	**Data**	**Chapters**	**Papers**
Commodity production *Expansion of liquid biofuel production for the EU market*	EU	Commodity production of firms	Spatio-temporal analysis	Certification databases	3, 5	I
	EU & Sweden	Commodity production of firms	Spatio-temporal analysis	Official statistics*	3, 5	III
	Sweden	Transport energy landscape	Spatio-temporal analysis	Official statistics*	5	
	Sweden	Views of firms	Survey	Survey responses	3, 5	III
	Tanzania	Views of firms	Semi-structured interviews	Interview transcripts	4	II
	Tanzania	Land-grabs (outcomes)	Literature review	Academic literature	4	II
Regulatory development *Expansion of EU biofuel regulation*	EU	EU regulation (state)	Document analysis	Legal documents	3, 4, 5	I, II, III
	EU	EU regulation (private)	Document analysis	Certification standards*	3, 4, 5	I, II, III
	Sweden	Views of firms, government bodies, NGOs	Observations, participatory observation, and informal interviews	Field notes	3, 5	-
	Sweden	Views of firms	Survey	Survey responses	3, 5	III
	Sweden	Views of firms, government bodies, NGOs	Meetings and workshops	Field notes	3, 5	-
	Tanzania	Policy processes (views of participants)	Semi-structured interviews	Interview transcripts	4	II
	Tanzania	Policy processes (outcomes)	Document analysis	Legal documents, government policies and policy drafts	4	II
	Tanzania	Land-grabs (drivers)	Literature review	Academic literature	4	II

actors and institutions. Article II and Article III arose during this period, and are products of that time. Consequently, my work did not focus on (finding) 'challengers' (Fligstein & McAdam, 2011) - agents that seek to change how institutions and social structures interact with nature. Identifying these challengers is required in a comprehensive approach to ESS, meaning that this is one way that my Ph.D. deviates from an ESS approach.

Second, in the iterative process of defining 'the problem', I benefitted greatly from the creative and critical reasoning that took place in my specific interdisciplinary research setting at Lund University. This atmosphere flourished in part because of the funding opportunities that allowed us doctoral students to organize Ph.D. courses, conferences, workshops, and outreach activities. Moreover, as I was continually provided with alternative views, and perspectives that problematized specific theories, this research setting had an especially positive effect on how I chose and used of theories to interpret the empirical setting of winners as losers. While this may seem to be 'common-sense' in any rigorous interdisciplinary science, I can say, based on my personal experience from multiple interdisciplinary research institutes dealing with environmental issues at Lund University, this in fact cannot be taken for granted.

3. EU biofuel regulation in the global North

This chapter builds the foundation for my analysis of EU biofuel regulation by explaining the geo-historical context and the regulatory mechanisms (including their effects on firm-level decision-making) through which the EU promoted the economic pursuit of land-based resources for liquid biofuel production designated for transport. Following my CR method of presentation (see Section 2.1.1), I start by elucidating the 'invisible and intangible' domain of the real: making initial theoretical clarifications surrounding the geopolitical aspects of territorialisation and explain how they relate to the central analysis in this thesis.

3.1 The geopolitics of territorialisation and the structure of the proceeding arguments

What I refer to as geopolitics in the context of this thesis has to do with territorial struggles that revolve around the capture of benefits and control over land and land-based resources in places where the energy for liquid biofuel production is (to be) sourced. As argued in section 2.3.1, these struggles assume a territorial aspect due to the 'history of geographically uneven development' and the 'variegated nature of capitalism'. Here I would like to emphasize the role of 'crises' in these territorial struggles.

Broadly, crises here refers the threatened failure of the socio-economic structures, which is inherent to capitalism itself because:

> [capitalism's] endogenous dynamics frequently and characteristically produce situations in which: (i) workers, collectively, cannot afford to buy the commodities they produce (a crisis of underconsumption); (ii) more commodities are produced than can be absorbed by all available purchasing power (a crisis of overproduction); (iii) capitalists accumulate more capital than they can invest in profitable enterprises (a crisis of over-accumulation); or (iv) a large portion of the total labour force cannot be profitably employed in the production of commodities (a crisis of unemployment

> or underemployment). These various manifestations of crisis are closely related, with one often leading to or accompanying another. (Gregory et al., 2011: pp. 120-121)

Sheppard (2011: p. 327) underlines that territories seek different development trajectories depending on their relative position within the broader regional political economy. To postpone a crisis within a framework of uneven geographical development, 'territorial alliances' can emerge (Harvey, 2006b) meaning that territorial interests and capitalist interests collaborate and/or compete against each other. This is where "the relative strength of different territorially based alliances become an important factor" (Harvey, 2006b: p. 427), as certain territorial alliances become increasingly powerful over time, in terms of their political-economic ability to protect and enhance their material interests. To postpone a crisis, these alliances may attempt to protect various interests by capturing and containing the benefits that can be derived from flows of capital and labour power under their political-economic control (Harvey, 2006b: pp. 419-422). I understand the EU's territorialisation process (i.e. re-territorialisation of the state onto a supranational scale, and the de-territorialisation through the globalization of commodity production) as the workings of such a geopolitical alliance (see Brenner, 1999; Harvey, 2006a).

Proceeding from these premises, I go on to develop three arguments in the sections that follow:

Firstly, I explain how liquid biofuels became an energy commodity through a complex and contradictory geopolitical response of the European Commission (EC) to multiple crises. I do so through a historical account of the political and economic interests in liquid biofuels as expressed by the EC and certain member states. I also explain the regulatory outcomes of these processes (in terms of mechanisms). The account is based on a thorough document analysis informed by extensive engagement with the academic literature on EU biofuels (secondary sources) and various EC publications and legal documents about liquid biofuels (primary sources).

Secondly, I explain how EU biofuel regulation created regulatory mechanisms with bearings on firm-level decision-making processes. These mechanisms are positioned within broader underlying structures of capitalist social relations of production and exchange, and are argued to further promote intensification of land-use. In more detail, I explain the normative assumptions, decision-making mechanisms, and networks of actors in the EU's 'regulatory regime on liquid biofuels for transport', and go on to conceptualise it as part of the 'regulatory capitalism' (Levi-Faur, 2005) that was institutionalized in the renewable energy directive. The analysis is based on primary sources such as legal documents, certification standards, and statistics (retail prices and delivered amounts of, and

subsidies for, liquid biofuels), and some secondary sources (academic literature on EU biofuels).

Third, in accordance with my approach to sustainability science, I conclude the chapter with a critique of EU biofuel regulation: focusing on the claim that regulation can assure that energy commodities that reduce GHG emissions in transport will be delivered. Here, I relate my analysis of regulatory mechanisms and their effects on firm-level decision-making to other aspects of my empirical work. More specifically, to my analysis of the content of EU biofuel regulation and the material outcomes generated in the Swedish transport sector. In particular, I refer to the type of liquid biofuels delivered, the types of land-based resources used, and the origins of those.

3.2 A historical account of EU biofuel support

3.2.1 A response to crises of energy and rural development?

Although the idea of using plants and vegetable matter to produce fuel is old[14], growth of political-economic interests in liquid biofuels can be identified in many European nation states only since around the oil price shocks of the 1970s (Kutas, Lindberg & Steenblik, 2007; Pacini, Silveira & da Silva Filho, 2013). Triggered by the rising prices of oil and its dependence on foreign oil, the German government began to promote biofuels as an alternative, and received support from an emerging environmental movement (Franco et al., 2010: pp. 676-677). Similarly, the Swedish government (inspired by Brazilian ethanol) established research and development programmes for ethanol production, receiving support from the trade union and dominant agricultural organizations, who faced difficulties because of domestic overproduction of sugar (Eklöf, Ekerhom & Mårald, 2012: pp. 628-629).

However, it was not until 1985 that the EC implemented the first European directive on "crude-oil savings through the use of substitute fuel components in petrol" (EC, 1985: p. 1). In this directive, the complementarity of liquid biofuels was highlighted, as it was argued that by "broadening the raw materials base for the production of fuels for use in internal combustion spark-ignited engines" (ibid.: p. 1), member

[14] Henry Ford is known to have said in 1925 that "[t]here's enough alcohol in one year's yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a hundred years" (Kovarik, 1998: p. 1). Swedish ethanol pioneer and economist Erik Johan Ljungberg presented a similar argument to the Swedish government in 1912, declaring that "Ethanol is the fuel of the future. You never run the risk of its depletion. As long as the sun keeps shining on our fields, it will be produced eternally, and humans never need to fear the depletion of coal deposits." (Ljungberg, 1912: p. 8 – translation from Eklöf, Ekerhom & Mårald, 2012: p. 624).

states could reduce their oil dependency, but still work within existing energy physical infrastructure and vehicle fleets (ibid.).

The first more ambitious biofuel proposal was presented in 1992 (Nordangård, 2012: pp. 124-125). Considering the upcoming reforms of the common agricultural policy (EC, 1992; 1993a), French commissioner Christiane Scrivener proposed "a substantial reduction in the rates of excise duty on fuels from agricultural sources" (EC, 1992: para. 1). She argued that such a tax reform would support rural development by diversifying the markets on which farmers could sell their produce, thereby creating better economic conditions for agro-industrial production (EC, 1992).

While Scrivener's proposal was not approved by the EC (EC, 2001: p. 7), the commission soon thereafter started the Altener research programme that supported liquid biofuels as one of many forms of renewable energy (EC, 1993b) capable of addressing environmental problems and, more specifically, climate change (Nordangård, 2012). In his Ph.D. thesis, Nordangård (2012) argued that the way that the Altener research programme coincided with the Earth Summit in Rio 1992 and the Kyoto Protocol gave further political mandate for the substitution of fossil fuels with biofuels. Nordangård argued that during this period, the EC established an EU-based, pro-biofuels platform; which included environmental NGOs who were supported by EU financing programmes to be involved in the formal decision-making processes (ibid.).

The dual crisis logic expressed in this period was fuelled by rising oil prices coupled with dependency on foreign-import for oil, alongside overproduction in the agricultural sector. By some, liquid biofuels were viewed as having a high degree of complementarity with the existing energy infrastructure (e.g. vehicle fleet, roads, fuel stations), as well as the already existing agricultural production systems. An opportunity to kill two birds with one stone.

3.2.2 A response to the climate crisis?

Despite proponents of biofuel being around since the 1970s, the share of road traffic propelled by biofuels in the EU remained miniscule (see Figure 2). Significant growth of liquid biofuel consumption took off only after the implementation of the EU's biofuel directive of 2003 (EC, 2003a; 2003b; 2003c).

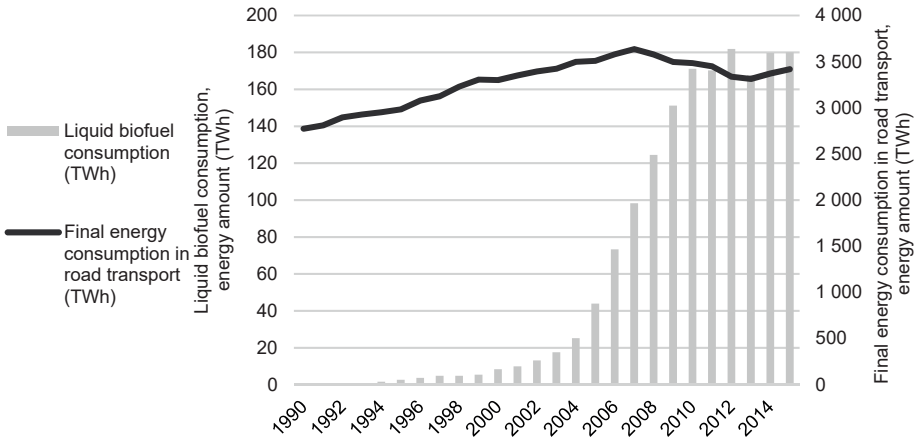


Figure 2 Liquid biofuel consumption and final energy consumption in transport in the EU (28 countries), 1990-2015. Sources: Eurostat (2017a; 2017b).

In 2001, oil prices reached a ten-year high when OPEC, Norway, and Mexico increased the price on crude-oil by lowering its supply to the market (Nordangård, 2012: p. 157). Drawing on EU commitments from the Earth Summit, communications from the EC indicated that decision-makers became more inclined to use taxation policies to achieve future renewable energy targets – renewable energy that included biomass (EC, 2002). By this time, liquid biofuels had become more explicitly viewed as a viable alternative through which climate change mitigation could be achieved.

Although biomass for liquid biofuel production was assumed to come from European sources during this time (EC, 1997; 2000), the EC also viewed liquid biofuels as a potential opportunity for the Candidate Countries[15] of the time; which had "more agricultural land and less diesel and gasoline consumption per capita than present EU member states" (EC, 2001). This is indicative of the prevalence and assumed truth of the theory of comparative advantage: where one territory is viewed as having the potential to produce goods for another (one that has more land and lower energy demand, for example) that suffers from a deficit (one that has less land and higher energy demand, for example), thereby achieving complementarity between the two. As we will soon see in the context of liquid biofuels, over the years the scale of this theory will be expanded to include the global South.

However, by this point, contradictions in pro-biofuel arguments had manifested more clearly within the EC. In external communications (EC, 2001), the EC had

[15] These countries were Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia, and they formally entered the EU in 2004 (EU, 2017).

acknowledged three constraints in the biophysical world: the world has limited amounts of arable land; land-use for biomass production could compete with food production, and; emissions caused during crop and fuel production could impede possible GHG savings, not least due to liquid biofuel production competing with other land-uses, such as food production. These interconnected constraints remained pertinent issues throughout the regulatory development that followed, as I will further demonstrate throughout the thesis.

Nevertheless, despite the looming doubts, the EC decided to actively promote liquid biofuels through the new directives on voluntary transport biofuel targets and, consequently, biofuel blending obligations were adopted in the EU (EC, 2003a; 2003b; 2003c). These directives set voluntary share-based biofuel consumption targets[16], but more importantly, also opened up the possibility for the active taxation policies that were necessary to make liquid biofuel production competitive compared to the production of conventional gasoline and diesel (EC, 2003a; 2003b; 2003c). Furthermore, these directives intersected with the EU's common agricultural policy, which offered tax incentives for energy production on agricultural land (Kutas et al., 2007; Pacini et al., 2013). In the directives, the EC maintained the argument that liquid biofuels could reduce dependency on foreign oil and had now added the argument that liquid biofuels could contribute to reducing GHG emissions – again emphasising the complementarity of liquid biofuels with the existing distribution infrastructure and vehicle fleet (EC, 2003b).

3.2.3 Managing crisis through self-regulation?

By the 2000s, EU biofuel regulation had come to revolve around three arguments, here disaggregated by Franco et al., (2010: p. 670):

> Biofuels will enhance energy security by diversifying sources beyond oil in an era when its supply becomes scarcer, more expensive, and politically unstable.
>
> Biofuels will spur rural development by invigorating livelihoods, creating new jobs and diversifying incomes in both the global North and global South, including many countries where rural poverty is most concentrated and entrenched.
>
> Biofuels produced either in the North or the South can contribute [to GHG] savings by replacing fossil fuel in an expanding transport sector, although the amount of savings will vary according to certain factors that are identifiable and therefore manageable.

[16] In these voluntary targets, the EC suggested that 2% by 2005 and 5.75% by 2010 of total energy consumption in transport should come from biofuels (EC, 2003b).

Notably, arguments made by the EC had, by this time, expanded the scope of prospective areas of sourcing to (more explicitly) include the global South – scaling up the reach of the EC's implicit theory of comparative advantage. Brazilian sugar-cane based ethanol was praised for its economic and environmental performance, and Indonesia, Malaysia and the Philippines were viewed as potential exporters of (palm-based) biodiesel (EC, 2006). Importantly, third countries were assumed to "be able to benefit from the promotion of renewables in the EU through the supply of biofuels […] which meet sustainability requirements" (EC, 2008a: p. 4).

Indeed, at the EC, political and scientific contestation had come to revolve around the concept 'indirect land-use change' (ILUC). ILUC refers to how the shift in land-use from food production to liquid biofuel production could result in the movement of food production to new, previously uncultivated land. The reason for why land-use change matters for the GHG performance of liquid biofuels has to do with the carbon cycle, as demonstrated in the following quote from Searchinger et al. (2008):

> Because existing land uses already provide carbon benefits in storage and sequestration (or, in the case of cropland, carbohydrates, proteins, and fats), dedicating land to biofuels can potentially reduce GHGs only if doing so increases the carbon benefit of land. Proper accountings must reflect the net impact on the carbon benefit of land, not merely count the gross benefit of using land for biofuels. Technically, to generate greenhouse benefits, the carbon generated on land to displace fossil fuels (the carbon uptake credit) must exceed the carbon storage and sequestration given up directly or indirectly by changing land uses (the emissions from land-use change). (p. 1238)

Moreover, the academic debate on agrofuels referenced in my introduction was growing, and the critique from both outside of and within the EC had become increasingly vocal, not least due to rapidly increasing food prices in 2007 and 2008. Rosegrant & Msangi's (2014) extensive review of literature on the socio-economic and land-use change impacts from biofuel policies indicated that biofuel policies, together with other factors, had resulted in higher commodity prices (see Figure 3). The conclusion of their review echoes the concerns in the debate:

> Several studies have reported impacts on poverty and hunger, with low- and middle-income countries affected the most because they absorb a large share of any decline in the world food supply. Moreover, the biofuel expansion certainly adds to overall commodity demand and raises the number of people at risk for poverty and hunger due to higher commodity prices. Likewise, the feed and livestock sectors worldwide are negatively affected, but some of the loss is offset by increased amounts of feed by-products generated by the biofuel production process. (Rosegrant & Msangi, 2014: pp. 289-230)

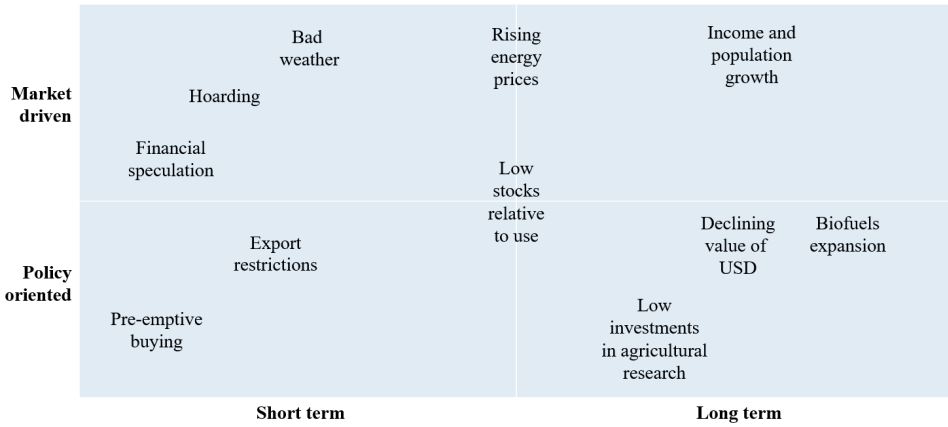


Figure 3 Relative impact of factors behind food price spikes, 2007-2012. Source: Rosegrant & Msangi (2014).

From the EC's perspective, these environmental problems and social harms were deemed manageable via self-regulation and/or possible to mitigate via technological innovation (see also Franco et al., 2010). As the EC was to gather the scattered renewable energy initiatives that existed all over the EU into a singular renewable energy directive, the EC set up public-consultation rounds for their upcoming 'sustainability safeguarding scheme' (EC, 2008a; 2008b). Feedback in the process came predominantly from European actors, especially from a panel of experts (EC, 2008b). Here, the pro-biofuels lobby organisations that had been established (with support from the EC in the early 2000s) also had some mandate to inform EU biofuel policy (Franco et al., 2010: p. 663). Although the EC had consultation meetings with representatives from Brazil, Malaysia, and Mozambique (all considered potential export countries), the process has been criticised for lacking meaningful representations of issues in the global South, especially sub-Saharan Africa (Di Lucia, 2010). The national negotiator for Sweden went so far as to say that the entire regulatory process was rushed due to the EC wanting demonstrate a united front on the issue at the 2009 UN Climate Change Conference in Copenhagen (Appendix I.3:C).

In parallel to developments at the EU level, numerous forms of regulation on liquid biofuel production had already started to take shape outside of, and within, the EU.[17] For example, in Sweden, the non-profit state-owned firm Svanen – which produces green label services and is fully owned by the Swedish government – had, by 2008,

[17] A report from the UN Conference on Trade and Development (UNCTAD) identified over 30 sustainable biomass certification initiatives all over the world, many of which were developed by EU member states (UNCTAD, 2008).

developed a label that focused on certifying transport fuels (Svanen, 2008).[18] The Government of the Netherlands established a commission in 2006 that consisted of policy experts and academics that were to develop criteria for biofuel standards, and the United Kingdom's government formulated a package of regulatory measures for public-consultation in 2007 (UNCTAD: pp. 6-8). Other governments collaborated more directly with corporate actors. For example, although the German government passed its own Biomass Sustainability Ordinance in 2007 (ibid.: pp. 8-9), it also backed the creation of the International Sustainability & Carbon Certification in 2006, yet another a private certification system targeting liquid biofuels (see Article I). Similarly, the Swiss government developed its own system in 2007 (UNCTAD, 2008: pp. 6-9) and was simultaneously involved in creating the Roundtable on Sustainable Biofuels (RSB) that gathered:

> environmental organisations (such as WWF and the IUCN, both initiators of the RSB), big corporations (Petrobras, Boeing. Shell), Banks (Inter-American Development Bank), ethanol producers (UNICA), rural development NGOs, UN organisation (UNEP, UNCTAD) and governments (Switzerland) (Hermele, 2012: pp. 99-100).

As we can see, during the time when EU biofuel regulation was taking shape, the problems of liquid biofuels were not only deemed as manageable by the EC, but they could even be solved through various forms of self-regulation. In the concluding remark that follows, I take note of the specific geo-historical context in which EU biofuel regulation was developed in relation to governance, neoliberalism and contested claims of 'ecological' modernization.

