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Assessing the gender and social equity dimensions of energy transitions

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Contents

Abstract

Transitions to low-carbon energy systems are essential to meeting global commitments to climate change mitigation. Yet “greening” energy systems may not make them any more fair, inclusive or just. In this paper, we review the academic literature to understand the state of knowledge on how diffusion of low-carbon technologies impacts gender and social equity. Our findings indicate that renewable energy projects alone cannot achieve gender and social equity, as energy interventions do not automatically tackle the structural dynamics embedded within socio-cultural and socio-economic contexts. If existing power asymmetries related to access and resource distribution are not addressed early on, the same structural inequalities will simply be replicated and transferred over into new energy regimes.

1 Introduction

Transitioning to low-carbon energy systems is central to meeting global commitments to climate change mitigation (IPCC 2018). To better understand the factors driving and hindering this transition, valuable research is being done on the socio-technical challenge of transitioning whole energy systems towards sustainability (Geels et al. 2017; Li et al. 2015) through confronting incumbent energy policies (Strambo et al. 2020; Unruh 2002), diffusing new low-carbon – or renewable – energy technologies (Iyer et al. 2015; Raven et al. 2016), establishing new value chains and business models (Hoggett 2014; Richter 2012), and changing user behaviour (Muhoza and Johnson 2018; Schot et al. 2016; Stephenson et al. 2015).

However, transitions are not only socio-technical, but also gendered and deeply socio-political (Ahlborg 2017; Lawhon and Murphy 2012; Meadowcroft 2009). Inequalities can persist in low-carbon energy systems; they may not be any more fair, inclusive or just than the conventional systems they displace (Miller et al. 2013; Ottinger 2013). Thus, questions of context are of fundamental importance: Who are the energy users? What are their social positions and aspirations? Who is consulted during the process of implementation, and how is the energy supply organized? This is often represented in the concept of "just transitions", whereby energy transition processes also ensure fairness via equal distribution, full recognition of rights and labour contributions, equal participation in decision-making procedures, and equal capabilities in renewable energy outcomes (Healy and Barry 2017; Newell and Mulvaney 2013). Indeed, the 2015 Paris Agreement notes:

> "Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights…. as well as gender equality, empowerment of women and intergenerational equity" (UNFCCC 2015, p.2).

Despite strong evidence on the links between energy, gender and society (e.g. Clancy and Roehr 2003; Oparaocha and Dutta 2011; Ryan 2014), dedicated research and knowledge on the gender and social equity (GSE) implications of low-carbon energy transitions is only slowly emerging (see ENERGIA 2019; Pachauri and Rao 2013). In this scoping study, we explore the state of knowledge in academic research on how diffusion of low-carbon technologies impacts gender and social equity.

Our study used a structured approach to analyse journal articles, reports, book chapters, and other papers that dealt with the gender and social equity impacts of transitions to low-carbon energy systems. We then mapped these impacts at local and national levels, and examined how these impacts were addressed. Our aim was to find insights in the academic literature on whether energy transitions will affect current power dynamics shaping the production and consumption of energy. As such, our guiding research question was: What are the gendered and social implications of introducing low-carbon energy technologies into traditional or conventional energy systems?

This paper is structured as follows. Section 2 describes the method used to review the state of knowledge on gender and social equity in energy transitions. Section 3 sets out the results and findings from our review. Section 4 concludes with policy recommendations and areas for future research.

2 Methods

To explore the state of knowledge in academic research on how diffusion of low-carbon technologies impacts gender and social equity, we conducted a literature search, drawing upon systematic review methods. In this section, we describe the review methodology that was applied.

2.1 Literature search

The reviewing team consisted of three researchers at the Stockholm Environment Institute. A search of the literature was conducted during June and July 2019. Due to time and resource constraints, we chose to narrow our search to two academic databases: Scopus and Web of Science Core Collection. A brief search of the thesis repositories ProQuest and Ethos came up with few results, so these repositories were not included.

In order to search the literature in Scopus and Web of Science, we developed a search string using a combination of search terms related to (a) low-carbon energy, (b) transitions and (c) gender and social equity impacts (see Table 1). We aimed for specificity in our search term, but included some search refinements to exclude very unrelated fields of study and to limit our results to English language papers. For example, we linked “solar” with “power”, “photovoltaics”, “PV”, “concentrated” (as in concentrated solar power), “home system”, and “industry”; this ensured that our search was less likely to pick up results related to topics outside our scope of inquiry, such as solar flares or solar eclipses. Additionally, we added a range of qualifiers – such as “group”, “people” and “community” – to issues around gender and social equity to make our search more targeted. When adding descriptive terms to group, people and community, we used positive and negative terminology. For example: [“poor” AND (...)]and [rich AND (...)].

