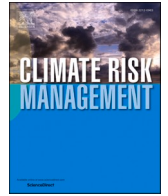




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Defining affordability and adaptation resource prioritisation

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ABSTRACT

Across Europe there is an increasing behavioural turn in flood risk management, focussing on individual behaviour and responsibilities. For example, a greater focus on implementing property-level resilience measures. A conclusion from this trend is that there are additional burdens being placed on the residents of flood-prone areas, in the hope of reducing their overall burden; therefore, we must understand the burden that is being created as we can unintentionally create new patterns of inequality in terms of who is and is not protected if certain individuals can be judged to be overburdened. This is particularly relevant in the aftermath of disaster events when there is a push to build resilience. One concept for measuring this aspect of the burden generated is affordability, which seeks to define and measure what a suitable burden on an actor is, and then can be targeted for additional assistance, for example, loans, vouchers, or subsidies to eliminate the burden. The concept of affordability can be used to identify how to best spend resources after a disaster event to support a process of 'building back better'; however, the way this burden can be defined and addressed can also be influenced by different social justice considerations and definitions. This research explores the implications of different social justice concepts for defining what is a reasonable burden that can be placed on the individuals expected to adapt to and limit flood impacts and on the policy strategies and outcomes.

1. Introduction

Natural hazards significantly threaten society as, for instance, in 2021, the monetary losses totalled \$280bn globally, with a single flash flood event in Germany incurring a loss of \$54bn (Munich Re, 2022). The threat of flooding is expected to increase due to a combination of climate change and socio-economic development (IPCC, 2022). This is because the threat of flooding can be summarised as the product of three elements: hazard (the hydrological assessment of flood events in terms of frequency and magnitude), exposure (the people and assets that can be harmed), and vulnerability (the physical and social susceptibility to loss). Hazards are to some extent beyond human control but exposure and vulnerability are the direct result of individual and collective human decisions and behaviour (Kuhlicke et al., 2020). Managing this collective outcome of flood risk requires multiple actors to collaborate and jointly act to reduce and prevent the creation of new risks (Hartmann and Driessen, 2017), which, in turn, is further complicated by societal implications and decision-making priorities (Thaler and Priest, 2014). Often, due to limited funds for investing in flood alleviation

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schemes communities with predominate marginalised communities, can be overlooked by the policymakers (Thaler & Priest, 2014). Booth and Tranter (2017) argue that this privileges higher socio-economic communities, which effectively further marginalises lower socio-economic communities. This is further emphasized as socially vulnerable groups can be overrepresented in flood-prone areas (Rözer and Surminski, 2021, Chakraborty et al., 2014, Collins et al., 2018, Grineski et al., 2015; Smiley, 2020). The design and implementation of flood risk management strategies, therefore, have significant social justice implications (Kaufmann et al., 2018, Shively, 2017; Siders, 2019).

One important consideration within social justice is the burden that is placed upon people when they are expected to take part in flood risk management. The increasing behavioural or governance focus of flood risk management means that those living in flood-prone areas have a greater expectation laid on them to act and manage the level of flood risk (Kuhlicke et al., 2020). This focus, therefore, places additional burdens on residents who only represent a single link in the chain of the flood risk system. An understanding of this burden is required because we can unintentionally create new patterns of inequality in terms of who is and is not protected, and to whom assistance can be prioritised. This can be especially relevant in the aftermath of a flood event, where there is a push to consider how to 'build-back-better', or aid is immediate and does not suitably aid long-term recovery or impacts that occur dynamically. A currently common concept for identifying who needs this assistance is affordability as it also forms a common refrain in policymaking (Hudson, 2020). Affordability is a concept that seeks to define and measure what is a suitable burden on an actor, who then can be targeted for additional assistance should they not be able to bear the burden in question. People who are deemed to find the burden unaffordable can then be targeted with, for example, loans, vouchers, or subsidies. However, the way this burden can be defined and addressed can also be influenced by different social justice formulations and ethics, which can also guide wider risk management (Thaler, 2021, de Goër et al., 2022).