3.2.4 Neoliberal governance and ecological modernization

In this section I have argued that EU biofuel regulation was developed within a geopolitical context of multiple crises (energy, rural development, and, more recently, climate change). My analysis also shows that EU biofuel regulation was developed by the EC with a key ideological assumption: that problems were manageable by pursuing efficient and rational decision-making processes where stakeholders and experts were brought together to develop ideal and politically impartial policies and regulation (see also Harvey, 2009a: p. 71).

[18] The argument being that local and regional governments that want to develop fuel procurement strategies could rely on the Svanen label as a way to distinguish the good from the bad when developing procurement contracts.

This 'neoliberal'[19] mode of government is (like capitalism) variegated and takes different forms depending on the institutional context (Brenner, Peck & Theodore, 2010). Since pre-existing regulation must first be dismantled to give way to reform, the process of 'neoliberalization' often generates ambiguous hybrids as a concrete outcome (ibid.). The promises of liquid biofuels, and their fit with 'ecological modernization' is a clear example, I argue, of neoliberal governance. As we argued in Article II, a re-regulation has occurred, in which policies and regulation sought to facilitate the growth of liquid biofuel markets through the activities of firms – and states were indeed very active agents in facilitating this move, and maintaining the mode of government that follows as a result. As we will see in the next section, many of the (seemingly) disparate governance initiatives that were taking shape were subsumed into, and were allowed to be used to demonstrate compliance with, the EU's renewable energy directive and its associated sustainability criteria.

3.3 EU biofuel regulation as containing mechanisms with effects

What mechanisms generate what effects in EU biofuel regulation? To emphasize the changing role of the state, I draw on David Levi-Faur's conceptual work on 'regulatory capitalism' (2005) to identify salient features of a European 'regulatory regime' on liquid biofuels for transport – a regime that encompasses "the norms, the mechanisms of decision-making, and the network of actors that are involved in regulation" (Levi-Faur, 2011: p. 13; see also Article II). This regulatory regime is set up in the EU's renewable energy directive (EC, 2009a) and fuel quality directive (EC, 2009b). The directives, adopted in 2009, introduced four key regulatory changes to be implemented throughout all EU member states: (1) a mandatory renewable energy target of 10% for energy used in transport by 2020 (and biofuel blending obligations), (2) the opening up for states to implement fiscal policies for meeting targets, (3) the definition of mandatory requirements for all liquid biofuels through a norm-setting regulatory standard, and (4) the delegation of regulatory authority to non-state actors as complementary to state actors.

[19] What neoliberalism *is* has of course been subject to much debate; at times resulting in a concept that conflates too many things, thus losing its explanatory power (Peck, 2013). Nevertheless, two general principles can be distilled: "increased competition—achieved through deregulation and the opening up of domestic markets, including financial markets, to foreign competition" and "a smaller role for the state, achieved through privatization and limits on the ability of governments to run fiscal deficits and accumulate debt" (Ostry, Loungani, & Furceri, 2016: p. 38).

3.3.1 Four regulatory mechanisms with causal power

Energy targets that have material implications

Oil has unrivalled capacities as a transportation fuel. When one compares oil to coal or natural gas in terms of energy density, it becomes evident that oil packs "nearly twice as much as coal by weight, and around 50 percent more than liquefied natural gas by volume" (Bridge & Le Billon, 2017: p. 9). Indeed:

> Unlike bulky coal or indiscernible gas, crude oil is an incredibly cooperative substance fuelling the "time-space compression" of global transportation and commodity production. (Huber, 2013: p. 133)

The scale of, and the mandatory nature of, the 10 per cent energy targets (coupled with the biofuel blending obligations) come with material implications as regards land-use dynamics and broader spatial relations. This is due to the material differences between oil (which is the biggest energy source in transport) and the forms of energy that liquid biofuels embody. Liquid biofuels are predominately produced from sugar-, starch- and oil-based agricultural crops, but also more recently from oils and fatty acids from plants and animals in agriculture and forestry.[20] In terms of embodied energy, industrial agriculture today is heavily intensified, and relies on manufactured fertilizers and pesticides (both of which are energy intensive products) to maintain its economic output (L. Harvey, 2010). Add to that the energy used on agricultural farms in the form of fuels and electricity, and the energy appropriated by agro-industrial regimes via transport, processing, storage, and consumption of agricultural products, and liquid biofuels come to embody a lot of energy (ibid.).[21] Consequently, substituting liquid fuels from oil with liquid biofuels will mean different spatial relations (e.g. land-use requirements) in the production and consumption of energy commodities for transport.

The varied spatial relations between oil-based liquid fuels and liquid biofuels can be exemplified with Vaclav Smil's work on power densities (2015: p. 226):

> Crude oil extraction proceeds mostly with densities of 10^2-10^3 W/m^2, and in the largest fields the rate goes up well into 10^4 W/m^2 – while the dominant feedstocks for the production of liquid biofuels are harvested with power densities of 10^{-1} W/m^2 and the rates are further reduced by their processing.

[20] This claim will be substantiated in Section 3.4.

[21] It would be remiss not to mention that there are many environmental problems associated with such large-scale harvesting of phytomass for energy, including "the further destruction of natural ecosystems, demands for nutrients and water, the extension of monocultures, vulnerability to pests and diseases, and competition with land uses to grow food and feed." (Smil, 2015: p. 231).

In terms of the land-use requirements for achieving the EU's energy targets and biofuel blending obligations, different estimates and illustrations have been proposed. The EU (with its historically accumulated capital stock and industrialized member states) consumes significant amounts of energy for transport within its territory (see Figure 2; for regional comparisons see Sims et al., 2014). Smil (2015) provides a span of power densities for liquid biofuels that range from 0.15 W/m^2 to 0.4 W/m^2 (for comparison with oil, see Figure 4).[22] Based on these estimates, a 10 per cent target of final energy consumption in transport for 2015 achieved through liquid biofuel consumption would correspond to between 119 000 km^2 (i.e. roughly the land area of Bulgaria) and 317 000 km^2 (i.e. roughly the land area of Poland) of land used to produce the energy commodities that propel vehicles over road networks. 100 per cent would range from the land area of Colombia to that of India (i.e. 1 190 000 – 3 170 000 km^2).

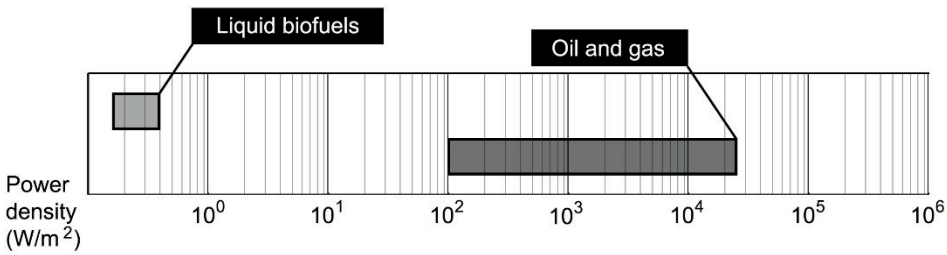


Figure 4 Comparison between the power densities (W/m^2) of crude oil and liquid biofuels. Source: Smil (2015)

As a result, both the mandatory nature and the scale of these energy targets create a significant market demand for land-based resources to be extracted for energy production. Although the total land areas involved is subject to debate, it is not uncontroversial to declare, like the OECD & FAO have done, that the EU would have to rely on the import of liquid biofuels to meet its 2020-targets (OECD & FAO, 2014).

Fiscal policies that generate economic mechanisms

Subsidies (e.g. tax exemptions) to liquid biofuels for transport allow them to compete with their fossil fuel counterparts on the market (although the fact that fossil fuels are also heavily subsidized should also be acknowledged). These fiscal policies differ between EU member states, however. Estimates of the total amount

[22] These estimates are based on calculations that do not incorporate the energy involved in the processing of liquid biofuel (see Smil, 2015).

of subsidies given throughout the EU in 2011 include 5.5 – 6.9 billion Euros (Charles et al, 2013: p. 34) and 8.4 billion Euros (IEA, 2012: p. 235).

In Sweden, liquid biofuels are eligible for exemptions on taxes that target the retailers of liquid fuels: the energy tax and the carbon tax (Government Office in Sweden, 2017a). Thus, liquid biofuels receive a tax premium when compared to the retail price of conventional fuels (see Figure 5), which results in new profit opportunities. As expressed by a retailer and producer with a significant share of the liquid fuel market in Sweden at a workshop that we organized (Appendix I.3:C):

> Because of the tax incentive, there's suddenly a lot of money in *sustainability*.

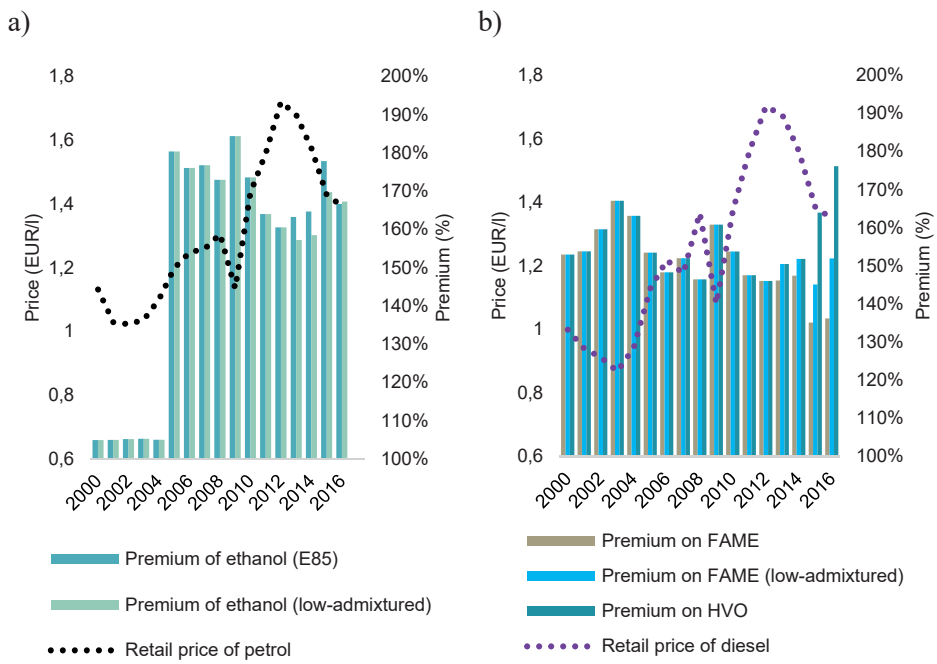


Figure 5 Retail price of petrol and diesel compared with tax exemptions provided for liquid biofuels, ethanol, FAME and HVO, 2000-2016. The 'tax premium' is calculated by dividing the retail price of petrol/diesel with the price for each corresponding liquid biofuel after having deducted their associated tax exemptions. Data on the retail price of petrol and diesel was acquired from Swedish Petroleum and Biofuel Institute (SPBI) (SPBI, 2017a). Data on taxes on liquid (bio)fuels was acquired from the Government Office in Sweden (Government Office in Sweden, 2017a) and cross-verified with information from the Swedish Tax Agency (Swedish Tax Agency, 2017) and the Swedish Petroleum and Biofuel Institute (SPBI, 2017b).

The *sustainability* referenced in the quote refers to the EU's "sustainability criteria for biofuels used in transport": the mandatory regulation that defines the specific relations of commodity production for the energy market.

Standards that define specific commodity production

All firms that deliver liquid biofuels to the regionally regulated EU biofuel market must demonstrate that their production complies with the 'sustainability criteria for biofuels used in transport'. This is required for liquid biofuels to be eligible for tax exemptions and to fulfil the mandatory renewable energy targets. Hence, we can understand the definite social relations of EU biofuels (and where firms see possible revenue streams) by unpacking this regulation (see Jessop, 2000). Through this we can start to unravel how EU biofuel regulation may have effects on firm-level decision-making processes.

For an illustrative example for this logic, I think back to fieldwork during 2013 when I attended a regulatory meeting organized by the Swedish Energy Agency about upcoming amendments (Appendix I.2:A). Although I attended the meeting mainly to follow regulatory developments, I listened in to a 'speech event' (Briggs, 1986) where a retailer and a producer exchanged what was, to them, relevant business information (i.e. can Retailer A count on buying liquid biofuel from Producer B after the amendments)[23]:

> Retailer A: How sustainable is your fuel?
>
> Producer B: 90 per cent.
>
> Retailer A: So, you will have no problem with the amendments then.

Indeed, what is eligible for the subsidies in the EU market are energy commodities that abide to the GHG emission reduction-centred sustainability criteria for liquid biofuels. The "90 per cent" sustainable referenced above refers to GHG emission reductions when compared with a default value for fossil fuels when using specific calculation methods and default values defined in the renewable energy directive.

The use value that has been commodified in EU biofuels is the *supposed potential* of 'biomass' (as an energy source) in reducing carbon emissions when compared with oil (see Article II and Article III). I italicise *supposed potential* with reference to the debate on the actual potential of liquid biofuels to deliver convincing GHG emission reductions. In the articles (especially Article II and III), there is much more information on the important details of the sustainability criteria that have been constructed in EU biofuel regulation: such as the GHG reduction criterion, other procedural requirements, and the different land criterion (e.g. biofuel feedstock may not be grown on land with high soil carbon stocks) and biodiversity criterion (e.g.

[23] If the speech event itself was about engaging in a deeper debate on sustainability, other discourse(s) would/might have emerged, rather than this one which revolved around market transactions.

biofuel feedstock may not come from land categorized as primary forest, legal nature protection areas, and grasslands of high biodiversity).

The definition of 'biomass' is also of importance to unpack the definite relations that determine what constitutes as 'EU biofuels'. The EC defines 'biomass' as:

> the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste (EC, 2009a: Article 2:e)

This definition is very broad and includes various outputs from pre-existing geographies of production and consumption (e.g. crops from agriculture, tall oil forestry, and animal fat from slaughterhouses). It is also not an uncommon definition; it is used by most energy scholars, as well as the IPCC's working group on mitigation of climate change.[24]

Finally, the term 'waste and residues' is also of importance to truly unpack what 'EU biofuels' actually are. This is due to the fact that biomass categorized as 'waste or residues' is double counted towards fulfilling the mandatory renewable energy targets to further incentivize their production (EC, 2009a). This happens under the assumption that all biofuels produced from waste and residues lead to less ILUC, and thus have greater potential to reduce GHG emissions (ibid.). The EC defines 'waste and residues' as:

> wastes, agricultural crop residues, including straw, bagasse, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined) (EC, 2009a: Annex V, point 18, para 4).

These were considered to have "zero life-cycle [GHG] emissions up to the process of collection of those materials" (EC, 2009a: Annex V, point 18, para 4) and were emitted from certain procedural requirements because of this (see Article III for details). This system gives rise to some (minor) additional economic incentives for two main reasons. More surplus value can be extracted from the tax premium, as transaction costs are lowered. The probability for more long-term viability is also established, since waste-based biofuels are not as deeply associated with doubts of their environmental performance.

To summarize, amongst firms interested in the EU's liquid biofuel market for transport, 'biomass' is land-based resources derived from numerous different

[24] In the glossary of the IPCC's report on "Mitigation of Climate Change", biomass is defined as "products, by-products, and waste of biological origin (plants or animal matter), excluding material embedded in geological formations and transformed to fossil fuels or peat" (Allwood et al., 2014: 1253)

crops/plants/animals (at times construed as waste and residues). This embeds the EU liquid biofuel market for transport in many and long-existing geographies of production and consumption – resulting in specific implications and effects on firm behaviour in the market's expansion presented hereafter.

The agency of firms in expanding markets and regulation

Who then is responsible for ensuring the growth of the EU's liquid biofuel market for transport? While states are expected to provide institutional support (by implementing energy targets, biofuel blending quotas, fiscal policies and standards), firms are expected to drive geographical expansion. However, the EU has not only created an economic incentive for firms that produce 'biomass' and/or liquid biofuels; it has also created a hybrid regulatory system in which firms that provide private certification systems also have an economic interest in EU biofuel regulation. Let me clarify what I mean and why this is important.

According to EU biofuel regulation, firms that produce or deliver liquid biofuels have one of three choices to demonstrate compliance with the sustainability criteria: (1) through national regulatory systems[25], (2) through private certification systems approved by the EC, or (3) through specific bilateral agreements (e.g. arrangements made with supplier countries). The private certification systems that are operated by firms, totalling 16 separate entities as of February 2018 (EC, 2018), must include the same requirements as the sustainability criteria, but are also allowed to include additional requirements (EC, 2009a).[26]

Once a private certification system is approved by the EC, the firms that operate these are provided a market for their service (i.e. certification). Hence, in EU biofuel regulation, firms that organize private certification systems can tap into revenue streams enabled by national fiscal policies – if they can find consumers of their service (e.g. liquid biofuel producers). This market is different from that of liquid biofuel producers, who deal with production of physical goods (i.e. liquid biofuel).

In Sweden, 62 per cent of the total energy amount of liquid biofuels delivered between 2011 and 2016 was certified by private certification systems, whereas 38 per cent only relied on the national regulatory system (SEA, 2017a). The most common certification system was the International Sustainability & Carbon Certification (ISCC), whose certifications were responsible for 35 per cent of the total energy amount for the same period (ibid.). Subsequently, the ISCC was chosen

[25] For a detailed explanation of the Swedish national regulatory system, see Article I.

[26] For a more detailed explanation of how the number of actors involved in the regulatory regime developed 2009 - 2014, see Article II (pp. 9-14). For a more detailed explanation of how the Swedish transposition of EU biofuel regulation relates to private certification systems, see Article III. For a detailed case study of one of these private certification systems, see Article I.

for a detailed case study of how these private certification systems operate in Article I; a choice further justified by the ISCC having no feedstock or regional restrictions – thereby covering all possible types of 'biomass' from all over the world.

This hybrid regulatory system connects to how the EU sought to address concerns about adverse social effects caused by the expansion of its liquid biofuel market EU.[27] By incorporating private certification systems into its regulatory framework, the EU could suggest that they indeed incorporate social aspects (and other environmental aspects) through self-regulation in their regulatory framework:

> In developing countries, the multi-stakeholder EU sustainability certification schemes (e.g. ISCC, RSPO RED, RSB EU RED) cover also social, economic and environmental sustainability aspects that go beyond the EU mandatory sustainability criteria. (EC, 2017: p. 16)

Many have criticized these voluntary private certification systems as they: have gaps in procedural rules (German & Schoneveld, 2012); the standards don't cover or superficially cover some critical social concerns raised in the surrounding debate, such as land-rights, support of small-holder business models, and economic redistribution for rural development (ibid.); fail to adequately include actors from developing countries (Partzsch, 2011); justify standards that may mask larger political struggles (Fortin, 2013); and are largely incapable of disciplining the companies that they are financially dependent upon (Fortin & Richardson, 2013).

In summary, firms that produce 'biomass' and/or liquid biofuels, and firms that organize private certification systems, jointly push the geographical expansion of the EU's biofuel market as they both have economic incentives to facilitate its continual growth as long – as it can be profitable.

3.3.2 Effects on firm-level decision-making

The regulatory mechanisms through which EU biofuel regulation shapes outcomes are two-fold: (1) the EC creates significant market demand for 'biomass' and certificates for liquid biofuel production (defined in regulation), and (2) EU member states create economic incentives for firms to comply with regulation. Although the environmental promises are riddled with scientific uncertainty and extensive critique, the logic adheres to that of ecological modernization, with an attempt to

[27] The EU also put in place a bi-annual reporting obligation, stipulating that the: "Commission shall, every two years, report to the European Parliament and the Council on the impact on social sustainability in the Community and in third countries of increased demand for biofuel, on the impact of Community biofuel policy on the availability of foodstuffs at affordable prices, in particular for people living in developing countries, and wider development issues. Reports shall address the respect of land-use rights." (EC, 2009a: Article 17, point 7, para 2)

utilize market-based mechanisms to make it profitable for firms to deliver eco-innovations to the market (see Article II). Further, the regulatory mode is similar to most forms of certification initiatives (see Bartley, 2011); the main difference being that the price of non-compliance is not set by market forces[28] but by an administrative authority[29] at a supranational level. The question remains then: are there any specific effects on firm-level decision-making processes caused/supported by these mechanisms?

In Article III, we applied a firm-centred explanatory model to analyse the co-ordination of 'global value chains' (Gereffi et al., 2005) that delivered liquid biofuel for transport to the Swedish market. Based on official energy statistics on liquid biofuels delivered to Sweden and a survey study of firms (producers and retailers) that complied with regulation in Sweden, we argued that the EU biofuel market was organized as (global) production networks. These production networks include inter-firm relations with three characteristics: (1) a high degree of complexity of transactions due to the diverse set of production systems involved; (2) a high ability to codify transactions given the EU market follows the same standard; and (3) the possibility of both low and high capabilities in the supply base of biomass producers. Given that producers of liquid biofuel and 'biomass' within the EU territory have procedural benefits in relation to regulation (see also Article I), we argued that suppliers outside of the EU with low capacity to demonstrate compliance will find it more difficult to gain entry to the EU market. One way to resolve this economic problem is the type of horizontal and vertical integration mentioned above.

The underlying capitalist social relations of production and exchange are profit-maximising and competitive. In Article I, I explain the more specific social relations involved amongst firms that operate within EU biofuel regulation. Drawing on my analysis of how firms certified by the ISCC behaved over time and space, I argue that two forms of firm-level decision-making processes were supported by EU biofuel regulation. First, vertical integration is promoted, as many certified firms (in liquid biofuel commodity chains) decide to merge/integrate over time, in effect becoming part of one single certificate instead of multiple certificates. Second, further intensification of land-use was encouraged, as horizontal integration across several industries could be observed in that many firms (especially in Europe) dealt with multiple biomass feedstock in their liquid biofuel production (indicating highly mechanized large-scale production systems). If the market continues to grow, this will, over time, further exclude small-scale production models in the process, because of the competition-enforced firm-level decision-making processes inherent

[28] Such as through public procurement strategies resulting in organizations only buying specific goods and services from certified firms.

