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SYNTHESIS ARTICLE

Social impacts of climate change mitigation policies and their implications for inequality

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ABSTRACT

The Paris Agreement and the Sustainable Development Goals (SDGs) set ambitious targets for environmental, economic and social progress. Climate change mitigation policies play a central role in this process. To maximize the benefits and minimize the negative effects of climate change mitigation policies, policymakers need to be aware of the indirect and often complex social and inequality impacts that these policies may have and the pathways through which these impacts emerge. Better understanding of the distributional and inequality impacts is important to avoid negative social and distributional outcomes as countries ratchet up their climate policy ambition in the post-Paris context. This paper synthesizes evidence from the existing literature on social co-impacts of climate change mitigation policy and their implications for inequality. The analysis shows that most policies are linked to both co-benefits and adverse side-effects, and can compound or lessen inequalities depending on contextual factors, policy design and policy implementation. The risk of negative outcomes is greater in contexts characterized by high levels of poverty, corruption and economic and social inequalities, and where limited action is taken to identify and mitigate potentially adverse side-effects.

Key policy insights

- The risk of adverse social outcomes associated with climate change mitigation policies, including worsening inequality, increases as countries ratchet up their ambition to meet the Paris Agreement targets. Many policies that have so far only been piloted will need to be up-scaled.
- Negative inequality impacts of climate policies can be mitigated (and possibly even prevented), but this requires conscious effort, careful planning and multi-stakeholder engagement. Best results can be achieved when potential inequality impacts are taken into consideration in all stages of policy making, including policy planning, development and implementation.
- Climate change mitigation policies should take a pro-poor approach that, in best case scenarios, can also lead to a reduction of existing inequalities.

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Introduction

In 2015, the world adopted two major international agreements – the Paris Agreement and the 2030 Agenda for Sustainable Development. The objectives of the Paris Agreement and the Sustainable Development Goals (SDGs) are mutually reinforcing and co-dependent: climate change poses a risk to economic development, and a successful low-carbon transition depends on social, economic and environmental development (Carraro, 2016; Gomez-Echeverri, 2018; Hallegatte et al., 2016; von Stechow et al., 2015). These synergies

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create opportunities for using climate change mitigation policies to achieve SDGs and positive equality outcomes, and to facilitate a 'just transition' to a low-carbon economy.

Climate change mitigation policies are known to have various types of co-impacts, both positive (co-benefits) and negative (adverse side effects), including in relation to the SDGs. Co-benefits of climate change mitigation policy for the SDGs are increasingly cited by policymakers as part of the motivation for climate action, especially in developing countries where basic development objectives often outweigh the importance of climate objectives (e.g. Hallegatte et al., 2016; Ürge-Vorsatz, Tirado Herrero, Dubash, & Lecocq, 2014; von Stechow et al., 2015), and some attempts have been made to develop conceptual frameworks that capture these co-benefits in cost-benefit analyses (e.g. Dubash, Raghunandan, Sant, & Sreenivas, 2013; O'Neill et al., 2014; Spencer, Pierfederici, Waisman, & Colombier, 2015). However, successful policy integration also requires a comprehensive understanding of the adverse side-effects that may negatively affect countries' progress towards the SDGs, including SDG-10 (reduced inequalities) (e.g. Ekener-Petersen, Höglun, & Finnveden, 2014; Jakob & Steckel, 2014; Marcu & Vangenechten, 2018; The Intergovernmental Panel on Climate Change [IPCC], 2014). Yet the methodological challenges of capturing the full extent of various types of co-impacts have largely prevented their systematic incorporation in most quantitative policy analyses (Klinsky & Winkler, 2018; Stern, 2016).

Social impacts and inequality outcomes of climate change mitigation policies have so far received little attention, with detailed discussions about them often being narrowly focused and scattered across disciplines, typically examining the impacts of a given policy in a specific geographical context and from a certain disciplinary view (e.g. Hallegatte & Rozenberg, 2017; Klinsky et al., 2016; Marcu & Vangenechten, 2018; Petrini, Vieira Rocha, & Brown, 2017). This paper provides a synthesis of evidence on inequality and distributional effects of social co-impacts of climate change mitigation policies to improve our understanding of how policy design and implementation can influence disparities of wellbeing, especially for the most vulnerable. The purpose of this synthesis is to enable policy makers to more easily consider the need identified by Klinsky et al. (2016) and Reckien et al. (2018) to incorporate equity and inequality concerns in climate change policy analysis.

Our underlying logic guiding the discussion follows Ürge-Vorsatz et al. (2014, p. 559): even if the magnitude of the co-impacts cannot be accurately assessed (or the net impact at national/global level is negligible), awareness of the direction of the impacts and of any severely affected population sub-groups can aid decision making. Making information on possible inequality outcomes readily available in a synthesized format is also becoming increasingly important as countries ratchet up their ambition beyond their current nationally-determined contributions (NDCs) to meet the Paris Agreement targets (Michaelowa, Allen, & Sha, 2018). Although the influence of contextual factors should not be forgotten, lessons drawn from small-scale ex-post analyses that highlight the *potential* risks and opportunities can provide the evidence to help policy makers avoid negative outcomes and maximize co-benefits, including positive equality outcomes.

The paper is organized as follows. The concepts of inequality, equity and justice in the context of climate change policy are discussed in Section 2. Section 3 provides a brief description of the research methodology and a summary of the existing literature on social co-impacts of specific climate change mitigation policies. Section 4 analyses the inequality outcomes of selected policies, followed by a discussion. Section 5 concludes.