There is not a single overall conceptual basis for the definition of affordability that can be used to judge the burden that adaptation expectations generate, due to its nature as a subjective concept (Saenz, 2009). The following section discusses how different concepts of social justice alter how affordability is defined, based on the ethical underpinnings of risk management (Rozell, 2018). One concern to keep in mind is the potential differences in the scale and scope of concepts. There is a great deal of ambiguity of within the term social justice (Thrift and Sugarman, 2019), where different philosophical ideas on resource allocation result in different conceptualisations of what is just. For instance, Adam Smith's position as a moral philosopher is that just outcome is where an interaction has not made someone worse off than they would have otherwise been (Ward, 2004; Otteson, 2017, Herzog, 2014). In this formulation there is not a positive obligation to improve a person's position, just an obligation not to worsen it by our actions (Ward, 2004, Otteson, 2017). Therefore, if one were to consider Smith's belief that state interventions require a great deal of local knowledge to be successful (Otteson, 2017), then this creates an approach could be considered libertarian. Cowen and Trantidis (2021) state that classical liberals revere autonomy, but where interventions must take place the intervention must be routed in individual choice while providing information that facilitates welfare improving activities (Cowen and Trantidis, 2021) as freedom of choice encourages better outcomes when acted upon in a decentralised manner (Thaler and Sunstein, 2009; Halpern, 2016). This in turn is a useful perspective to bring because it argues a need to beware that we cannot judge behaviour against unrealistic baseline of neoclassical rationality. Though there is an element of this is Smith's approach as he argues that there should be an impartial spectator that provides equal weight to all perspectives (Herzog, 2014). There is also a line towards a Rawlsian perspective of "justice as fairness" (Otteson, 2017), which was a different perspective to that of Smith (Salter, 2012, Herzog, 2014). The Rawlsian approach can be considered as the equitable allocation of benefits and burdens (Rawls, 1971). One could also consider this as equality of opportunity (Herzog, 2014), especially for the most underprivileged (Rawls, 1971) which could mean that just interventions are considered to be towards the advantages of this groups.

A pertinent area of discussion for each social justice philosophical basis is, therefore, how the concept is applied and how the perspective differs in applicability. In this paper, we look at these concepts from the perspective of how decision-makers could approach and use these definitions to develop "affordability" concepts. We focus on conceptual methods for identifying the additional burden imposed upon individuals who are expected to adapt and what are potential implications. This paper explores the implications that different social justice concepts have for defining what is a reasonable burden that can be placed on the individuals/households expected to adapt to and limit flood impacts. The aim of the paper is to provide an explorative study to operationalise philosophical concepts into natural hazards research; to demonstrate how different philosophical concepts of justice might influence the potential changes in our political strategy.

2. Conceptual framework

2.1. Proportionality justice

2.1.1. Concept and operationalisation

This ethical basis dictates that a person should not have to carry a disproportional burden of something that benefits the collective (in our case the employment of adaptation measures to limit collective disaster losses). The current approaches using this ethical approach are primarily concerned with comparing financial situations and current (or potential) expenditure levels to judge whether an action is a burden. Moreover, the financial burden is judged external to the decision to adapt or not to adapt. As such, it is only focussed on what is deemed a fair contribution and not on whether the measure employed itself is cost-effective (Thaler et al., 2020). Proportionality definitions focus on adaptation as a purely financial consideration. Factors such as the effort or time that an action requires are excluded, as well as potential maintenance expenditures (both monetary and non-monetary).

Proportionality offers pragmatic approaches for measuring affordability of adaptation measures. This is so as it can readily fit across

many different current policy dimensions, due to its simplicity and overall compatibility with ‘means testing’. For proportionality-based definitions to be successfully used a line must be drawn to create a suitable indicator (burdened or non-burdened, and to what extent) of who can be considered burdened. In the absence of political consensus, there are multiple potentially valid indicators of affordability; therefore, it may be convenient to use existing accepted threshold indicators or other social issues to limit the potential for new conflicts.