[29] Such as the EU directives resulting in that every firm has to demonstrate compliance with regulation in order to be eligible for economic support.

to capitalism and the expansionary nature of these markets. Taken together, it is clear that this economic rationale benefits agents, such as firms, that seek to include more land into intensified forms of production and exchange.

3.3.3 Territorialisation through new economic flexibilities

The regulatory mechanisms that are promoted through the EU's liquid biofuel market for transport give rise to more specific capitalist social relations of production and exchange. Specifically, regulation allows firms to produce commodities in more 'flexible' ways, as states create demand by shifting surplus (through fiscal policy) to establish new energy markets for 'EU biofuels' as specific energy commodities. The creation of new energy markets for (broadly defined) 'biomass'-based energy commodities brings with it new arenas of exchange for a very broad coalition of firms (both producers of 'biomass' and certification systems). In fact, most crops that 'EU biofuels' actually embody can, to different degrees, be interchangeably sold on a variety of markets depending on their material basis, technological capacity, and profit viability (see Borras, Franco, Isakson, Levidow & Vervest, 2016).

The dynamic relation of 'flex crops and commodities' (Borras et al., 2016) has at least three implications for firm-level decision-making. First, this means that a firm's (or a farmer's) biomass production may at one time be sold to a liquid biofuel producer, and at another time to a food processer, and so forth, since an additional market (with significant demand) has been created. Second, given the right conditions for production, firms can readily move between different biomass-based markets, based on where the best accumulation opportunities lie. Third, it also means that the political-economic interests for biomass aligns with other economic opportunities in multiple economic sectors. Hence, the more specific capitalist social relations of production and exchange presented in this chapter suggest structural benefits for large-scale agro-industrial production systems with increasing horizontal and vertical integration of biomass-based production networks. A more in-depth exposé of how firms behave within these more specific social relations is presented in each of the articles.

Enabling this 'flexing' is a defining feature of EU biofuel regulation and constitutes a crucial aspect for explaining how it relates a European geopolitical territorialisation process. By having states use fiscal policies to shift surplus to support the production of liquid biofuels, the EU sought to address crises of rising prices and dependence on foreign oil, rural development, and domestic overproduction of agricultural crops – while working within the pre-existing infrastructure and institutions (i.e. transport energy landscape and geographies of production and consumption).

3.4 A critique of EU biofuel regulation in Sweden

Following my research approach, I will now develop a critique of EU biofuel regulation. Can the EU declare with confidence that EU biofuel regulation delivers outcomes that meet its internal goals? More precisely, is regulation able to ensure that this new energy market will deliver energy commodities that reduce GHG emissions in transport?

3.4.1 Internal limitations to EU biofuel regulation

As argued by Jessop (2000), regulation can only target definite relations between consumption, distribution, and exchange of specific commodities. I go on to present three internal limitations that show how the way that the categories 'renewable energy', 'biomass', and 'waste and residues' are constructed in EU directives cannot assure that commodity production will be organized towards meeting EU biofuel regulation's internal goal of GHG emission reductions.

First, the GHG calculation methods and the default values that are institutionalized in EU biofuel regulation do not acknowledge the fact that a substitution of oil by 'biomass' will systematically run into conflict with other land-uses.[30] The ILUC debate indeed revolved around the notion that using land for producing liquid biofuel feedstock could result in land-use change in previously uncultivated land areas. Examples from research of how the land-use dynamic evolved will undermine the very premise of the GHG promises of liquid biofuels, including: canola in the EU (Baral & Malins, 2016); corn in the USA (Searchinger et al., 2008); sugarcane and soybean in Brazil (Lapola et al., 2010); palm in South-East Asia (Malins, 2018; Danielsen et al., 2008).

However, the GHG calculation methods do not incorporate ILUC in any way, and the default values of cereal, sugar, and vegetable oil feedstock (EC, 2009a: Annex V) affectively allow food-based crops to be used within the EU market. That said, the EC built in a caveat about eventually incorporating ILUC into GHG calculation methods: which would/could imply that liquid biofuel produced from food-based crops would not be eligible for subsidies, as they would not be able to meet the requirements (EC, 2009; EC, 2012; EC, 2015). I will return to the outcome of this caveat in Chapter 5.

[30] As will be clarified in the argumentation below, this becomes the case even if we assume that EU biofuel regulation's mandatory land criteria are abided to: meaning that land with high carbon stock capacity may not be cleared, nor may land with high biodiversity be used, for producing biofuel feedstock eligible for the EU market.

Second, ‘waste and residues’ was partly created as a category to address critique raised in the ILUC debate. As land-use change is part of the problem, there is at least some validity to this claim, since biofuels that use “carbon that would re-enter the atmosphere without doing useful work that needs to be replaced” (Searchinger et al., 2008: p. 1240) would have less direct impact on land-use change. If then liquid biofuels were produced from ‘biomass’ that did not have any uses on other markets, they would not lead to the displacement of food, feed, fibre or industrial production to land located elsewhere. In EU biofuel regulation, this premise meant that benefits were given to waste-based commodities in GHG emission calculation methods (i.e. zero life-cycle GHG emissions up to the process of collection), procedural requirements (e.g. does not need to abide to land criteria).

However, feedstock defined as ‘waste and residues’ by the EC may still be connected to environmentally problematic geographies of production and consumption. The most powerful illustrative example is palm-fatty acid distillate (PFAD) and the related deforestation caused by palm-oil expansion. In Article I, I showed how the ISCC certified around 1400 firms in South-East Asia (mainly Indonesia and Malaysia) that dealt with palm-based value chains 2010-2017. In 2016, 26 per cent of the total energy content of liquid biofuels delivered to Sweden came from PFAD (SEA, 2017a). In Article I, I argued that as EU biofuel regulation opened up for new profit opportunities for palm-based value chains, it created mechanisms that further supported the scaling up of the economic activities in this geography of production and consumption; a scaling up of which has historically been associated with an extractivist pathway to development in South-East Asia (see Article I).

Therefore, although ‘slaughterhouse waste’, ‘used-cooking oil’, and ‘vegetable or animal-fat based oil’ are categorized as waste and residues, these may still embody energy derived from more ecologically destructive land-use relations. To exemplify, though the production of HVO diesel used slaughterhouse waste from Ireland, the fact that it was produced from a waste product indicates nothing about how the meat (that this waste comes from) was produced. The meat may still come from energy intensive, highly mechanized, industrial agricultural production systems that disrupt nutrient and carbon cycles. Thus, EU biofuel regulation may contribute to be scaling up this kind of production, as the EU at least creates some additional economic incentives to do so as the market demand for ‘waste and residues’ grows.

Third, and again based on the premise that ‘waste and residue’-based biofuels are desirable, the directives allowed these to be counted twofold in meeting the renewable energy targets (EC, 2009a: Article 20, point 2). However, the double counting of specific energy sources does not lead to an actual replacement of fossil fuels. When comparing Sweden’s statistics from 2016 with and without double

counting, the figures differ dramatically: going from a 40 per cent share of liquid biofuels in road transport down to a 23 per cent share in terms of energy content.[31]

My argument here is not that there does not exist specific conditions under which individual production systems of certain liquid biofuels *can* result in net GHG emission reductions when compared with fossil fuels. Instead, these internal limitations question the efficacy of any sectoral approach to regulating commodity production from 'biomass' (and 'waste and residues') as the phenomenon itself becomes multi-sectoral since its energy geography is embedded in many and long-existing geographies of production and consumption. However, more systemic scrutiny will show that the market-based approach that the EU has taken to promote liquid biofuels undermines the very assumption that liquid biofuels can deliver meaningful GHG emission reductions in transport.

3.4.2 Structural contradictions of EU biofuel regulation

EU biofuel regulation has gaps, but could still meet its own internal requirements if it could be proven scientifically that (on a systemic level) the liquid biofuels that firms deliver actually result in significant GHG emission reductions. By closely following the activities of firms, I attained a deeper understanding of what energy commodities were actually being delivered. With this analysis as a basis, I can more explicitly discuss the spatial relations involved; which are important as they affect the GHG performance of liquid biofuels due to the land-use dynamics involved.

Looking to the short-term implications, from 2011 to 2016 around 60 TWh of liquid biofuels were delivered to the Swedish transport energy system (SEA, 2017a) compared to around 74 TWh of conventional petrol and diesel for transport in 2016 (SEA, 2017b). Liquid biofuels delivered between 2011 and 2016 were indeed produced from many different types of 'biomass'; most of which came from the food-based crops that were raised in the ILUC debate (see Figure 6). The 'waste and residues' came in the form of 'palm fatty acid distillate', 'slaughterhouse waste', 'tall oil' and 'vegetable- or animal fat-based oil' (see Figure 6). While mainly extracted in Europe, the biomass feedstock was sourced from many different countries, mainly outside of Sweden (see Figure 7). These findings can also be supplemented with the spatio-temporal analysis of the ISCC presented in Article I (see Figure 7). With this data in mind it seems clear that although some of the 'waste and residues' used for liquid biofuels are likely to deliver some net GHG emission reductions, the market is delivering a very broad spectrum of embodied energy that is unlikely to achieve meaningful mitigation of GHG emissions in transport.

[31] Data used for calculations: Swedish Environmental Protection Agency (2017) and SEA (2017a)

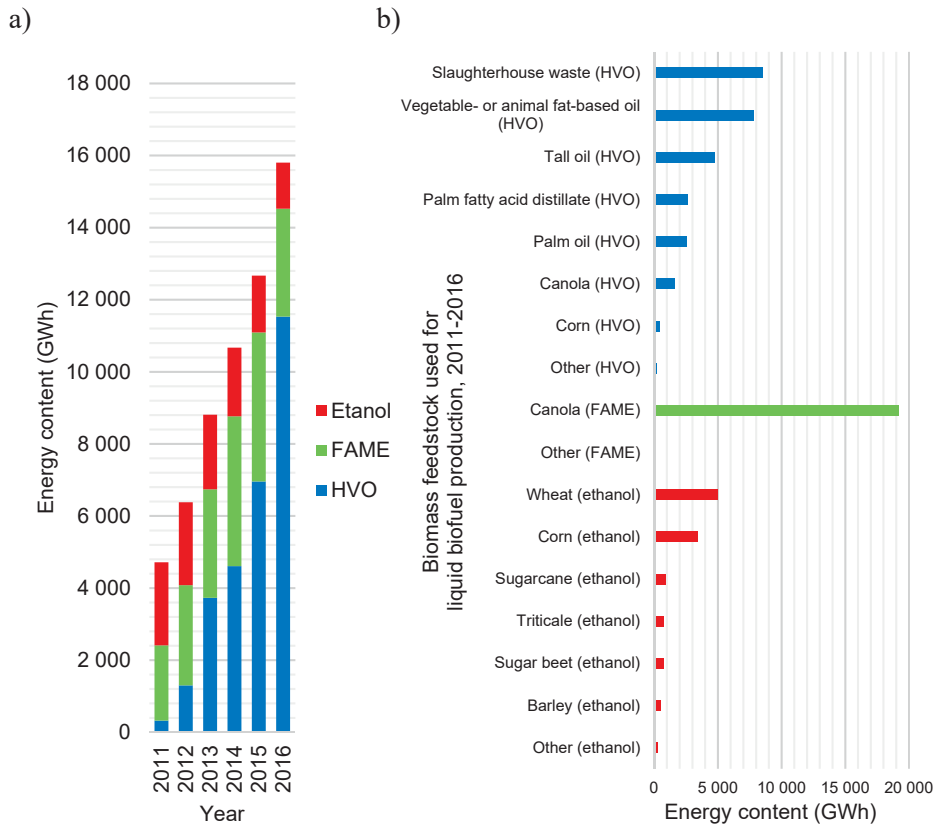
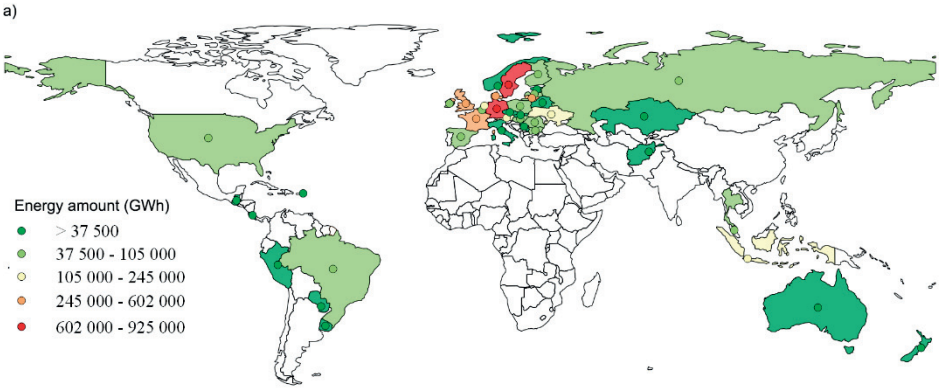


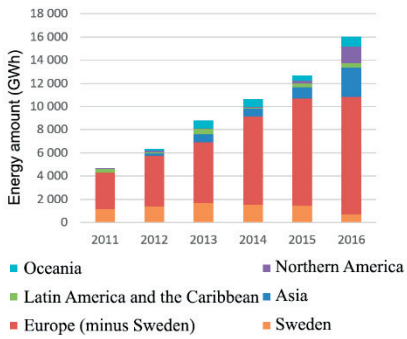
Figure 6 Liquid biofuel consumption in, and biomass feedstock of liquid biofuels delivered to, Sweden, 2011-2016: **(a)** the type and total delivered amount of liquid biofuel in terms of energy content; **(b)** the type of biomass feedstock used for liquid biofuel production for the entire time period. The category "Other (HVO)" consisted of soy, barley, technical corn oil; the category "Other (FAME)" consisted of vegetable- or animal fat-based oil, solid waste from food processing industry and commerce, liquid waste from food processing industry and commerce, sludge from grease separator and fat from restaurants and large-scale catering establishment; and the category "Other (ethanol)" consisted of Rye, wine residues, molasses, brown lye, oats, solid waste from food processing industry and commerce. Source: SEA (2017a).

When we understand this development within the context of a world characterised by ecological limits and a geo-historical context of uneven geographical development, we find a long-term contradiction. The geopolitics of territorialisation imply that some territories can mobilize more political-economic resources towards the achievement of political goals than others. Looking to what EU biofuel regulation is generating in Sweden, we find that the Swedish transport energy system is appropriating land-based resources from other territories (see Figure 7). As the Swedish liquid biofuel market for transport grows, we see that increasing amounts of land-based resources come from outside of Swedish territory and beyond European borders. Drawing on the estimates on power densities provided

a)



b)



Above: Country of origin for biomass feedstock of liquid biofuels delivered to the Swedish transport fuel market between 2011 and 2016. Each dot represents the territory of a nation-state. The colour of each dot represents the total energy amount delivered across the time period, with categorization based on Jenks natural breaks optimisation. Source: SEA (2017a).

Left: Country of origin (region) for biomass feedstock of liquid biofuels delivered to the Swedish transport fuel market for each year between 2011 until 2016 (GWh). Source: SEA (2017a).

Below: Total amount of individual firms certified by the International Sustainability & Carbon Certification as 'biomass producers' between 2010-04 and 2017-04. Each dot represents the territory of a nation-state.The colour of each dot represents the number of distributed certificates across the time periiod,with categorization based on Jenks natural breaks optimisation. Source: data from Article I.

c)

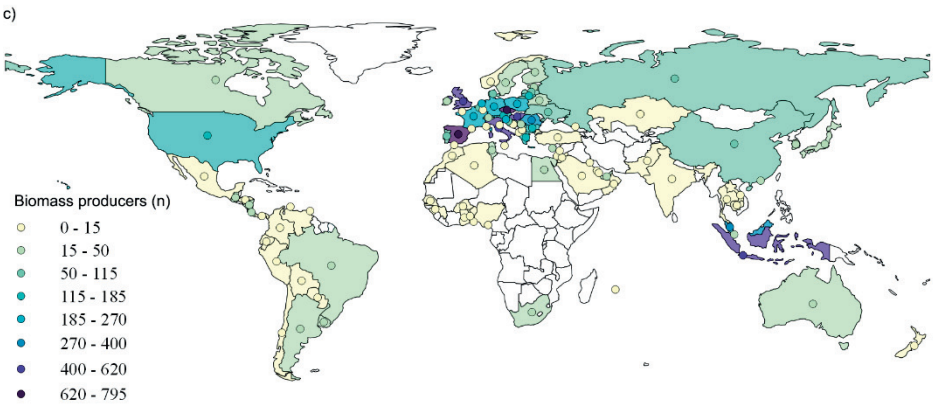


Figure 7 Country of origin for biomass feedstock of liquid biofuels delivered to Sweden, 2011 - 2016, and biomass producers certified by the International Sustainability & Carbon Certification, 2011 - 2017. Sources: SEA (2017a) and data from Article I.

by Vaclav Smil (2015), the amount of work performed by liquid biofuels in the Swedish transport sector in 2016 would roughly equate to between 17 000 and 46 000 km2 (i.e. from the land area of Kuwait to the land area of Estonia, or in Swedish terms, from Värmland to Jämtland) every year. Hence, if there were to be a long-term and global push for reducing GHG emissions in transport by substituting oil-based fuel with liquid biofuels (as defined in EU biofuel regulation), there would likely not be enough land available.

Therefore, I suggest that the specific relations that define 'EU biofuels' (found in EU biofuel regulation) cannot ensure that the liquid biofuels that firms deliver to this energy market actually result in convincing GHG emission reductions. Challenging this premise means questioning the framing of EU biofuel regulation (and liquid biofuels) as ecological modernization. This idea is veiled in uncertain environmental claims, a conclusion we hint at in Article II, but should have been even more explicit about.

Moreover, I argue that the geographical expansion (of commodity production and regulatory development) associated with EU biofuel regulation is conflict-laden as it systematically pits certain land-uses against each other. As the EC creates significant market demand for increased production of land-based resources for the production of liquid biofuels, it effectively mobilizes European capital into new accumulation opportunities. Such grand economic opportunities serve as incentives for firms seeking business ventures with profit potential – and (at least at one point in time) they were able to find investors. The theory of comparative advantage also matters, as it prescribes that territories with more land and lower energy demand should use that to produce goods for territories with less land and higher energy demand. This is not necessarily a problem, but as I will show in the next chapter, EU biofuel regulation has distinct affinities to promote land and labour relations that exacerbate the social conditions of the transnational rural precariat in the global South, rather than generate social benefits for the local population.

4. EU biofuel regulation in the global South

In this chapter, I seek to illuminate the mechanisms rooted in EU biofuel regulation that generate effects in the global South and interrogate how they come to do so. My historical account showed that the EC argued that the global South could benefit from the promotion of liquid biofuels, if production were to abide to the EU's sustainability criteria. Yet research on agrofuels has criticized numerous liquid biofuel projects in the global South for having deprived communities of access to land and natural resources, increasing conflicts without delivering ample socio-economic benefits.[32] Yet how can we know if mechanisms resulting from decisions made by the EC are responsible for such detrimental effects on stakeholders in Tanzania? In line with CR, I argue that finding answers to these questions requires a scientific explanation of the emergent properties of liquid biofuel markets (see Section 2.1.1).

In the sections below, I follow the geographically expanding process of commodity production and regulatory development that results from EU biofuel regulation: from the actors, processes, and mechanisms that originate in the EU to the appropriation of land at the source of energy extraction in Tanzania. To re-iterate my methodological justifications for going to Tanzania: I sought to incorporate the 'transnational rural precariat' into my approach to ESS. This was because the transnational rural precariat constitutes a group of vulnerable formal/informal/unpaid workers who live in rural areas, mostly located in the global South, who can easily slip into disfavoured livelihood conditions as "global economic structures intersect with local status hierarchies and national political structures" (Fraser, 2010: p. 370). This justification was made both in reference to the debate on liquid biofuels and the globalizing nature of capitalism. Tanzania as a choice is justified in part because the Tanzanian government welcomed foreign direct investments to develop liquid biofuel production (Coulson, 2013; Sulle & Nelson, 2009). Further, Tanzania did not have any domestic interest in, or actual production of, liquid biofuels prior to policy-stimulated growth in the 2000s (see

[32] For more on the debate, see Section 1.1.1.

Article II). Early scoping also showed that many of these investments had clear connections to actors with interests in the EU biofuel market (see Article II).[33]

In this chapter, I will develop three points. First, I enhance my argument on how the expansion of the EU's biofuel market serves a geopolitical purpose. I argue that the geographically expanding process of commodity production and regulatory development resulting from EU biofuel regulation may serve as a 'spatial fix' to devaluation problems inherent to the geopolitics of capitalism; wherein the territorial logic of the EU (seeking to reinvest surplus value into liquid biofuel production to avert crisis) and the Tanzanian state (seeking foreign direct investments in land and agriculture to facilitate growth), for a moment, aligned with the capitalist logic which means facilitating the expansion of capital. Drawing on the agrofuels-literature, I depart from both territorial and capitalist logics to further elaborate on why the EU (through regulation) would continue to direct both material and economic interests towards land-based resources. Second, I explain why the Tanzanian state welcomed such land-based investments as a means to development – through practises that played out as 'accumulation by dispossession' due to their neoliberal approach. Drawing on academic literature, and my own empirical work, on changes in land-use and tenure relations, I situate the expansion of liquid biofuels in a neoliberal developmental continuum. Third, I delineate some of the effects that actors with interests in EU biofuel regulation had on land and labour relations in Tanzania. The critique focuses on the EU's stance that its biofuel regulation can safeguard against social harms that might occur because of increased demand of 'EU biofuels'. This critique departs from within the neoliberal development argument that I identify in this chapter, and the social claims made by the EU (in regards to the promises of its regulation) identified in the previous chapter, and focuses on tensions in the desirability of Tanzanian land and labour for EU biofuels.