Table 1. Search string

Database	Search string	Search refinements	Date
Scopus **(Title, keywords, abstract**	(((("sustainable?energy" OR (("low?carbon" OR renewable*) AND (development OR energy OR power OR electricity OR generation OR industry))) OR (solar* AND (power OR photovoltaics OR PV OR concentrated OR "home?system*" OR industry)) OR (wind* AND (power OR electricity OR turbine* OR industry)) OR hydropower* OR (geothermal AND (power OR electricity OR industry)) OR (biomass AND energy) OR bioenergy OR biofuel* OR agrofuel* OR "mini?grid*") AND (transit* OR transform* OR change* OR shift* OR pathway* OR polic* OR strateg*)) AND (("social?impact*" OR "social?outcome*"OR "socioeconomic*") OR gender* OR wom?n* OR m?n OR girl* OR boy* OR child* OR youth* OR "young?people" OR elder* OR "old?people" OR (disable* AND (group* OR people* OR communit*)) OR (poor AND (people* OR communit*)) OR (rich AND (people* OR communit*)) OR (wealthy AND (group* OR people* OR communit*)) OR ("low?income" AND (group* OR people* OR communit*)) OR (vulnerab* AND (group* OR people* OR communit*)) OR (marginal* AND (group* OR people* OR communit*)) OR (ethnic* AND (group* OR people* OR communit*)) OR (indigenous* AND (group* OR people* OR communit*))))	AND (EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "NURS") OR EXCLUDE (SUBJAREA , "HEAL") OR EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "DENT")) AND (LIMIT-TO (LANGUAGE , "English"))	9 Jul 2019
Web of Science core collection **(Topic search)**		[excluding] WEB OF SCIENCE CATEGORIES: (BIOCHEMISTRY MOLECULAR BIOLOGY OR CLINICAL NEUROLOGY OR BIOTECHNOLOGY APPLIED MICROBIOLOGY OR MICROBIOLOGY OR PHYSIOLOGY OR PLANT SCIENCES OR FOOD SCIENCE TECHNOLOGY OR BIOCHEMICAL RESEARCH METHODS OR SPORT SCIENCES OR MEDICINE GENERAL INTERNAL OR RADIOLOGY NUCLEAR MEDICINE MEDICAL IMAGING OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH OR MEDICINE RESEARCH EXPERIMENTAL OR OBSTETRICS GYNECOLOGY OR LIMNOLOGY OR PEDIATRICS OR TOXICOLOGY) AND LANGUAGES: (ENGLISH)	30 Jun 2019

2.2 Screening process and review criteria

Screening involved three steps. In the first step, duplicates were automatically removed using Mendeley software, and the remaining references (comprising title, abstract and metadata) were then imported into Rayyan software[1]. One researcher was responsible for this first step. A total of 11,818 references were identified in Scopus (7,196) and Web of Science (4,622). Of those, 2,342 non-English-language references were removed. The remaining 9,476 English-language references were downloaded: 5,585 from Scopus and 3,891 from Web of Science. We then removed 2,526 duplicates, leaving a total of 6,950 references that were included in the second step.

In the second step, titles and abstracts were screened according to the following pre-determined inclusion criteria:

- **Relevant subject:** References address the introduction of low-carbon energy systems as part of a shift away from traditional or conventional energy systems. We discarded references that focused only on the environmental impacts of low-carbon energy systems.
- **Gender and social equity considerations:** References mention the impacts of low-carbon energy systems on certain people, communities or social groups.

Three researchers took part in the screening process, and items were not double-screened. A consistency check was performed in order to reduce risks of bias and inconsistency across the team. This check involved all researchers screening the same 100 titles. Any discrepancies were then discussed among the team to resolve differences before broader screening began. This was also done for 50 abstracts. Out of the 6,950 references included in Step 2, 778 were included after title screening and, of these, 206 were included after abstract screening.

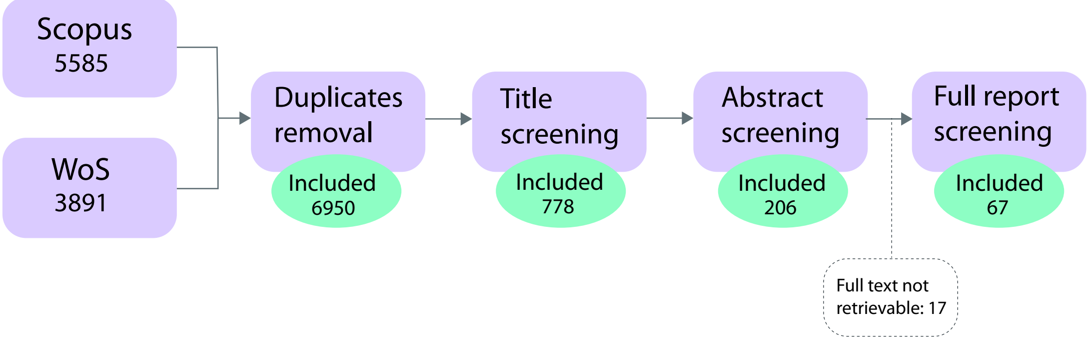
The third step involved full-text screening of the 206 references that passed Step 2. A full list of these publications can be found in Appendix 1. Researchers downloaded and read full texts of these references. A total of 17 references could not be accessed and were thus omitted from the review.

In this step, researchers screened the full text following this criteria:

- **Type of study:** References contain real world case study (rather than focus on theory of transitions, hypothetical cases, or technology potential).
- **Gender and social equity considerations clearly analysed:** References analyse issues related to class, displacement, education, employment, energy supply, food security, gender, health, human rights, indigenous/race, land ownership, or poverty.

The full-text screening process narrowed down the final number to a total of 67 references that explicitly dealt with the gender and social equity impacts of renewable energy transitions. Figure 1 provides a flow chart of the screening process and results.

Figure 1. Flowchart of screening process



1 https://rayyan.qcri.org/welcome

2.3 Data extraction and coding framework

In order to analyse the final 67 references that made it through Step 3, data was extracted from each paper and put into a coding framework. Data extraction was undertaken by two researchers, who coded data in an Excel file. The Excel file was designed to document and characterise details of the studies in each paper, including geographical location, energy resource, and type of impact. Table 2 sets out the coding framework.

