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Social vulnerability to climate policies: Building a matrix to assess policy impacts on well-being

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ABSTRACT

In this article, we address the social vulnerability of people to climate mitigation policies and contribute to assessing the social impacts of climate policies by introducing a matrix tool for conducting vulnerability assessments and participatory climate policy planning. The matrix serves as a methodological tool for identifying social groups in their social spaces. First, we lay the foundation for the matrix by linking social vulnerability to equality and justice, demonstrating the importance of addressing social vulnerability in climate policy design and research. Next, we introduce the ways in which social vulnerability has been addressed in the integration of social and climate policy dimensions in the Nordic welfare states that also serve as the test bed for our contribution. We then establish a methodological tool for assessing and discussing social vulnerability to climate policies, especially with relation to policy impacts on equal opportunities for well-being, and fostering participation in policy planning; a vulnerability matrix. The matrix is flexible, and adjustable to different policy contexts and governance levels. We demonstrate matrix use in the Nordic context, reflect on its potential uses and discuss the benefits and limitations of the matrix as a tool for addressing social vulnerability to climate policies.

1. Introduction

Climate change will have wide-ranging, adverse impacts on humanity and well-being, which brings the issue of social vulnerability to the forefront of social scientific studies on climate change. *Social vulnerability*¹ refers to the ability of communities and/or individuals to deal with the harms and stresses caused by climate change (Kelly and Adger, 2000). The various definitions emphasise different aspects of vulnerability, but they share the key elements of exposure, sensitivity and adaptive capacity. Exposure refers to the amount and type of stress the communities or individuals are exposed to, such as heat waves or sea-level rises. Sensitivity indicates the extent to which those affected may suffer from the exposure; for example, the elderly and ill are more sensitive to heat waves. Adaptive capacity means the ability of subjects to deal with those negative impacts (determined by exposure and sensitivity), such as the capacity to acquire a cooling system for one's apartment. (Adger et al., 2006: 269–270.) The overall vulnerability depends on all three factors. Differentiation in sensitivity and adaptive capacities depends on the person-specific, community-level and

environmental factors influencing and changing vulnerabilities over time (Otto et al., 2017: 1652). Vulnerability is constitutive of being a human and cannot be eradicated, but different vulnerabilities and their distribution should be given due attention (Barry, 2012) since they are significantly influenced by societal circumstances. The high differentiation in vulnerability to climate change within a given society indicates inequality, which means that different groups have unequal opportunities to secure their well-being in a world influenced by climate change (Otto et al., 2017).

Hence, vulnerability is closely associated with social equality (Barry, 2012; Schlosberg et al., 2017), which makes it a central and normatively loaded notion for evaluating and planning public policies (Adger et al., 2006). Its connection to justice requires further clarification however: what kind of equality matters for justice and the central societal goals? Many approaches to justice emphasise the equality of well-being, or equal opportunities for well-being, as a key measure of the justness of a society (e.g. Sen, 1979; Dworkin, 1981; Arneson, 1989). Climate mitigation and adaptation policies are, in such views, normatively entrusted to decrease the vulnerability of people and communities to climate

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¹ Hereafter also vulnerability (for simplicity). Social vulnerability denotes the vulnerability of human beings or communities distinct from, though related to, the vulnerability of biophysical systems.

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change, and even out the differentiation in this respect to protect the equal prospects for well-being. Particular attention should be paid to the status of social groups that are most vulnerable due to their increased sensitivity or limited adaptive capacity. The urgency of paying attention to the social impacts and vulnerability issues is highlighted both by the increasing ambition of mitigation activities in the post-Paris era (e.g. Hermwille et al., 2019) and the aggravating impacts of climate change.

Research literature on the latter – vulnerability to climate change itself – is extensive. It has widened from biophysical impact assessments into both vulnerability assessments that consider the different aspects influencing vulnerability and adaptation policy assessments that recommend specific measures to mitigate vulnerability to climate change (Füssel and Klein, 2006). The literature also addresses the adaptation-related vulnerabilities; this includes the facilitation of adaptation policies and adaptive capacities (Kelly and Adger, 2000; Heltberg et al., 2009) and equality and well-being (Otto et al., 2017; O'Brien et al., 2007; Sovacool and Linnér, 2016). However, one important theme is less present, specifically the social vulnerability of people and communities to *climate mitigation policies*. Despite the claims that mitigation may affect the external factors that influence vulnerability (Füssel and Klein, 2006: 20), Markkanen and Anger-Kraavi (2019) maintain that the eventual inequality effects of climate policies – including vulnerability considerations – have until now received little attention, and the discussion often focuses on sector- or policy-specific impacts. In the following, we owe much to their overview on recent literature concerning the evidence of inequality and the distributional effects of climate mitigation policies. While in this article we focus more on building a tool for conducting qualitative assessments of the social impacts of climate mitigation policies, we share the interest of Markkanen and Anger-Kraavi (2019) in attempts to better understand the dynamics of mitigation policies and the social spaces in which they are implemented, and an interest in improving the designs to protect those who are at risk of being adversely affected.