4.1 Agrofuels as spatial fixes to crises

Following a CR method of presentation, I again start by developing a more theoretical argument before proceeding to the insights on the actual and the empirical that I garnered through my research. To explain the emergent properties of liquid biofuel markets in Tanzania, it is important to re-iterate that these 'agrofuels' have been intentionally associated with a win-win energy future, promoted by "a coalition of energy and climate scientists, environmental NGOs, global corporations, international financial institutions, and states" (Hermele, 2012: p. 13). While many framed liquid biofuels as a response to crises of energy and

[33] For further justification, see Section 2.3.1.

climate (see also Borras, McMichael, & Scoones, 2010), critical sociologist Philip McMichael argued that these agrofuels represent a response to crises in the food regime and neoliberalism (2009, 2010, 2011). McMichael (2009) made the point that beneath the surface of agrofuels lies underlying social relations and processes of corporate appropriation of agriculture. In his research, agrofuels and the more general growing economic interest in land – understood as a key driver in land-grabs – was eventually attributed to capitalism's inherent tendency towards crisis (McMichael, 2012).

My argument connects to these points, but goes to explain the distinct geopolitical aspects of 'EU biofuels': as a project where the territorial logic of the EU (seeking to reinvest surplus in liquid biofuel production to avert crises) and the Tanzanian state (seeking foreign direct investments to facilitate economic growth), for a moment, sought to collaborate to facilitate a transnational expansion of capital. In this section, I explain both the theoretical and material basis for this argument.

Harvey (2006a) posits a geopolitical scenario against the historical backdrop of geographically uneven development in which crises can be averted through increased flows of capital and labour power *between* territories. Or, in more conventional terms: how mutually beneficial patterns of economic growth can be enabled through international trade by means of comparative advantage (an argument that was prevalent during the development of EU biofuel regulation). According to Harvey (2006: pp. 108-109), the possibility to pursue such a strategy would be conditioned by: (1) existing opportunities for the surplus of one territory to be profitably invested in another; (2) ability to create jobs in one territory without resulting in (massive) unemployment in the other; (3) a systematic reduction of barriers, such as transportation costs and institutional restrictions, between territories, and; (4) that place-specific struggles inherent to (and against) capitalism do not result in regional protectionism.

Against the backdrop of uneven geographical development, the material interests for some territories 'to try and open up other territories' and for others 'to try and open up their territory for others' will differ across time and space. However, the capitalist logic remains about the same, as it is still conditioned by social relations that drive it towards accumulation and the continued pursuit of profit-maximization. I suggest that both investments for starting-up commodity production and support for regulatory development of liquid biofuels are the means 'to try to open other territories' (pursued by the EU), and neoliberal development practises are 'the means to open for other territories' (pursued by the Tanzanian state).

Harvey conceives the notion of 'spatial fixes' as one possible strategy for territorial alliances to avert crisis faced by distinct forms of capitalism (such as the necessity to reinvest surplus value in profitable enterprise to avert devaluation) (2006a, 2014). By 'fixating' surplus in locations where it may generate new revenue streams, one

can continue accumulation and thereby postpone the devaluation of one's capital. Since agrofuels represent an increasing economic pressure on land not least through land-based investments, I suggest that they may also (at least partly) represent a 'spatial fix' to crises. I am not the only one to make this connection. Bergius et al. (2017) argued that recent Scandinavian development assistance in Tanzania supports "the proliferation of large-scale and often technology-intensive agriculture" as such an investment strategy (p. 16). They came to this conclusion by studying the same firm that we did in Article II (Agro EcoEnergy Ltd.). Importantly, the pursuit of spatial fixes involves many actors and processes, as de-territorialisation has opened territories to international flows of capital and labour. In this transnational context:

> Interregional competition becomes the order of the day. And the relative strengths of different territorially based alliances become an important factor (Harvey, 2006b: p. 427).

What then are the material interests that drive a certain territory (e.g. the EU) to direct its political-economic resources towards land investment in other territories (e.g. Tanzania)? Short-term drivers include the rise in prices of food and energy commodities, which may mobilize resources in post-industrial territories to invest in land for profitable food and energy production in territories where land is cheap (see Olsson, Yengoh, Faran & Jerneck, 2012). Long-term drivers include the incentive for territories to secure stable access to food – especially in the context of an uncertain future climate with increasing demand for food and other land-based resources (Robertson & Pinstrup-Andersen 2010; Rosset 2011; Sulser, Nestorova, Rosegrant & van Rheenen, 2011). Thus, as land-based resources become scarcer, the price of land is also likely to increase, which partly explains the increased material interest in land, particularly in the global South where land is relatively cheaper.[34] The territorial interest of 'the recipient' will be explained through the Tanzanian context in the following section.

Finally, financialization also creates incentives for (or drivers of) investments in land and land-based resources. In regards to EU biofuel regulation, there are at least three reasons why financialization triggers added financial pressure on land. First, biofuel regulation provides additional economic incentives and new profit opportunities for financial capital; thereby mobilizing it. The reason being that a commodity's value is increasingly constructed and co-produced within the

[34] In classical political-economy, rising and continuously high food-prices would be argued to be a factor that reduces the opportunities for profits in the industry (in contrast to agriculture). This is because a larger share of the disposable income would have to be directed towards food, rather than other goods and services from the industry of their (post-)industrialized economy. Hence, territories with little to no control over agricultural production would be incentivized to attain access to more land to keep food prices low.

architecture of its financializaton (see Fairhead et al., 2012). Second, for agriculture today, and the global food system in particular, financialization is playing an increasingly significant role, with financial derivatives, such as index funds that track the price of commodities, farmland, and shares of agrifood corporations (see Clapp, 2014). This means that price dynamics of land-based resources become even more connected with the activities of financial actors. The work of both Clapp & Helleiner (2012) and McMichael (2010) showed that the bundling together of food and energy commodities was also driving upward price shifts of food and energy commodities in 2007/2008. Third, price shocks tend to reward financial speculation, during which land may provide a safer investment opportunity, while simultaneously catering to those hoping to capitalize on the fast-growing demand in land and land-based resources (see Daniel, 2011). So, since profits in other sectors converged with those in energy, rural development, climate, and conventional financial markets, finance capitalist could now see land and agricultural production as potentially profitable investments.

4.2 A historical account of agrofuels in Tanzania

The reasons that territorial alliances (e.g. between EU member states and finance capital) direct economic pressure on land and land-based resources are real, and the mechanisms they create/utilize have causal power, and, in this case, are at least partly connected to EU biofuel regulation. However, the reasons and the mechanisms do not fully explain why the Tanzanian government would facilitate the appropriation processes that practically meant land was given away for free.

For the interpretation developed hereafter, David Harvey's concept of 'accumulation by dispossession' (2003, 2005, 2006b) helps to explain and emphasize the roles of, and plausible outcomes for, different actors in accumulation practices under neoliberalism. While Harvey himself mainly applied the concept to explain urban development in the global North, others have used it to explain rural development in the global South (for theoretical application in Tanzania, see Shivji, 2009).

In his notion of 'accumulation by dispossession', Harvey draws on four processes to explain the particularities of accumulation practises under neoliberalism. Other than three processes of privatization, financialization, and the construction and perpetuation of a sense of crises that I have already written about, Harvey shows how the state is key for making land readily available for capitalist interests. Harvey argues that under neoliberalism, the state is pushed to: (i) make assets available, including land and other marketable resources, in order to encourage national and international investors (ii) design fiscal policies to favour investment, catering to

those with capital to invest instead of redistribution of incomes and security for the poor, and (iii), create regulation which supports the leasing of land, and schemes which generate payments for natural resources (2003, 2005, 2006b). This fourth process is particularly applicable for states with limited fiscal resources in the global South, as they have stronger incentives to cater towards investors within a neoliberal paradigm (see Shivji, 2009). To facilitate such appropriation, international financial institutions are actively providing support, advice, finance, and insurance. Although there is nothing new to suggest that states in the global South are facilitating accumulation by dispossession, my contribution hereafter is to elucidate the transnational geopolitical aspects of agrofuels between the EU and Tanzania.

4.2.1 The opening up of Tanzania to transnational capital

To understand the emergent properties of liquid biofuel markets in Tanzania, we first must understand how the Tanzanian state's approach to economic transformation changed over time.

The post-independence state of Tanzania that emerged in the 1960s has been characterized as African national socialist (see Saul, 2012; Alden Wily, 2012). In his "*Citizen and Subject*", Mahmood Mamdani (1996) argued that Tanzania, with its radical and statist approach, showed great success in the de-racialization of civil society, but not with the detribalization of the Native Authority (which I will return to shortly).[35] In terms of land-use and tenure relations, Tanzania's statist approach is most apparent in two programmes: (1) the compulsory Ujamaa villagization programme, partly aimed at mobilizing peasants' efforts for collective farming, and (2) the parastatals, or government corporations, in agriculture, partly aimed at maximizing agricultural production, often through large subsidies (Coulson, 2013).

However, after the neoliberal turn in development at the end of the 1970s – exemplified in the implementation of structural adjustment programmes in Africa in the 1980s (see Simon, 2013) –, the statist approach in Tanzania became subject to change. This was mainly due to the global competitive conditions that privileged

[35] Mamdani (1996) argues, that one needs to recognise how the State was constructed and forged under colonialism while keeping the 'the native question' in mind. The government mode of the colonial state was a two-tiered structure within which "peasants were governed by a constellation of ethnically defined Native Authorities in the local state, and these authorities were in turn supervised by white officials deployed from a racial pinnacle at the centre" (ibid.: p. 287). This forged a Janus-faced state of bifurcated power – the 'bifurcated state' – within which the peasantry was ruled by a multiplicity of ethnically defined Native Authorities. Any independence movement that mobilized to change this structure was forced into an agenda that was threefold: civil society needed to be deracialized, the Native Authority needed be detribalized, and the economy needed to be developed in the context of unequal international relations (ibid.: p. 288).

East Asia over sub-Saharan Africa (Arrighi, 2012) and the inability of the ruling class to bring about economic transformation (Coulson, 2013).

Giovanni Arrighi (2002) argued that African countries, particularly when compared to East Asian countries, were impeded by structural constraints to the accumulation of capital. He refers to three main and closely related conditions: (1) African countries experienced a structural shortage of labour; (2) there was a lack of an indigenous capitalist class capable of mobilizing labour, and; (3) not only was the United States privileging its East Asian allies by giving them favourable access to the US domestic market, the colonial legacy of the Tanzanian state had also come with severe restrictions to economic development (Arrighi, 2002).

Furthermore, in his "*Tanzania: A Political Economy*", Andrew Coulson (2013) asked two pertinent questions: (1) who can use the power of the state in Tanzania, and (2) in whose interest does the state act? His findings showed how a coalition of national politicians of the independence movement and selected university graduates struggled to accumulate capital but faced several obstacles[36] (Coulson, 2013: see p. 375, para 2).[37] Coulson's main point about the Tanzanian state was that this 'bureaucratic bourgeoisie' was not a successful class of accumulators:

> It had little experience of industrial production and marketing. It had almost no experience of large-scale agriculture, and little faith in small-scale agriculture […] When allocating resources, it did not think instinctively of investment and competition; rather it wanted 'the fruits of independence' (Coulson, 2013: p. 376)

Together, the competitive conditions in global markets made it even more difficult for a Tanzanian state, that pursued the 'fruits of independence'[38] rather than allocating resources in terms of investment and competition, to develop a stronger integrated economy (Arrighi, 2002; Coulson, 2013). The post-independence Tanzanian state was thus unsuccessful in bringing about industrial and agricultural

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[36] Coulson (2013) delineates the following restrictions to accumulation: "the almost total lack of intermediate and capital goods production enforcing a dependence on trade and foreign borrowing, especially if the country wishes to purchase machinery; the restrictions on returns to labour, in agriculture and industry, which derive from colonial policy; the dependence on a number of agricultural products which can only be exported profitably on world markets if they are produced with large quantities of low-wage labour; the poor infrastructure, especially in health and transport, which must be expanded at great cost before much production can take place outside the capital city; the limited research, even in agriculture; and the small numbers of Tanzanians with technical skills." (p. 375)

[37] In his analysis, Coulson drew on both his own historical analysis of Tanzania's political economy, and also work by Issa Shivji and Michaela von Freyhold (Coulson, 2013).

[38] In Coulson's analysis, these were in the form of: "higher living standards, more consumer goods, and better social services. These had been available to the colonialist; now they should be made available to the mass of the population system." (Coulson, 2013: p. 376)

reform, and was thus forced to accept a SAP in the 1980s. As the statist model was gradually being dismantled, corporate capital started to enjoy increased freedom of movement, as Tanzania was exposed to competition from international market. Development reforms in Tanzania now became subject to the neoliberal ideas that underlined the SAP: "the proliferation of individual private property rights, the rule of law and the instruments of freely functioning markets and free trade" (Harvey, 2009b: p. 64).

4.2.2 The shaping of neoliberal developmentalism in Tanzania

After the global economic recession of the 1980s, development policies were liberalised (as the SAPs so clearly exemplify) and had become dominated by the idea that privatization, property rights, and deregulation would serve as lubricants to the supressed entrepreneurial spirit of developing country producers (see Bayliss and Cramer, 2001: p. 60). Through literature reviews, eleven semi-structured interviews, and document analysis, I learnt that agrofuels in Tanzania in the 2000s were part of this developmental continuum.

In Tanzania, one of the early steps towards a more concrete manifestation of neoliberal developmentalism was the drafting of investment and land laws during the 1990s. One important reform was the *Tanzania Investment Act No. 26 of 1997* (URT, 1997a), through which the government established the Tanzania Investment Centre (TIC). The objective of the TIC was:

> to co-ordinate, encourage, promote of centre and facilitate investment in Tanzania and to advise the Government on investment policy and related matters (URT, 1997a: part 2, no. 5)

The TIC was given the power to facilitate the acquisition of land by investors; which also necessitated that land policies and laws were changed. Thus, in parallel to investment laws, the state also developed national land policies (URT, 1995; 1997b) that informed the new land legislation (URT, 1999a; 1999b). The new land laws categorized land as either of the following: (1) village land (roughly 70 per cent), (2) reserve land (28 per cent, compromising forests, wildlife areas, etc.), and (3) general land (2 per cent). The category 'village land' and associated laws were intended to protect customary rights to land by providing communities with mechanisms to gain legal title to traditional lands (see Alden Wily, 2012). Furthermore, based on the by law defined 'radical title' which the President has on behalf of the citizens, s/he has the power to transfer land between categories.

Although land in Tanzania had not quite yet become an attractive asset for investment in agriculture (other aspects of land had already been targeted[39]), regulation that supported the leasing and purchase of land had been put in place. Partly due to the difficulties of radically changing the previous statist approach towards a more liberalized and privatized approach, these laws have been described as "ambitious, complex, contradictory and extremely comprehensive" (Knight, 2010: p. 153). To put it simply: if a private company wants to lease or buy land, either the government must transfer it from 'village land' to 'general land' or it must have been categorized as general land all along. In this process, villages must agree through a by-law prescribed decision-making process. Companies can either go through the TIC – which is also tasked to actively attract investments – or contact a village directly. If tracts of land are larger than 2.5 km^2 (i.e. 20 ha) the Minister responsible for land decides on the request, partly based on the recommendations of s/he receives from the Village Council and the District Council. Finalizing this process also requires permission from the Ministry of Agriculture, the Ministry of Lands and Housing Development, and the Ministry of Environment. If all goes through, the TIC will then create and give investors a derivative land title with right of occupancy: a lease of up to 99 years to a specific land plot. I will return to the implications of that dynamic later in this chapter, and hereafter proceed to how liquid biofuels became a means for the Tanzanian state to attract investments.

4.2.3 Attracting investments to agriculture via liquid biofuels

Coulson (2013) explains that by 2005, the economy of Tanzania:

> […] was already growing – led by mining and tourism, and manufacturing exports to other African countries, though not the traditional agricultural exports. Mobile phones spread to every population centre. The internet (with fast connections installed along every main road) became widely available. Travel and transport was easier as tarmac increasingly replaced earth roads. Tanzania was becoming a more connected, more open country, with a lively press and some frank debates in the parliament. Exchange controls were largely removed. Doners were impressed. Public sector salaries were raised. Private investments flowed in, especially from South Africa in mining, tourism, hotels, mobile phones and shopping malls, and from China in construction, infrastructure, mining and agriculture. (Coulson, 2013: p. 7)

[39] There were inflows of foreign direct investments outside of agriculture during the 1990s. For example, the "introduction of new mining policies at the end of the 1990s triggered a large inflow of foreign investment into the mining sector." (UNDP & URT, 2014: p. 33) Another example of how land also an economic targeted can be seen in conservation tourism (see Benjaminsen & Bryceson, 2012)

While institutions for attracting investments had started to take shape during the late 1990s, it was during the presidency of Jakaya Mrisho Kikwete (2005-2015) that the Tanzanian government started to actively cater to foreign direct investments in agriculture; wherein liquid biofuels initially played an important role. Despite an 'Agricultural Sector Development Strategy' that had been adopted in 2001, and an 'Agricultural Sector Investment Programme' adopted in 2005, the implementation of actual practices under the banner of these strategies was slow (Coulson, 2010). As highlighted during several interviews, the increased interest from the state in attracting land-based investments came during the political regime of Kikwete and is exemplified in this quote:

> The political regime under Kikwete was more for bringing these [land-based] investments in the country, and whole investment policies where hatched at the time that he was president. (Appendix I.1:I)

The investment strategies of the Kikwete regime included investor forums and export processing zones in which the Ministry of Finance and Planning – housing the TIC – was operationalizing the Investment Acts. Furthermore, as highlighted in a report by land-issues oriented NGO Haki-Ardhi (2008), the president also had:

> personally taken a high profile role by, among others, visiting and calling on [the Ministry of Energy and Minerals] to take initiatives, undertaking familiarisation tours to Sweden and the US, as well as to those areas of rural Tanzania, earmarked for the production of biofuel related crops. (p. 5)

While liquid biofuels were booming in the EU during the early 2000s, there was no production of, nor any policies or regulation supporting, liquid biofuels in Tanzania. The way I see it, come 2005, the Tanzanian government applied an ad-hoc approach to attract the booming investment opportunities in liquid biofuels. But they did not do it alone. As we showed in Article II, a broader network of actors with interests in securing biomass supply for EU biofuel regulation mediated in the political space of liquid biofuels in Tanzania. Specifically, we showed that government bodies and firms from Germany, the Netherlands, Sweden, Denmark, and Norway played role in creating this space by providing funding and expertise. This included the funding and partial structuring of policy platforms designated for developing a Tanzanian liquid biofuel policy and the activities of external policy experts (where one expert advocated for export of raw material, biomass, to be processed in Europe due to higher economic efficiency).[40] Even the government argued that liquid biofuels were not meant to be consumed in Tanzania, but for export (see Article II: p. 20).

[40] As shown in Article II, this was met by arguments from actors from civil society organizations and academia that advocated for keeping the value chain inside Tanzania, urging policy to include restrictions on how much liquid biofuel could be used for export

In Article II, we also showed how the Tanzanian government tasked the TIC and the Ministry of Energy and Minerals with facilitating foreign direct investments in liquid biofuels: operationalized via the new National Biofuel Task Force.[41] The Tanzanian government proceeded to draft specific investment guidelines "to properly guide interested stakeholders, including local and foreign investors/developers who would like to invest in liquid biofuels in Tanzania" (URT, 2010: p. 1). One strategy to attract investments was to present potential investors with exaggerate estimates of land availability. Haugen (2010) showed that the Tanzanian government, WWF Tanzania, and the German Technical Cooperation claimed that 550 000 km^2 (almost two thirds of Tanzania's land area) were 'arable', 'potentially available for agriculture', and could be 'potential area for rain-fed crop production'.[42]

Moreover, beyond the findings presented in Article II lies the connection between of how the politics of liquid biofuels in Tanzania intersected with a domestic pursuit of 'conventional agricultural modernization' (see Isgren, 2018: Ch. 2). In 2009, the Kikwete regime launched a strategic agenda called *Kilimo Kwanza* – a declaration for the transformation of agriculture formulated by the Tanzanian National Business Council (see Coulson, 2010). During fieldwork in 2014, interviewees involved in the main policy platform for liquid biofuels identified this strategy as a key document for explaining the political support of liquid biofuels in Tanzania (see Appendix I.1).[43] Further suggestions of this being the case were observed through a document analysis of the liquid biofuel investment guidelines and liquid biofuel policy drafts. The rationale expressed in these documents suggested liquid biofuels were a means to achieve technological change through the use of modern technical equipment in agriculture (see Article II).

In short, *Kilimo Kwanza* has been interpreted by many as a set of state-driven initiatives to move agriculture away from small-scale production models towards commercial large-scale production models (see Coulson, 2010: pp. 4-5). To operationalize *Kilim*o *Kwanza*, the state launched initiatives such as the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) (SAGCOT, 2013, 2017a)

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[41] See Article II for explanation on the National Biofuel Task Force.

[42] Haugen (2010) also presents three other estimates from the Food and Agricultural Organization (FAO) and the World Bank; ranging from 51 000 km^2 (arable land), 102 000 km^2 (arable land and permanent crops), and 342 000 km^2 (arable land, permanent crops, and permanent pastures).

[43] In the early scoping process for the research that resulted in Article II, we identified the main policy platform for liquid biofuels in Tanzania, the Tanzania Bioenergy Forum, and interviewed five of its participants. Through semi-structured interviews, we asked open-ended questions that were based on previous research on liquid biofuel development in Tanzania and with clear reference to the EU's regulatory regime. Prior to fieldwork, we had also identified policies and legal documents that related to biofuels. Interviewees were asked to identify documents from this list that they thought were salient for explaining biofuel developments in Tanzania.

and the New Alliance (Sulle & Hall, 2013); garnering support from many international development partners (SAGCOT, 2017b; New Alliance, 2017). The SAGCOT investment blueprint clearly reasserted the position that there was an abundance of underutilized land ripe for investment (SAGCOT, 2011). To facilitate further, the Kikwete-regime established the "SAGCOT Centre Ltd.", whose role was to be a third party entity mediating negotiations between state and investors, to regulate all investments in the SAGCOT region, and to monitor socio-economic impact of these investments.