Table 2. Coding framework

Nature of the literature	
Bibliographic Info	Author(s)
	Title
	Date
	Journal
Nature of case	
Research methods	Qualitative, quantitative or mixed methods
Geographical Location	City, region, country (include multiple locations if relevant)
Urban/Rural	Urban, rural
Energy Source	Low-carbon energy sources studied (e.g. hydro, solar, etc.)
Energy Use	Energy service studied (e.g. lighting, heating, etc.)
Scale of energy use	Household, local/community, national
Gender and social equity issues	Class Displacement Education Employment Energy supply Food security Gender Health Human rights Indigenous/race Land ownership Poverty
Impacts of transition	
Outcome of transition	Positive/negative
Gender and social equity benefits	Poverty alleviation Energy self sufficiency Job creation Health benefits Environmental benefits (local) Cost-effective Social mobility Improving gender equality None stated
Who benefits?	Description of people/groups that benefited
Location of benefits	Local, regional, national
Negative gender and social equity impacts	Exacerbate/increase poverty Energy poverty Job loss Adverse health impacts Environmental impacts (local) Not cost-effective Resource dependency Widened wealth gaps Worsening gender equality Food security Loss of land / displacement Human rights violations None stated
Who is adversely impacted?	Description of people/groups that were adversely impacted
Resistance/opposition to negative impacts?	Yes/no (if possible, give details)
Long-term impacts discussed?	Yes/no (if possible, give details)
Details of the transition process	
How did the transition process occur?	Description
Who implemented transition process?	Description of people/groups that implemented process
Formal impact assessment study before transition	Yes/no (if possible, give details)
Stakeholder consultation before transition	Yes/no (if possible, give details)

2.4 Methodological limitations

There are a number of limitations to this study. First, time constraints meant we could only focus on peer-reviewed academic publications. This means this study does not include insights from the grey literature, despite considerable work on this topic reported by NGOs, civil society organizations, consultancy groups and international organizations. However, we believe the focus on peer-reviewed academic publications is a useful and important starting point for this exploratory study.

Second, we expect that some literature on the topic will not have been picked up by our precise search string. Hence, we may have missed some important findings from the literature. However, this is to be expected in an exploratory study such as ours. In further research, refinement of the search string, combined with testing and validation, would help to avoid this limitation.

Third, our search did not distinguish between literature that featured small hydropower projects from those that featured large ones. Small or micro-hydropower (plants that produce less than 10 megawatts) are typically considered renewable; however, large hydropower is sometimes not considered a renewable resource, due to its potentially large environmental and controversial social impacts. We have tried to bear this in mind when drawing insights from any analysis of hydropower cases.

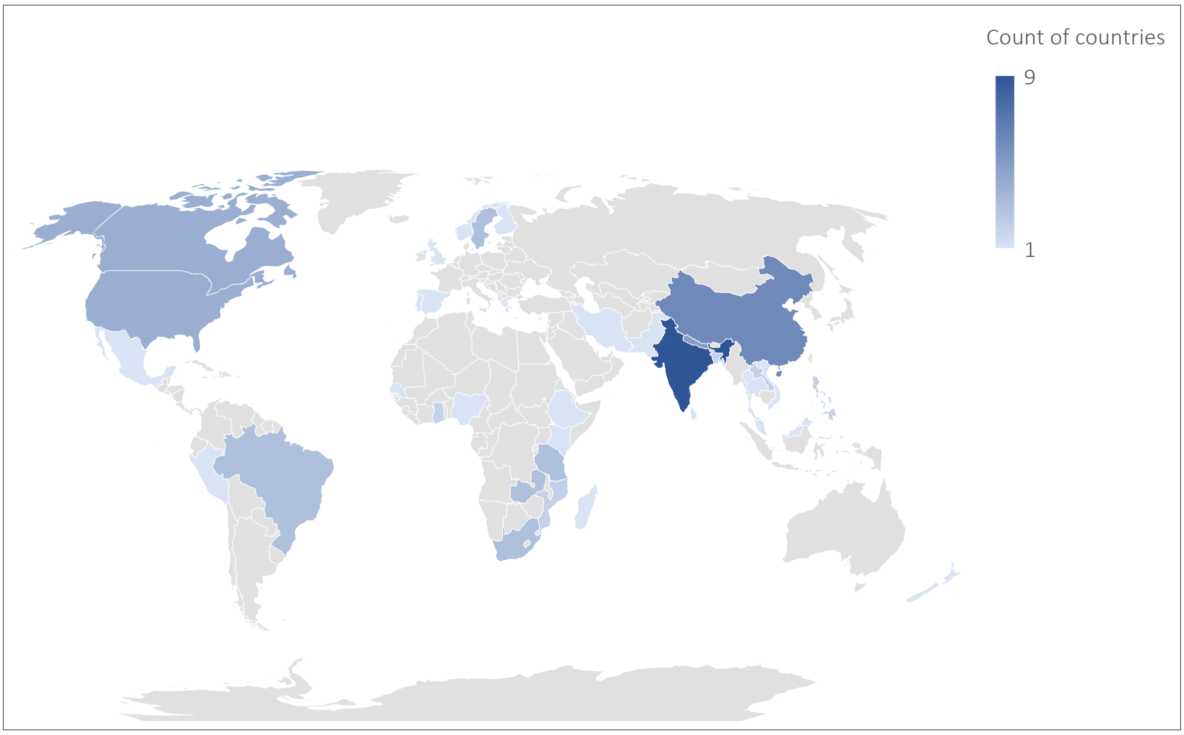
Lastly, we did not include the term “household” in our search string, which was an oversight on the part of the research team. Nevertheless, we believe related search terms – that were included – likely reduced the number of references omitted from our search due to this error.

