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Renewable energy in the Brazilian Amazon

The drivers of political economy and climate

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Abstract: Understanding the political economic drivers of energy planning in the Brazilian Amazon is critical since the forest is increasingly vulnerable to destruction and related, increased poverty. This research investigates how political economy affects biomass and hydroelectricity development in that region. It focuses on political economy as characterized by: 1) the needs and agenda of local communities, 2) economic interests and politics at the national level, and 3) international social actors and financial interests. Findings advance our understanding of the political economy of renewable energy by first, focusing on a critical global resource, and second, by implementing a multi-scalar framework that also considers impacts and drivers of climate change.

Keywords: hydroelectricity, biomass, Amazon, Brazil, sustainability, qualitative methods

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1 Introduction

Brazil has long been a nation leading the usage of renewable energy. Historically, hydroelectricity has been the central energy source (Bermann 2007), and more recently, biomass has developed. While energy resources have long existed outside of the legal Brazilian Amazon, both types of energy development have recently increased within that region (da Silva Soito and Freitas 2011). Yet, expansion of energy development there threatens the rainforest with potentially tremendous ramifications for Amazonian sustainability and climate change (Schaeffer et al. 2013). The expansion of these energy types also affects local populations who are actively attempting to shape energy development. The political economy of energy including local community-level social actors, Brazilian private sector investors, Brazilian government agencies, and international private sector interests intersect to affect this relatively new trajectory of renewable energy. These social actors differentially consider and are differentially affected by climate change in that region, with some taking current risks and future projections into account and others discounting these effects.

While technical factors are important in decisions regarding renewable Amazonian-based energy development, political economic factors are possibly even more influential. Past research has shown that, in the other areas of Brazil and the world, political economic factors are often bigger drivers of energy decision-making than are considerations of economic viability or environmental sustainability (Hochstetler 2011). Current research has only minimally investigated this topic in regards to energy development in the Amazon.

This research investigates how political economy affects the growth of renewable energy in the Brazilian Amazon, and the relationship of this energy development to climate change. In this case, political economy is characterized by: 1) the needs and agenda of local communities, 2) economic interests and politics at the national level, and 3) international social actors and financial interests. This paper seeks to make unique contributions to the literature on the political economy of renewable energy transitions by including a multi-scalar approach to considering political economic factors, such as considering the perspectives of local and state actors, and by considering the role of climate change, both in terms of how energy development may contribute to it and how climate change may affect renewable energy potential. This is similar to the approach by Tanner and Allouche (2011) who see the intersection of development and climate change across scales, but distinct in focus on political economy. Several bodies of research have previously considered the socioeconomic needs of local Amazonian communities, of the Brazilian state, and the effects of climate change on renewable energy, but few previous analyses have looked at the political economy of renewable energy in the Amazon through a lens that includes them. In so doing, this research seeks to create a comprehensive understanding of how renewable energy in the Amazon may be sustainable from the perspective of diverse social actors and over an extended period of time, such as that in which climate change effects will be felt.

This research focuses on biomass and hydroelectricity since these are the only two forms of renewable energy being developed in the Amazon. Since hydrological planning is expanding more rapidly, this research focuses on large hydroelectric dams in the Brazilian Amazon and on the case of Belo Monte dam, in particular. Belo Monte has recently been constructed after almost thirty years of planning, local contestation, and renegotiated planning.

Understanding the political economic drivers of decision-making in the Brazilian Amazon is critical since the forest is increasingly vulnerable to destruction and related increased poverty. While renewable energy development, and more specifically hydroelectricity, which is the largest area of focus, may increase temporary opportunities for economic development and employment, it is also likely to increase the destruction of rainforest, driving massive in-migration by workers and supporting populations, as well as flooding forest, disrupting livelihoods, and altering ecosystems for decades. By examining the political economy of renewable energy in the Amazon rather than the ecological or economic viability alone, this research seeks to identify how sustainability is being considered in its broadest sense. In other words, this research seeks to answer questions regarding how the current trajectory of renewable energy development in the Amazon can consider long-term impacts it may have on climate change, the effects climate change may have on it, and the effects these developments have on local populations.