Looking to outcomes: when comparing the net inflow of foreign direct investments during the political regime of Kikwete with previous data, it becomes clear that the regime managed to attract large amounts of foreign direct investments through this strategy (see Figure 8). This state-facilitated endeavour resulted in a total number of 42 potentially liquid biofuel-related land deals made throughout Tanzania by 2014 (see Table 3 – see Article II for further methodological explanation). On a global scale, by 2010 Tanzania had become "the leading non-oil destination for foreign direct investment in Africa after South Africa" (Roe, 2010).[44]

However, gradually, the liquid biofuel boom died down: partly due to falling oil prices and the ILUC debate that made the investment climate for liquid biofuels less favourable, partly due to domestic opposition becoming strong and vocal, and partly due to natural gas findings shifting the interest of the responsible ministry (see Article II). Interviewees in civil society, firms, academia, and the government, also referenced how the uncertainty around the long-term economic support of food-based liquid biofuel production in the EU had made investors lose interest. Yet many firms had already acquired land titles, and some were now moving away from talking about liquid biofuels to instead began to talk about agriculture.[45] As for the liquid biofuel projects we studied in Article II, investors had backed out from smallholder- and jatropha-based small-scale project Diligent Energy System that had been active in the Arusha district for 7 years; and no new investors were found. The large-scale project we studied, Agro EcoEnergy Ltd. in the Bagamoyo district, had shifted their focus, and instead began to talk about sugar-production for a domestic market (which Tanzania imported more than it exported) rather than ethanol production for a European market of liquid biofuel for transport. Eventually, Agro EcoEnergy Ltd. connected to SAGCOT and New Alliance to attract funding for their project to be realised – although as we will see in the following section, the firm's new found economic hope did not last for long. The question is: in the end, how much resulted in liquid biofuel production, at what cost, and for whose benefit?

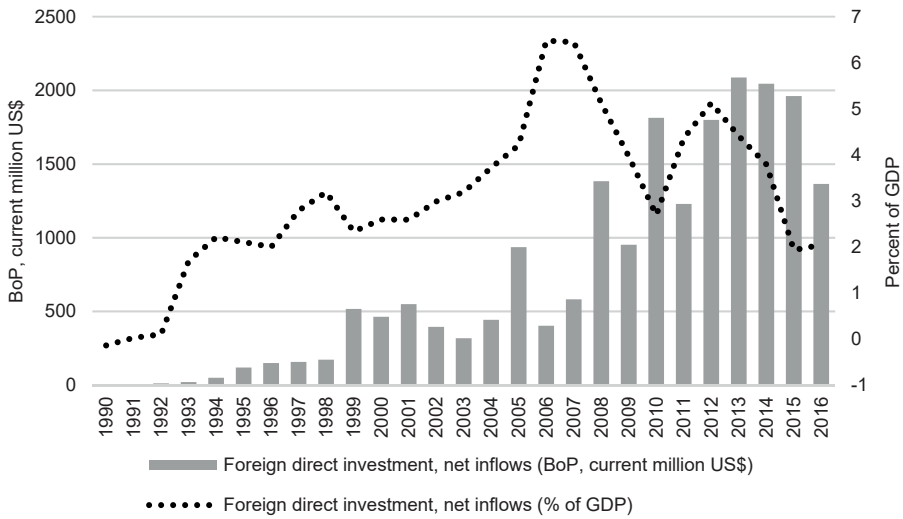
[44] "Mining grew at around 13% across the 2000s, and it is now the largest recipient of foreign direct investment and one of the fastest rising sectors of the economy." (UNDP & URT, 2014: p. 33)

[45] For an explanation of this 'discursive flexibility', see Hunsberger & Alonso-Fradejas (2016).

Table 3 A summary of liquid biofuel-related land deals in Tanzania. Author's interpretation of Locher & Sulle (2013, 2014). *Other feedstocks referred to in deals are castor oil, soybeans, Pongamia, sunflower, paddy, and "biofuels".

Type of land deal	Total number of liquid biofuel-related land deals	Feedstock					
		Jatropha	Sugar cane	Oil palm	Sorghum	Maize	Other*
Deals by foreign investors and joint ventures by Tanzanians and foreigners	20	7	8	2	2	2	4
Compilation of domestic land deals	7	6	1	0	0	0	3
Deals with unclear information about investor's background	6	4	1	1	0	0	0
Land deal projects that have been confirmed ceased or aborted	9	5	1	2	1	0	1
Total	42	22	11	5	3	2	8

Figure 8 Foreign direct investment, net inflows, Tanzania, 1990-2016. Sources: World Bank (2017a; 2017b). Date of data extraction: 2017-11-29.



4.3 A critique of EU biofuel regulation in Tanzania

Land for liquid biofuels had become a strategy for the Tanzanian state to pursue a neoliberal approach to development by attracting transnational capital. The argument of neoliberal *developmentalism* here being (as interpreted from reports published by the World Bank and World Economic Forum on bioenergy and interest in farmland): financial capital can be directed towards land-based investments to improve the productivity of underutilized land, to create new opportunities for wage labour in rural areas, and to enable technology transfer between the global North and the global South (King, Inderwildi, Williams & Hagan, 2010; Deininger et al., 2011; see also Borras et al., 2016). I view this message as revolving around land and labour as two production factors in economic transformation with transnational capital as the means to improve their productivity.

In my specific research context, the Tanzanian government sought to attract transnational capital that was partly mobilized through EU biofuel regulation. Based on my analysis in the previous chapter, I argue that the EC shares aforementioned neoliberal position on development, adding the caveat that the EC suggested that liquid biofuels would create new jobs and diversify incomes in the global South (where rural poverty is most concentrated and entrenched) as long as production abides to EU biofuel regulation (the content of which was explained in the previous chapter).

In the following, I develop a critique from within this neoliberal developmental argument. My main interest is again whether the EU can declare that EU biofuel regulation can ensure that no adverse social effects will occur due to increased demand of liquid biofuels. It follows then that I maintain focus on the mechanisms created by EU biofuel regulation and their implications for land and labour relations in Tanzanian agriculture. Drawing on my own empirical work and secondary data, I delineate the effects of actors with interests in EU biofuel regulation on land-use and land tenure relations in Tanzania.

Some initial conceptual clarifications on political economy are needed. Land and labour can be conceptualized as distinct production factors. Labour as a production factor refers to human capital in terms of both physical and mental effort. Land as a production factor refers to physical capital, or space, potentially including the many natural resources that physical spaces can entail. For land, place specificity gains further economic importance as its physical geography creates ecological limits, which affects the possibility and the costs of exceeding those limits (Mitchell, 2008: p. 30). Technology may increase labour productivity, thereby lowering labour costs and/or enabling an expansion of a given cultivated area. It can also be used to increase the productivity per unit of land (i.e. intensifying land-use). Institutional change may enable technological change and commercialization through land

reforms (e.g. for investment), economic reforms (e.g. subsidizing inputs), and research (e.g. for finding and disseminating new practises).

In broad terms, land and labour in Tanzanian agriculture has the following features. Agricultural production mainly occurs on smallholder farms (UNDP & URT, 2014). In 2010-2011, over 80% of adults in rural areas participated in farming outside of wage employment, while an additional 9% farmed within wage employment (McCullough, 2017).[46] The productivity of agriculture has hardly changed since independence, with growth rarely exceeding population growth rate and increases in output being attributed to area expansion (Korotayeva & Zinkina, 2015; Binswanger-Mkhize and Gautam, 2010; Skarstein, 2005). However, reports indicate declining yields in maize, sorghum and beans – which are key food staples together with rice – during the 2000s (Lokina, Nerman & Sandefur, 2011). There have also been reports of decreasing soil productivity since the 1990s (Kangalawe, Christiansson & Östberg, 2008; Baijukya, De Ridder, Masuki & Giller, 2005), argued as an ecological consequence of the agricultural intensification come the 1970s villagization programme (Shao, 1986; Kjekshus, 1977). Tanzanian agriculture is also mainly characterized as rain-fed, with some semi-arid areas experiencing "that rainfall amount has been decreasing overtime while temperatures have increased" (Mongi, Majule & Lyiomo, 2010: p. 379). The pace of technological change has been slow, with inputs such as fertilizers, tractors, and irrigation methods remaining low, when compared to, for example, Malawi and South Africa (UNDP & URT, 2014). The types of institutional changes that have occurred in regards to land and investment laws around agriculture was introduced above (in Section 4.2).

4.3.1 Tensions in the desirability of land in Tanzania for EU biofuels

My first point of critique is the claim that (underutilized) land can, via land deals, become subject to investment for liquid biofuel production designated for the EU transport energy landscape without generating adverse social effects (such as loss of access to land, water, and food and increased conflicts over scarce resources).

I argue that the appropriation of land-based resources for 'EU biofuels', under the Tanzanian state's neoliberal approach to development, has distinct tendencies that deprive the rural population of access to land and natural resources (thereby also likely increasing conflicts). My argument has two interconnected parts. First, I argue that the EU, through EU biofuel regulation, mobilized agents (with material and

[46] This in comparison to 2.7% of adults engaged in wage labour in industry and 5.1% as self-employed, and 8.6% of adults engaged in services, and 25.6% as self-employed in 2010-2011 (McCullough, 2017).

economic interest in the EU's liquid biofuel market for transport) that sought to invest in land in Tanzania thereby triggering an additional economic pressure on land. Second, I suggest that this added economic pressure coincided with the Tanzanian state's neoliberal approach to development, which has resulted in accumulation by dispossession. Thus, while EU biofuel regulation is not the sole transnational force at hand, its emergent properties in Tanzania (enabled through the state's neoliberal developmentalism) worked to change land-use and tenure relations in ways that worsened the livelihood conditions of rural communities.

Proceeding, how do land deals for liquid biofuels play out in Tanzania?

In theory, rural communities in Tanzania can make claims to protect their rights to land, and, through communal decision-making processes, can choose whether and how private investors gain access to idle or underutilized land. However, in practise:

> Tanzania has a history of state disruption, changing laws and territorial allocations, and state-society conflicts. Many villages, for instance, were created during the early period of independence through the compulsory Ujamaa villagization programme, in which entire communities were moved to communal lands. This disrupted traditional knowledge and land uses, dislocated identities and livelihoods, and created confusion over land claims and community boundaries. (Neville and Dauvergne, 2012: p. 281)

Furthermore, access to, ownership of, and control over land in Tanzania is also gendered, as women own less land than men, regardless of how ownership is conceptualized (Doss, Kovarik, Peterman, Quisumbing & Bold, 2015); despite the fact that women represent the majority of the labour force in informal agriculture (McCullough, 2017). Taken together, these complex social and historical dynamics affect the possible outcomes of struggles revolving around land-use and tenure.

To exemplify the conrete outcomes of land-investments in practise, we can draw on the different liquid biofuel-related land deals that were made during the biofuel boom in Tanzania. Many of these land deals resulted in land being converted from village land to general land, meaning that land was leased to firms for 99 years in accordance with the institutions created by the state.

In Article II, we analysed two (purposively sampled) liquid biofuel projects, focusing on the role that EU biofuel regulation had in the project pursued by the firms. We showed how the EU market demand was initially a major driver; that (European) agriculture-, energy-, and development organizations had provided funding; and that the EU-approved private certification system had tried to secure them as purchasers of their service or used them as test sites for regulatory development. Hence, there were many agents involved in pushing the geographical expansion in Tanzania – not least firms that sought to produce 'biomass' and/or liquid biofuels, and firms that organize the related private certification systems (see Sections 3.2 and 3.3).

The originally Sweden-based Agro EcoEnergy Ltd. was the one of our two sampled liquid biofuel projects that acquired land through the land investment process. The project was to be established on a former state-owned cattle farm that closed down in 1994, and thus had been deemed underutilized land suitable for investment by the government. However, the land acquired by the firm had been repopulated by hundreds of subsistence farmers in scattered settlements after the closure of the state cattle farm. The situation thus eventually resulted in multiple controversies about rights to (economic) compensation surrounding the project (see Article II).

During my final fieldwork period in Tanzania (in 2016), interviewees highlighted that they were yet to hear about any of these projects leading to actual production of liquid biofuels. Even more so, local communities and civil society were still struggling to regain the land that they had lost their formal rights to. This dynamic was verified in media coverage (The Citizen Tanzania, 2015; 2013a; 2013b; 2013c). Concerns over lost land rights caused by 'land-grabs' were even used by John Magufuli during his presidential campaign trail in 2015 (Daily News Tanzania, 2016). In fact, Agro EcoEnergy Ltd. eventually had its land title revoked on environmental grounds by the Tanzanian government in 2016 – and went on to become registered in the name of the then newly elected President Magufuli (see Article II; The Citizen Tanzania, 2016; EcoDevelopment In Europe AB, 2017). While Tanzanian land laws allow the president to transfer land between categories, the firm did not exactly embrace this decision. Having spent more than ten years of work and a total investment of 52 million USD, the firm – making reference to bilateral investment protection treaty between Tanzania and Sweden – now seeks legal redress through an international arbitral tribunal (EcoDevelopment In Europe AB, 2017).

Regulatory development was also affected by the pursuit of Tanzanian land for 'EU biofuels'. As we followed the policy process in Article II, we saw that civil society and academia were forced to mediate in a political space designed for liquid biofuels: despite the fact that this conflicted with the rising domestic critique concerning land-use and tenure policies. While civil society and academia argued for the government to pursue new and more holistic land policies, the Tanzanian government and their expert consultants pushed regulatory development to focus on a commodity-specific liquid biofuel policy.

At the same time as the liquid biofuels boom died down, the Ministry of Minerals and Energy shifted its focus to natural gas which is poised to be the "new episode in [Tanzania's economic transformation, because of extensive onshore and offshore gas reserves have been discovered." (UNDP & URT: p. 34). The result being that the liquid biofuel policy also failed to materialize into any actual regulatory change – and informants joking about which drawer at the Ministry of Energy and Minerals the most recent draft may be hidden.

My analysis suggests that, in the case of Tanzania, land for 'EU biofuels' has (thus far) only resulted in further struggles around land-use and tenure. This dynamic is clear in the case of Agro EcoEnergy Ltd. and can also be seen in other examples of 'EU biofuel'-projects that have stalled or failed to materialize, such as: Africa Green Oils and Eco-Energy (formerly SEKAB) in Rufiji district (Neville & Dauvergne, 2012), Sun Biofuels in Kisawawe district (German, Schoneveld & Mwangi, 2013; Purdon, 2013; Habib-Mintz, 2010), East Africa BioDiesel in Bahi district (Habib-Mintz, 2010), and Bioshape in Kilwa district (German et al., 2013).

More broadly, the land dependent rural population of Tanzania is not only subject to dispossession through investments in agriculture, but land alienation is also driven by multiple processes across multiple sectors (including investments in mining, conservation, and tourism) (Bluwstein et al., forthcoming). Land alienation and dispossession is then further reinforced by how rural people respond to these processes, such as through migration, not least resulting in conflicts over land (ibid.). Given this, many have argued that the construction of underutilized land and its associated land deal politics tends to produce social harm and oppression insofar as it works to reshape agrarian livelihoods without delivering ample social benefits (see Baka, 2013; Borras et al., 2011). Thus, rather than enabling economic transformation, I argue that processes of 'accumulation by dispossession' for EU biofuels – supported by the Tanzanian government and through the mechanisms of EU biofuel regulation – have only moved the uses and values of land away from the transnational rural precariat; with the tendency to deprive these communities to land and resources which their livelihoods depend upon (thereby also likely to increase conflicts).

But what would have happened if liquid biofuel projects designated for the EU market had been successfully established? I will attempt to use this question to discuss the implications of EU biofuel regulation on labour relations in Tanzania.

4.3.2 Tensions in the desirability of labour in Tanzania for EU biofuels

The second claim that I critique is that local populations can benefit from being incorporated into the expansion of the EU's market of liquid biofuels for transport because of employment opportunities that come with the establishment of new corporate enterprises (on underutilized land). The amount possible benefit to be gained is determined by the employment intensity of a given economic activity, and thus is different for each global value chain, as different goods and services are associated with different labour intensities and degrees of mechanisation. Also assumed here is the growth of the new economic opportunities for smallholder farmers to sell their produce to firms, if/when they install the advanced processing technology necessary to compete in the global markets (e.g. through outgrower

schemes). Furthermore, a firm that appropriates land to establish an economic activity (in this case, to produce biomass/biofuel designated for regionally regulated energy markets outside of the domestic territory) could contribute to poverty reduction by positioning the original landowners to gain a share of the exchange value through rent or purchase, tax revenues, or fees, which could further enable local or national governments to supply physical infrastructure and public goods.

Because most land deals related to production for the EU liquid biofuel market for transport have either failed to materialize or stalled, concrete examples of actual production are difficult to find. To the extent possible, my research examined the effects of EU biofuel regulation on firm-level decision-making processes, and the way these processes (would) affect labour relations, in Tanzania.

For investments that seek access to the EU liquid biofuel market's global value chains, the intended land-use, at least initially, is for export. The theory of comparative advantage expressed throughout the development of EU biofuel regulation suggests that countries in the global South can benefit from selling biomass or liquid biofuel to the EU's regional market if production abides to the sustainability requirements. However, any form of social requirements was left to be voluntarily organized in private certification systems, which are to be used on a voluntary basis. Hence, there is already here little reason to believe that EU biofuel regulation will have strong enough mechanisms to systematically redistribute socio-economic benefits of economic activities to a local community in the Tanzanian setting, where land-use and tenure relations are subject to accumulation practises under neoliberalism. Instead, it is more likely that the general tendencies of profit maximisation and cut-throat competition on international markets will prevail in the appropriation of land-based resources as these firms compete in global value chains.

The effects that the mechanisms of EU biofuel regulation could have on labour relations in Tanzania are perhaps most visible in the dispersed and small-scale production system sought by Diligent Energy Systems (see Article II for a more detailed explanation of their model, and Appendix I.1:C). For Diligent, one major aspect concerned the added costs associated with reporting were too steep, since their model of economic organization involved up to 40 000 smallholder farmers. Based on Diligent's experiences, EU biofuel regulation does not fit with the Tanzanian smallholder context: characterized by numerous farmers and large variability in the character of the biophysical landscape. Even the NTA8080-certification system (approved by the EC to be used in EU biofuel regulation) that had explicit aims to support development in the global South through biofuels failed to forecast the issues encountered when implementing certification in Tanzania (see also Romijn et al., 2012). The labour involved in Diligent did produce jatropha-based biodiesel for some time, but according to our informant (Appendix I.1:C), they only sold smaller samples to European actors. Despite attempts to sell their fuel

locally, which they marketed by suggesting an added marketing value for tourism, this initiative failed as it was deemed too expensive by potential consumers, and also performed poorly in vehicle engines. The findings in Article II, strengthen the argument that the mechanisms in EU biofuel regulation systematically support large-scale production systems over small-scale ones.

Looking more broadly at the promises of large-scale production systems, characterized by increases in labour productivity, there is reason to be cautions in regard to their social promises in Tanzania. In a recent analysis on labour productivity and employment gaps in Tanzania, McCullough (2017) shows that "the agricultural sector [in Tanzania] is not a bastion of low productivity but, rather, a large reservoir of underemployed workers" (p. 134). If labour demand is reduced without a labour market capable of absorbing it, sudden increases in labour productivity may worsen poverty. This analysis has also been made research on land-grabs, which has questioned if commercial farming for global markets via land-based investments actually creates jobs or simply makes local labour redundant (see Li, 2011). Large-scale agricultural investments often involve the mobilisation of highly mechanised labour regimes that require skilled labour to perform certain tasks. This means that to be involved in these regimes individuals require a higher level of education; which Beyene (2014) argues translates to an average of 2 people per 42 ha in sub-Saharan Africa, thus reducing the demand for labour locally.

This critique connects to the more long-standing debate around whether plantations, out-growers, and/or commercial farming as agricultural models can contribute to development (see Hall, Scoones, & Tsikata, 2017).[47] Efforts to 'link up' farmers to global value chains reorients production away from local people; a relationship that also "implies increased vulnerability to changes in global markets, and a greater concentration of social and economic hazards on the less powerful participants" (Barrientos & Hulme, 2009: p. 7). Further, the potential to "upgrade" or "link up to" is deeply shaped by the geo-historical context in which highly mechanized technologies have been developed and the already industrialized territorial alliances in the global North have various import restrictions (e.g. standards for food and fuel), and subsidies for exports and agricultural produce (e.g. the EU's common agricultural policy). Thus, given the cut-throat competition on international markets, alongside the more general re-orientation of markets (from local to transnational), I argue that the appropriation of land for EU biofuels in Tanzania is very doubtfully positive in regards its possible social benefits for the transnational rural precariat.

[47] Borras & Franco (2013) remind us not to assume that large-scale agricultural projects always adversely affect local communities as each land deal, and the way that local communities respond to it, varies across and within localities.

5. The scope for change: a discussion on alternatives and transformation

I have now explained the mechanisms of EU biofuel regulation. I have also shown some of the effects that they generate in the global North and the global South. To do this, I focused on how these outcomes relate to the goals of the EU. Before proceeding according to the organizing principles of ESS, I will revisit my key arguments and clarify why the EU pursued liquid biofuels for transport through regulation, and why EU biofuel regulation has failed to achieve its internal goals.

5.1 Revisiting the key arguments and the critique

I suggested that the EU's support of liquid biofuels for transport constitutes a dual problem: (1) liquid biofuels for transport are persistently pursued by the EU as a means for climate change mitigation in transport despite contested claims around their environmental performance, and; (2) the growth of liquid biofuel markets has adverse social effects on rural populations, particularly communities in the global South (i.e. the group I have conceptualized as the transnational rural precariat). If the EU could convincingly demonstrate that EU biofuel regulation ensured that capital in each territory benefitted from trade of energy commodities that reduced GHG emissions and that those benefits would eventually reach the transnational rural precariat, then we could say that it was achieving its stated internal goals. However, given that my analysis suggests that EU biofuel regulation is delivering liquid biofuels of uncertain/unconvincing GHG performance, and actually has added economic pressure on land in the global South (often leading to dispossession, given prevailing neoliberal development practices), the EU does not live up to its own social and environmental claims.