3 Results

3.1 Countries studied in the literature

The 67 references in our analysis described case studies in 39 different countries, not including repeats and multi-country analyses. The vast majority of cases are located in developing countries in Asia (45%) and Africa (24%), as shown in Figure 2. It is important to note that almost all of the case studies from the literature are based in rural settings; only two describe cases in an urban setting.

Figure 2. Geographical concentration of case studies



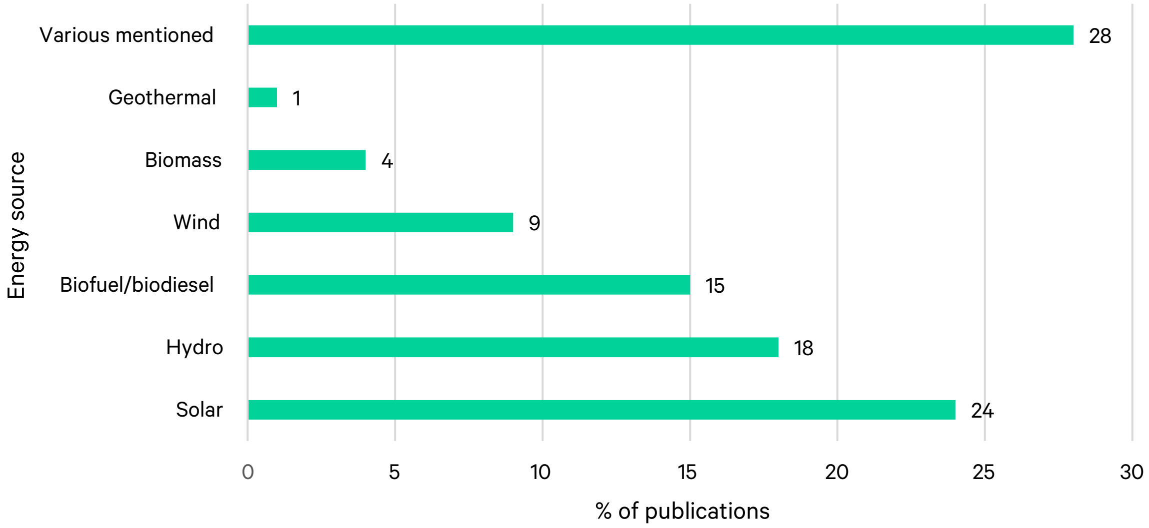
3.2 Energy sources covered and causes of transitions

As shown in Figure 3, the energy source that receives the most attention is solar energy, with coverage in 24% of the reviewed literature. Hydropower is addressed in 18% of the literature, and biofuel and biodiesel are examined in another 15%. While most references do not explicitly state the cause of a transition, many provide context; they often cite policy pronouncements (such as national targets to reduce greenhouse gas emissions), and the private sector is often involved in the implementation of such policies, sometimes with state endorsement (Ahlborg 2017; Amin and Langendoen 2012; Amjid et al. 2011; Baker 2019; Brent and Rogers 2010; Cooke et al. 2017; De Andrade Meireles et al. 2013; Devkota et al. 2014; Gustavsson and Ellegård 2004; Jackson and Sleigh 2000; Katuwal and Bohara 2009; Lawrence 2014; Winther et al. 2018; Wlokas 2011; Wong 2012; Yenneti et al. 2016).

Since almost all of the cases in the literature reviewed are based in rural areas, decentralized energy systems are commonly mentioned – particularly decentralized electrification powered by solar energy. In these cases, various non-government actors promote and invest in these renewable energy sources and decentralized systems. Actors mentioned include non-profit organizations (Ahlborg 2017; Amjid et al. 2011; Kattumuri and Kruse 2019; Wong 2012), local social enterprises (Gray et al. 2019), private enterprises or developers (Amin and Langendoen 2012; Winther et al. 2018), and even church organizations (Ahlborg 2017).

Within the reviewed literature, private companies are behind most cases of biofuel and biodiesel production and consumption; most of these companies are endorsed by the government.Both Montefrio and Sonnenfeld (2013) and Schoneveld et al. (2011) outline the joint role of the private sector and the local government in establishing jatropha[2] plantations in rural Philippines and Ghana, respectively. Similarly, Vermeulen and Cotula (2010) examine the ways that land-use changes – due to land deals for biofuels – shape social vulnerabilities in various African countries. Interestingly, as opposed to fitting under a wider narrative of environmental sustainability, the discourse around biofuel initiatives tend to have a heavier focus on stimulating economic growth (Amjid et al. 2011; Arndt et al. 2011; Montefrio and Sonnenfeld 2011; Montefrio and Sonnenfeld 2013; Schoneveld et al. 2011; Vermeulen and Cotula 2010). This aligns with the fact that most of the case studies on biofuel plantations are located in impoverished and rural areas.

Figure 3. Percentage of publications that examine each energy source



Note: "Various mentioned" include counts of solar, wind, biofuel, and biomass energy source. "Hydro" includes both large and small hydropower plants.