This paper is based on interviews with experts, non-governmental leaders, community members affected by energy development, and governmental representatives working in the area of renewable energy and deforestation in the Brazilian Amazon. Twenty-nine semi-structured interviews were conducted with these actors from summer 2015 through winter 2016. Interviews were recorded or extensive notes were taken. Themes were identified across interviews. Data in this paper are also drawn from extensive research of government documents and media coverage, when necessary. For example, evidence regarding corruption in the energy sector is largely only available through investigative reporting, and so was drawn from such media venues. The findings of this research promise the following conclusions relevant to policy-makers. First, it will articulate the big picture of how political economy affects energy development in the Amazon. Second, this research will offer a coherent understanding of how energy development in the Amazon accounts for local populations. It, therefore, provides a cohesive picture of how poverty alleviation and sustainability can best be implemented in congruence with their needs. Third, findings clarify the degree to which diverse social actors consider climate change. As such, it will point to specific policies that can better account for climate factors, improving the actualization of real energy potential in the face of climate change. Without such an analysis, it is possible that planners will fail to reach this potential, thus undermining Brazilian economic development and possibly repeating the energy crisis that occurred in 2001.

This research was conducted at a particularly historic moment wherein the country is in transition. While Brazil has been seen as a transitional nation for many decades, the current transition is a relatively new one. This transition is from a model of deforestation that focuses solely on the private landholders in the region, to one that accommodates large-scale government energy and infrastructure projects. This moment is one in which a new model of both forest protection and energy development must be made if the Amazon is to be protected. By documenting this moment and exploring the dilemmas therein, this research seeks to demonstrate how unexamined social costs of Amazonian energy generation may undo recent widely-publicized decreases in deforestation, consequently having negative impacts on climate change. I argue that only through addressing these unexamined, and sometimes illegally affected social costs can deforestation rates remain relatively consistent or decrease. As such, this analysis offers a warning against the advancement of energy infrastructure in the Amazon without serious consideration of concomitant measures to reduce deforestation and social impacts.