Much of the recent discussion regarding the distributional effects of mitigation strategies has emerged within the *just transition* discourse. 'Just transition' research and discourse has its origins in two directions. It was initially introduced in policy discourse by the trade union movements in the 1970s as a call for reconciling the environmental and social concerns in the industry and creating environmentally safe jobs (Morena et al., 2020). The discourse only broadened quite recently, in the 2000s, to consider the impacts of climate action on worker communities and employment (Roseberg, 2010; Stevis and Felli, 2015; Morena et al., 2020), and then went beyond labour issues. The interest in just transition is also increasing rapidly due to the impacts of the COVID-19 pandemic that has aggravated many inequalities. Sustainability transition research first acknowledged just transition concerns in low-carbon energy transition studies. The initial focus on the livelihood and employment impacts of transitions on regions with fossil fuel-reliant economies (e.g. (Evans and Phelan, 2016)) soon widened to include energy poverty, power relations and participatory justice issues (e.g. Ürge-Vorsatz and Herrero, 2012; Sovacool et al., 2016; Healy and Barry, 2017; McCauley and Heffron, 2018; Williams and Doyon, 2019; for vulnerability, see especially Carley et al., 2018). Just transition pays attention to the fact that even if climate mitigation (and adaptation) policies reduce the harmful and unequal impacts of climate change, they may simultaneously reinforce some existing inequalities and vulnerabilities or create new ones as 'side effects'. The described literature, however, typically focuses on the adverse effects of climate policies as a matter of outcome distribution and the identification of exposed groups (Markkanen and Anger-Kraavi, 2019), and does not look at the issue from the viewpoint of overall vulnerability.

Social vulnerability to the negative impacts on well-being of climate mitigation policies (hereafter also climate policies) deserves particular attention for several reasons. First, vulnerability matters for social justice assessments. Not all distributionally unequal policy impacts are injustices; the well-off groups are more capable of securing their well-

being, even if they face greater pressure to make behavioural changes and bear a greater share of the mitigation costs. Attention to social vulnerability, especially with respect to well-being-related harms, helps distinguish between unequal impacts that are with good reason concerns of justice from those impacts that may cause disappointment but are of lesser concern. Second, social vulnerability influences the substantive legitimacy of climate policies. Substantive legitimacy requires that policies have an overall positive impact (or at least lack a negative impact) on the welfare and life conditions of those affected, and that policy benefits and costs are distributed fairly (Fiack and Kamieniecki, 2017). Third, the social impacts of climate policies are likely to influence their social acceptance, which means that reducing the experienced loss of well-being could increase acceptance and help promote just transition (McCauley and Heffron, 2018). Fourth, paying attention to the vulnerability to climate policies is important for procedural justice. The principles of justice and equality require participatory approaches to engage local communities in the identification of local vulnerabilities (Measham et al., 2011; Loo, 2014; Schlosberg et al., 2017), and this concerns policy impacts as well.

In this article, we contribute to the existing literature on the social impacts of climate policies, in particular their potential inequality outcomes. We provide a method for characterising social vulnerabilities systematically by designing and establishing a methodological tool, the vulnerability matrix, for assessing and discussing social vulnerability and fostering participation in climate policy planning. This tool enables policymakers and other relevant actors to identify and address the social and inequality impacts of climate policies, and consequently to mitigate them. While concerns regarding these aspects have been described as crucial (Markkanen and Anger-Kraavi, 2019), tools for testing the implications of mitigation policies for social equality in practice are still lacking. Our work proceeds as follows. First, we provide the context for the application of the matrix by theorising the intersection of climate policy and social vulnerability in welfare states, using the case of Nordic welfare states as an example. The matrix is then built by combining theoretical approaches to well-being with matrix design principles and iteration rounds with empirical test data. After that, we demonstrate the application of the matrix using the particular case of climate policy evaluation in Finland, and discuss how the matrix can be applied in climate policy planning and for fostering participatory policy processes.

2. Theoretical background

2.1. Climate policy and the issue of social vulnerability in Nordic welfare states

The interest of building a vulnerability matrix is rooted in similar heuristics as using an *ex ante* impact assessment in public policy planning (Burdge and Vanclay, 1996). The assessment of social impacts has been developed in connection with the environmental impact assessment, yet often with insufficient coverage concerning the *social* impacts (e.g. Larsen et al., 2015). Therefore, we chose an alternative approach aiming at embedding selected *ex ante* considerations directly in the welfare context, because practical climate mitigation will have differentiated social impacts that ought to be anticipated when effective mitigation measures are designed.

Public policies (including climate policies) are embedded in specific historical circumstances with unique ideas and objectives and are rarely implemented identically in different regions. Yet, similar policy regimes can be found across regions since one region may consider another as the example for policy design. The Nordic welfare states have many similarities and can be considered as a single welfare state model (e.g., Normann et al., 2014), even if each of them has particularities in implementing the ideas of welfare provisions and social equality. Nordic countries have acknowledged the promotion of social equality by reducing social risks of diverse groups and individuals as one of the main targets of public policy (Graubard, 1986). Even if this aim is today

perhaps less visible than it has been earlier (Kangas and Kvist, 2019), the historical achievements of the Nordic welfare state in endorsing social equality through state legislation and other top-down measures of welfare state regime still remain.