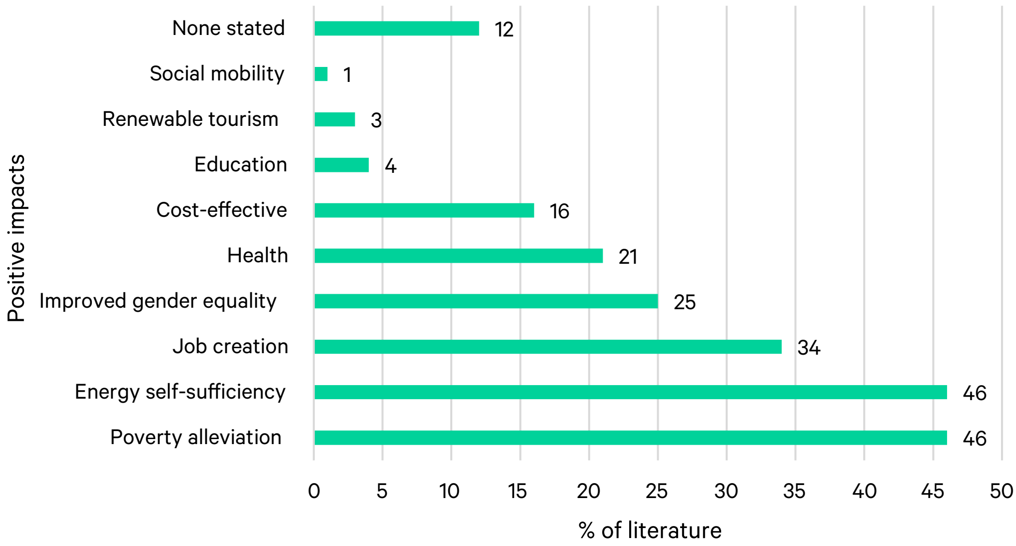
3.3 Gendered and social impacts of transitions: key themes

The review examined the impacts of energy transitions on aspects broadly related to gender and social equity, including employment, education, poverty, land ownership, food security and health. Figure 4 and Figure 5 show the percentage of publications that mention various types of positive and negative impacts on these dimensions.

The most documented positive and negative impacts are broadly related to economics. This includes impacts on poverty, energy cost-effectiveness, and labour (such as a gain or loss in jobs). Poverty alleviation and energy self-sufficiency are dominant positive impacts, with 46% of the literature discussing these outcomes. Issues of land loss and displacement appears to be a dominant negative impact, with 27% of the literature mentioning it as a negative outcome of the transition. Various impacts are interrelated; for example, poverty alleviation is largely influenced by energy self-sufficiency and job creation, which are mentioned in 46% and 34% of the literature, respectively. Likewise, land loss and displacement influence other negative impacts, such as increased poverty and job/livelihood loss, which are both mentioned in 18% of the literature, respectively. Similarly, these impacts have gendered outcomes. For example, shifts in traditional forms of livelihoods induced by land-loss may prompt an increase of outmigration that traps women in further poverty (Weeratunge et al. 2016). For example, women may have difficulties

2 The *Jatropha curcas* is a species of plant that provides one of the highest productivities of biodiesel.

Figure 4. Percentage of literature mentioning positive impacts of transition



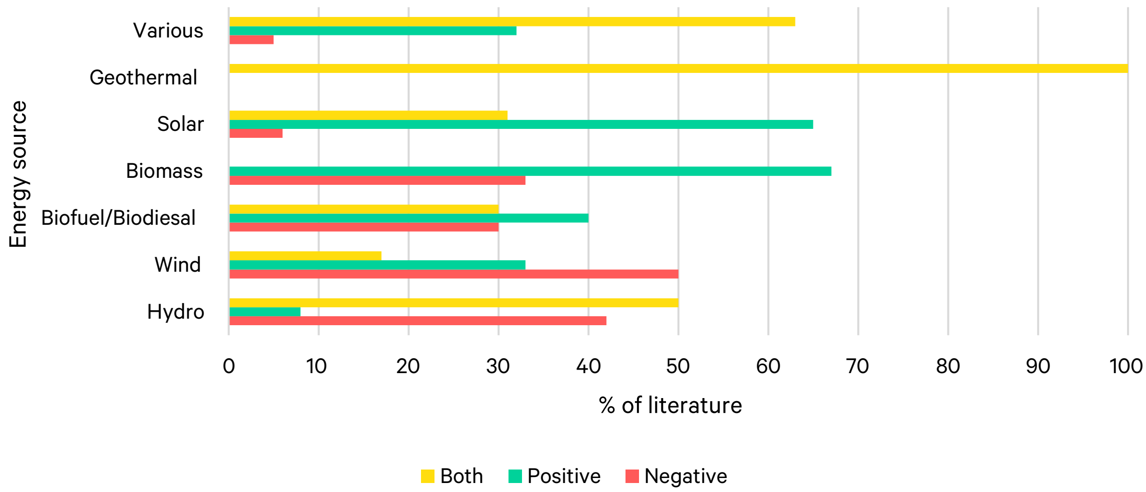
Note: The percentages are mutually exclusive as one piece of literature can have multiple counts of impacts

finding jobs in their new locations, or they may face an increased burden of physical labour as their husbands flock to urban areas in search of work (Ding et al. 2019).