My research has shown four key reasons why EU biofuel regulation is unlikely to achieve its own internal goals. First, because fulfilling certain social requirements is not mandatory within the EU's regulatory framework certification, and since

voluntary market-based initiatives are incapable of delivering necessary structural change, exploitative tendencies of underlying capitalist social relations of production and exchange will prevail. Second, EU biofuel regulation has no support system for small-scale production models nor geographically dispersed production models, which results in their exclusion. Third, the economic flexibilities created by EU biofuel regulation further support tendencies for vertical and horizontal integration through global value chains by giving rise to more economic opportunities for firms that engage in large-scale production (not least through the 'waste and residues'-category); thereby further supporting large-scale production models with intensified land-use practises. Fourth, within this hybrid regulatory system, we know that firms only abide to regulation in flexible ways[48], and a sectoral approach to regulating biomass production cannot assure ecologically sound and socially beneficial land-use practises as outcomes generated by regulatory mechanisms. While I do not reject the notion that there are certain conditions under which some liquid biofuel production systems could demonstrate convincing GHG performance when compared with petrol and gasoline (this notion was indeed part of the reason why liquid biofuels gained traction), my thesis does suggest that EU biofuel regulation is incapable of generating such outcomes.

My research has shown that both the biophysical reality and the geo-historical context are important explanatory factors of the emergent properties of liquid biofuel markets. Through science we can show that substituting fossil fuels with other energy sources (here crude oil with EU-defined 'biomass') will require more land. For 'biomass', this land will tend to be in rural areas rather than urban: hence more immediately affecting rural populations than urban ones. Moreover, the mechanisms built into EU biofuel regulation tend to reap benefits for powerful territorial alliances, while thte burdens are placed on the transnational rural precariat. The social conditions of rural livelihoods in the global South are noticeably misrecognized in EU biofuel regulation: as the safeguards put in place are insufficient to safeguard against negative impacts and the large-scale production system promoted by regulation may actually serve to make local labour redundant. When coupled with a neoliberal approach to development, land-investments will also more often lead to dispossession than win-win futures. My analysis suggests that the politics of transport energy in the EU has 'misframed' the entire geo-historical context and biophysical reality: resulting in the transnational rural precariat being subject to institutional practises of 'maldistribution', 'misrecognition', and 'misrepresentation' (see Fraser, 2013; 2010; 2009).

Then, despite its inability to resolve the dual problem of liquid biofuels: why would EU biofuel regulation be supported? Although my critique of the EU's support of

[48] As Article I shows, firms may decide to be certified at one point in time and decide to not renew their certificate at the next.

liquid biofuels for transport is tough, I do not suggest that it is caused by some great conspiracy: wherein commissioners in Brussels allied themselves with Tanzanian government officials to deliberately exploit the rural poor. Instead, I have suggested that the explanation lies in how liquid biofuels for transport are a response to (multiple) crises in capitalism that takes a geopolitical form due to the 'variegated nature of capitalism' and the 'history of geographically uneven development' (see Section 2.3.1). To postpone multiple crises (e.g. energy, over-production in agriculture, rural development, climate, finance), the territorial interests of the EU, Sweden, and Tanzania, and broader capitalist interests, sought to find ways to re-invest surplus in profitable ways, partly by fixating surplus in space (i.e. land and land-based resources for liquid biofuel production).

To continue in the structure prescribed by ESS, my diagnosis and critique suggest that what causes the dual problem of liquid biofuels is how the specific mechanisms of EU biofuel regulation interact with the underlying structure of capitalist social relations of production and exchange – given the spatial relations imposed on commodity production by the transport energy landscape. My contribution hereafter develops a partial theory of social reproduction to explain this persistence, as the gaps and contradictions within this social reproduction are connected to scope for change.

5.2 A theory of social reproduction (and gaps and contradictions) in Sweden

In this section I will present a theory of social reproduction. My argument will centre on the way that physical infrastructure and institutions in Sweden work to continually secure a steady supply of energy commodities for the transport energy landscape (without actively trying to reduce their demand other than through energy efficiency gains). Through my research, I have identified three processes that reproduce this underlying structure: (1) complementarity between liquid biofuels and the fossil fuel landscape, (2) dynamic interconnections of material interests, and (3) institutional constraints on reform space. In terms of data, my analysis relies on statistics on fuels, vehicles, road networks, and fuel stations, and qualitative material from field work in Sweden (see Appendix I). To the extent that it is possible, I also present gaps and contradictions in these processes.

Again, following the CR method of presentation, let me start by providing a theoretical foundation for how my three analytical domains of 'geopolitics', 'energy markets' and 'energy landscapes' (see Section 2.3) speak to each other: starting from the production of energy commodities.

The production of energy commodities is subject to the laws of thermodynamics[49]: meaning energy conversion losses throughout their production stages. This implies that different energy commodities embody different spatial relations in terms of land-use. For example, drawing on Smil's work on power densities (2013), driving a car with liquid biofuels requires the equivalent of 250-6500 times the amount of land than when using oil-based liquid fuels (this of course depends on the land, land-based resources, and the production system of said liquid biofuel). Yet in capitalist economies, energy commodities are treated just like any other commodity, thus comprising of both use values and exchange value. As energy is turned into a means of accumulation (e.g. when firms get payed for producing, delivering, and/or exchanging liquid fuels on a market), capitalist social relations of production and exchange start to "determine the level, the speed and the inequality of capital accumulation" (Osti, 2013: p. 320).

These accumulation processes occur in a world of pre-existing physical infrastructure in which only certain energy commodities can be used. Moreover, different types of infrastructure differs in terms of possible energy conversion pathways, and each are associated with its own historical development. Therefore, today, – due to both the social and material aspects of energy – certain infrastructures are more economically efficient at performing specific energy-related activities than others. In the case of road traffic, as we will see, there is no denying that industrial capitalist societies are dominated by liquid fuels produced from oil-based commodity chains that are used in internal combustion engines to propel vehicles that are re-fuelled at fuelling stations – and transport infrastructure reflects and reproduces this.

These coupled social and material conditions are important for explaining the persistence of liquid biofuels. In his work on the electricity grid, Hughes (1993) demonstrated how 'energy systems' are 'territorialized'; and went on to explain that the spatial relations of energy systems matter for how they are controlled by political action at different scales. Specifically, networks of energy infrastructure differ in their degrees of contiguity (e.g. how dense/dispersed of a geographical form), connectivity (e.g. how many points of connection), and centralisation: "the degree to which power and authority over a network are centralised or devolved can be significant for its capacity" to contribute towards meeting political goals (Bridge et

[49] Energy must be extracted and transformed into a useful form to provide humans with, for example, warmth, mechanical work, or processing heat for industrial purposes. Whenever energy is converted from one form to another, the quantity of useful, low-entropy energy is partly converted into high-entropy energy, namely waste heat. As determined by the second Law of Thermodynamics, entropy also increases spontaneously in all energy processes. There are different forms of energy, and one form of energy can be converted into another, such as when the chemical energy stored in hydrocarbon bonds are set on fire and converted into heat, then used to evaporate water that is directed into a turbine where it is transformed into mechanical work that propels an automobile.

al., 2013: p. 336). Thus, infrastructure for energy and its associated material flows can become channels for social and financial power (see Mitchell, 2011); wherein each infrastructural node not only reflects the uneven geographical nature of this power, but also actively works to reproduce it (Huber, 2015: p. 5).

Below, by elucidating the spatial relations imposed on the underlying structure of capitalist social relations of production and exchange, I suggest that we can explain why liquid biofuels for transport are persistently pursued by the EU as a means for climate change mitigation in transport despite contested claims around their GHG performance.

5.2.1 Complementarity between liquid biofuels and the fossil fuel landscape

Through research, I identified the core mechanism of EU biofuel regulation so as to roughly define which energy commodities are allowed in the new subsidized energy market. In response to EU regulations, firms organize their commodity production (given profit opportunities) to provide economically efficient goods/fuels (and certificates). In his work on market-based mechanisms in climate policy, Wim Carton (2017; 2016) convincingly demonstrated how the material, social, and political inertia of fossil fuel energy dependence delimits possible outcomes that can be expected from market-based approaches. Simply put, the cheapest and easiest solution for decarbonising the economy will be prioritised over what may be more scientifically convincing alternatives to mitigate detrimental impacts caused by climate change. The specific theory of social reproduction developed hereafter begins from the assertion of the obvious complementarity of liquid biofuels with the 'fossil fuel landscape' that has developed through the history of industrial capitalism.[50]

To develop my argument, I draw on the conceptual work on energy landscapes by Pasqualetti & Stremke (2017) in order to make some 'substantive', 'spatial', and 'temporal' qualifications with regards to liquid biofuels complementarity with the prevailing transport energy system. Through this, I will explain the complementarity of liquid biofuels in substantive terms by showing what energy resources are being used in the fossil fuel landscape, and in spatial terms by explaining the physical appearance of the fossil fuel landscape over time.

[50] As argued by Foster et al. (2010) the history of industrial capitalism has been one powered by fossil fuel extraction and consumption (see also Malm, 2014).

Where, then, would we start unpacking EU biofuel regulation's complementarity with the complex fossil fuel landscape? I suggest that a fuel station is an appropriate place to begin this analysis. The main economic purpose of a fuel station is to provide oil-based commodities in the form of petrol and diesel for vehicles. It is connected through vast and seemingly never-ending road networks. Driving on these roads, countless vehicles arrive to refuel their tanks with the condensed form of heat energy that can be derived from liquid fossil fuels. This energy is then utilized by internal combustion engines to propel the vehicles over the fossil fuel landscape. All of this – the extraction of hydrocarbons, and the production, transportation, and consumption of liquid fossil fuels – is effectively organized by global value chains in the contemporary capitalist economy.

Fuel stations are infrastructural nodes that deliver liquid fuels to end-consumers of energy in the transport energy landscape. Over 3300 fuel stations are spread out across road networks that cover large parts of land areas in Sweden, particularly in more densely populated areas (see Figure 9:a-c). In Sweden, this network of infrastructure includes three oil refineries that produce petrol, diesel, and heating oil, around 30 oil harbours, around 40 oil terminals, and 800 oil tank trucks (SPBI, 2017d). Four firms out of fifteen total retailers[51] deliver 99 per cent of the total volumes of petrol and diesel to over 3300 fuel stations: Circle K (30 per cent), St1 (18 per cent), Preem (28 per cent), and OK-Q8 (23 per cent) (SPBI, 2017c). These firms are the ones that have to demonstrate compliance, and consequently, are also those who receive tax exemptions (see Article III). Since the 1970s, firms that operate fuel stations have delivered increasing volumes of liquid fuels, predominately from oil-based commodity chains (see Figure 9:d). Since 2003, the increase of delivered volumes comes instead from liquid biofuels: ethanol, FAME, and HVO (see Figure 9:d-e). The most important point to make here, one that is clearly apparent, is that liquid biofuels fit neatly into this liquid fossil fuel landscape; particularly since they are mainly delivered in low-admixtured forms (i.e. blended together with conventional petrol and diesel, thus not requiring specific internal combustion engines) (see Figure 9:e).[52]

[51] "In addition to these 15 comes a number of fuel stations that do not adhere to an established retailer. There are statistics about these, but the Swedish Petroleum and Biofuel Institute estimate a few of hundred may exist. They are often located in rural parts and smaller societies." (Govenrment of Sweden, 2017b: p. 25 – own translation)

[52] What constitutes as 'EU biofuels' and their associated 'biomass' was presented in 3.3, and the origin of the 'biomass' that these liquid biofuels embody was presented in Section 3.4.

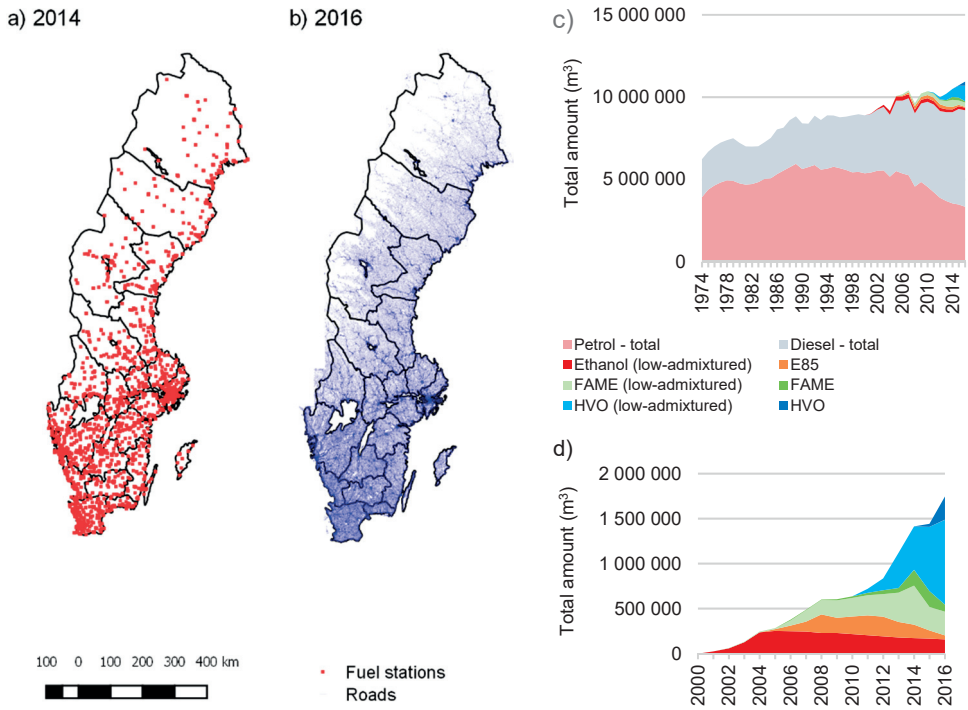


Figure 9 Road traffic infrastructure and types and amounts of liquid fuels in Sweden: **(a)** locations of fuel stations in Sweden, 2014; **(b)** roads in Sweden, 2016; **(c)** total amounts and types of liquid fuels delivered in Sweden (d) total amounts and types of liquid biofuels delivered in Sweden. Sources: a (County Administrative Boards of Sweden, 2017a), b (Lantmäteriet, 2017a), c-d (SPBI, 2017a).

Vehicles used for various purposes are refuelled at these fuel stations. One way to elaborate on these differences is to break fuel statistics into different categories of vehicle types. In Sweden, since the 1990s, passenger cars have roughly made up two thirds of energy consumption in road traffic, whereas heavy goods vehicles (HGV), light commercial vehicles (LCV), and buses represent the remaining third (see Figure 10:a). Lighter vehicles (like passenger cars and LCVs) mainly rely on petrol (see Figure 10:b), whereas HGVs mainly rely on diesel (see Figure 10:c). Noticeably, the total energy consumption levels of HGVs has increased slightly since the 1990s – indicating an increase in spatial flows (i.e. increased mobility of goods and services between markets).

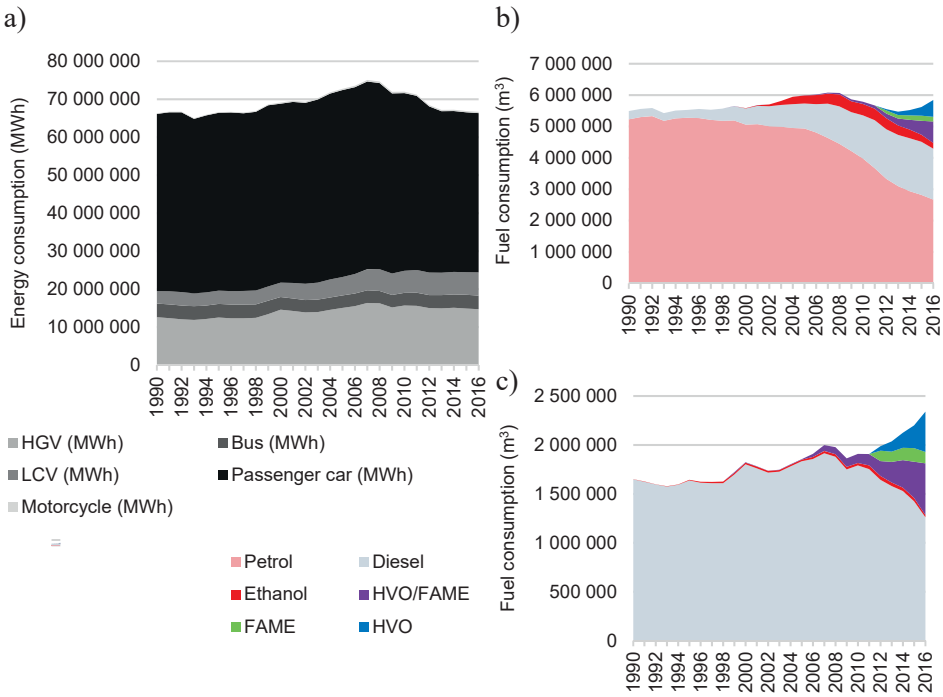


Figure 10 Energy consumption and fuel consumption per vehicle type in road transport, Sweden, 1990-2016: **(a)** energy consumption in the transport sector per vehicle type; **(b)** liquid fuels used for passanger cars, light commercial vehicles (LCV), and motorcycles; **(c)** liquid fuels used for heavy goods vehicles (HGV) and buses in Sweden. Source: Swedish Environmental Protection Agency (2017).

In regards to personal vehicles, more and more people own a car, with car ownership increasing from an national average of 309 per 1000 in 1974 to an average of 478 in 2016 (see Figure 11:a-c). The average driving distance per capita has remained roughly the same between 1999 (5690 km) and 2016 (5870km). On a county level, the amount of cars per land area is greater in the more densely populated areas (see Figure 12:a-b); the average driving distances are roughly the same – although people in the most densely populated county drive the longest distances (despite having access to more public transportation) (see Figure 12:c). Fuel efficiency gains have been made, indicated by the fact that the levels of energy consumption have stabilized at very high levels despite car ownership increasing and annual distance driven per personal vehicle remaining almost stagnant (compare see Figure 8:a-c and Figure 7:a). Moreover, between 1974 and 2016 the total amount of passenger-km[53] per year has increased by 83 per cent for personal vehicles, whereas it only increased by 48 per cent for public transport (buses and rail traffic); compared to a 19 per cent increase in population during the same period (Figure 13).

[53] Passenger-km: the transport of one passenger by a defined mode of transport over one km.

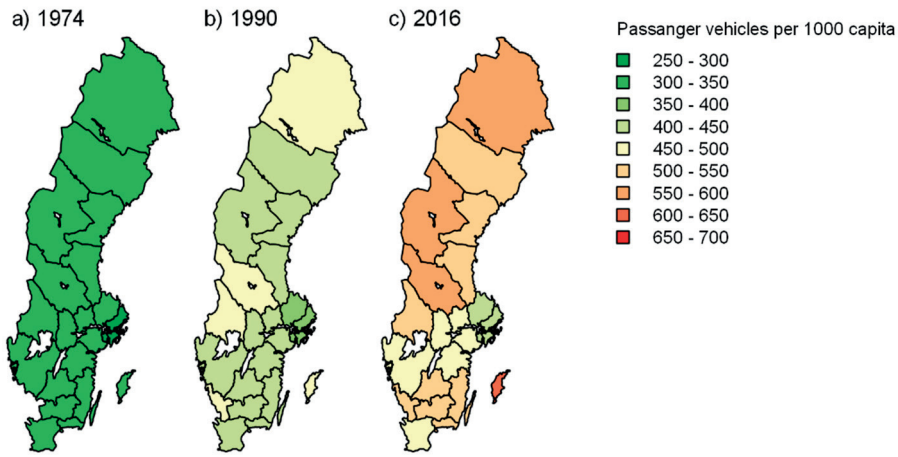


Figure 11 Amount of passenger vehicles per 1000 capita over time for each county in Sweden: **(a)** 1974; **(b)** 1990, **(c)** 2016. Source: Country Administrative Board, 2017b).

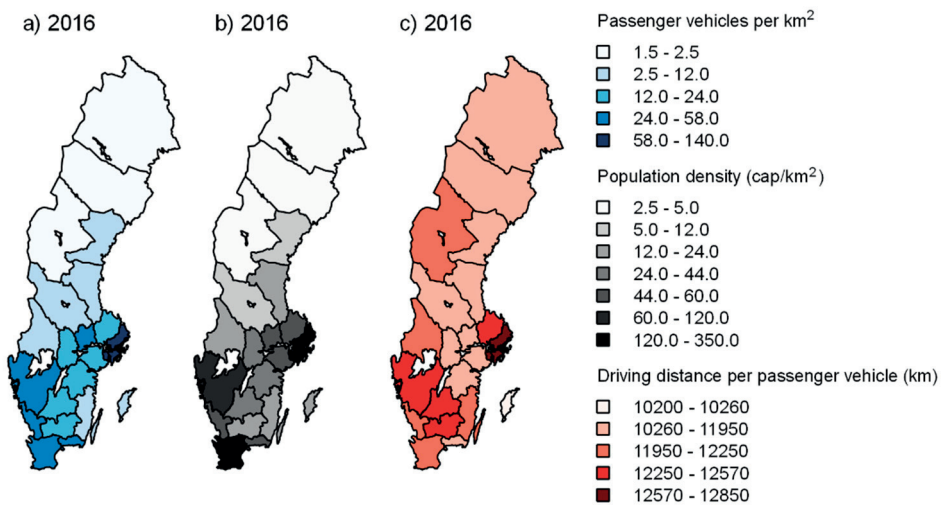


Figure 12 Amount of passenger vehicles per area, population density, and average driving distance of passenger vehicles, for each county in Sweden: **(a)** passenger vehicles per km^2; **(b)** population density, 2016, and **(c)** driving distance per passenger vehicle (km). Sources: a (County Administrative Boards of Sweden, 2017b), b-c (Statistics Sweden, 2017a; Statistics Sweden, 2013).