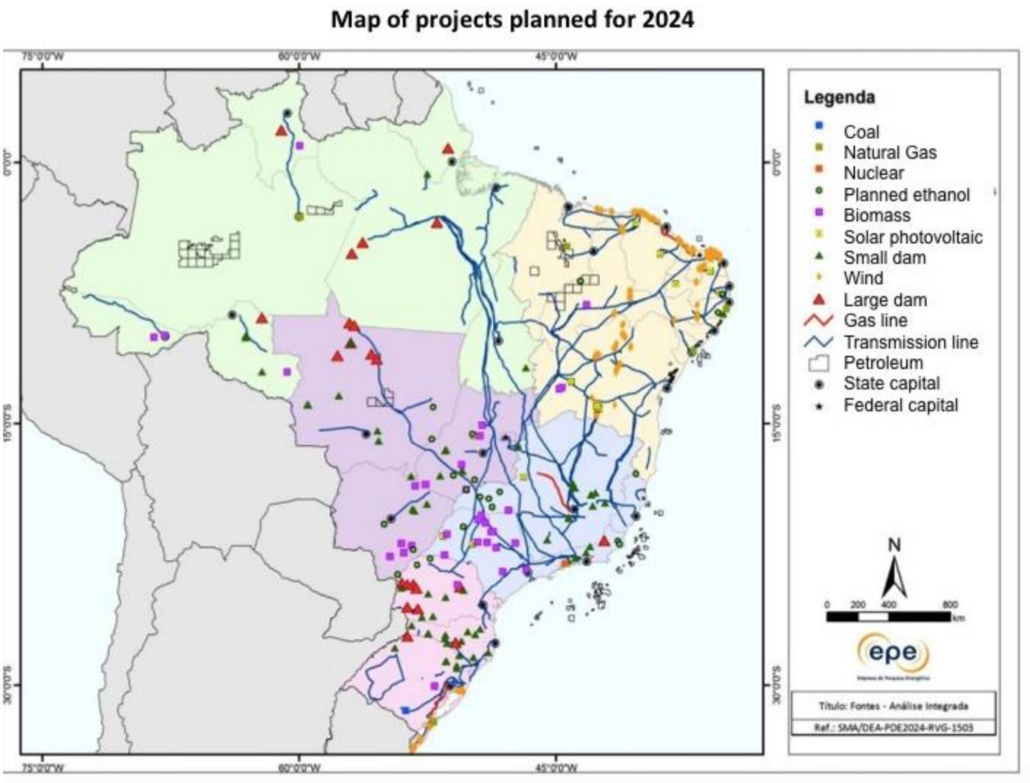
2 Background

2.1 Energy development in the Amazon

Brazil's energy mix encompasses 82 per cent hydroelectricity, followed by 7 per cent biomass, 5 per cent natural gas, 3 per cent nuclear, 2 per cent petroleum, and 1 per cent coal. While this energy mix is shifting due to urbanization, international trade, and climate conditions, the long-term dependence on hydroelectricity and the growing usage of biomass make these two forms of energy some of the most important to understand.

Brazil has long been dependent on hydroelectricity for the majority of its energy supply. The country has the third largest installed hydroelectric capacity in the world and sees the Amazon as the hydroelectric frontier (da Silva Soito and Freitas 2011). Planning for power generation is therefore generally based on hydroelectric capacity. However, in the past four to five years, hydroelectricity has generated less energy than projected resulting in difficulties in supplying the base load for the economy and also meeting increasing economic growth. As a result, several other forms of energy have advanced in the country, including oil, natural gas, and several other types of renewable energy, particularly solar and wind. Biomass has also grown to 7 per cent of all energy resources resulting in the Amazonian energy mix being focused in these two areas. (See Figure 1.) Installations planned in the next eight years will be predominately large dams, small dams, and biomass, in that order of investment. Two areas of petroleum extraction have been developed already. Several ethanol plants will be developed in the north and eastern part of the region. While hydroelectricity is planned across the region, biomass is planned largely for the frontier region in the southern Amazon and one installation in the northern Amazon. The exact number of installations planned is a point of disagreement amongst experts and officials. Figure 1, which is translated from the national energy plan for 2024, or the most recent documentation of energy planning, reflects the planning of five new large dams. However, some other studies have argued that there are up to thirty new dams being planned.

Figure 1: Energy installations planned for 2024



Source: Empresa de Energetica, Ministerio de Minas e Energia, Governo Federal do Brasil (2015).

Since the installation of the democratic government, only one large dam complex has been completed. The Rio Madeira Dam complex, constituted by the Santo Antonio and Jirau Dams, are being built in the Western Amazon. The dams have an expected 3,150 MW installed capacity that will be consumed in the northern and southern regions of the country. They have had multiple negative localized consequences, such as displacing local indigenous people, threatening the migration of fish populations, and destroying the habitats for multiple species. Most importantly, however, the dam complex reservoirs are meant to be a part of a series of waterways facilitating the export of soy grown in the region (Fearnside 2014). The dam complex began commercial production in 2012, but the second of the two, Santo Antonio, is not yet complete. The second large dam that has been proposed since the 1980s and recently has neared completion is the Belo Monte Dam near Altamira in the western Amazon. Belo Monte will be the third largest dam in the world. It is the most controversial dam project in the history of Brazil and has resulted in numerous violations of human rights laws.

The second largest source of energy in Brazil is biomass. While biomass can be developed in many parts of the country, depending on the type, biomass development in the Amazon has traditionally come from the centre-west region and the north, focused on large-scale conversion of pasture and/or rainforest to crops of carbohydrates, such as sugar cane, soy, and palm. It has grown as an area of investment in recent years with promising future growth (Lora and Andrade 2009). There are several major forms of biomass: sugarcane, soy, switchgrass, and wood. While 61 per cent of Brazil's land is forest, 1 per cent is used for sugarcane, .8 per cent is manually forested, and 3.25 per cent is used for soy bean planting (Colodette et al. 2014). Recently, sugar cane has been one of the forms resulting in approximately 30 million tons of sugar and 20 million tons of ethanol annually (Griffin and Scandiffio 2009). Wood production for charcoal, firewood, wood chips, and soy (Walter et al. 2006) has been based around several types of trees, such as eucalyptus and acacia, that can be produced across the country. The development of soy (along with cattle ranching) has been cited as a primary driver of deforestation (Soares-Filho et al. 2006). Other forms of biomass have been found to drive deforestation, although some of these resources can be developed in locations outside of both the legal Amazon and the frontier area, resulting in less deforestation risk.