Nordic countries have also shown high ambition in building facilities and infrastructure to reach carbon reduction targets in the energy sector. They have succeeded, at least to some extent, in promoting renewable energy and in decoupling economic growth from environmental impacts. (Urban and Nordensvärd, 2018; Nordic Action on Climate Change, 2017.) Because of their strong historical traditions of both social policy and renewable energy policy, the Nordic countries have a high potential for being the forerunners in addressing social vulnerability to climate policies by bridging social policy with energy and climate policies (e.g., Gough, 2016: 43, 2017: 109). Nordic welfare states have also been characterised as strong welfare states with high capacity for regulation (Kühnle, 2000). However, even the Nordic countries have not succeeded in bridging these policy domains effectively so far: the challenge of climate change for European and Nordic welfare states has been only recently recognised (Schøyen and Hvinden, 2017). Climate policy discussion has been largely pursued as if its impacts would be only technically effective or ineffective, lacking social and vulnerability dimensions. There is only little knowledge of how the ambitious de-carbonization of the economy will affect social well-being with respect to the standards of social equality among citizens (Sygna et al., 2004; Sovacool, 2017). Knowledge deficiency relates to the (so far) faint interest of connecting climate policy issues to strong social policy.

The bridging of social policy and climate policy measures will likely become even more important in the future. The growing demands of well-being allowances and benefit policies (due to, for example, the ageing of the population and the impacts of the pandemic) will increase pressure on the fiscal resources of the welfare state, which could well invoke tensions concerning priorities between traditional social security and climate policy measures (Gough, 2017: 112–113). Such tensions create a need to identify synergies to achieve goals in both policy domains simultaneously, or to mitigate the eventual negative impacts through parallel policy design and implementation in both domains. Nevertheless, climate policy implementation will create ‘winners and losers’. In the most unjust case, climate policies adversely impact those who are already disadvantaged, thus worsening existing injustices. This happens if policies bear more heavily on poor people and their subsistence emissions (Gough, 2015: 1209; Markkanen and Anger-Kraavi, 2019). Social policy measures are needed to remediate the consequent imbalances and injustices and to secure a decent level of well-being for those who already suffer from accumulated vulnerabilities in society.

Social policy can, however, do more than just identify and alleviate social injustices. This also directs attention to the bottom-up policy processes. Affluent societies have recently witnessed a call for more participatory policy processes that bridge social and ecological issues (Koch, 2018). Social policy could promote this aim by investing in human, social and community resources (Gough, 2017: 113). Community engagement has received much emphasis in vulnerability research (Schlosberg et al., 2017) and can contribute to creating ‘a green welfare state’ (Bäckstrand and Kronsell, 2015). The human and institutional resources that could contribute to mitigation should also be identified and assessed locally and translated into community matters (e.g. Landholm et al., 2018). Nordic countries already boast a variety of community initiatives and participatory networks that aim to confirm climate strategies locally or regionally, for example by endorsing the implementation of the Paris agreement and the EU climate targets (Karhunen, 2019), and by empowering communities and citizens. In this way, social policy can also provide a major socio-cultural contribution to climate action and inclusive societal transformations, thus highlighting the bottom-up dynamics that are increasingly visible in climate policies.

2.2. Matrix as a tool for vulnerability evaluation and citizen engagement

Vulnerability matrices have been created and utilised in several research areas as a qualitative analysis framework for identifying the drivers/sources of vulnerability and those groups or system elements that are vulnerable to the identified drivers of vulnerability (Cannon, 2000; Mavroulidou et al., 2004; Özyurt and Ergin, 2010; Grando et al., 2016; Paloviita et al., 2016). A vulnerability matrix provides information about the relations of vulnerability, arranged in cells where each matrix cell describes a potential instance of vulnerability (‘A is vulnerable to X’).

A social vulnerability matrix can be used to illustrate and systematise how particular socio-political factors influence the vulnerability of different social groups and thereby social equality. It also serves as a framework for fostering citizen participation in climate policy by providing a tool to structure concerns regarding climate policy impacts. A matrix can improve policy planning by helping ask holistic, macro level questions and by pointing out the vulnerability ‘hotspots’, like particularly vulnerable groups or the major drivers of vulnerability (Paloviita et al., 2016). The extensiveness and distribution of revealed vulnerability impacts can then be considered against the expected effectiveness of a given policy, which produces a qualitative cost-benefit analysis that could be particularly beneficial to climate policy planning (van den Bergh, 2004). This advances the identification of policy synergies that could reduce vulnerability and related social inequalities most effectively (Cannon, 2000).