Inequality, equity and climate change mitigation

'Inequality' refers to the unequal rewards or access to opportunities for different individuals within a group, or between groups within society (Marshall, 1998). Inequalities can take various forms at various spatial scales. Much of the literature on inequality focusses on wealth and income (economic inequality), health and access to health services (health inequality) or uneven access to opportunities for social, economic and political participation along the lines of socially defined categories, such as gender, age, ethnicity, religion, ability or class (social inequalities). In reality, social categories intersect and overlap (Alber, Cahoon, & Röhr, 2017), and inequalities are often mutually reinforcing – for example, wealth inequalities can influence health status, access to educational opportunities and housing, and locational choice (Reckien et al., 2018; The Marmot Review, 2010). Membership of a certain social category may also increase the likelihood of facing discrimination which – together with inequalities in terms of health, wealth and access to opportunities – increase people's vulnerability and reduce their capacity to adjust to changing circumstances (Reckien et al., 2018).

In policy discourse, inequality is generally regarded as undesirable, with economic inequality in particular increasingly recognized as a barrier to economic growth and political stability (Dabla-Norris, Kochhar, Suphaphiphat, Ricka, & Tsounta, 2015; OECD, 2015; Pickett & Wilkinson, 2015; Piketty, 2014; Stiglitz, 2015), international development (Ramos Pinto, 2013) and greater climate ambition (Klinsky & Winkler, 2018). Alleviating inequality and poverty thus constitute important macroeconomic and development objectives (OECD, 2015; Ramos Pinto, 2013).

Equality (or inequality) is often discussed in relation to 'equity', but these two concepts have an important qualitative difference. While 'equal' distribution would imply allocating the same resources[1] to all, 'equitable' distribution involves allocating resources according to the level of need, prioritizing those whose level of need is perceived to be greater. 'Equity' and 'equitable' outcomes are therefore achieved through processes that account for existing inequalities, i.e. unequal starting points, and strive to overcome these. In social policy, 'equity' entails designing and implementing policy in a way that actively seeks to improve the circumstances of the most vulnerable groups (Ekins, Pollitt, Barton, & Blobel, 2011; Reckien et al., 2018).

In climate change discourse, inequality and equity are typically mentioned in reference to the inequitable distribution of the costs (including economic and social) and benefits of climate change and climate change policies, often across the globe. The poorest and marginalized populations (such as indigenous peoples) are least responsible for past greenhouse gas emissions (benefits), most vulnerable to climate change (costs), and possess least resources to adapt to extreme climate events and rising temperatures (Brugnach, Craps, & Dewulf, 2017; Klinsky & Winkler, 2018; Klinsky et al., 2016; Marino & Ribot, 2012; Ramos-Castillo, Castellanos, & Galloway McLean, 2017). In recent years, growing attention has been directed to the risks associated with climate change that may exacerbate inequalities, and the barriers this would present to the achievement of the SDGs (e.g. Hallegatte & Rozenberg, 2017; Lövin & Bamsey, 2017; Winsemius et al., 2018).

Less attention, however, has been given to the potentially adverse inequality effects of climate change mitigation policies (e.g. Alber et al., 2017; Brugnach et al., 2017; Klinsky & Winkler, 2018; Ramos-Castillo et al., 2017), although research in this field has progressed in the second half of 2018. For example, a recent assessment of equity and environmental justice in the context of urban climate change drew attention to the way in which existing inequalities result in differential vulnerability to climate change, highlighting a need for urban climate policies to 'include equity and environmental justice as primary long-term goals' (Reckien et al., 2018, p. 174). The concept of 'just transition', which emerged to stress the need for equity and fairness to underpin the transition to a low-carbon economy, has also gained momentum over the past few years. Expanding from the initial focus on industrial transition and workers' rights, just transition is now increasingly acknowledged as having a remit across the various aspects of the transition, including the distributional impacts of climate change policy more broadly (IMPACT, 2017; International Labour Organisation, 2015; Jakob & Steckel, 2014; Newell & Mulvaney, 2013). The importance of considering social aspects to gain approval for the low-carbon transition and the necessity of providing appropriate support for negatively affected individuals and communities was recognized in the Solidarity and Just Transition Silesia Declaration adopted at the Katowice Climate Change Conference (COP24) in December 2018.[2]

Although scholarly literature distinguishes between various forms of equity, the focus of this paper is on outcome-based aspects of equity as defined by Reckien et al. (2018), i.e. equitability[3] in the distribution of costs and benefits of policies between individuals from different social groups or income categories, between households within a community or communities in a given area. Outcome-based equity is acknowledged as important in developed countries as well as emerging economies and developing countries (Reckien et al., 2018). Some groups, such as migrants, ethnic minorities, and low-income households are almost universally less involved in decision-making processes, whilst being most exposed to the negative impacts of poorly designed and/or implemented policies (Bhatta, Karna, Dev, & Springate-Bagniski, 2008; Brugnach et al., 2017; Marino & Ribot, 2012; Nhantumbo & Camargo, 2015). The Paris Agreement and European guidelines for policy preparation highlight the need to consider the effects of climate change and their mitigation strategies on vulnerable populations (Bee, 2017; European Commission, 2015; UNFCCC, 2015). Yet there is no internationally shared, explicit, definition for 'vulnerable populations' (Alber et al., 2017; Mazorra, Lumbreras, Fernández, & de la Sota, 2017).

Building on the notion of outcome-based equity, the approach to existing literature in this paper was informed by an assumption that equitable climate change mitigation policies can result in reduced levels of inequality between individuals, social groups, households and communities. Inequitable policies, on the other hand, may exacerbate existing inequalities. Although an extremely important topic for global climate change policy discussions, equitable distribution of costs and benefits between countries is beyond the scope of this paper.