2.2 Energy development in the context of climate change

Climate change is likely to affect how successful energy development is in the Brazilian region (de Lucena et al. 2009). Droughts in the past decade have been the worst in history, reflecting the effects of climate on forest health (Marengo et al. 2011). The Amazon is an important climate resource as it represents a carbon sink and its destruction could contribute significantly to climate change. The viability of local populations hangs in the balance, as they are affected both by climate change impacts and energy development. Therefore, the Brazilian government and global environmental community currently must identify how to protect the Brazilian Amazon and its local populations while also supporting the expansion of clean energy.

Climate change presents two challenges to energy development in the Amazon. First, energy resources could be taxed or reduced due to a changing climate. Second, the need to reduce greenhouse gas (GHG) emissions could affect energy choices. A central mechanism for the release of GHGs in the Amazon is deforestation. In 2009, Brazil committed to a 36–38 per cent reduction in GHG emissions by 2020, which included a reduction in deforestation by 80 per cent in the legal Amazon. Therefore, energy development should be sensitive to the way it affects deforestation, but may not always be.

Energy development in the Amazon could be plagued by a variety of challenges. Biomass development could be threatened by changes in rainfall that, in turn, affect the growth of such resources. In addition, climate change can reduce the availability of land necessary to grow biofuels and could shift the distribution of insects that affect their growth, in addition to a wide variety of other factors that could negatively affect biomass (de Lucena et al. 2009). This is unfortunate since biomass can be a critical source of energy for the poorest local populations who depend on its burning for cooking and livelihoods. Forest die-back may occur in the frontier region of the Amazon as biomass is developed, reducing the availability of biomass and further driving migration into the forest as the search for viable land to develop continues.

Hydropower resources will likely be taxed by changes in seasonal water availability, drought, dry spells, and changes in air temperature that increase evaporation from reservoirs (Andre Lucena 2013). Increasingly severe droughts in the Amazon are likely to affect the viability of existing and planned dams, especially if deforestation continues and impacts microclimates driving precipitation patterns.

There are several critical impacts that energy development in the Amazon may have on rainforest resources, possibly demonstrating that they are less sustainable than generally considered for renewable energy resources. Deforestation is not a factor traditionally accounted for in environmental impact assessments (EIAs) that preface the construction of energy installations. However, large infrastructure projects in the Amazon often have unintended and largely unmeasured effects on deforestation. Infrastructure development, such as that for energy and transportation, in the Amazon may present a newly influential factor driving deforestation rates to increase in the Amazon (Southworth et al. 2011; Malingreau et al. 2012).

Recent studies of biomass development have demonstrated a clear connection between the planting of new crops to provide biomass resources and deforestation (Fearnside et al. 2009). This is a less-known issue in the case of large dams, although a few studies have demonstrated the effects of such installations on deforestation. There are several drivers for this phenomenon. First, large dams require tens of thousands of employees during the construction period. These workers often migrate from other areas to the work site. In addition to individuals who work on the dam itself, populations whose occupations support the workers generally appear in the surrounding area. These include, but are not limited to, physicians, prostitutes, farmers, and restaurateurs. After the dam project is complete, its workers and these additional populations often stay in the area, next developing new roads and housing to accommodate their permanence. They, in turn, increase deforestation. In the case of Santo Antonio and Jirau in the western Amazon, unexamined and unintended environmental and social impacts included the expansion of soy production amongst other long-term consequences of development (Fearnside 2014).