3. Methodological standpoint and data

The purpose of the present exercise is to establish a methodological tool for climate policy processes and research: a vulnerability matrix for identifying and assessing social vulnerability to climate policies and helping organize related discussion and citizen engagement at different governance levels. This kind of methodological work is primarily theoretical but draws on empirical information. Due to the highly practical and contextual nature of climate policy, the matrix development utilised an iterative process where the initially theoretically constructed matrix was predisposed to empirical data and then revised accordingly to increase its application value and flexibility. The policy context that was chosen for the iteration purposes is the Nordic welfare state and, particularly, the Finnish national energy and climate policy program (Huttunen, 2017).

We focus on mitigation but suggest that the matrix could be applied to adaptation policies, too.

The empirically informed iteration of the matrix was grounded on workshop discussions arranged in 2017 as a part of a synthesis study on the health and well-being impacts of national climate policies in Finland. Workshop participants (N = 19) were experts in different fields of environmental, social, and health sciences, and represented mainly research institutes and universities. They were organised into discussion groups according to the national climate policy program themes (energy, transportation, land use and planning, and private consumption) to ensure a comprehensive treatment of various themes. Participants were asked to identify the health and well-being impacts of policy measures proposed in the program, describe the impact mechanisms behind these impacts, and discuss measures to increase the potential health/well-being benefits or alleviate the undesirable impacts. In this way, our exercise has been inspired by the idea of co-producing transformative knowledge (MacDonald, 2012). The data from workshop discussions (approximately 8.5 h in total) were transcribed and analysed by content for the matrix revision.

The workshop discussion supported the matrix iteration process well. Probably, this was at least partly due to the fact that the discussants were experts on welfare and social equality research. Yet it is worth noting that, as professional experts, they are also socio-economically privileged members of society, and this should be kept in mind while

reading the demonstrative empirical data. Consequently, the data highlight research-based but not necessarily all community-based vulnerability concerns. In any case, the inclusiveness of identification procedure needs to be addressed in any identification process by asking how to ensure that workshop participants (whether academic or non-academic), who are to identify vulnerable groups, really identify them all and how well they know and understand the different daily realities of people. Moreover, we suggest that the identification should always be complemented with or checked against research literature.

4. The social vulnerability matrix

4.1. The matrix structure

Vulnerability matrices differ in their layout and focus: the appropriate framing depends on information needs. Since we are interested in the social vulnerability impacts of climate policies, the matrix should illustrate how various climate policies influence different aspects of social vulnerability. The two matrix dimensions should then signify climate policy measures that may cause vulnerabilities (vulnerability drivers), subjects who may be vulnerable, and eventually the particularly pressing dimensions of vulnerability (Adger et al., 2006: 269–270). The latter aspect involves two questions: who is vulnerable and in which respects? We focus on vulnerabilities that may affect social equality grounded on the idea of equal prospects for well-being. Consequently, the other dimension of the matrix should depict the constituents of well-being that may be hampered by undesired climate policy impacts.

Information needs determine the basic structure for the social vulnerability matrix: *rows* describe the climate policy measures that may impact on well-being, and *columns* describe the constituents of well-being that may be vulnerable to particular climate policy measures.² While the matrix application context defines the contents for policy rows each time, columns describing the constituents of well-being are grounded on a theoretical basis to provide a common objective platform for discussions that may manifest diverse conceptions of well-being, some of which may be grounded on unsustainable desires and preferences.

Vulnerable groups are commonly classified and identified according to internal factors (race, ethnicity, sex, age, religion, disability, health status) and external socio-economic factors (class, type of housing, education, assets, cultural knowledge, access to social networks, and political power) (Otto et al., 2017: 1652; see also Markkanen and Anger-Kraavi, 2019). Groups who are identified as particularly vulnerable to a given climate policy or policy measure are indicated in matrix cells with specifying letters, like ‘C’ for children. Potentially vulnerable groups are context-dependent. The participatory process should choose the considered groups carefully in each context (and eventually adopt complementary input from experts or research literature): the choice determines which vulnerabilities become visible in the matrix. We acknowledge that socio-economic grouping involves unavoidable ‘homogenization’ with regard to any particular group. However, any matrix aiming at applicability needs to make a compromise between clarity and preciseness.

4.2. Matrix columns with a view to equal opportunities for well-being

The vulnerability of a person to negative climate policy impacts depends on one’s exposure, sensitivity, and adaptive capacities to the undesired policy (side) effects. Individuals with equal exposure to climate policy impacts may have differentiated vulnerabilities because of the differences in sensitivity or adaptive capacities. As we noted,

² The columns and rows could also be presented in the opposite order: policy columns and well-being rows. In our iteration process, the order we chose was considered easier to use and read.

differentiated vulnerability matters for social equality and justice but not in every case: for example, the higher exposure of the ‘wealthy wunderlusters’ to increased flight prices is not a concern for justice, since impacts target a deliberately chosen luxury hobby rather than basic and hardly replaceable constituents for well-being. The relevance of certain vulnerability impacts for justice arises from their impact on the opportunities for well-being (see introduction). The protection of equal prospects for well-being constitutes a crucial condition for just climate policies. Another reason for incorporating well-being aspects into the matrix instead of a plain identification of ‘vulnerability as such’ or of different vulnerability dimensions (exposure, sensitivity, adaptive capacity) is pragmatic. Social policy targeting to alleviate social vulnerability to climate policies is likely to succeed better if the identified vulnerabilities are linked to specific social policy domains or issues, such as the dimensions of well-being.