Assuming a monetary focus, mechanisms should be put in place reduce to any excess burden over the threshold. This can be achieved via vouchers to pay for the unaffordable portion of insurance premiums, or loans for more expensive property-level flood risk adaptation measures (Hudson, 2020). Though the consequence and effectiveness will in part depend on how proportionality is defined in a specific case, what measures will be supported, and which mechanisms will be used to support the purchase of adaptive measures. For example, the National Research Council (2015) suggests multiple different ways to define a threshold that could be measured in financial terms regarding the purchase of insurance.

Firstly, the threshold requires establishment of a suitable percentage of income that can be spent on adaptation, for example, 5 % of income or that the sum of income and housing rent should be less than 40 % of income. These are expenditure cap definitions and if the expenditure does not exceed this value the adaptation expenditure is deemed to be affordable. Setting the precise threshold requires local deliberation to understand what is acceptable in terms of expenditure. In comparison to housing expenditure, this may be a simpler process as there are existing affordability thresholds that can be employed such as when mortgage affordability is confirmed. In the United States and Europe, for example, affordable rent thresholds are set at 33 % and 40 % of income, respectively. Selecting the type of income to focus on is comparatively simple. Another definition can be based on comparisons with poverty-lines or residual income definitions. The internal logic behind these thresholds is that a person’s standard of living should not be forced too low. Bundorf and Pauly (2006) consider affordability for health insurance in this way; people must be able to purchase the insurance premium and still be able to achieve a minimum standard of living. For example, consider the European Union which employs a relative poverty threshold of 60 % of median national disposable income.

In all cases, those who fall below the threshold are selected to receive prioritised support for the implementation of adaptive measures. A proportionality definition linked to a poverty threshold is likely to be closer to the intent driving proportionality, as the poverty threshold implicitly includes the relative opportunity costs of expenditure on adaptation (i.e. expenditure is fungible over needs) while the expenditure cap definitions do not directly consider the needs of an individual and how they may need to prioritize different areas of expenditure.

2.1.1.1. Mechanisms to address unaffordability. Maintaining an assumption of a monetary focus on the proportion of a person’s resources that can be allocated to adaptation, the mechanisms developed should reduce to the affordability threshold any excess monetary value over it. This can be achieved via vouchers to pay for the unaffordable portion of the expenditure or loans (Hudson, 2020). Vouchers are in effect a one-off payment for the measure, while loans convert a large up-front expenditure into a series of smaller payments over time following the repayment schedule. Both aim to reduce the expenditure of a particular actor to below the threshold; however, under definitions linked to poverty-lines it will be the case that some proportion of the population will have incomes that exist below the determined threshold. For these individuals, loans will not be an effective mechanism as they will also find the repayment schedule to be unaffordable; therefore, vouchers might be more effective in aiding them to find measures affordable.

2.2. Libertarianism

2.2.1. Concept and operationalisation

This approach is focussed on the individual and allowing them to act as they wish in line with their private property rights, without undue concern for wider society. In this sense, all responsibility is left to the individual or to what a collective voluntarily agrees upon. In a sense, affordability and such issues are not valid concerns unless a person is making an uninformed choice regarding their activities in a flood-prone area (Thaler et al. 2020). Any action is affordable if willingly undertaken as the result of an informed decision and it is not the role of an external observer to judge whether there is a burden or not. A person employs a measure having decided whether in their view that it is best for them or not, and not necessarily for the wider community good. The resulting implication for this definition is that the flood risk manager should be providing people with the information required for them to decide and remove this potential “market failure” of information barriers being present. However, this definition most strongly impacts on property owners due to the focus on property rights defining who and how action must be taken. Therefore, renters could be more readily seen as facing a burden from adaptation decision-making. This would be if they were expected to conduct actions that are the responsibility of the property owner, though a renter would be expected to protect the contents from damage.