In this way, infrastructure and migration patterns into the Amazon are major determinants of deforestation and sustainability. In particular, migration into the Amazon can expand deforestation. Since some cities are already established in the Amazon, some deforestation can be expected as it comes from cities within the Amazon into adjacent areas. This migration is driven by economic need and or familial networks (Randell and VanWey 2014). Many who occupy the Amazon and could move to urban areas, therefore taxing the Amazon less, choose to stay outside of urban areas because their skills are not suited to the urban environment, but rather to rural activities (Macdonald and Winklerprins 2014).

Deforestation rates have been decreasing in the Amazon for the past decade with some slight variation over time. These rates have been widely touted as a success and many believe will remain fairly static now that there is a well-established surveillance system in place. However, infrastructure development there may change this recent trend. There are large-scale plans to develop many forms of infrastructure in the Amazon (Fearnside 2002). Research has demonstrated that the development of such infrastructure will lead to vastly increased deforestation rates due to 'contagious deforestation' wherein one small area of deforestation leads to more deforestation nearby (Laurance et al. 2002). The development of roads is a wellknown mechanism for increases in deforestation, yet there is little analysis of how these long-term infrastructure projects may affect deforestation (Barni et al. 2015).

Some research has shown that infrastructure development, such as increases in electrification, can decrease deforestation rates because it increases productivity (Assunção et al. 2015). However, cost-benefit analyses of large infrastructure in the Amazon is often insufficient or mischaracterized. For example, the economic value of the Belo Monte dam would change from US$1.62 billion to negative US$3.56 billion if the estimation of water flow were conducted correctly (Livermore and Revesz 2013).

3 Data and methods

This research is based on a broad-scale literature review, qualitative interviews with officials, local communities, and experts, and ethnographic observations of local communities in the State of Para. The literature review encompassed the fields of climate science, social sciences, energy studies, and sustainability science in order to capture the multiple, intersecting factors affecting the political economy of energy development. Twenty-nine interviews were conducted in person, over the phone, or on Skype from summer 2015 through winter 2016. Interviews were either taped and transcribed, or in-depth notes were taken, depending on the comfort of the interviewee. Interview subjects were selected through a snowball sample approach, starting with experts, officials, and local non-governmental organization representatives who work on related issues. Ethnographic observations were made of local communities and their interactions with state representatives in the State of Para near the site of the Belo Monte dam. This included the observation of a licensing hearing for the dam, local protests, and newly constructed resettlement communities in the City of Altamira.

4 Political economic dimensions of Amazonian renewable energy

Energy expansion and related infrastructure development in the Amazon is driven by the political economy of energy in Brazil and internationally. There are several key perspectives that shape the political economy of energy development in the Amazon. They include: the local communities and social movement organizations that represent them, Brazilian government agencies on the local and federal levels, Brazilian financial interests that are sometimes represented by government agencies but also include private interests, and international entities such as lenders and governments. These diverse social actors both conflict and align with one another to shape the political economy and its outcome in the Amazon. The following section outlines the role and effects of each factor in the political economy of renewable energy in the Amazon.

4.1 Local socioeconomic development: communities and social movement organizations

The Amazon is an incredibly diverse region composed of over 200 indigenous groups, people of Portuguese descent and of African descent. Energy development is often characterized by conflicts with local communities. This is especially true in Brazil where the long history of dam building has encompassed conflict with communities and social movements in sites across the country (Cummings 2013). The shifting landscape of biomass is also affecting socioeconomic development locally. Both forms of energy development often involve the in-migration of larger economic investors and resources, which have effects on local populations.

Biomass facilities are often characterized by the displacement of small-scale landholders and the concentration of land tenures often involving mechanization (Tanner and Allouche 2011). Jobs for sugar workers are low-paying and involve difficult working conditions. In order to protect the forest, conservation techniques have been implemented and localized management strategies have been employed (Naughton-Treves et al. 2005). The Bolsa Floresta programme, a programme in the State of Amazonas, supports the conservation of forests with a targeted approach to engaging forest communities in resource management, such as through payment for ecosystem services. Evaluations of this programme have had mixed results, and few have paid attention explicitly to biomass development in the context of forests.