To incorporate the well-being dimension into the matrix, we compared the prominent social theoretical approaches to human well-being from the viewpoint of vulnerability assessment and applicability to the matrix structure. This yielded several iteration rounds: the empirical test material (see Section 5) was used to test different approaches to see how well they help classify and identify the social vulnerability to climate policy impacts within the framing of well-being that distinguishes the justice-relevant impacts from other impacts. The needs-based ‘Doyal-Gough model’ (Doyal and Gough, 1991; Gough, 2015, 2017) of human well-being turned out most promising for our purposes. Gough has also addressed the interplay between social and climate policy. The model conceptualises a universal yet relational approach to well-being. Its openness to contextual sensitivity makes it broadly applicable but not too complex for the matrix.³

The Doyal-Gough model defines human well-being in relation to basic needs. Basic needs are empirically grounded ‘universal pre-conditions for effective participation in any form of social life’ (Gough, 2017: 42). Universalisability means that whatever one’s conception of a good life is, achieving it requires the satisfaction of the basic needs, and the failure to satisfy them constitutes a serious harm (Gough, 2015: 1991). The satisfaction of basic needs is a threshold for minimum social justice (the sufficientarian principle) and the goal is to bring all individuals over that threshold (Wolf, 2009; Gough, 2017). We maintain that a needs-based approach to well-being is required for approaching social equality and justice in the world where desires and preferences are (subjective and) infinite yet resources finite, as is Earth’s ecological capacity to provide for human well-being (Gough, 2015: 1193–1195; 2017). Climate policies cannot be judged as unjust solely on the grounds of restrictive impacts on some forms of preference satisfaction (consumption). An increasing number of recent studies on consumption maintain that in high consumption societies upper segments could significantly reduce material consumption and still satisfy basic needs and support individual well-being (Helne and Hirvilampi, 2015; Koide et al., 2019).

The essential constituents of human well-being in the Doyal-Gough model are physical health, autonomy of agency, and critical autonomy (Gough, 2015: 1195–1198).⁴ Physical health denotes the absence of objectively disabling conditions. Autonomy of agency means the ability to make competent, informed choices and participate in social life, which requires sufficient mental health and understanding about the cultural environment one lives in and the social norms within that

³ For example, the central capabilities approach (Nussbaum, 2011) was found to be too complex for operationalisation. Another approach that was at first promising yet rejected was the ‘having-loving-being’ theory of Erik Allardt (1976) that did not provide sufficient details for distinguishing between different policy impacts.

⁴ The problems of measuring the fulfilment of all needs objectively has been addressed in the literature. Precise measuring is not necessary for identifying and reducing social vulnerability to climate policies.

environment, which build the basis for a healthy self-relation. The realization of agency also requires social inclusion, the opportunity to participate in central social activities in a society. Gough's conception of autonomy is relational: autonomy is conditional and constructed through interpersonal relations (cf. Häkli and Kallio, 2014). Critical autonomy enables political participation by autonomy of agency and political freedom (Gough, 2017: 44). Critical autonomy refers to political agency and the opportunities of contesting prevailing cultural boundaries. We considered it to be a complex and dynamic dimension (Gough, 2015) beyond the purpose of this matrix design.

Overall, the Doyal-Gough model provides a comprehensive yet applicable account for operationalising human well-being and vulnerability in the climate policy context. We draw on its categorization of the constituents of human well-being to construct the axis of well-being for the vulnerability matrix (the columns). We modified the initial model in the iterative process where we compared the model with the data from workshop discussions. Iteration helped improve the well-being axis of the matrix. Eventually, the constituents of well-being were operationalised into sub-elements that can be both impacted by climate policies and also addressed with social policy measures. They are:

- *Physical aspects of well-being*: 1) food and energy security; 2) material basic security (including housing); 3) environmental health and safety; and 4) physical health. These aspects also cover the economic aspects that may be a concern for the equality of well-being.
- *Social aspects of well-being (autonomy and agency)*: 5) mental health; 6) cultural identity and self-respect; and 7) opportunities to participate in social life. The seventh aspect includes those immaterial economic aspects that may be a concern for the equality of well-being.

The matrix (Fig. 1) can be used for identifying both adverse and positive impacts of climate policy on well-being. This helps ensure that the concern for the social impacts of climate policies is not downplayed due to fears that such concerns only slow down climate action. The established matrix is visualised below and filled, to exemplify its use, with some central observations in the workshop discussions we used in the matrix iteration. It should be noted that the vulnerable group listing in this matrix is here only exemplifying, comprising groups that were mentioned in the co-creation context of the matrix development. Numerous other vulnerable groups are identified in vulnerability related literature and a more comprehensive identification of relevant groups is a part of applying the matrix. For example, employees in fossil fuel industries (e.g. coal phase-out, Jakob et al., 2020) comprise a relevant group in some contexts; unemployment can influence both their material basic security, mental health, self-respect, and opportunities to participate in social life. Moreover, the indicated vulnerable positions do not obtain only negative impacts to such groups. For example, urban densification may indeed have negative impacts on urban inhabitants' environmental health but these can be mitigated by green infrastructure applications (Pérez-Urrestarazu et al., 2015) that, in the best case, provide benefits to people who were initially identified as vulnerable to the densification related harms.