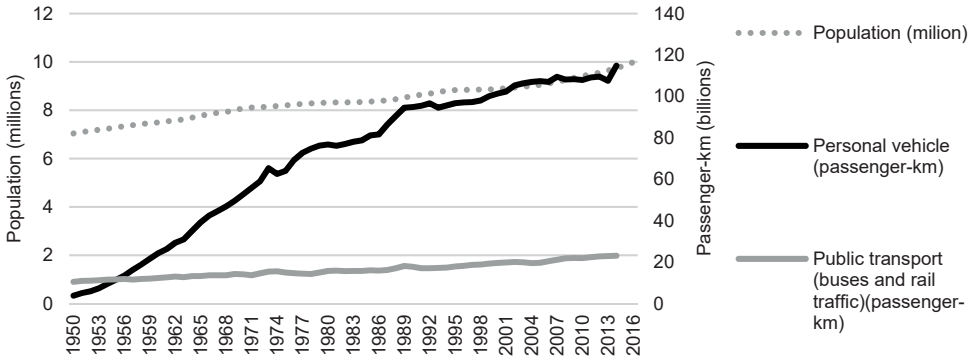


Figure 13 Changes in population and land-based inland passenger transport in Sweden. Sources: Trafikanalys (2015) and Statistics Sweden (2017).

The analysis above shows how physical infrastructure in the transport energy landscape in Sweden has a very disperse geographical form and a high degree of connectivity. It also shows that four firms control the majority of the distribution of liquid fuels that are being sold to an increasing number of individuals who own personal vehicles, and with increasing total amount of fuel being sold to HGV. When coupled with tax subsidies, the mandatory renewable energy targets, biofuel blending obligations and standards, are resulting in these firms (retailers, producers, and private certification systems) providing energy commodities mainly in ways that fit within prevailing physical infrastructure. When looking to the geography beyond each individual fuel station, as is particularly well-illustrated in Article I, an even more dispersed geographic form emerges: with numerous firms categorized as 'biomass producers', 'conversion units', and 'warehouses' that converge to feed the transport energy landscape with energy commodities in the form of liquid biofuels. Consequently, the fossil fuel landscape itself is not changing, but is rather being reproduced, and, in part because of EU biofuel regulation, further integrated into other geographies of production and consumption.

This is problematic, as even with *actual* eco-innovations and technological development, meaningful climate change mitigation would require substantial demand reductions of transport energy in the global North. Globally, GHG emissions from transport have doubled since 1970, increasing at a higher rate than any other energy end-use sector, and about 80% of this increase comes from road traffic (Sims et al., 2014). OECD countries dominate road transport emissions (with over 50% of emissions in 2010), and although the variance between North America and Western Europe shows that the development path of infrastructure matters, both regions are well beyond the climate change mitigation targets (ibid.). Furthermore, history has shown that:

> As economies have shifted from agriculture to industry to service, the absolute GHG emissions from transport […] and the share of total GHG emissions by the transport sector […] have risen considerably. (Sims et al., 2014: p. 611).

As passenger and freight traffic is expected to grow continually, it is unlikely that deep GHG emission cuts can be achieved through technological change alone (Sims et al., 2014), especially since ecological modernization almost mainly targets energy supply rather than energy demand (other than through efficiency gains).

5.2.2 The dynamic interconnections of material interests

Throughout this thesis, I have given considerable analytical attention to the territorial interests of and regulatory mechanisms in both the European territorialisation process and the Tanzanian neoliberal approach to development. These two became aligned in what I referred to as the geopolitics of capitalism, within which I studied how the effects of this emergence was affected by underlying structures of capitalist social relations of production and exchange. Hereafter, I suggest that the confluence of particular material interests also constitute an underlying process in reproducing the way in which physical infrastructure and institutions in Sweden work to continually secure a steady supply of energy commodities for the transport energy landscape.

For Harvey (2006b), the material basis for why alliances between labour and capital assume a territorial form has a geographical explanation. As he puts it:

> Factions of labour that have, through struggle or historical accident, managed to create islands of privilege within a sea of exploitation may also rally to the cause of the alliance. (Harvey, 2006b: p. 420)

Given the geo-historical context of uneven geographical development, localities/cities/regions/nations tend to be pitted against each other, as each alliance will "seek to capture and contain the benefits to be had from flows of capital and labour power through territories under their effective control" (Harvey, 2006b: p. 420). The consequence being that during times of more general crisis, "struggles erupt over which locale is to bear the brunt of the devaluation", resulting in a variety of territorially based conflicts (ibid.).

Moreover, from a sociological perspective, and arguably one that takes less combative tone, Erik Olin Wright (2010) suggests that under capitalism, there is also a material basis for the mechanisms which tie the welfare of individuals to the effective functioning of capitalist structures as:

> […] it places a considerably greater burden on the argument that an alternative to capitalism would be preferable. It underwrites broad public support for a wide range of state policies designed to sustain robust capital accumulation and acts as a systematic constraint on the pursuit of policies that might in other ways benefit a large majority of people but which might threaten capitalist profits. So long as capitalism can effectively tie the material interests of the larger majority of the population to the interests of capital, other mechanisms of social reproduction have less work to do. (Wright, 2010: p. 287)

The role that the EU and firms in agriculture, energy, forestry, and finance have in supporting European territorialisation and doing so by creating and utilizing new economic flexibilities, has already been laid out in the previous chapters. Here, I would like to emphasize the importance of transport for all of these.

For Harvey, transport is understood as a spatial structure designed to facilitate spatial flows (Harvey, 2006b: p. 428). Transport is crucial for enabling the mobility required for goods and services to flow between markets, while at the same time requiring fixity in the sense that these spatial structures need to be built and maintained if they are to result in the anticipated expansion (ibid.). This mobility may here be represented by vehicles[54], and the fixity may be represented by the road networks and fuel stations.

Huber (2015) argues that although Harvey does not discuss energy (at least not in conceptual terms), the "built environment" in cities would not be possible without energy landscapes being part of the "fixed capital" of urbanization. For example, as Huber (2015) highlights, research on urban political ecology (at times conceived of as a global political ecology) has examined urbanization's dependency on mobility, and the socio-ecological processes involved in its metabolism (see Heynen et al., 2006; Kennedy et al., 2011, see also Green, 2004). Coming at it from a different but related angle, Wright interpreted suburbanization and automobilization as "central components of the hegemonic integration of material interests of workers with capitalist development in the decades following World War II" (Wright, 2010: p. 269).[55] By 'fixating' workers in space through home ownership, workers became more dependent on a stable wage income to stay afloat. These material conditions provide a convincing rationale for labour and capital in territories in the global North

[54] For example, the main economic purpose of HGVs that traffic roads in Sweden is to move physical goods across time and space. These were also shown to be the vehicle category that was associated with increased total energy consumption.

[55] Wright (2010) further explains that these "processes also destroyed much of the physical infrastructure of public transportation, most notoriously in Los Angeles, and imposed serious constraints on the future development of transportation systems." (Wright, 2010: p. 269. Though OECD countries dominate transport emissions, the variance between North America and Western Europe shows that the development path of physical infrastructure matters (although both regions are well beyond their ecological limits) (Sims et al., 2014).

to pursue territorially based interests that are convenient to both territorial factions of capital and labour (i.e. maintaining the transport energy landscape), at least in the short-term, at the expense of the transnational precariat.

Indeed, transport is not only used for producing and exchanging commodities, but also to improve the welfare of individuals, not least within healthcare. This became even more apparent during my fieldwork in Sweden. To illustrate this point, I will draw on my experiences from collaborating with the non-profit firm SKL Kommentus (SKL-K) that deals with developing procurement strategies for local and regional governments in Sweden (see also Appendix I). SKL-K is owned by the Swedish Association of Local Authorities and Regions (SALAR, or SKL in Swedish): an employers' organisation that both represents and is an advocate for local and regional governments in Sweden (SALAR, 2017). Thus, SKL-K as an actor is partly capable of moving beyond the competition-enforced dynamics of accumulation that usually steer firms towards profit maximization. Through my field work activities in Sweden, I identified SKL-K as a relevant actor to approach in my research on liquid biofuels, as SALAR had assigned them the task of developing a procurement strategy for "*sustainable transport fuels*" to be presented to all local and regional governments in Sweden. This procurement strategy would potentially be implemented in all public institutions at the local and regional level (see Table 4); therefor it constituted a space where more progressive demands could be placed on the firms that own, produce, and deliver liquid fuels to the transport energy landscape.

Table 4 Energy consumption in road transport of members of the Swedish Association of Local Authorities and Regions, and in Sweden, 2009-2014. Sources: Swedish Environmental Protection Agency (2017) and SALAR (2015).

	2009	2011	2012	2013	2014
Total road transport energy consumption in Sweden (GWh)	71 900	71 200	68 400	67 200	67 200
Total energy consumption of transport fuel in public transport, SALAR (GWh)	3 100	3 100	3 300	3 700	3 900
Total energy consumption of transport fuel in personal vehicles and light trucks, SALAR (GWh)	674	638	632	597	585
SALAR member's share of total road transport energy consumption in Sweden (%)	5,2	5,3	5,7	6,4	6,7

For SKL-K, the balancing act that ensued involved pursuing a more progressive transport fuel standard in public procurement, while also assuring stable supply of transport energy for public institutions located throughout Sweden. Although it was important for many SALAR members that public institutions did not use transport fuels produced from palm, the claim had to be dropped, partly because the firms

(retailers and producers of liquid biofuels) said that they could not meet the energy demand without relying on the palm-based supply of liquid biofuel.

Through engagement with SKL-K employees at meetings and a workshop, I gained a deeper understanding of the numerous material interests SKL-K were balancing. The main struggle for SKL-K was to try to assure long-term stability for healthcare services, which depends on transport (the average driving distances being different for each region), while assuring that procurement strategies actually lead to more sustainable modes of transport. Indeed, suggesting that healthcare personnel should drive less and ride bicycles more in their day-to-day activities would not be well-received by SALAR members, especially those with a larger rural population. While these questions remain crucial in the longer run, the ways in which the fossil fuel landscape is reproduced through day-to-day interactions within prevailing infrastructure (e.g. settlement patterns) and institutions becomes apparent, resulting in a form of lock-in of transport choices.

Therefore, I argue that territorialisation itself is enabled by the energy contained in fossil fuels that are used in the internal combustion engine; wherein the very real material properties of crude oil have been pivotal (e.g. Bridge & Le Billon, 2017; Huber, 2013). Any attempt to change the relationship to these oil-based energy commodities will come with profound material implications for capitalist development; and the transport energy landscape is an insightful case of this dynamic. The vested interests of territorial alliances built into physical infrastructure and supported by institutions are difficult to challenge, as the capitalist economy seemingly depends on its social reproduction. I suggest that this is perhaps the strongest active mechanism of social reproduction that results in infrastructure and institutions continually working to secure a steady supply of energy for the transport energy landscape – even if it ends up with the EU pushing EU biofuels that are characterised by a dual problem of deeply contested social and environmental promises.

In terms of the scope for change, for both Wright (2010) and Harvey (2006), economic crises in capitalism appear when the weak link between material interests of individuals/labour and capital becomes most visible; and also when possibilities for more progressive struggles emerge. Yet as EU biofuel regulation has partly served as a spatial fix to avoid multiple crises, the continued exploitation of nature and labour (not least the transnational rural precariat), can continue, as the most fundamental mechanism of social reproduction of global capitalist society prevails (i.e. the material basis for territorial alliances to be pitted against each other against the backdrop of uneven geographical development).

5.2.3 Institutional constraints on reform space

The tension expressed in the activities of SKL-K reflects how institutional rules affect the scope for change. While the effects of path-dependency of physical infrastructure explained above are widely known, they also connect to those effects that impact institutions and social structures, as:

> […] the institutions which play an important role in macro-social reproduction are created under specific historical conditions, facing particular problems and design possibilities. Their subsequent development bear the stamp of these initial conditions. (Wright, 2010: p. 294)

Procedural "rules of the game" can contribute to social reproduction by making the space for some strategies easier and "less threatening to the stability of capitalism than more difficult strategies" (Wright, 2010: p. 281). It is easier to work within the confines of existing institutions and social structures than to (strive to) radically change them.

Going forward, I provide examples of how minor changes have been made within EU biofuel regulation to illustrate the mechanisms of infrastructural and institutional path-dependency. To clarify, I do not claim that my findings are representative of the diverse forms of collective action around the transport energy landscape. Instead, I merely seek to illustrate how pre-existing institutions also affect the scope for change at the EC and in Sweden.

At the EU-level, critique of EU biofuel regulation has revolved around ILUC[56]. Indeed, the debate on social and environmental implications of liquid biofuels left imprints in EC documents; and these imprints revolve around the inclusion/exclusion of ILUC into GHG emission calculation methods. In regulatory terms, incorporating ILUC into GHG emission calculation methods would mean that the climate change mitigation capacity of liquid biofuel produced from food-based crops would be (significantly) reduced – so much so that many/most would not abide to the EU's minimum requirements. As presented in the review of Rosegrant & Msangi (2014):

> There is also widespread agreement that biofuels have increased GHG emissions and land use change, pressing more land into agricultural and energy production, but estimates vary widely. (p. 230)

The ILUC debate went through several iterations at the EC, some were more focused on GHG emission reductions, while others were more focused on the effects on food prices. In 2012, the EC put forward a proposal that, amongst other changes,

[56] Indirect land-use change: see Sections 3.2.2, 3.2.3 and 3.4.

suggested altering the default GHG savings calculations for liquid biofuels based on cereal, sugar, and vegetable oil feedstock (EC, 2012). While this proposal was rejected, more details on it and how firms (more specifically retailers and producers that abide to EU biofuel regulation in Sweden) perceived its possible impacts on the market on the market, can be found in Article III (pp. 587-590).

Discussions on the matter within the EC eventually resulted in Directive 2015/1513 (EC, 2015b). Working within the institutional framework, the directive (EC, 2015b) adds several new requirements (see Table 5). Although the directive added a 'reporting obligation' (see Table 5); it did not result in firms having to change their production, other than by increasing the institutional uncertainty around the future of non-'waste and residue'-based liquid biofuels. Moreover, I would like to emphasize that none of these requirements challenge the underlying structure of continually providing a steady supply of fuels for transport without reductions in energy demand.

Table 5 A summary of additions come EU Directive 2015/1513. Source: EC (2015b)

Additions come the 'ILUC amendment'
• Only 7% of energy consumption in transport may consist of biofuels from crops grown on agricultural land and still be counted towards the 2020 renewable energy targets; • Any new biofuels produced from new installations must emit at least 60 % fewer GHG than fossil fuels; • A 0.5% target for "waste and residue"-based biofuels for national targets should be set by EU countries in 2017; • Harmonises the list of biomass that counts double towards the 2020 target of 10 % for renewable energy in transport; • Fuel retailers, EU countries, and the EC must report estimates on GHG emissions caused by indirect land-use change; • Renewable electricity in transport should be counted more towards the 2020 target of 10 % for renewable energy consumption in transport – more specifically, five times for electric road vehicles and 2.5 times for electric rail transport.

Throughout my fieldwork, I followed another example that illustrated how regulatory development worked both within the abstract paradigms of governance and neoliberalism, and the concrete context of the institutional rules put in place through EU biofuel regulation.

As I have explained, the EU's regulatory regime on liquid biofuels is a hybrid regulatory system that includes both mandatory regulation driven by administrative forces and voluntary regulation that goes beyond the minimum requirements[57] and is driven by market forces. In order to generate consumer demand for *more*

[57] Many have criticized the extent to which these voluntary private certification systems actually pursue more progressive standards (Fortin, 2013; German & Schoneveld, 2012; Partzsch, 2011).

sustainable fuels within these institutions, the application of a labelling system has been discussed in Sweden. Most recently, this resulted in the government issuing the SEA to provide a memorandum on how a system for mandatory environmental labelling for transport fuel could be designed (Government of Sweden, 2017b). The memorandum references the NGO Green Motorists' campaign "*I want to know*" [58] as especially influential in pushing this idea (Government of Sweden, 2017c: p. 7), while also referring to the Svanen label (see Section 3.2.3) as an already existing voluntary initiative on the market.

The underpinning assumption during these discussions was that by exercising individual consumer power, people could create market demand for more sustainable fuels; thereby creating economic incentives for the market to deliver. Working within the paradigm in this context implies a particular mode of regulation that can be seen in most certification initiatives: where behavioural change of firms is assumed to be driven by various forms of procurement strategies of large organizations, political consumerism, and brand building activities by firms (see Bartley, 2007). The argument being that people are willing to pay extra for products that claim to represent values with which they identify (see Clapp & Fuchs, 2009).

However, in the specific context of the effects of EU biofuel regulation in Sweden, the paradigmatic push towards consumerism has resulted in (even more) perverse outcomes. This because the information that is to be provided to consumers is the very same contested information that firms are reporting to the regulatory authorities. Looking to the memorandum from the SEA on labelling at fuel stations, it indeed has a crucial delimitation in its scope:

> The report has only considered information that is already being reported to the agency in accordance with the existing legal framework. Other aspects that might be interesting, such as energy intensity and indirect land-use change, has not been taken into consideration (Government Office in Sweden, 2017b: p. 6 – own translation).

Moreover, although the information provided to 'green consumers' is dubious, the entire labelling-reform represents the very essence of a neoliberal approach to greening the economy through ecological modernization. As Huber (2013) puts it:

[58] The main purpose of the "*I want to know*" campaign was to make the information that firms were already reporting to the Swedish Energy Agency available to consumers at fuel stations. I observed these lobby activities during the political week of Almedalen (see Appendix 1.2) prior to the Swedish national election in 2014: both during events organized by Green Motorists and by the Swedish Biofuel Petroleum Institute (SPBI) (Green Motorists, 2017).

> We are continually told that the solutions to ecological problems lie in the reproductive arenas of consumer choice. In other words, we are supposed to lead "green lives" after coming home from work – our homes, our transportation, and our consumer choices become the only admissible expression of our political commitment to moving society away from fossil-fuel sources of energy. Meanwhile, outside of this political logic, the "hidden abode" of capitalist production continues to hang the sign Marx spoke of: "No admittance except on business." The mass production of commodities continues to be organized on a basis of the fossil-fuel energy regime and, more important, around production for profit over any kind of ecological sanity. (p. 162)

This brings me to the question of what might constitute 'ecological sanity' in this specific context. Drawing on the ESS theory of transformation, my research approach would here suggest that collective action (working for more meaningful climate change mitigation) may benefit from scientific knowledge on what alternatives could disrupt the mechanisms (rooted in nature-society interactions) that generate dual problem of liquid biofuels. If not liquid biofuels for transport, then what?

5.3 Putting out the fire: a concluding discussion on viable alternatives

Proceeding with my approach to sustainability science, and to conclude, I will discuss what might constitute *viable alternatives* to the dual problem of liquid biofuels. Such alternatives would further climate change mitigation of transport emissions in a meaningful way, while at the same time avoiding adverse social effects on the transnational rural precariat.

Wright (2010) makes the distinction between *desirable*, *viable*, and *achievable*[59] alternatives. In accordance with my approach to sustainability science, a *desirable* alternative will help resolve the problematic outcome of how existing institutions and social structures interact with nature. A *viable* alternative would, if implemented, be capable of generating fewer problems than those they replace, and hence lead to net improvements to the problem at hand.

My contribution here is aimed for *desirable* and *viable alternatives* that will more effectively reduce GHG emissions without causing adverse social effects in the global South. Broadly defined, these are: (1) the scaling up of initiatives that reduce

[59] The great challenge of *achievability* falls outside of the scope of my Ph.D. thesis (see Section 2.1.2 and the concluding Chapter 6 for more reasoning on this third distinction of *alternatives* in ESS).

energy demand in the transport energy landscape, in Sweden, and (2) continued struggles against neoliberal developmentalism, in Tanzania.

5.3.1 A desirable and viable transport energy landscape in Sweden?

My thesis has argued that the EU has mainly 'added fuel to the fire' via their biofuel regulation. A *desirable alternative* would thus be to be 'put out the fire', via an alternative capable of both mitigating GHG emissions in transport and safeguarding against negative social consequences, particularly those that impact the transnational rural precariat. What might then constitute a *viable alternative* that can deliver the *desired outcome* based on the analysis presented in this thesis?

The EC's approach was on the side of energy supply: promoting 'renewable energy', while regulating its production. However, my critique showed that this approach is unable to deliver the *desired* outcomes on a systemic basis, due to the geography of the transport energy landscape – even if standards in regulation encompassed more of the complexity of these issues (due to the significant differences in power densities between liquid biofuels and oil). As I see it, this systematic flaw is caused through three steps. First, market-based mechanisms prioritize energy commodities that fit within pre-existing infrastructure and institutions, which ends up promoting liquid biofuels due to the geography of the transport energy landscape. Second, liquid biofuels (even more so than other forms of 'renewable energy') require significantly more land than the oil-based energy commodities they replaces to generate the same amount of work. Third, since the geography of liquid biofuels is embedded in multiple pre-existing geographies of production and consumption (e.g. food, feed, fibre, fuel, and industrial products), this promotion further encourages firms to continue the already ongoing expansion of intensified land-use practises. Consequently, even if EU biofuel regulation defines specific types of land that may not be used for liquid biofuel production, the overall market-based approach adds significant economic pressure on land (which is scarce). This results in a slew of emergent properties, not least the ILUC that calls into question the GHG performance of liquid biofuels. In the process, the mechanisms of EU biofuel regulation reproduce the underlying 'energy landscape' (and its social relations) that drive GHG emissions in transport.

I would like to emphasize that my argument does not suggest that GHG emission reductions in transport must wait until capitalism is transformed. But we need to know what might constitute better alternatives in achieving decisive cuts in GHG emissions. I suggest that the guiding principle for a *viable alternative* would be to regulate energy demand. This implies a shift in the level of analysis in societal decision-making processes: towards one that focuses on reducing energy demand in transport by changing (at least the mode of transport in) the transport energy

landscape. At least when looking to the natural sciences, this may constitute a more viable pathway to resolving the mitigation problem that liquid biofuels represent, and may also deliver outcomes that challenge the causal powers of the fossil fuel landscape (which is currently being reproduced).