Conflict with local communities regarding dam development is largely driven by displacement of local populations and community fragmentation (Windsor and McVey 2005). Hydroelectric dams have displaced over one million people in Brazil. They are controversial since many populations have not been resettled, and those who have been resettled by the state often live in conditions of greater poverty than before they were moved (Araujo 1990). Displacement is very common, which results in impacts on living patterns and kinship systems (Tilt et al. 2009). Job capacity often actually decreases as mechanization related to dam building takes the place of more labour-intensive industries.

Another human impact of dam construction is increased illness in directly affected and adjacent communities. Often, infant mortality rises, malaria and other illnesses increase at the local level (Lerer and Scudder 1999). Some of these problems are caused by the fragmentation of community and home and decreased access to proper nutrition, among other social determinants. Others are related directly to environmental degradation, such as standing water causing proliferation of mosquitoes that cause malaria. For example, at Serra da Mesa dam in Goias, schistosomiasis increased dramatically because of dam construction (Thiengo et al. 2005). Mercury is also released into the food chain through reservoir leaching.

Since these conflicts have generally occurred in tandem with development of specific projects and most large dams in the country are in regions outside of the Amazon, less conflict has occurred in this region than elsewhere. Local communities are often divided over dam development, with some community members in favour of dam building, anticipating positive effects on the local economy. This is generally true of local political leaders whose governments receive an annual portion of the profits of such energy installations. Local communities affected by flooding or drying of river resources often protest against dam building. This activity is reflected in a long history of the anti-dam movement in Brazil that began in the south of the country in the 1970s and has spread throughout the nation where dams are built (McCormick 2009). The Movement for Dam-Affected People has often led this movement while collaborating with local organizations. In the Amazon, this has included organizations such as the Indigenous Missionary Counsel, the Xingu Lives, and the Socio-Environmental Institute.

In the Amazon, local communities that oppose dam construction and the organizations that represent them are often focused on protecting the rights and livelihoods in the area. These dynamics have occurred in several Amazonian cases, especially in two built since the abandonment of the military government. The first was the Rio Madeira complex whose impacts were close to the city of Porto Velho. Two companies, FURNAS and Odebrecht, led the development of these dams with support from the newly elected President Inacio Lula da Silva. Viability studies for the Rio Madeira dams began around the same time that the second model of Belo Monte was being developed in 2001 and 2002. When Belo Monte was again defeated in 2003, the Ministry of Mines and Energy proposed a new focus on Rio Madeira rather than Belo Monte. However, populations in the area around Porto Velho, the main town that would be affected, were divided in their support for the dam complex. A number of local organizations protested its construction citing law 10257/01 which guarantees that indigenous communities impacted by development projects will have access to information about it and ability to engage in discussion regarding its planning, but they were defeated.

The Belo Monte dam was first proposed and defeated in 1989 after a massive local protest supported by international organizations and celebrities. In the following 25 years, a variety of models of the Belo Monte dam were proposed, discussed, and rejected. In 2005, it was proposed and it received the first licence. A variety of national and local organizations contested Belo Monte, siting its environmental impacts and the potential it had to illegally displace indigenous communities. MDTX worked in partnership with Forum Carajas, Living Rivers, and the Catholic Church, protesting its construction. The Federal Prosecutor supported these organizations by launching over a dozen lawsuits against the dam. Even after the second licence of the necessary three was granted in 2011, protests continued, including violent occupation of the dam site. As of January 2016, the third operating licence for the dam has been suspended due to the lack of address for impacts on indigenous communities.

Local communities have some influence on the renewable energy portfolio in the Amazon both through vocal opposition to specific projects and through their official inclusion in national programmes for inclusion. However, their increased participation could both bolster their socioeconomic development and improve outcomes of projects through the use of their localized understanding of environment and land use.

4.2 Brazilian governmental and private interests

Energy expansion in the Brazilian Amazon is meant to match the growing economy and fill the shortfall of energy generation, in part due to drought conditions reducing the viability of hydroelectricity generation since 2010. Negative trade balances also drove the further expansion of hydroelectricity and biomass development, especially as a replacement for other oil derivatives in the case of the latter (Griffin and Scandiffio 2009). Renewable energy in the Amazon is also driven by the need for continued economic development in the south to which energy in the Amazon is transmitted, and for electro-intensive industries in the Amazon, such as mineral extraction (Fearnside and Figueiredo 2015).