5. How to apply the vulnerability matrix?

We next illustrate the matrix application with one topic from the policy workshop discussions: transportation (passenger traffic) related climate policies. The social impacts of climate policy related to transportation attracted a lot of attention because transport is so central for daily life, which is further emphasised in Finland, where distances are long.

The national climate strategy listed policy measures or 'themes' focused on policy objectives rather than specific instruments (Huttunen, 2017), and these 'themes' were used to establish the rows of the matrix. In this case, the state level of discussion creates guidelines for points that

should be considered when choosing the particular policy instruments for the given objectives. Overall, four types of passenger transportation related policy measures that may influence human well-being were identified in the strategy. For each, a corresponding matrix row was created and filled with the perceived vulnerability impacts that were identified with relation to their impacts on well-being. Hence, after consulting the workshops, particular groups were identified as potentially vulnerable to passenger transportation related climate policies: rural, urban, poor/low-income, children, elderly, farmers, and men. The vulnerability of these groups was specified in the matrix (Fig. 2).

After the experiment of filling the matrix in the workshop with experts of social equality research, we could make visible some important equality issues related to the selected climate policy measures. First, policies that promote cycling or walking were perceived to improve well-being and benefit people equally or might even benefit more the presently disadvantaged people. Increased physical activity benefits especially the health of the disadvantaged groups. Decreased pollution would benefit low-income urban people who inhabit cheaper yet more polluted neighbourhoods (see also Markkanen and Anger-Kraavi, 2019, 832). Some negative impacts were identified too: children and the elderly were estimated as vulnerable to increased traffic accident risks⁵ (although this can be influenced with policy planning). However, the overall benefits were considered to outweigh the emerging risks. Hence, it was concluded that the promotion of human-powered transportation would generally imply an increase in social equality and well-being.

Second, public transportation policies benefit the public and environmental health by increasing traffic safety and reducing pollution, benefitting people who are prone to traffic safety risks or to environmental health harms. Consequently, these policies can balance some of the above noted risks and concerns.⁶ Public transportation also supports the participation opportunities of those who cannot afford a private car, especially improving social equality in cities. The relative disadvantage is faced by rural people who cannot enjoy these benefits. On the other hand, if they do not pay the costs of the public transportation either, the distribution of benefits and harms appears fair, since rural people also enjoy lesser traffic safety risks and pollution levels.

Third, policies that regulate private car use (like driving prohibitions in city centres) benefit urban environmental health by reducing pollution. Regulations could also foster equal opportunities for social participation by making urban activities more affordable if expensive urban space is freed for non-car uses. On the other hand, regulations would interfere with the daily practices of urban drivers and require investing in other transportation modes and changing habits. Car owning has symbolised success and autonomy, especially in male culture and identity (Belk, 2004) where it has become a central constituent of the image of a successful and capable member of the society. Hence, some urban men ('M') with presently high-carbon lifestyles ('Ls') may actually experience social depreciation if required to forgo driving, especially if their rural fellows continue driving as usual. In the short term, this does influence their experienced well-being and even their well-being in terms of cultural identity. Because of the present cultural values, the sensitivity of men to car use restriction impacts may well be higher than that of women (although the adaptive capacities to respond to these policies may again differ and vary even within these groups). Over the longer term, car use regulations are unlikely to truly harm needs-based well-being and social equality. However, we suggest that this requires cultural change in values, identity comprising factors, and the material

⁵ Children are unexperienced and hence prone to traffic accidents. The elderly are also highly over-represented in fatal cycling accidents; for the EU, see: https://ec.europa.eu/transport/road_safety/specialist/knowledge/pedestrians/crash_characteristics_where_and_how/age_groups_most_involved_in_fatal_crashes_en. (Accessed Feb 04, 2021)

⁶ The higher risk of spreading contagious disease was noted but perceived as insignificant and hence excluded.

Policy measures	Vulnerable elements							
	Food security	Energy security	Material basic security	Environmental health / safety	Physical health	Mental health	Cultural identity, self-respect	Opportunities to participate in social life
Energy policies								
Energy use of forest industry residues				U				
Increased energy taxation	P	P	P					P
Transportation policies								
Promotion of cycling / walking	See table 2 for details for transportation policy impacts							
Promotion of public transportation								
Land use and planning policies								
Promotion of accessible services								+
Digitalization of services								E
Urban centre densification				U		U,P		
Consumption policies								
Promotion of low-carbon housing	Impacts very unclear, requires further research							
Promotion of plant-based diets	+				+		R,M,Ls	Ls
Groups: (R)ural, (U)rban, (P)oor, (C)hildren, (E)lderly, (F)armers, (M)en, (Ls) Followers of 'carbon-intensive' lifestyles. (+) Indicates positive, vulnerability-reducing effects.								