Luckily, there are already several forms of collective action working on changing the transport energy landscape, whose goals match my suggested guiding principle. Some of these goals include, but are not limited to, free public transport, de-automobilization, car-sharing, city planning for cycling cities, and so forth. If anything, this thesis (while acknowledging the reasons for the substitutional approach's dominance) argues for increased space for collective action that can allocate the resources necessary to scale up initiatives that work to reduce energy demand. This, of course, includes acknowledging differentiated impacts on urban and rural areas – both in the short and long term.

However, scaling up these initiatives would require a gradual shift away from transport prices set by markets towards other forms of social relations. Where for example, transport services would be provided on the basis of non-market-based principles. I argue that this approach constitutes the basis for a *viable alternative* that recognizes ecological limits and the scientific knowledge available on 'climate change mitigation' (including the critique of ecological modernization). It also suggests that much needed future research can benefit from the work in this thesis. At the same time, reduced demand of land-based resources in the global North would also reduce the economic pressure that adversely affects the land dependent transnational rural precariat, at least in territories that pursue neoliberal developmentalism.

5.3.2 A short remark on struggles against neoliberal developmentalism in Tanzania

I do not claim that my research presents a comprehensive understanding of the diverse and numerous struggles that have taken, and are taking, place in the global South across time and space. Although some political activity against these developments was identified in the Tanzanian liquid biofuel policy process and media coverage, understanding these as part of larger struggles was not the focus of my work. What I have done is present a more specific critique of what occurs when neoliberal developmentalism intersects with transnational economic forces (in this case, triggered by EU biofuel regulation). I have suggested that these encounters tend to result in the loss of access to land, water, and food for the transnational rural precariat, and in the process increase conflicts. In theory, there could be alternative social arrangements that result in better social outcomes for the rural population in

Tanzania – the answer to which seems, at least, to lie beyond neoliberal developmentalism.

Importantly, the transnational rural precariat in the global South (especially sub-Saharan Africa), would indeed benefit from increased agricultural productivity – especially given escalating climate change. However, the approach in conventional agricultural modernization has been shown to suffer from systemic shortcomings on both social and ecological grounds (Isgren, 2018: Ch. 2). I still acknowledge the challenge of creating new opportunities for smallholder farmers to interact with producers and retailers as important in Tanzania. As an issue, it will most likely only increase in relevance with the current rate of urbanisation, income growth, and a growing middle class, as this requires new types of procurement channels for small-scale farmers to interact with the urban population. However, the extent to which this can be combined with corporate expansion strategies in which private interest has control over both land and the processing, storage, and distribution of goods is extremely doubtful, especially when connected to the fierce competition of global value chains. Instead, I direct the reader to Ellinor Isgren's Ph.D. thesis on agroecology as an alternative development pathway (in Uganda) for a more promising approach (Isgren, 2018).

As a concluding remark here, it is important to acknowledge the emerging South-South relations in finance, trade, and commodity markets which relate to liquid biofuels. A study by Dauvergne and Neville (2009) drew on data on the increase in South-South trade, arguing that the emerging economies such as Brazil and India were increasingly part of the core investors in the South alongside developed countries. Further, based on a mapping of 'biofuel alliances and coalitions' between these emerging economies, multi-national corporations, and the developed states in the North that followed, Dauvergne and Neville (2010) argued that these dynamics are "likely to reinforce the economic and political power of emerging economies of the South." (p. 655). For example, recently it was reported in Tanzanian news that domestic cassava is "poised for export" to China for ethanol production in Beihai, and was described "as an increase not only in production and farmers earnings but also foreign currency" (Elinaza, 2016). Thus, moving forward, struggles against neoliberal developmentalism will not only relate to traditional North-South dynamics, but also to emerging South-South relations – including the possibilities for North-South, South-South, and transnational alliances.

6. Concluding remarks

6.1 Answering my research questions

The main puzzle I sought to solve in this thesis is why the EU so persistently pursued liquid biofuels for transport despite considerable doubts about their overall GHG emission reduction performance as well as the adverse social effects on rural populations that the expansion of their market has had, especially in the global South. There are several explanations to this. I suggested that new ways of solving the puzzle could be found in the complex interdependencies between energy and geography. In my scholarly journey, I posed five associated research questions:

1. Why did the EU pursue liquid biofuels for transport through regulation?
2. Can EU biofuel regulation:
    a. assure that GHG emission reductions in transport will be delivered?
    b. safeguard against adverse social effects in the global South that may arise because of increased demand of liquid biofuels in the EU?
3. If not, why has EU biofuel regulation failed?
4. What might constitute better alternatives for delivering the desired outcomes of EU biofuel regulation?

Why did the EU support liquid biofuels for transport? My analysis suggests that the EU's support of liquid biofuels is a response to (multiple) crises in capitalism, wherein liquid biofuels provided new accumulation opportunities for both territorial and capitalist interests. I have argued that the geographical expansion of commodity production and regulatory development resulting from EU biofuel regulation was part of a geopolitical territorialisation process.

EU biofuel regulation involved mandatory 'renewable energy' targets in transport, fiscal policies (e.g. through tax exemptions), and standards that defined what constitutes 'EU biofuels' as energy commodities. The 'renewable energy' targets for transport had material implications on the land-use dynamics involved in maintaining the transport energy landscape, as they created significant market demand for the extraction of land-based resources for the production of energy

commodities (i.e. liquid biofuels used in internal combustion engines). Fiscal policies (implemented by EU member states) generated economic mechanisms that allowed liquid biofuels for transport to compete with their fossil fuel counterparts on the market. Standards defined by the EU declared what constitutes 'renewable energy'. Importantly, 'EU biofuels' were defined as energy commodities (used for transport) produced from a broadly defined category of 'biomass', which included numerous types of land-based resources such as agricultural crops, forestry residues, and animal fat. Finally, firms were tasked to push the geographical expansion of the EU's liquid biofuel market for transport; not only firms that produce 'biomass' and/or liquid biofuels, but also firms that organize private certification systems.

Through EU biofuel regulation, EU member states were mandated with creating demand by shifting surplus (through fiscal policy) to establish new energy markets for 'EU biofuels'. Taken together, these regulatory mechanisms allowed firms in pre-existing geographies of production and consumption to produce commodities in more 'flexible' ways. Importantly: firms could now sell biomass to liquid biofuel producers at one moment, and then to a food processer at another, and so forth, since an additional market (with significant demand) had been created. Given the right conditions, they could even readily move between different biomass-based markets, based on where the best accumulation opportunities were found. This also implied that the political-economic interests for biomass now aligned with other economic opportunities in multiple economic sectors. Enabling this 'flexing' is a defining feature of EU biofuel regulation that explains how it relates a European geopolitical territorialisation process. By giving EU member states the incentives to use fiscal policies to shift surplus to support the production of liquid biofuels, the EU sought to address crises of rising prices and dependence on foreign oil, rural development, domestic overproduction of agricultural crops, and climate. Importantly, all of this while working within the physical infrastructure and institutions inherited from the fossil fuel-based transport energy landscape and pre-existing geographies of production and consumption.

Can EU biofuel regulation assure that GHG emission reductions in transport will be delivered? I have argued that EU biofuel regulation cannot ensure that GHG emission reductions in transport will be delivered.

If not, why has it failed? The EU's approach was to regulate production on the energy supply side through mandatory energy targets, fiscal policies, and standards. However, this approach fails to meet its internal goals for two main reasons. First, the materiality of energy implies that liquid biofuels require large tracts of land to produce energy commodities that deliver the same amount of *work* as those that they replace. Second, the sector-based approach of regulating the production of liquid biofuels for transport does not incorporate the fact that the production and consumption of 'EU biofuels' are embedded in multiple pre-existing geographies of

production and consumption. Consequently, the EU standards' GHG calculation methods and default values have internal limitations such as not acknowledging the fact that 'biomass' conflicts with other land-uses, and the fuels produced from feedstock of the category 'waste and residues' may still embody energy from more ecologically destructive land-use relations (as seen in the case of palm). Hence, even if standards attempted to encompass more nuanced understandings of the issues at hand, public support of liquid biofuels would still be likely to further encourage firms to expand intensified land-use practices – spilling these land-use practices over to new land areas. Taken together, EU biofuel regulation alone cannot assure that the liquid biofuels that are being delivered to the market are actually delivering convincing GHG emission reductions. Moreover, in the process, 'EU biofuels' interact with the prevailing transport energy landscape in ways that reproduce the fossil fuel landscape developed over industrial capitalism, instead of changing it.

Can EU biofuel regulation safeguard against adverse social effects in the global South that may arise because of increased demand of liquid biofuels in the EU? I have argued that EU biofuel regulation cannot safeguard against adverse social effects that increased demand of liquid biofuels in the EU might trigger in the global South.

If not, why has it failed? The EU suggested that countries in the global South could benefit from establishing liquid biofuel production for the EU market if the supply met the EU's sustainability requirements. These requirements targeted GHG emission reductions and defined specific types of land (of high carbon stock capacity and biodiversity) that was not allowed to be used for liquid biofuel production. Any form of social criteria was only incorporated in the private certification systems that the EU gave authority to act as non-state regulators – a service procured by firms (biomass and/or liquid biofuel producers) on a voluntary basis. However, this approach fails for two main reasons. First, the voluntary market-based initiatives (e.g. private certification systems that firms can procure services from on a voluntary basis) alone cannot safeguard against the exploitative tendencies of the underlying capitalist social relations of production and exchange, as firms that seek access to the EU market are subject to the cut-throat and profit-driven competition on international markets. Second, the emergent properties of liquid biofuel markets in the global South, enabled through neoliberalist approaches to development of states in the global South, shift social relations in ways that worsen the livelihood conditions of the transnational rural precariat. This emergence tends to result in land dispossession and make local labour redundant, which is especially problematic in these times characterised by climate change.

What may constitute better alternatives for delivering the desired outcomes? I suggest that *viable alternatives* for delivering the *desired outcomes* (GHG emission reductions in transport achieved in a way that does not give rise to adverse

social effects on the transnational rural precariat) would focus on regulating the consumption on the side of energy demand. Importantly, scaling up initiatives that reduce energy demand in transport would require a gradual shift away from transport prices set by markets towards other forms of social relations. Where for example, transport services would be provided on the basis of non-market-based principles. I argue that this approach constitutes the basis for a *viable alternative* (to the dual problem that liquid biofuels represent) that recognizes ecological limits and the scientific knowledge available on 'climate change mitigation' (including the critique of ecological modernization). It also suggests that much needed future research can benefit from the work in this thesis. At the same time, reduced demand of land-based resources in the global North would also reduce the economic pressure that adversely affects the land dependent transnational rural precariat, at least in territories that pursue neoliberal developmentalism. As regards Tanzania, I suggested continued struggles against neoliberal developmentalism as a *desirable alternative* for avoiding the political-economic dynamic in which land-investments predominately result in dispossession of the largely land-dependent rural population without. This will obviously have ample social benefits.

6.2 Theorizing the energy geographies of climate change mitigation

What theoretical contributions can be distilled from my work on the EU's support of liquid biofuels for transport? As a scientific field, sustainability science is interdisciplinary, and draws on several bodies of theory to explain a world of diverse nature-society interactions. In my research, I drew on different bodies of theory to conceptualize and explain just that. Nevertheless, eclecticism is an undesired scientific pathway, and I have strived to be consistent in my choice of theories.

In my research, I unpacked the multifaceted and complex nature of how the materiality of energy relates to space. I did so by conducting research that spanned three analytical domains: geopolitics, energy markets, and energy landscapes. Specifically, the spatial relations involved in the production of energy commodities were examined; where I looked specifically to the substitution of oil-based energy commodities for transport (i.e. petrol and diesel) to those that are biomass-based (i.e. liquid biofuels). Although fossil fuels are also heavily subsidized, I argued that these liquid biofuels required supporting regulation for being able to compete with oil-based energy commodities within the transport energy landscape. The fact that liquid biofuels as energy commodities were produced from non-oil based energy sources mattered, because it implies that they embody different spatial relations. Liquid biofuels require more land than the commodities that they replace for

conducting the same amount of mechanical work, which undermines their potential for delivering GHG emission reductions.

Within the geo-historical context of uneven geographical development, I showed how the more specific spatial relations imposed on commodity production by the materiality of energy intersects with the more general spatial relations of capital accumulation. In the context of transport energy, both path-dependency of physical infrastructure and institutions affected material social practises – be it in terms of the types of energy commodities being delivered to markets, or in terms of the scope for change (although the latter, especially collective action for change, was not my focus).

A consequence highlighted in my analysis was that territorial alliances with political-economic capacity to mobilize resources had the power to shape the social relations involved in the extraction, production, and distribution of energy commodities. A predictable outcome of this dynamic is that if surplus is shifted towards supporting non-fossil fuel-based energy commodities (more so the case for 'biomass' but also the case for other 'renewables'), capital will further mobilize towards land (which is scarce in absolute terms) and land-based resources where energy can be sourced from – if it is profitable enough. A predictable consequence under neoliberalism is that capitalist social relations of production and exchange that focus on intensifying land-use may be applied onto already existing struggles over land and accumulation by dispossession; which has particularly significant effects on North-South and urban-rural dynamics, due to the historical backdrop of uneven geographical development.

6.2.1 Future research

Having made these theoretical contribution, I would like to highlight two possible avenues for future research on energy and climate change mitigation.

First, if fossil fuels are to be phased out and partly replaced with other energy sources (that can reduce the total amount of GHG emissions), we can expect certain spatio-temporal dynamics (not least struggles over land) in rural areas. In this context, the institutions that guide decision-making processes around land-use are likely to become subjects of additional economic interests and pressure. To assure socially beneficial and ecologically convincing outcomes from these processes, the institutions may need to be re-envisioned to better fit the nature-society interactions that science has revealed.[60] Therefore, more research is needed on the messy

[60] For example, how persistent social problems such as poverty and inequality, hunger and malnutrition, and corruption, are exacerbated by sustainability challenges such as climate change, biodiversity loss and water scarcity.

solutions to the dilemma of how institutions can be designed to allocate the costs and benefits of scarce energy resources – both in the global North and the global South.

Second, if we accept the argument that *viable alternatives* to mitigation of transport emissions have to focus on creating institutions and social structures that reduce transport energy demand, then further research on the *achievability* of this alternative is relevant – to create the potential for, and the long-term support of it.

6.3 Advancing an emancipatory sustainability science

I have sought to advance the critical problem-solving agenda that exists in sustainability science by developing a meta-theoretical approach that combines sustainability science with CR and ESS. The rationale behind this decision was that I saw the need for a more systematic way to approach social change in science on nature-society interactions. CR allowed me to ask realist questions about a natural world that co-exists with a social world; where causality occurs in specific geo-historical contexts. ESS allowed me to understand causality as rooted in social relations, and provided me with organizing principles that could systematize the production of scientific knowledge that seeks envision and work towards change in the world. In my specific research setting, this critical approach to social science benefited from Nancy Fraser's reasoning, which inspired my epistemological thinking on scalar issues of emancipation involved in global phenomena (such as climate change, globalizing commodity production, and regional regulation). This was important for my research process as it allowed me to reach a fuller understanding of the dual problem of liquid biofuels when I moved beyond the individual nation-state. Moreover, I modified ESS with CR by adopting a more immanent mode of critique and used this combination to complete my work within the emerging, interdisciplinary tradition of sustainability science (which provided me with tools, methods, and procedures for doing interdisciplinary research).

The historical approach to knowledge production embedded in my meta-theory has played a crucial role in the analysis. For example, I would not have been able to explain the emergent properties of liquid biofuel markets had I not examined the historical trajectories of EU biofuel regulation, neoliberal development practises in Tanzania, and the transport energy landscape in Sweden. By asking questions about geo-historical contexts, I could explore the relations between territories through my analytical domains of geopolitics, energy markets, and energy landscapes. When understanding liquid biofuels as a response to the (multiple) crises in capitalism, the connections between findings from across the analytical domains and the empirical settings could explained more clearly – though not entirely.

I argue that incorporating geo-historical context into research is important for the research agenda of sustainability science. The reason being that ahistorical accounts of social relations may result in inadequate conceptualization of objects, structures, and mechanisms; which of course has implications in regards the types of '*solutions'* that may end up being suggested by sustainability scientists. Understanding 'problems' and their 'solutions' as existing in specific but varied geo-historical contexts has methodological implications because it requires knowledge on how the past shapes current and future opportunities/barriers for transformation. I have argued that the historical approach has significant impacts for how scientific knowledge is to identify '*sustainable'* alternatives to current harmful social practises (be them socially and/or ecologically problematic). While the root causes of harmful social practises are understood to exist in the interactions between nature and society, and within society, the agency for changing social structures and institutions is mainly contingent on social forces. Although opportunities for change may not exist now, history has shown that these could (or even tend to) emerge over time. My position is that sustainability science can have a role in taking advantage of these opportunities, or even creating them, to make sure that alternatives that are actually capable of delivering emancipatory outcomes might be manifested by social structures and institutions. However, if inadequate analytical space is given to history, sustainability science risks undermining its own scientific legitimacy and credibility in regards to its research agenda.

My thesis has argued that sustainability science can benefit greatly from a critical approach to social scientific research. I found that sociology (in this case mainly the work of Erik Olin Wright) and critical geography (mainly the work of David Harvey) offered important insights that help identify the underlying social structures and mechanisms that generate problems in nature-society interactions. However, these approaches do not by themselves provide enough guidance for how to deal with the natural dimension of sustainability. In the eclectic field of sustainability science, we need to bring in theories and perspectives from the natural sciences to understand the promises and limitations of various initiatives, interventions and policies. I drew on thermodynamics, whereas others have drawn on bio-geomorphology (Boda, 2018), or the ecological dynamics of agriculture (Isgren, 2018), to find and discuss much needed viable alternatives for achieving sustainability.

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Appendix I

1.1 List of interviews in Tanzania

A. Informant from International Development Consultants (2014-02)
B. Informant from Agro EcoEnergy Ltd. (2014-02)
C. Informant from Diligent Energy Systems (2014-02)
D. Informant from the Ministry of Energy and Minerals (2014-02)
E. Informant from Haki Ardhi: Land Rights Research and Resources Institute (2014-02)
F. Informant from the University of Dar es Salaam (2014-02)
G. Informant from the National Environment Management Council (2014-02)
H. Informant from the Nelson Mandela Institute (2014-02)
I. Informant from the Tanzania Natural Resource Forum. (2016-08)
J. Informant from the Agricultural Non State Actors Forum. (2016-08)
K. Informant from WWF Tanzania. (2016-08)

1.2 List of observation sites

Throughout my Ph.D. project, I visited several observation sites, either as a more passive observer (see “Observation” below) or as a participant in the activities (see “Participant observation” below).

Observation

A. Swedish Energy Agency: Forum Hållbara Bränslen 2013. (2013-11-25).

   Context: The Swedish Energy Agency arranges ”Forum Hållbara Bränslen” once every year to give firms the opportunity to exchange experiences on the laws and regulation that apply for biofuels.

B. Almedalen Week 2014 (2014-06-29 – 2014-07-06)

Context: The annual political week in Visby, Sweden, is a meeting place for actors involved in Swedish politics. Not least does the political week involve many events from various interest groups and lobby organizations. Furthermore, the Swedish general election was held in September 2014.

C. Swedish Energy Agency: Meeting for independent auditors. (2014-10-17).

Context: The Swedish arranged an information meeting for those that act as independent auditors within the legal framework of "sustainability criteria for biofuels used in transport and bioliquids".

Participant observation

A. Swedish Standards Institute: Pilot study LCA and sustainability criteria in BioInnovation (2017-03-31)

Context: A pilot study on sustainability-issues related to the "bioeconomy" within the strategic innovation programme BioInnovation. The pilot study sought to develop a project to support BioInnovation's various projects and the bio-based industry in large with sustainability issues.

B. Swedish Association of Local Authorities and Regions Procurement Centre – Kommentus. (2017-05-30)

Context: Working group on procurement strategies for transport fuels. The group consisted of representatives from the market, the Swedish Energy Agency, the National Agency for Public Procurement and local and regional governments. The purpose of the working group was to discuss procurement strategies for transport fuels.

1.3 List of meetings and workshops

As part of my Ph.D. project, I organized several meetings (see "Meetings" below) and one workshop (see "Workshop" below).

Meetings

A. Personal meeting with Swedish Energy Agency. (2013-11-24).

Context: Early meeting with the Swedish Energy Agency to discuss developments of the legal framework of "sustainability criteria for biofuels used in transport and bioliquids" – both at Swedish- and the EU-level.

- 2 participants.

B. Personal meeting with Swedish Association of Local Authorities and Regions Procurement Centre Kommentus (SKL-K). (2017-08-24).

Context: I organized a meeting employees SKL-K involved in "sustainable procurement strategies", vehicle fleets, and transport fuels, together with an employee at the SKL-K. The meeting consisted of three parts. First, we introduced ourselves to one another, and gave shorter explanations of our day-to-day practises. Second, I presented the outcomes of my research on the effects of EU biofuel regulation on firm-level decision making – framed within the critical debate on liquid biofuels. This included many discussions throughout the presentation. Third, I got the opportunity to ask more detailed questions about their activities and the institutional and market-oriented constraints they face.

- 4 participants.

Workshops

C. Workshop on global trade of biomass (2017-07-13)

Context: We (Lund University Centre for Sustainability Studies and Mistra Center for Sustainable Markets - Stockholm School of Economics) organized a workshop global trade of biomass. The idea was that engage Swedish actors pursuing/following an emerging "bioeconomy" with the critical debate on liquid biofuels and findings from our research on EU biofuel regulation. We sought to discuss: how the EU's sustainability criteria for liquid biofuels relate to the critical debate, and if and how global trade of biomass could be organized fulfil aspirations of sustainability.

The workshop consisted of three major parts. The first part consisted of an introduction and a general problem framing (much like the one in this thesis), and proceeded to three presentations of research, including time for discussion. The second part consisted of a scenario exercise - centred around the implications on biomass trade of the government's political target to have a vehicle fleet that is independent of fossil fuels by 2030. The third part consisted of a concluding full group discussion and wrap-up session.

- 9 participants.