Method and coverage

Approach

The vast quantity of academic papers and reports that mention 'climate change mitigation policy', 'social impacts' and 'inequality' or 'equitability' means that it was not possible for this synthesis of literature to include all relevant studies. Therefore, a selection process was designed, consisting of four stages. The first stage involved a review of high level literature on climate change mitigation policies to identify three main categories, based on their primary objective: (1) policies to reduce energy consumption; (2) policies to increase the deployment of renewable energy; and (3) policies to develop and preserve natural carbon 'sinks' through forest conservation. This categorization has been used to organize and summarize evidence in Table 1S (on co-benefits and adverse side-effects, provided in the Supplementary Material), and Table 1 (on equality outcomes) in Section 4 of this paper. The specific policies selected for more detailed discussion were chosen based on the availability of evidence regarding social co-impacts with potential inequality implications.

The second stage of the process consisted of a review of general policy literature that provides detailed descriptions of the various types of policy instruments (e.g. economic, regulatory, etc.). We then searched the existing literature for examples of how the various types of policy instruments have been utilized in the field of climate change mitigation, under the three broad policy categories identified in stage one, across various sectors of the economy.

The third stage involved focussed searches of all available literature on co-benefits and adverse side effects of policies that have been associated with specific policy instruments and sectors identified in stage two (e.g. economic policies to reduce emissions from the transport sector), organizing the information under the three main climate change mitigation policy categories defined in stage one. We started by identifying broad evidence reviews of the co-impacts of climate change mitigation policies (e.g. Ürge-Vorsatz et al., 2014; von Stechow et al., 2015), including relevant contributions to the IPCC's Fifth Assessment Report (AR5) Working group III (2014). Following this, we searched for smaller-scale studies focusing on specific social outcomes linked to specific types of policy instruments, again focussing only on climate change mitigation policies. Because of the extensive amount of literature available on some policy instruments (such as various economic instruments, certain regulations and forest protection initiatives), we did not continue searching for additional sources once at least three consecutive papers failed to provide evidence that had not been cited elsewhere. Some of this literature also offered suggestions for maximizing social co-benefits or minimizing potential adverse side-effects (see Supplementary Material for the full list of references).

The final stage of the process involved specific searches on inequality outcomes using terms such as 'inequality', 'equality', 'equitable', 'inequitable' and 'poverty' in combination with specific policies and policy instruments. This final stage also entailed a certain degree of analytical thinking to draw out the potential distributional impacts in terms of health, wealth and economic outcomes, gender and ethnic equality based on who may be positively or negatively affected by the policies, even if the study in question did not explicitly mention inequality outcomes. In this process, we assumed that inequality would increase if individuals, households or communities regarded as 'low income', 'poor' or 'vulnerable' were negatively impacted (for example, as a result of increased cost of basic consumer goods or restricted access to livelihoods). Policies that improve the welfare or the opportunities available to low income, poor or vulnerable populations were assumed to reduce inequality. The evidence presented in this paper draws primarily from the third and fourth stages of the research process.

Co-benefits and adverse side-effects

Existing literature shows that most policies can generate both co-benefits and adverse side-effects (Klinsky & Winkler, 2018; Ürge-Vorsatz et al., 2014; von Stechow et al., 2015), with the direction of co-impacts and inequality outcomes depending on contextual factors, policy design and implementation, and action that is taken to address the potentially negative social co-impacts. The evidence on social co-benefits and adverse side-effects, as well as potential measures to mitigate adverse side-effects or to maximize the co-benefits, provided the basis for further analysis on potential inequality impacts. The co-impacts are synthesized in Supplementary Material Table S1 and not discussed further in the main body of the paper. The main body of this paper draws on the literature on social co-impacts but the key focus is on the inequality outcomes of climate change mitigation policies.

Inequality impacts

Pathways to inequality outcomes

Many of the inequality impacts of climate change mitigation policies emerge through complex dynamic relationships and feedback loops, primarily through co-impacts, which are difficult to predict and estimate (Ürge-Vorsatz et al., 2014). The effects of policy design and contextual factors on policy outcomes are already generally acknowledged in policy analysis, although the importance of contextual factors and their effect on distributional impacts is still frequently overlooked or poorly understood, especially in quantitative modelling (Chiroleu-Assouline & Fodha, 2014; Ekener-Petersen et al., 2014; International Labour Organisation, 2015; Marino & Ribot, 2012; Rao, van Ruijven, Riahi, & Bosetti, 2017; Ürge-Vorsatz et al., 2014).

Figure 1 builds a conceptual framework that illustrates the processes leading to social co-impacts and equality outcomes. The relationships that are widely acknowledged in policy analysis are shown as solid black lines, while the relationships that are less commonly considered, but often influential in generating social co-benefits and positive inequality outcomes, are shown as dashed lines. 'Policy design' refers to the design of a specific climate change mitigation policy. 'Mitigating action', on the other hand, refers to practices or complementary policies that can be implemented parallel to climate change mitigation policies to maximize their co-benefits or to minimize adverse side-effects.