Fig. 1. The social vulnerability matrix, filled for the purposes of demonstration with some prominent impacts identified in the workshop discussions. Letters in cells signify groups that were identified as particularly vulnerable.

Policy measures	Vulnerable elements							
	Food security	Energy security	Material basic security	Environmental health / safety	Physical health	Mental health	Cultural identity, self-respect	Opportunities to participate
Transportation								
Promotion of cycling / walking				C,E,+U	+			+
Promotion of public transportation				+C,+E	+			R,RE
Private car use restrictions			+UP	+U			(Ls)	+U
Fuel price increases	(P)	R,P	R,P,F	+	+		R,P	R,P
Groups: (R)ural, (U)rban, (P)oor, (C)hildren, (E)lderly, (F)armers, (M)en, (Ls) Followers of 'carbon-intensive' lifestyles who lack adaptive capacity. (+) Indicates positive, vulnerability-reducing effects.								

Fig. 2. The social vulnerability to low-carbon transportation policies in Finland.

ideas associated with a good life in some communities. Consequently, this does not raise justice concerns that would be similar to many other (need-based) impacts we have discussed.

Fourth, fuel price policies were perceived as most problematic for social equality. This is because low-income groups in particular are vulnerable to the increased prices of basic material needs like energy, since they spend proportionally more on necessities (Gough, 2017; Markkanen and Anger-Kraavi, 2019). Vulnerability to energy poverty caused by fuel price affects both the material and social aspects of well-being. Rural people are more vulnerable to these impacts: longer distances make human-powered transportation difficult, public transportation is lacking in rural areas, and changing one's car into a model that runs on renewable fuels requires big investments. Farmers in Finland are found to be doubly vulnerable in terms of material security due to their fuel-intensive livelihoods and often lesser resources for investing in any changes to decarbonise their energy procurement (Puupponen et al., 2017). The rural elderly are also doubly vulnerable to

inequalities caused by policies that make transportation more difficult or expensive: digital modes of participation may compensate regional inequalities over time but the elderly may not benefit from this because of their lesser (though heterogeneous) capacities to adopt digital modes of participation and services (Taipale and Hänninen, 2018).

As the case demonstrates, low-carbon passenger transportation policies have varying impacts on vulnerability and social equality. Some are weightier than others: one positive impact does not necessarily compensate one negative impact, and the matrix is not a sum exercise. The most serious inequality impacts in the exemplifying context are related to fuel price policies. Their implementation may require compensative measures to avoid social injustices that relate to achieving basic material security. Importantly, climate policies do not create only vulnerabilities: some policies were perceived to benefit health and improve social participation opportunities, at least in cities, and these benefits often especially concern the lower-income groups. Well designed and implemented climate policies can also decrease immediate

vulnerability and improve social equality.

The application of the matrix for workshop discussions demonstrated how it helps structure and understand the diverse policy impacts, intersections of vulnerabilities, and places for ‘social-climate’ policy bridging. In the case above, the matrix highlighted the vulnerability of rural people, especially of farmers and the elderly with lower adaptive capacities for policy impacts. This implies a need for social policies that reduce the exposure or sensitivity of those groups for transportation policies or increase their adaptive capacity. The matrix demonstrated certain positive policy impacts on public and environmental health, indicating synergies between social and climate policies. The matrix also made the trade-offs visible: while fuel price increases benefit health, they essentially expose some groups to decreased participation opportunities by increasing transportation costs. Harms can be compensated in cities by promoting public and human-powered transportation, but the same does not apply to rural areas. Hence, the well-being of the least resourced people in rural areas is a particular concern and eventual topic for particular design (such as better policy targeting) in climate policies: otherwise, the vulnerability of these groups may result in increased social segregation in a climate-constrained world.

6. Discussion

Adherence to the normative principle of social justice necessitates paying attention to the social vulnerability impacts of climate policies. Such concerns have been addressed only little to date although social vulnerability relates closely to social equality, social justice, and just transition to carbon neutral societies (Markkanen and Anger-Kraavi, 2019). Neglecting the vulnerability impacts of climate policies creates a risk that effective climate policies will increase social segregation and experiences of injustice and decrease human well-being. It is insufficient to focus solely on the distribution of policy effects: such evaluations address the exposure aspect of vulnerability but sideline sensitivity and adaptive capacities that are essential for understanding why certain groups are more vulnerable than others (Schlosberg et al., 2017; O’Brien et al., 2007).

To identify and address the undesirable policy side effects from the viewpoint of vulnerability, we have established a social vulnerability matrix in this paper. The matrix provides a tool for citizen and/or expert engagement, discussion, and the identification of climate policy impacts and their distribution. It allows construction of ‘the big picture’ of policy options from the viewpoint of well-being and can also be used by experts in that context (as our demonstrative application implied). We suggest that the matrix is at its best as a framework for fostering participatory decision-making. In that sphere, it helps combine the objective approach to well-being, which is important in addressing unsustainable consumption and standards of life (cf. Gough, 2017), with a bottom-up exploration of the experiences of community members that is essential for a just transformation towards sustainable communities (Schlosberg et al., 2017; McCauley and Heffron, 2018).