Positive and negative impacts are also commonly mentioned in conjunction with one another (see Figure 6). For example, in some cases, the introduction of a solar energy source decreased an area's overall poverty, but its limited accessibility meant that the benefits were not equally distributed, thus leading to widened wealth gaps (Mahat 2004; Mohammed et al. 2013). In another case, the development of a hydropower project increased jobs initially, yet the change in land use negatively affected local livelihood systems, eventually resulting in food insecurity (Chandy et al. 2012). Similarly, while the positives outcomes of wind energy have been attributed to energy self-sufficiency and job creation (Devine-Wright 2005; Du and Takeuchi 2019; Greene and Geisken 2013), its negative impacts are related to issues of land loss which, in the long run, may threaten livelihood options (De Andrade Meireles et al. 2013; Lawrence 2014; McCauley et al. 2016). Additionally, aesthetic issues and noise disturbances have also been mentioned as adverse impacts of wind energy (Delicado et al. 2016). Thus, energy transitions bring about complex consequences that are seldom discrete: 42% of the examined literature explicitly addresses mixed consequences of a particular transition. This ambiguity underscores how there are not necessarily clear winners and losers of energy transitions, as impacts of transitions are intersectional and cannot be disaggregated in clean-cut ways. Social differences including gender, ethnicity, race, class, and age are intertwined, which leads to complex forms of disadvantages and privileges related to energy use.

The cases from the literature illustrate that low-carbon energy systems may not be more inclusive or empowering than traditional energy systems. Indeed, it is not the technology that determines the outcome of a transition, but rather the ways with which the technology interplays with the existing socio-cultural, socio-economic and institutional context.

Figure 6. Overall impact of energy source



Note: "Various" include counts of solar, wind, biofuel, and biomass energy source.

3.4 Key themes emerging from the literature

In this vein, the following section outlines key themes related to gender and social equity that emerged from the reviewed literature.

3.4.1 Double-edged consequences on women's labour

The type of energy use that is frequently credited with having a positive impact on gender equality is modern household electricity and heat (such as modern cookstoves and lighting) (Baruah 2015; Devkota et al. 2014; Gray et al. 2019; Gustavsson 2007; Gustavsson and Ellegård 2004; Katuwal and Bohara 2009; Millinger et al. 2012; Mohideen 2012; Sesan 2012; Winther et al. 2018). Small-scale household solar systems, such as solar lanterns, can be particularly beneficial to children, women and poor rural households; the increased availability of light extends studying and working hours, allowing for better educational, health and livelihood outcomes (Baruah 2015; Gray et al. 2019; Gustavsson 2007; Gustavsson and Ellegård 2004; Millinger et al. 2012).

However, a pattern observed in the literature is that despite the obvious benefits, energy transitions sometimes merely shift inequalities, rather than eliminate them. This is most evident in the ways in which energy sources affect women's workloads. Several studies state that solar and biofuel energy has had a positive effect on women's empowerment in rural villages; it significantly decreases women's workloads (such as cooking and collecting firewood), allowing them to use the daylight hours on other activities, such as engaging with local communities and even pursuing other forms of employment (Amjid et al. 2011; Devkota et al. 2014; Ding et al. 2014; Katuwal and Bohara 2009; Millinger et al. 2012). However, other studies have shown that women's labour simply transferred from one domain (such as cooking) to another (such as taking care of livestock) (Ding et al. 2014; Ding et al. 2019; Fernández-Baldor et al. 2015; Johnson et al. 2019; Katuwal and Bohara 2009; Winther et al. 2018). In this sense, social norms and gendered divisions of labour remains entrenched despite the introduction of new energy sources.

A few pieces of literature highlight the ways in which men and women reap the benefits of new energy sources differently. While renewable energy sources may provide the potential for women to expand livelihood options, their entry into other domains of labour is affected by existing social norms and contextual factors. For example, when more shops are owned by men – because of gendered norms around business – then men are able to use the introduction of electricity to enhance their businesses; women, however, have significantly fewer options to capture the advantage of electricity to increase their income (Johnson et al. 2019). Besides gendered norms, the intersecting relationship of gender and class also plays an important role in determining which parts of the population benefits from renewable energy services (Ahlborg 2017). Thus, contextual and systematic factors play a crucial role in determining the extent to which the benefits of renewable energy sources can be reaped.

3.4.2 Poverty, employment, and precarity

The introduction of renewable energy in poor communities does not guarantee a decrease in poverty. While 46% of literature recorded poverty alleviation as a positive impact of transitions (which includes aspects of job creation, energy self-sufficiency and improved education opportunities), many of these outcomes are two-sided upon closer examination, as issues around precarious employment persists (Chandy et al. 2012; Mohammed et al. 2013; Nkoana 2018). Much of the literature that cites job creation as a beneficial outcome attributes that creation to jobs on biofuel plantations. However, in many cases, this holds double-edged consequences. Several of the references note that while biofuel plantations can initially bring about employment opportunities, many of the jobs are precarious; this is due to the plantation structures, where smallholders under private sector holdings tend to receive unequal shares and are subject to unfair land allocation processes. The benefits of employment also may be overshadowed by the long-term consequences of land loss, which significantly constrains livelihood options (Arndt et al. 2011; Montefrio and Sonnenfeld 2011; Schoneveld et al. 2011; Vermeulen and Cotula 2010). In their study of jatropha production systems in the Philippines, Montefrio and Sonnenfeld (2013) examine the contract farming arrangements of indigenous smallholder farmers with parastatal and private firms. The study finds that biofuel contracts compel smallholder farmers to adopt agro-industrial practices as opposed to traditional crop management; this priority of “efficiency” over sustainability may fundamentally affect local livelihood options and capacity in the long run, due to resource scarcity induced by land-use change. Thus, while communities have accepted plantations due to a narrative that promises poverty alleviation and job creation, the industry’s irresponsible practices have instead led to the long-term disenfranchisement of local communities (which are disproportionately indigenous).