2.2.2. Mechanisms to address unaffordability

The basis of this approach is to make sure that people can make informed decisions as the burden appears when people decide without having a full sense of the facts on the degree of risk that they face, and what are their respective obligations within flood risk management overall. For these reasons, the only true mechanism that can be used are those geared towards providing information and improving understanding. There may, however, be scope for governmental activities that increase the capacity to act upon the request of a particular individual. The libertarian approach would suggest excluding all state-provided flood defence schemes except to provide general information about the hazard status; the aim is for people to decide and protect themselves. This must mean that when

asked about their level of knowledge they should be able to strongly state what they think, and that it should be accurate. The logic behind this choice is based upon policy of informed positive consent. Consent cannot be inferred from an absence of “no” but only through a positive affirmative statement therefore, this represents a potentially easy avenue for where support is required. For example, a positive affirmation could be achieved through increased disclosure of living in a floodplain when buying or renting in flood-prone areas. For example, requiring the actor to specifically acknowledge their flooding potential when signing the relevant contract. Otherwise, information campaigns can be conducted. Under this definition, there is no need for the government to invest in risk management strategies, or promote specific ones for individuals, just to provide an accurate baseline of hazard information that allows people to make informed choices as risk patterns evolve.

2.3. Egalitarian and prioritarian

2.3.1. Egalitarian and capabilities: concept and operationalisation

The egalitarian and capabilities approaches are fundamentally the same as they are concerned with making sure that everyone has equal access to the considered adaptation measures, which can also be inferred to mean that they also have (at least) the same potential capacity to act and employ suitable adaptation measures; for example, see [Schlosberg \(2012\)](#). The objective under this definition, therefore, is to reduce inequality by increasing individual capabilities to what is deemed the socially optimal level. Under egalitarian and capabilities approach, therefore, an action needs support if a person wishes to employ a measure but faces an excessive barrier to employing the measure, such as lack of financial resources, legal restrictions, knowledge, or personal barriers. However, the complexity of this definition renders it difficult to implement. A financial barrier is one possibility, and a threshold must be set so that either measures are suitably priced, or the actors have sufficient resources not to be burdened by the purchase. However, this could be expanded into psychological models that explain the choice of an individual to employ protective measures. For instance, Protection Motivation Theory assumes that action is driven by a combination of a combination of threat appraisal (i.e., the perceived probability and consequences of a negative event), self-efficacy (i.e., a belief the respondent can undertake protective actions), response efficacy (i.e., that the protective actions will be successful), and response costs (i.e., is the burden of the action sufficiently low). For example, if it is known that higher education leads to a higher coping appraisal because of higher perceived self-effectiveness or perceived response-effectiveness, then groups or individuals with low education levels should receive aid (e.g., targeted educational programmes or communication efforts) to boost these levels to a suitable level that allows for adaptation to take place ([Thaler et al. 2020](#)). Unaffordability is determined by the inability to marshal the resources (cognitive or otherwise) needed to reach a certain adaptation potential therefore, a person is burdened when the action exceeds their reasonable capacity, either financially, psychologically, or a combination of both. However, this will require a highly individualised approach to produce an indicator that can be used across multiple different contexts so that a socially suitable adaptation potential can be reached and supported for those at risk.

2.3.2. Prioritarian: Concept and operationalisation

In this ethical underpinning, risk management policies and actions should focus on the most vulnerable members within the community/area considered or the most impacted. This approach is in effect a mixture of the various other ethical concepts discussed above for in essence, it asks where we can target resources for the ‘largest’ impact, however it is defined. This is particularly useful because it implicitly acknowledges (much like the egalitarian approach) that managing flood risk is not just an individual activity but one that is strongly influenced by the social environment in which a person acts and the resulting power and social dynamics ([Rufat et al., 2020](#), [Kuhlicke et al., 2020](#)). This approach to defining social justice and affordability is, therefore, one of the more complex in line with the capabilities approach ([Thaler et al., 2018](#)).