As to the more technical aspect, the matrix provides a flexible framework for a variety of applications to assess social vulnerability impacts of climate policies. Policy rows can be composed of different policy sets in different contexts. This allows the use of the matrix in addressing even culturally challenging climate policy domains, such as food policy, that require the reassessment of cultural value horizons. The matrix can also be operationalised on different scales. We have demonstrated its application for national climate policy, yet the matrix is equally applicable to cross-country, regional, and city-level policy evaluations. From the viewpoint of effective and inclusive citizen engagement, municipal level applications would be particularly interesting. The actual application of the matrix in participatory ways should involve broad community participation to include local concerns, vulnerable groups, and marginal voices (Cannon, 2000).

Along with identifying vulnerabilities, mitigating them and related inequalities is an important task (Markkanen and Anger-Kraavi, 2019).

The task can be approached with several strategies. First, outcome-effective climate policies with partly adverse and unequal social impacts can be revised to reduce the exposure of potentially vulnerable groups (improved policy targeting) or coupled with strategies that reduce or balance the vulnerability of the negatively affected. Second, the design of new policies can aim to promote climate actions and social equality in parallel, by, for example, investing in social and community resources (Gough, 2017). Regardless of the chosen pathway, climate policy planning should be integrated with vulnerability assessment to advance the substantive legitimacy of policy measures, effective implementation, and social justice in a climate-constrained world.

The main benefits of the established matrix are the following. 1) It supports the qualitative cost-benefit analyses of climate policies (van den Bergh, 2004) by strengthening the viewpoints of social impacts and well-being. 2) It supports participatory climate policy planning by helping structure citizen concerns and relating them to equality and well-being. 3) It advances the comparison of policy options, regarding their impacts on social equality, and the identification of groups that are particularly vulnerable to policy harms (which is not identical to the identification of impact distribution). Furthermore, the matrix helps bridge social and climate policy aspects and develop sustainable welfare states by helping identify synergies and promoting coherence between social and climate policy, as demonstrated by the case example. The assessment of the ‘social equality costs’ of climate policies helps avoid policies that would pose the most detrimental risk to the welfare state project, social cohesion, and legitimacy of the low-carbon transition. The matrix also helps identify vulnerabilities that emerge at the intersections of inequality-prone statuses, like the rural elderly and farmers, where attention to social impacts is most crucial.

The matrix has its limitations. A matrix-like structure necessarily assumes some homogeneity in the described groups. Yet, in reality, there is much variation among the low-income groups, the elderly, and so on. This problem concerns all approaches that aim to provide a ‘big picture’ of the equality between various social groups: comprehensiveness has its cost. However, the matrix allows context-specific flexibility and participatory guidance in determining the groups that are relevant for the given context; this is also the reason why the matrix in the exemplary form presented here does not aim to include all groups that may be vulnerable to climate policies (for additional examples of social vulnerability, including ethnic groups, see Markkanen and Anger-Kraavi, 2019). Another limitation is that the matrix does not describe the influence mechanisms by which policies create vulnerabilities. Nor does it describe dynamics between policies. To increase its explanatory power, a filled matrix can be accompanied with a description of policy influence mechanisms and/or policy dynamics. Going into such details is not always necessary: the usefulness of details depends on the context.

The applicability of the matrix is to be tested in practice. We propose that the matrix would be at its best in fostering issue-based participatory policy and active citizenship while building citizen-expert dialogues. It provides a platform for applications regarding regional climate policies and helps pay attention to the social justice impacts of climate policies within and between regions. For justice, it matters greatly who actually defines and identifies climate policy vulnerabilities. The incorporation of both expert and citizen viewpoints is important to minimise the risk that some vulnerable groups or forms of vulnerability remain invisible. The matrix provides a framework for contextualising and structuring dialogues and helps citizens frame their concerns in ways that are translatable to different policy sectors. Experts who need to approach their tasks with a comprehensive and multidimensional outlook benefit from the matrix as a heuristic tool. Overall, the matrix is most beneficial for the *ex ante* (before implementation) evaluation. It supports in advance the establishment of compensative measures to reduce vulnerabilities and strengthen the adaptive capacity of individuals and communities to climate policies. Because increased adaptive capacity generally decreases vulnerability, capacity building also decreases the

need for compensatory measures to alleviate the negative social impacts of climate policies. Adaptive capacity building is, therefore, a central task for the integration of social and climate policy to reduce social vulnerability to climate policies and to foster the de-carbonization of welfare states in a just and sustainable way.

Author statement

This work has been carried out as a constantly ongoing collaboration, co-creation of the matrix, and co-writing of the manuscript, and the contribution of either author cannot be distinguished. Both authors take public responsibility for the work.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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