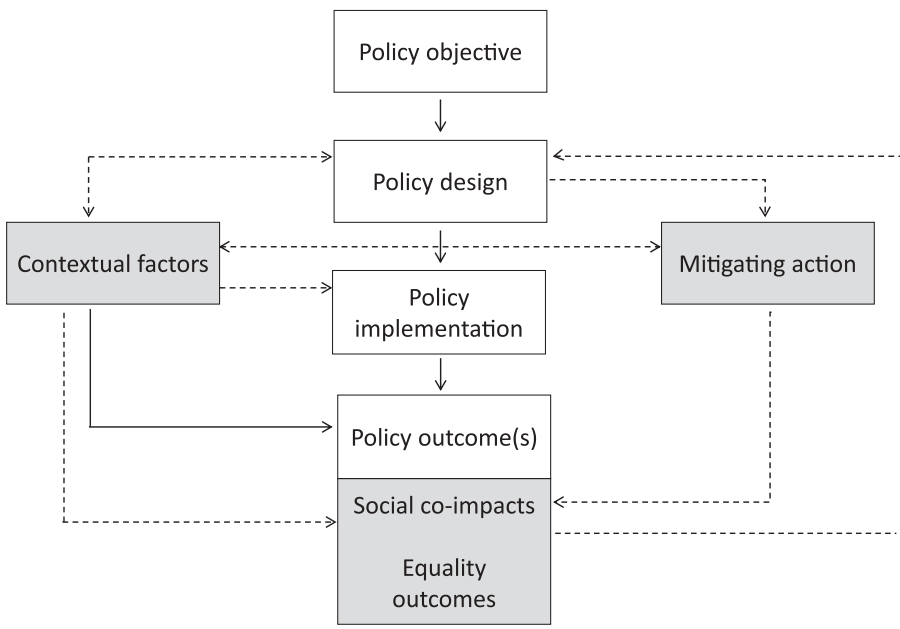

Figure 1. Conceptual framework of the processes leading to social co-impacts and equality outcomes. Source: Authors' analysis.

As shown in Figure 1 and Table S1 (in Supplementary Material), positive outcomes tend to emerge in situations where policy design, policy implementation and mitigating action are inclusive and informed by contextual factors. This applies across various types of policies and sectors, including energy access projects using renewable energy technologies, public transport policies, forest protection initiatives, large-scale renewable energy infrastructure projects, regulations and economic policies that may result in increasing living costs (See Table S1 for further detail). Existing knowledge from previous studies can help to identify risks and opportunities for maximizing social co-benefits and positive inequality outcomes, and to avoid negative impacts by informing measures to mitigate and prevent any potentially adverse side-effects.

Table 1 provides a synthesis of the evidence from existing literature on the potential impacts of specific types of climate change mitigation policies on inequality, including an overview of the factors that have been regarded as influential in determining the extent and direction of inequality outcomes. The upward arrows indicate potential for positive equality impacts (reduction in inequality), while the downward arrows imply potential for negative equality impacts (increase in inequality). The last column on the right lists actions that can help increase the likelihood and extent of positive equality outcomes and to prevent or minimize inequalities.

Health equality

As shown in Table 1, all climate change mitigation policies included in the analysis in this paper have the *potential* to improve health equality, largely as a result of reduced air pollution and greater living comfort (due to energy efficiency improvements – e.g. see European Commission, 2016; Hills, 2012; The Marmot Review Team, 2011), and indirectly as a result of policies that improve households' financial circumstances. The positive impacts are the greatest when energy efficiency improvements are implemented in fuel-poor homes or among households that previously underutilized heating (or cooling) services due to financial constraints. Improved ability of such households to afford a comfortable indoor temperature can reduce health and other social inequalities by improving living conditions and household finances, leading to better educational performance and improved overall wellbeing (e.g. European Commission, 2016; Grimes et al., 2012; Howden-Chapman & Chapman, 2012; Miller, Vine, & Amin, 2017; OECD, 2015; Smith, 2010; Willand, Ridley, & Maller, 2015).

Decreases in air pollution from transport can reduce existing health inequalities especially in large cities that presently struggle with high levels of air-pollution (Buekers, Van Holderbeke, Bierkens, & Int Panis, 2014; Parrish, Singh, Molina, & Madronich, 2011; Wenwei et al., 2017; World Health Organization, 2018). The greatest air quality benefits will accrue primarily to lower income households who are most likely to live in locations affected by poor air quality from road transport (e.g. Hajat, Hsia, & O'Neill, 2015; Pratt, Vadali, Kvale, & Ellickson, 2015).

However, not all climate change mitigation policies realize their potential to achieve positive health impacts and, in some instances, poorly implemented policies result in negative health outcomes. For example, insulation improvements that are carried out by unskilled traders can reduce air flows and damage indoor air quality, outweighing the positive health effects of improved indoor living comfort (European Commission, 2016; Howden-Chapman & Chapman, 2012; Miller et al., 2017). Similarly, failure to compensate involuntarily relocated populations adequately – for example by providing them access to affordable clean energy, irrigation and better health services – can lead to mental and physiological health problems as a result of community breakdown, environmental degradation, ecological changes, in-migration, social problems and loss of land and livelihoods (e.g. Cernea, 2004; Lerer & Scudder, 1999). The mental and physical health of communities in and around REDD and REDD+ areas may also be negatively affected, particularly if the forest protection initiatives are not accompanied by improved access to health services. However, most impact analysis on affected communities in relation to forest protection initiatives and large infrastructure projects such as dams tends to focus on environmental impacts, material wealth and cultural issues, with significantly less attention being dedicated explicitly to health impacts. Improved understanding and awareness of especially the mental health impacts of projects that result in involuntary relocation or loss of traditional livelihoods would be instrumental in enabling policy makers to better pre-empt the potentially adverse health outcomes of such projects through the implementation of effective benefit-sharing mechanisms that consider the potentially negative health implications (e.g. Cernea, 2004, 2008).

Table 1. Summary of potential inequality impacts of selected climate change mitigation policies.