The complexity of this definition arises from the fact that vulnerability is difficult to define in a way that captures the core concern of an ethical discussion. For instance, does one focus on physical vulnerability so that those with the highest vulnerability are focussed upon? This is then complicated by the observation that vulnerability is approached differently by different groups as to whether it can be considered simply the hazard element of flooding or how susceptible a person is to suffering a loss. This is then further compounded by difficulties in defining the social aspects of vulnerability and community. It is a common approach to assume that groups who are socially marginalised (e.g. ethnic minorities or poorer communities) or vulnerable (e.g. the elderly) are more vulnerable to flooding ([Babcicky et al., 2021](#)). The resulting implication is that these groups face outsized barriers to successfully conducting adaptation activities or that when impacted the subjectively perceived impacts are larger and/or longer lasting. These considerations further increase the complexity of defining who is vulnerable enough to receive prioritised help. This is because both concepts of community and social marginalisation are intersectional and alter depending on where a person stands. Both exist in a series of interacting and overlapping microsomes, creating the potential for the production of false positives. The potential complexity of this indicator means that it must undergo a necessary simplification as what is vulnerable in one case may not be in another and certain aspects may not be measurable in a suitable manner. Moreover, the type of indicator produced will also have to be considered.

2.3.3. Mechanisms to address unaffordability

In this paper, the proposed instrument would simply be for the government to provide and install the required flood adaptive measures. This can be considered similar to activities in several countries where houses can be insulated free of cost (for the resident). This overcomes the perceived lack of capacity for those who cannot fully act. There are, however, also other avenues that can be considered as providing the support needed under these approaches indirectly. Policy can be set in place that aims to “remove” the influence of the sources of vulnerability or influences that prevent suitability capabilities from developing. For instance, community-based flood risk management activities can be used to boost people’s coping appraisals through training and modelling how flood risk

management activities can be done successfully in the belief that the increased coping capacity in one area will impact other areas.

3. Empirical thought experiment

3.1. Data set

The data set is used to explore the operationalisation of the concepts developed above and their potential implications regarding the burdens placed on actors within flood risk management as a thought experiment. The data set originated from a cross-sectional survey of households that were impacted by the flood event of May/June 2013 in Germany; that is to say, they reported damage to the building structure or household contents. The original respondents were selected by identifying the streets impacted by the flood, allowing for the targeted identification of landline phone numbers to conduct computer-aided telephone interviews (CATI). The survey was conducted nine months after the flood event. Participation was voluntary, resulting in 1652 respondents. The questionnaire was focussed on flood damage and event characteristics, as well as socio-economic traits of the respondent. The questions included were derived from those that have been successfully used in other studies (Kienzler et al., 2015, Kreibich et al., 2011, Thieken et al., 2007). Respondents were mainly located in the federal states of Saxony-Anhalt (35 %) and Saxony (32 %) as these two states were the most severely impacted by the 2013 flood event. Respondents tended to be property owners (83 %) and the average age was 60 years, which is higher than the average German age at the time as children were excluded from the survey and only those households with landlines were sampled. This survey data set is used, as it represents variables of interest and a pre-existing standardized framework that has been extensively tested and deployed after major flooding in Germany, though it must be admitted that this is a limitation, as if more resources had been available a bespoke exploratory survey could have been designed for the current manuscript.

To produce the results presented below, the overall survey dataset was constrained to the set of individuals who could be compared across all the different approaches studied. This constrained the dataset to 449 observations. This is mainly driven by missing observations regarding income and what monetary damage was suffered during the flood. This allows for the same set of individuals to be compared under each provided definition.

3.2. Operationalised definitions

3.2.1. Proportionality

The first operationalised definitions use the relative poverty line approach (i.e. remaining disposable income should not fall below this threshold). Those who fall below the threshold are selected to receive prioritised support.