Within this discourse, the literature pays some attention to the gendered aspects of worsening poverty and shifts in labour. In certain contexts, existing norms surrounding access and divisions of labour means that land loss further constrains women’s access to vital livelihood resources (Schoneveld et al. 2011). Arndt et al. (2011) point out that while women make up between 60% and 80% of the agricultural workforce in Africa, they are typically involved in food crop production; men, however, tend to control cash crops and monetary proceeds. Interestingly, according to Arndt’s (2011) case study, the increase of women in biofuel production in Mozambique has led to increases in food prices, as women shift away from food production without replacement.

3.4.3 Land loss and echoes of colonial rationalities through market interests

The discourse surrounding renewable energy can be used against indigenous, rural, or marginalized communities, with an underlying narrative that implies community interests must concede to broader environmental concerns. Land loss is a dominant topic among the literature on renewable energy transitions, with 27% of the reviewed literature addressing this impact. Within those, biofuel plantations and large hydropower projects dominate, with cases illustrating stark conflicts of interest between private developers, investors, and local communities. The majority of the literature dealing with the impacts of land loss are related to the loss of livelihood and food security, as discussed in the previous section. This echoes existing literature on the consequences of land grabbing, as the privatization of common land alienates vulnerable communities from their sources of livelihood, thus increasing their precarity (Schoneveld et al. 2011).

This yielding of local community rights is repeatedly reflected in cases of hydropower developments (Baruah 2012; Cooke et al. 2017; Finley-Brook and Thomas 2011), mega solar energy projects (Yenneti et al. 2016), biofuel plantations (Montefrio and Sonnenfeld 2013; Hodbod and Tomei 2013; Schoneveld et al. 2011; Vermeulen and Cotula 2010), and wind power developments (Lawrence 2014; Krupa et al. 2015; McCauley et al. 2016). The topic of land ownership is particularly linked to indigenous causes; 50% of the literature that addresses indigenous issues concerns land loss and/or issues of food security related to land loss. Both McCauley et al (2016) and Ossbo and Lantto (2011) refer to cases of declined reindeer husbandry among Swedish Sámi communities to illustrate the ways in which renewable energy developments have threatened forms of livelihood specific to indigenous communities. Industrial encroachments on indigenous territories thus echo colonial rationalities. Indigenous interests are not only excluded from the market gains of renewable projects; those gains are also accumulated at the expense of indigenous communities.

The consequences of land loss and resettlement can fundamentally – and negatively – transform the social fabric of a community, including its power relations and gender norms. Several pieces of literature describe different repercussions for men and women when hydropower projects cause them to lose access to land and traditional forms of livelihoods (Chandy et al. 2012; Hill et al. 2017; Lebel et al. 2019). Hill et al.'s (2017) study on Laos and Vietnam notes that the displaced populations are often resettled on lands that are unsuitable for cultivation, forcing much of the population into informal wage labour or illegal work, such as timber harvesting. Many of the references discussing this outcome describe men as having an easier time finding work than women, which consequentially increases women's dependency on men after hydropower development.

3.4.4 (Unequal) Access

The issue of access is a reoccurring topic throughout the literature, particularly within solar energy sources. Several pieces of literature assert that the presence of certain renewable energy projects has deepened social and wealth divides due to unequal access (Ahlborg 2017; Baker 2019; Brent and Rogers 2010; Mahat 2004; Mohammed et al. 2013; Reddy et al. 2006; Sunter et al. 2019; Winther et al. 2018; Wong 2012). Examining renewable energy consumption in Sub-Saharan Africa, Mohammed et al. (2013:461) finds that the high start-up cost of household renewable technology blocks the poorest families from accessing technologies such as rooftop solar systems. In certain cases, poor families are even trapped in debt after borrowing money to pay for renewable energy technologies.

Similarly, Wong's (2012) study on Bangladesh and India identifies financial exclusion as one of the key obstacles to solar energy uptake: poor people simply cannot afford to rent or own solar light systems, due to the expensive down payment and monthly subscription fees. Wong (2012) further outlines the social and psychological impacts of this access divide, stating that solar electrification has deepened a middle-class divide: households that can afford solar home systems have improved educational opportunities (children can study easier at home), health conditions, and means of communication (through access to reliable recharging of mobile phones), while the poor lag behind on these aspects (Wong 2012). Thus, the lack of financial supports or subsidies poses a key barrier to renewable energy development.

Additionally, financial barriers to access can have a gendered dimension. In their study of solar electricity use in rural Kenya, Winther et al. (2018) highlight how fixed connections and subscription fees of solar energy give women less agency regarding access and appliances, as opposed to men, who in general are homeowners and have a higher income. As a response to this, the paper discusses two examples of successful decentralized systems of supply initiated by women-led community projects in the studied villages, pointing to the importance of community-based and participatory initiatives.

3.5 Responses

The literature documents several cases of organized resistance against negative impacts of energy transitions (Baruah 2012; Cooke et al. 2017; Curley 2018; Jackson and Sleigh 2000; Lawrence 2014; MacArthur and Matthewman 2018; McCauley et al. 2016; Nkoana 2018; Ossbo and Lantto 2011). Almost all of these cases concern land loss and displacement, with the majority of the resistance consisting of local protests against the government. There are few records of resistance that occurred on a more institutional level, with the exception of one study that mentions indigenous Sámi representation in the Swedish government (Ossbo and Lantto 2011). The Sámi representation has called for social impact assessments on any renewable energy projects in Sámi territories, as well as veto rights over projects.