Overall policy objective	Policy measure	Potential equality outcome(s)					Factors influencing the extent and direction of impacts
		Health	Wealth/ income	Gender	Ethnic	Risk of conflict	
Reduced energy consumption	Programmes to improve energy efficiency in homes (a)[a]	↑↓	↑↓	↑		Low	Targeting of fuel poor and low-income households can maximise co-benefits; policy design and quality of home improvements important to avoid adverse outcomes, such as health problems and growing cost of electricity
	Removal of fossil fuel subsidies (b)	↑↓	↓	↑↓		Low	Mechanisms for compensating vulnerable consumers for potential losses to reduce regressive distributional impacts
	Improved public transport networks (c)	↑	↑	↑	↑	Low	Consultation at planning stage to ensure that the proposed changes address the transport needs of the poor without creating cost barriers
	Financial penalties for private car use (e)	↑	↓			Low	Exemptions for poor rural households who have limited access to public transport
	Carbon pricing (f)	↑↓	↓	↓	↓	Medium	Mitigating action (through revenue recycling) to reduce regressive distributional impacts
Renewable energy policies	Large-scale Renewable energy (RE) projects (carbon pricing and obligations) (g)	↑	↑			Medium	Strategic location of large-scale RE projects to maximize employment benefits (and mitigate the impact of job losses in the fossil fuel industry); the direction of some impacts depends on compensatory measures to mitigate the impact on energy prices among the poorer segments of society
	Hydroelectric dams (g)	↑↓	↓		↓	High	Consultation and sufficient compensation to displaced populations to help retain similar quality of life; Support to receiving communities to prevent negative social outcomes
	Financial support for small-scale RE generation (feed-in tariffs/premiums) (h)	↑	↑↓			Low	Measures to ensure equitable access to grants for small-scale / on-site RE generation; measures to mitigate the impact of feed-in tariffs etc. on energy prices among the poorer segments of society
	Closure of coal, fuel and gas plants and coal mines (b,f,g)	↑↓	↓			High	Severity of the employment impacts (and associated negative side-effects) depend on how process is managed, investment in re-training and efforts to diversify the affected economies prior to closure, government funding, incentives for investors, coherent transition strategy and diversification that draws on skills of the existing workforce can mitigate negative impacts.
	RE systems to improve access to energy in remote communities (i)	↑	↑↓	↑	↑	Medium	Measures to ensure equitable access to new technologies (e.g. financial support through subsidies or micro-credit for poorer households); benefits can be maximised by incorporating RE projects with other

(*Continued*)

Table 1. Continued.

Overall policy objective	Policy measure	Potential equality outcome(s)					Factors influencing the extent and direction of impacts
		Health	Wealth/ income	Gender	Ethnic	Risk of conflict	
							development initiatives; strategic inclusion of women; inclusion of measures to incentivise commercial activity enabled by electricity access.
	Measures to support electrification of transport (j)	↑	↑↓			Low	Action to ensure that costs will not form an access barrier; attention to ensure costs will not reduce social spending in other essential public-sector services for low-income groups
	Disincentives to own or operate ICE vehicles (j)	↑	↓			Low	Exemptions for poor/rural households with limited access to public transport; fiscal incentives/means-tested subsidies to improve access to electric/hybrid vehicles for poor households
	Policy measures to incentivise the production and use of biofuels (k)	↑↓	↑↓			Medium	Negative impacts (food security and food prices) can be mitigated by social and environmental sustainability certification and measures to control land use conversion; measures to enable smallholders to engage in biofuel production can reduce the risks of exacerbated inequality.
Policies to develop and preserve carbon 'sinks'	Forestry carbon projects (REDD, REDD+, PES) (l)	↑↓	↑↓	↑	↑↓	Medium/ high	Clear (and enforced) communal land tenure or ownership rights for affected communities; the inclusion of **all** affected local populations in the decision-making process; equitable distribution of financial benefits or community projects fund (where applicable) essential to realize co-benefits and to avoid negative side-effects

[a]The letters in brackets refer to the full list of references that underpin the claims in the table for each policy type – please see the Supplementary Material for the full list of references.

Economic equality

Positive outcomes for economic equality (reduction in economic inequality) emerge when policies reduce essential expenditure or improve opportunities for economic participation among poorer households, regions or countries. Benefits can occur because of various different types of policies, such as new opportunities for income generation in deprived areas through participation in forest carbon markets (e.g. Bhattacharya, Pradhanb, & Yadavb, 2010; Jindal, Kerr, & Carter, 2012; Stringer et al., 2012a), improved access to electricity (e.g. Bhattacharyya, 2013; Borges da Silveira Bezerra et al., 2017; Sanchez, Torres, & Khalid, 2015; UN General Assembly, 2015; Valer, Mocelin, Zilles, Moura, & Nascimento, 2014), better public sector transport connectivity (Jennings, 2016; World Health Organization, 2011) and strategic location of large-scale Renewable Energy Systems (RESs) in areas with limited employment opportunities (e.g. Cernea, 2008; European Commission, 2016, 2017; International Labour Organisation, 2018; Moraes, Oliveira, & Diaz-Chavez, 2015; Sacchelli, 2016).

The transition to a low-carbon economy will create new jobs in renewable energy generation (IRENA, 2018), in the public transport sector (e.g. International Association of Public Transport, 2013; Jennings, 2016; Sims et al., 2014; World Health Organization, 2014), in retrofitting existing buildings, and the development and production of energy efficient technologies (e.g. European Climate Foundation, 2014; European Commission, 2016). In developing countries, many of these new jobs are likely to be more secure and better paid than previous

employment opportunities in the 'grey' economy (e.g. International Association of Public Transport, 2013; Just Transition Centre, 2017; Ürge-Vorsatz, Arena, Tirado Herrero, & Butcher, 2010).