Biomass has been an important form of energy crops especially in light of addressing climate change and the need to reduce greenhouse gas emissions. Sugar cane has been a central crop in the production of ethanol both for domestic consumption and export to advance the Brazilian agricultural sector. Due to the increasing efficiency of the agricultural sector and especially cattle ranching, sugar cane production has massive potential for expansion in Brazil without interfering with other food resources, which is driving increased national investment (Pimentel and Patzek 2008). Subsidized development of biomass development has been focused on the Amazon and the cerrado (bordering the southwest of the legal Amazon) with a portion of these developments planned as community managed (Walter et al. 2006). National programmes have been developed to support research and development in biomass across the country.

The northern region, dominated by Amazonian rainforest, currently has the most hydrological potential and is characterized by the greatest risk (Tundisi et al. 2014). Large dams have clearly caused long-term adverse impacts on biodiversity in the Amazon (Benchimol and Peres 2015). Some legally protected areas present major impediments to dam building. This is particularly true of indigenous lands whose inundation requires approval by the indigenous group living there. Drought conditions in other parts of the country also make this a particularly important region for development. Renewable energy is expanding throughout the country; however, the history of dam building in the country makes this form of renewable energy one of the more appealing approaches to supporting an expanding economy. Existing infrastructure for dam construction and relationships between political representatives and dam builders means that hydroelectricity may be prioritized over other forms.

While the hydrological resources in the Amazon have also played a role in attracting investors, the instability of precipitation patterns and the social conflict surrounding these projects has shifted who is willing to invest. For example, when the state-run public/private partnership for northern Brazil, Norte Energia, won the bid to build the Belo Monte dam, it was constituted by a group of medium-sized production companies including Bertin, Queiroz Galvão, J. Malucelli, Cetenco, Galvão Engenharia, Mendes Junior, and Serveng in collaboration with state-led CHESF (the hydroelectric Company of San Francisco). Since then, it has evolved into an association between the Brazilian government and pension funds. Today, the central Brazilian bank, the BNDES (Banco Nacional de Desenvolvimento Econômico e Social), has provided the biggest financial support for the project.

Government leaders have supported the expansion of large dams in the Amazon, including the recent President Lula and the current President Dilma Roussef, who was previously the Minister of Mines and Energy. Both of these presidents campaigned on platforms that included the completion of the Belo Monte dam. Traditionally, billions of dollars have been lent to the Brazilian government by external sources; however, Belo Monte is funded largely by a US$10.8 billion loan from the BNDES (Reuters 2012). Investors like Vale, the second largest iron-ore producer in the world, have supported the project (Leahy 2011).

Recently, the role of corruption in their platforms and political economy of energy generation has gained attention. Corruption in the Brazilian government has influenced the construction of infrastructure and energy projects. The former director of the Brazilian oil company, Petrobras, was arrested and convicted for corruption in dam construction. A consortium of Brazilian companies that won the bid to build the Belo Monte dam complex, such as Odebrecht, and Andrade Gutierrez were discovered to have given around US$6 million in bribes to local officials in order to gain the contracts to build the dam (2015). A former president of Camargo Correa admitted that his company gave millions of dollars to political parties in order to gain 15 per cent of the Belo Monte construction contract. These examples have recently revealed the ways in which large private companies are able to influence the planning of dams and energy infrastructure through bribes to public officials.