4 Conclusions and recommendations

In this study we asked the question: What are the gendered and social implications of introducing low-carbon energy technologies into traditional or conventional energy systems? We synthesized findings from 67 peer-reviewed academic references that assess this topic. Our analysis generated two main findings. First, a key motif is that it is not the technology that determines whether the outcomes of a transition will be inclusive and beneficial. Rather, it is up to institutions to shape the outcomes of the transition process. Social, political, economic and cultural dynamics manifest themselves in multiple ways, not just in the distribution of benefits and impacts, but also in decision-making and implementation (including within labour regimes and in technology design). Second, when transitions are enforced as a top-down mode of governance in rural, poor, indigenous or other marginalized communities, people's decision-making within their communities are constrained, thus limiting their roles and sense of ownership in society.

Our study was limited by a strict search string, which omitted other publications that may have been relevant, such as grey literature. However, we believe these findings are still valuable and have a number of implications for policy-makers and practitioners seeking to promote transitions to low-carbon energy systems. First, *institutional arrangements* that support just processes need to be enhanced in order to deliver more equitable outcomes. Specifically, there is a crucial need for a participatory framework that prioritizes the needs and concerns of local residents, particularly vulnerable stakeholders. Engaging communities during the implementation process is critical to realizing the full potential of renewable energy sources; this engagement should be bottom-up, where policy-makers prioritize the feedback from local people on the suitability of certain project developments, as well as establish an inclusive and just supply chain process.

Second, there is a need to conduct *gender impact assessments (GIA)* alongside environmental and social impact assessments. GIA findings can be used by governments and companies to take affirmative action to combat existing gender injustices (for example, women could be provided with access to certain resources that help ease their transition, officials could develop more holistic compensation plans, or land can be jointly titled in the case of resettlement). However, effective participation of multiple stakeholders (e.g., government, civil society actors, affected community members, etc.) is crucial in order for GIA to be suitably designed and implemented. This echoes the previous recommendation of enhancing institutional arrangements that prioritize a broadly inclusive and participatory framework.

Third, the question of *access* must be addressed at the outset at different levels of policy-making. Potential barriers to access, especially the cost of renewable technologies, is a key consideration that is particularly critical when implementing household-level technology in poor households. Strong cross-sectoral initiatives between the energy sector and other departments (such as the public sector) can be a way to develop inclusive energy policies, programs, or subsidy schemes. Such collaborations may also be a way to address complex socio-economic topics, such as women's social security and land ownership.

Fourth, more *holistic and longitudinal measurements of social and economic impacts* need to be considered when implementing and assessing outcomes of energy transitions. For example, development projects that promised new jobs – and then failed – raise the question of whether a "job increase" is a sufficient indicator in assessing long-term economic improvement. Instead of assuming renewable energy is a solution to social problems and creating policies around popular discourses, policy-makers should look at a renewable energy project as one of the many aspects that need to be considered when addressing issues of gender and social equity.

Our review revealed several gaps in the research literature that will benefit from future attention. Only two papers explicitly discussed the gendered dimensions of renewable energy leadership and how that may influence implementations and transitions related to social equity. As demonstrated in the review, poor women from rural regions often hold central roles in energy-related work. However, this perspective is severely lacking in the current "gender-blind" decision-making processes of renewable energy projects. The discussion on barriers or opportunities for women's *active role* in shaping transitions also has been limited, including in the implementation of gender concerns within renewable energy decision-making structures, the designs of alternative energy technologies, and the value chain of renewable energy technologies. Thus, further research is required to explore the various gendered dimensions of employment and representation in the overall trajectory of renewable energy industries and transitions.

Another aspect that can be further explored is whether the resource extraction needed to build low-carbon technologies poses the same, or potentially worse, environmental outcomes than fossil fuel extraction. The literature analysed in this paper largely focused on the gender and social equity dimensions of use and access, but an examination of the equity impacts of the production of low-carbon technology deserves further exploration.

Additionally, none of the reviewed literature specifically looked at the role of disabilities within renewable energy transitions. This raises questions on the wider employment opportunities from renewable energy transitions: To whom are these opportunities available? Are they inherently exclusive to those with certain disabilities? Will those with disabilities be further left behind as certain communities transition from one form of labour to another, with the arrival of renewable technologies? Whether renewable energy can pose unique contributions or limitations to those living with disabilities is a question largely overlooked.

Furthermore, most of the reviewed literature has focused on exploring the gender and social equity impacts on local communities that are physically near the development site of renewable energy projects. While proximity correlates to level of impact, it is relevant to explore the larger regional, national, and even global effects of certain renewable energy developments. This may paint a broader picture of how transnational actors influence and impact energy regimes.

Lastly, only one reference mentioned transitions related to nuclear energy (Chatzimouratidis and Pilavachi 2008). As nuclear energy is a dominant provider of the world's electricity – and with many more countries considering its adoption – a relevant field of study is the significant gender and social dimensions of nuclear transitions.

The global climate crisis demands a transition away from fossil-fuel-based energy and toward cleaner energy alternatives. Yet, as this study has shown, low-carbon energy systems do not automatically guarantee more equitable and inclusive outcomes. It is crucial to recognise that energy processes and sources are implicitly shaped by existing power structures and social norms, and that different renewable energy technologies have different impacts and contributions to social costs and benefits. While renewable energy technologies are an important means to wider social equity, a "just transition" cannot be achieved without inclusive institutional arrangements that ensure just processes.

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