Economic inequality tends to rise when policies have regressive distributional impacts through, for example, increasing the cost of essential goods, such as food, energy or mobility (e.g. Ekins et al., 2011; Frondel, Sommera, & Vance, 2015; Grösche & Schröder, 2014; Hayer, 2017; Lehtonen, 2011; Marcu & Vangenechten, 2018; OECD, 2015; Rosenow, Platt, & Flanagan, 2013; Sovacool, 2017; van der Horst & Vermeylen, 2011), reducing employment opportunities (e.g. IMPACT, 2017; International Labour Organisation, 2015; IRENA, 2016; Mercure et al., 2018) or limiting people's access to natural resources (e.g. Marino & Ribot, 2012; Smith et al., 2014; Work, 2017).

Any increase in the price of basic consumer goods (such as food and electricity) and services (such as public transport) will affect most severely the poorest and most vulnerable members of society who spend a large proportion of their income on such goods, and who rely more heavily on public transport for their mobility needs (Jennings, 2016; Ürge-Vorsatz et al., 2014; World Health Organization, 2011). Low-income households also tend to spend a larger proportion of income on energy-intensive products (e.g. space and water heating, electricity, fuel) and lack options for substitution (e.g. Benes, Cheon, Urpelainen, & Yeang, 2015; Ekins & Lockwood, 2011; Hayer, 2017; OECD, 2015; Wang, Hubacek, Feng, Wei, & Liang, 2016). Policies that have regressive distributional impacts can also exacerbate health inequalities (Ekins & Lockwood, 2011; Walpole, Rasanathan, & Campbell-Lendrum, 2009).

Transition-related job losses are likely to be locally concentrated, often in specific areas, sectors and social groups that may have already been negatively impacted by deindustrialization, globalization and the global financial crisis. Geographically concentrated large-scale job losses can have severe direct and indirect adverse socioeconomic impacts, including mass unemployment, loss of income, economic and population decline and social unrest (e.g. Just Transition Centre, 2017; Kowalska, 2015; Taylor, 2015; Vona, 2019), potentially exacerbating wealth disparities and access to economic opportunities between regions and countries. At the global scale, the adverse impacts are likely to be most acutely felt in energy-exporting developing countries (Cust, Manley, & Cecchinato, 2017; Mercure et al., 2018).

Projects such as those under the REDD (Reducing Emissions from Deforestation and Forest Degradation in developing countries) and REDD+ programmes can exacerbate income inequalities and increase the risk of conflict if the financial benefits are not equally distributed, if property rights are granted to only some of the local beneficiaries, or if marginalized groups such as women, indigenous groups or distant forest users (whose participation may be constrained by informal rules, customary laws, social norms, and bias) are not given opportunities to engage with the projects (e.g. Bee, 2017; Duker, Tadesse, Soentoro, de Fraiture, & KemerinkSeyoum, 2018; Khatun et al., 2015; Nhantumbo & Camargo, 2015; Westholm, 2016; Work, 2017).

Restrictions to participation, such as selective entry requirements or a need for large up-front investment, can also increase the likelihood of economic inequality. Negative equality outcomes because of inequitable access have been reported in relation to renewable electricity programmes (e.g. Mazorra et al., 2017; Shoaiba & Ariaratnam, 2016; Yaqoot, Diwan, & Kandpal, 2016), forest protection initiatives (Bhatta et al., 2008; Robinson, Albers, Lokina, & Meshack, 2016) and biofuel cultivation (Ekener-Petersen et al., 2014; Garvey & Barreto, 2016). However, mitigating strategies such as subsidies, exemptions and various types of revenue recycling mechanisms can often be utilized effectively to prevent or minimize adverse economic outcomes. For example, measures such as micro-credit, extended payment schedules, grants and interest-free loans can be used to make electricity access more affordable and to facilitate equitable access to new energy saving (and economic) technologies (Gomez, Tellez, & Silveira, 2015; Lahimer et al., 2013; Yaqoot et al., 2016).

Gender and ethnic equality

Policies that reduce economic inequality can also reduce gender and ethnic inequalities, especially in contexts where female-headed households and minority ethnic populations are over-represented in the low-income groups.

Positive gender equality outcomes emerge when policies improve women's access to economic or educational opportunities or reduce the burden of domestic workload, especially in rural communities where traditional gender roles and high domestic workload have previously limited opportunities open for women

(e.g. Mazorra et al., 2017; Sanchez et al., 2015; Sapkota, Lu, Yang, & Wang, 2014). For example, energy access through RESs can help progress towards gender quality as well as poverty reduction and climate objectives (Mazorra et al., 2017). The impact on gender inequality tends to be greatest when gender concerns are actively incorporated in policy design and implementation, and conscious efforts are made to enable women to take an active role and improve their circumstances (e.g. D'Silva & Nagnath, 2002; ENERGIA, 2010).