4.3 International actors and financial interests

The political economy of Brazil's energy development is embedded within international markets and financial interests that drive and inhibit particular pathways of energy development. On this global scale, there are three inter-related types of influence: international companies and investors that invest in or gain contracts for the construction of energy installations, international demand for forms of energy, and growing international needs to meet agreements made in the Kyoto Protocol and the Clean Development Mechanism (CDM). International actors that affect renewable energy development in Brazil include investors and financiers. This landscape of these social actors has been shifting. For example, although all private international investors originally interested in Belo Monte dam removed their involvement, some companies were paid for their role in construction. The French construction company, Alstrom, was paid over US$500 million to provide equipment and turbines for Belo Monte. The Chinese play a critical role in Amazonian development in that 82.3 per cent of their Foreign Direct Investment (FDI) was allocated to extractive industries in 2012 (Fearnside and Figueiredo 2015) and 7 per cent of Brazil's FDI was from China between 2005 and 2013. China has invested in renewable energy and related infrastructure development. While China does not have formal decision-making power regarding these measures, other than through the indirect governance framework regarding climate change of the United Nations Framework Convention on Climate Change (UNFCCC), the availability of its resources to advance specific projects in which the country has interests may also catalyse the development of dams, canals, railways, and other transportation infrastructure. China is the largest importer of Brazilian soy, whose export can be made more economically efficient by these developments.

Domestic and global policy frameworks influence decisions made by international investors. Global interest in reducing the effects of climate change have included increased commitment to the Kyoto Protocol and policies therein. As nations around the world attempt to decrease their emissions, demand for ethanol has increased, subsequently increasing its development in Brazil. The United States and India are the biggest importers of ethanol from Brazil. The UNFCCC has provided the international platform for Brazil to commit to a particular approach to the reduction of GHGs, or more specifically, to the commitment of reducing deforestation rather than shifting the energy matrix. The CDM has given Brazil credit for the construction of large dams despite the lack of estimation regarding their impacts (Fearnside 2013). The cases of new large dams already constructed in the Amazon demonstrate that the CDM facilitates the false impression of GHG reductions, when it may actually be increasing them due to methane emissions and other unintended impacts (Fearnside 2015).

5 Implications for the clean energy transition

This research has taken a trans-scalar approach to the political economy of renewable energy development in the Brazilian Amazon to demonstrate how it interrelates with local and global actors across scales and sits within the context of global markets and investors. By using this approach, it is possible to see how the needs of local, statal, and transnational actors are often in competition with one another, and the ways in which unresolved conflicts can decrease the quality of planning. Most centrally, local actors often stake claims that they lose livelihoods, land, and community cohesion due to energy development, often demonstrating the lack of sustainability in energy sources generally called renewable. State and international actors are more driven by market forces that can adversely affect the sustainability of Amazonian resources. While issues of deforestation, sustainability, climate change, and energy are incredibly complex in the Brazilian Amazon, this conceptualization of the political economy begins to highlight how the alignment of interests therein could improve long-term outcomes for both energy development and Amazonian preservation.

This research offers three implications for the expansion and improved implementation of clean energy in the Brazilian Amazon. First, any energy planning for the Amazon should take a more comprehensive approach to assessing environmental and social impacts than current planning methods do. This would include impacts outside of the project itself, such as the surrounding area, and the long-term consequences of each project. This is critical both to the preservation of the rainforest and to the sustainability of livelihoods and culture in the region. Without this, it will be impossible for the advancement of clean energy to take place that considers the needs of local populations who live and work adjacent to such facilities.

Second, renewable energy development in the Amazon must consider the role of climate change, both in terms of how it may affect hydrological resources and energy potential, and how it may affect the needs of local populations. Amazonian energy development has largely ignored both the needs of local populations and climate projections. However, the latter promises to reduce economic viability of renewable energy in the Amazon. Assessing the needs and legal rights of local populations is critical to advancing sustainability in the region. These populations are generally not the recipients of energy generated locally, and may, instead, face negative ramifications of infrastructure development, such as lack of access to water and displacement.

Finally, in the international sphere, Brazil needs to expand its presentation of national impacts on climate change by including the real potential changing deforestation rates that accompany infrastructure development, and the changing energy mix. This presentation should include both the increasing dependence on fossil fuels and, possibly even more critically, present and future methane emissions from hydroelectric dams in the Amazon.

A consideration of these three factors would help support the adoption of renewable energy in Brazil that is truly sustainable for the people of the Amazonian region and for the global community which is indirectly affected by the changes in that region through climate change.

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