Ethnic equality outcomes are also largely determined by how and where policies are implemented. In the existing body of literature, such impacts have been most frequently cited with specific reference to indigenous populations (e.g. Brugnach et al., 2017; Finley-Brook & Thomas, 2010; Ramos-Castillo et al., 2017; van der Horst & Vermeylen, 2011) and the urban poor in contexts where poverty and ethnicity are interlinked (e.g. Fecht et al., 2015; Hills, 2012; Jennings, 2016). Large-scale ethnic inequalities tend to arise when members of a specific ethnic community are forcibly relocated or lose access to traditional livelihoods and cultural sites to make way for large-scale infrastructure developments or forest protection initiatives (e.g. Hess & Fenrichb, 2017; Muggah, 2015; Naab, Nunbogu, Diniye, & Dongzagla, 2016; Renewable Energy Policy Network for the 21st Century, 2017; Stringer et al., 2012a; van der Horst & Vermeylen, 2011). However, forest conservation initiatives can improve ethnic equality if communal land rights are formally acknowledged and the financial and other benefits from project participation exceed any negative impacts due to loss of livelihoods for the local populations (e.g. Bhattacharya et al., 2010; Jindal et al., 2012; Khatun et al., 2015; Robinson, Holland, & Naughton-Treves, 2014; Smith et al., 2014; Stringer et al., 2012a). In developing countries, access to RESs and small-scale biofuel production can help indigenous communities and other remote rural populations to achieve greater energy security and better living standards, reducing both ethnic and regional economic disparities (e.g. Bhattacharyya, 2013; Borges da Silveira Bezerra et al., 2017; Gomez et al., 2015; Renewable Energy Policy Network for the 21st Century, 2017; Valer et al., 2014).

Discussion

This paper does not present generalizable results depicting a set of universally applicable pathways to equality outcomes. Instead, we have sought to synthesize evidence from multiple sources and contexts to encourage policy makers to better understand the range of equality/inequality outcomes that climate change mitigation policies may have. We have included evidence of the impacts of policies on *several types* of inequalities at *different scales* (individuals, households, social groups and communities) to offer a broad overview of the various *potential* equality outcomes acknowledging specific contextual characteristics. It is important to note that the materialization of *potential* outcomes, both positive and negative, depends on contextual factors and the way in which policies are implemented.

The aim of this synthesis is to contribute to the climate change policy discourse and to provide information to enable policy makers to engage in more equitable design and implementation of climate change mitigation policies; to avoid the risks of 'inequitable' policy design; and to realize the opportunities for using climate change mitigation policy and synchronized implementation of complementary policies to reduce existing inequalities. In this section, we have drawn on our conceptual framework (see Figure 1, above) and evidence from the reviewed literature to discuss ways of avoiding negative inequality outcomes. These guidelines can be classified under three main headings: inclusive design and implementation; a pro-poor approach; and strategic thinking and support.

Inclusive design and implementation refer to a practice of carefully considering who might be impacted by a given policy, and involving these groups or communities in the decision-making process and project delivery (e.g. Brugnach et al., 2017; Cotula, Dyer, & Vermeulen, 2008; Gambhir, Green, & Pearson, 2018; Jennings, 2016; Nhantumbo & Camargo, 2015). Tools such as community consultations can be used to identify interests and concerns, potentially adverse side-effects and possible co-benefits. Especially when delivering a project in a foreign context, community consultations can enable project organizers to tap into local knowledge and to use this information to guide their action, including measures to minimize and mitigate any adverse side-effects and to determine how best to maximize potential co-benefits and address existing inequalities (Nhantumbo & Camargo, 2015; Peskett, Huberman, Bowen-Jones, Edwards, & Brown, 2008; Reed & Varghese, 2007; Stringer et al., 2012a). Any consultation process must be inclusive and comprehensive, involving people from across

the community, including women, minority ethnic groups, poorer members of the community and people living on the edges of the affected areas (e.g. ENERGIA, 2010; Khatun et al., 2015; Larson et al., 2015; Mazorra et al., 2017).

In project delivery, the local workforce should be utilized where possible and efforts should be made to ensure equitable distribution of benefits at the local level. For example, the socio-economic gains from forest carbon projects and forest protection initiatives are greatest when the project design and set-up costs enable all (including the poorest) local residents to participate (Greiner & Stanley, 2013; Jindal et al., 2012; Peskett, Schreckenberg, & Brown, 2011) and the financial rewards are equitably distributed or directed towards civic projects (e.g. for improved water sources or housing), livelihood projects (e.g. agro-forestry systems) or social benefit funds (e.g. Bhattacharya et al., 2010; Reynolds, 2012). However, the risk of negative social and distributional outcomes is high in contexts with high levels of poverty, corruption or economic and existing inequalities (e.g. Cai, Mu, & Chen, 2014; Hunsberger, Bolwig, Corbera, & Creutzig, 2014; Larson et al., 2015; Petrini et al., 2017; Robinson et al., 2016; Westholm, 2016), and where no action (or limited action) is taken to identify and mitigate potentially adverse side-effects. In such contexts, inclusive design and implementation is particularly important but not always possible.

A pro-poor approach entails systematically considering how a policy can be used to benefit the poorest and taking active measures to address any regressive outcomes. This may require a holistic approach (Sills et al., 2014). For example, policy makers need to ensure that proposed climate change mitigation measures and activities are not financed by reallocation of public funds from social spending, leaving the lowest income groups financially worse off (Jennings, 2016; Lucas & Pangbourne, 2014). Policy measures must also be accompanied by sufficient mitigating measures to limit the extent of any regressive impacts and to ensure equitable access, including compensating for any restrictions to livelihood strategies by measures that provide alternative economic opportunities (Cernea, 2008; Nhantumbo & Camargo, 2015; Sills et al., 2014 – see also Table S1 in Supplementary Material; Work, 2017). Furthermore, pro-poor policies can actively seek to address economic inequalities, for example by targeting energy efficiency improvements at low-income households (e.g. European Commission, 2016; Grimes et al., 2012), choosing the location for large-scale renewable energy projects to create jobs in areas that have high unemployment (e.g. De la Rua et al., 2015; Rio & Burguillo, 2008; Sacchelli, 2016) or designing improvements to public transport systems to address the needs of the lowest-income areas (Jennings, 2016).

The co-benefits from small-scale initiatives such as localized energy efficiency improvement programmes can be maximized by making new job opportunities available to disadvantaged areas and population sub-groups, while simultaneously designing programmes to reduce fuel poverty (which tends to be concentrated in the same areas as high unemployment) (Ürge-Vorsatz et al., 2010). Distribution of employment impacts, however, depends heavily on equitable access to training opportunities. It is also important to note that effective targeting of energy efficiency improvement programmes to those in greatest need is often complex, time consuming and costly (e.g. Rosenow et al., 2013).

Strategic thinking and government support can be used to minimize the adverse long-term consequences of the transition to a low-carbon economy, such as job losses in the fossil fuel industry or other sectors of the economy that may be negatively affected through carbon pricing or because of other climate change mitigation measures/regulations (e.g. Campbell & Coenen, 2017; Just Transition Centre, 2017; The Investor Group on Climate Change, 2017). Repurposing obsolete sites and retraining newly redundant workers may help to mitigate the negative economic impacts of mine or plant closures (Department of Energy and Climate Change, 2015; HM Government, 2016), although examples of successfully completed projects to date have so far been reported primarily in the press (e.g. BBC News, 27 April 2018; Spiegel Online, 05 March, 2010) and are still to be evaluated in the academic literature. Government funding, incentives for investors, and coherent strategy for transition and diversification that draws on the skills of the existing workforce are all essential in facilitating the process of economic restructuring and mitigating the effects of industrial decline (Campbell & Coenen, 2017). Existing literature evaluating the success of retraining programmes to address the changing needs of the labour market, for example as a result of deindustrialization and digitalization, may provide useful insights into utilizing such programmes for achieving positive equality outcomes.

It is important to acknowledge that following the guidelines discussed above is not always possible, nor do they necessarily provide a sufficient 'roadmap' to prevent all adverse outcomes. While many of the suggestions above can lead to more equitable design and implementation of climate change mitigation policies, contextual factors may restrict the effectiveness or feasibility of some of the recommended actions listed here. For example, not all workers can be retrained, not all households are able to move to take up new employment opportunities, and not all obsolete sites lend themselves well to alternative purposes. As in previous economic and social transitions, some possible outcomes cannot be mitigated simply because they cannot as yet be predicted (e.g. Fouquet & Pearson, 2012). Likewise, the exact scale and nature of change in economic systems and the magnitude of policy impacts is difficult to estimate.

Conclusions

Awareness and consideration of 'justice' and 'equality' in managing the transition to a low-carbon economy are likely to become increasingly relevant as climate change mitigation policies become more comprehensive, extensive and ambitious to achieve the Paris Agreement's targets (Michaelowa et al., 2018; Millar et al., 2017). The evidence presented in this paper highlights that factors such as 'where', 'what' and 'how' all matter when seeking to identify and manage the potential inequality impacts of climate change mitigation policies. Well designed and carefully implemented climate change mitigation policies have the potential to generate social and economic co-benefits that can reduce poverty and provide opportunities to address gender, health and economic inequalities. However, the co-impacts of climate change mitigation will not be exclusively positive or equally distributed. Some people are likely to lose out unless measures are taken to ensure equitable access and to actively mitigate inequitable outcomes. Poor and marginalized population sub-groups that are highly exposed to the negative impacts of climate change (and thus among the greatest beneficiaries of successful efforts to limit global warming to 1.5–2°C), are also most vulnerable to the adverse effects of poorly designed or inadequately implemented climate change mitigation policies.

Some climate change mitigation measures that are currently underdeveloped, such as forest carbon markets, are likely to increase in importance in order to reach the Paris Agreement's balance between emission sources and sinks in the second half of this century. Managing new forest protection initiatives well will be essential to avoid inequitable outcomes (Food and Agriculture Organization of the United Nations, 2014).

Some of the social impacts of the large-scale transition to a low-carbon economy that will influence economic and health inequalities, social cohesion and wellbeing can at the moment only be speculated. For example, fairly little is currently known about the extent and nature of the long-term impacts arising from the decline in fossil fuel intensive industries or increased mining of rare minerals (Ali, 2014; Golev, Scott, Erskine, Ali, & Ballantyne, 2014; Massari & Ruberti, 2013; Mercure et al., 2018; The World Bank, 2017). Policies or initiatives (especially those that affect populations' livelihoods or access to resources) must be delivered in an inclusive manner to avoid exacerbating existing inequalities (e.g. Bhatta et al., 2008; Gomez-Echeverri, 2018; Klinsky et al., 2016; Nhantumbo & Camargo, 2015; Rosenow et al., 2013).

To facilitate a just transition, all stakeholders, including policy makers and members of civil society, will need to work together to identify potential negative outcomes at local, regional and national levels, while paying specific attention to the most vulnerable cohorts in society. Mitigation of adverse side-effects can, and will need to, take various forms, and is likely to require proactive management of social dislocation and governmental support to help diversify the economy in regions where jobs or livelihoods are at risk from the activities associated with the transition. Government investment and support, including subsidies, exemptions and careful targeting of interventions, will be necessary to avoid adverse outcomes.

Notes

1. Including type, quality and amount of resources.
2. Available online at https://cop24.gov.pl/fileadmin/user_upload/files/Solidarity_and_Just_Transition_Silesia_Declaration.pdf.
3. Equitability refers to 'fairness' in policy implementation. 'Equitable' action and practices will reduce inequalities whereas 'inequitable' action and practices may increase them.

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