3.2.2. Libertarianism

One way in which this can be operationalised is based on the underlying knowledge of the risk faced and the strategies of the measures that can be employed. A resident in a flood-prone area must, therefore, acknowledge that they are at risk, know what measures they can employ and believe that it is their responsibility to act. This indicator is provided by the following variables:

- Informed (0/1 binary answers, for a maximum total of 4 points)
 - o I find out how I can protect my house or apartment against flooding.
 - o I find out about the risk of flooding in my house or apartment (only on request: e.g., from the responsible Water management office or on the Internet)
 - o I take part in seminars/information events about floods and flood prevention.
 - o I knew I was living in a flood-prone area before the flood.
- Perceived response costs
 - o Private measures are too expensive (1 = completely agree, 6 = completely disagree, 6-point scale)
- Perceived private responsibility.
 - o Adaptation is the responsibility of the state and not the private individual (1 = completely agree, 6 = completely disagree, 6-point scale)

3.2.3. Egalitarian & capabilities

To judge this aspect, we construct a points-based indicator of factors that can be considered as limitations on a person's potential capability to proactively adapt and limit flood damage (Sayers et al., 2018). This indicator is produced via the construction of an index of the following factors that were contained in the underlying survey. Moreover, these variables are often used as indicators in studies looking at the adaptive potential of flood-prone residents to adapt to potential flood impacts, such as income below national median income, age is over the retirement age, renter, family size, dependence ratio (number of children below 14 and people over 65 years), gender and education.

Each of the responses provided is standardised so that they produce a uniform value that is on the scale of [0,1] where 0 was the worst possible response and 1 the best possible response. However, it must be noted that there are variables that are missing (e.g. ethnic origin, citizenship status, and disability) that could be important additions. These variables were not asked in the underlying survey which is being repurposed.

3.2.4. Prioritarian

The aim of this concept is to focus on the most vulnerable. As noted above, determining who is most vulnerable is a complex and dynamic topic, while an oversimplification determines the Prioritarian focus as one that focusses on the lowest-income individuals. This is determined by the relative poverty threshold as this is a value commonly used by the German and European Union governments. While this definition is an oversimplification, it is selected as many social issues intersect with problems that low-income communities tend to see.

4. Results

The tables referred to in this section can be seen in the [supplementary information](#).

4.1. Proportionality

Questions on income tend to be poorly responded to in surveys when respondents are asked to provide their income. A common approach for overcoming this barrier is to ask for a respondent's income level in categories. The use of income categories tends to improve the response rate to this question. The 6 income categories asked are presented in the first column of [Table 1](#) and taken directly from the survey. The survey derived income categories are then be compared with the median income of German residents. According to Eurostat, the median income in Germany in 2013 was €19,545,¹ which generates an affordability threshold of €11,727 per year or €977.25 per month.

[Table 1](#) presents the sample's income distribution over the 6 categories employed in the survey. Starting with the mid-points of these income categories, about 13 % of the studied population would find any measure unaffordable. Respondents in the €1000–1499 income category is where the turning point into potential affordability occurs as there is an annual surplus income of between €276 and €6264 (mid: €3262) per year. This surplus income is likely to be sufficient for low flood-risk households to buy flood insurance at risk-based rates; however, for higher-risk households this might not be the case. Depending on how people are distributed across the risky areas, therefore, the lower end of this income classification will find risk-reflective insurance premiums unaffordable.

For insurance, a direct comparison of these values to potential premiums is relatively straightforward and simple. This is because they are both flow variables (i.e., annual values). A comparison for structural adaptive measures is more complicated as these are stock variables. It would, therefore, be more appropriate to convert the costs of such measures into suitable payment schedules. For instance, the lower end of the €1000–1499 group has a surplus income of €23 per month. A max price of a structural adaptation measure can be estimated. Assuming a payment schedule of 25 years and an interest rate of 3 % produces a value of €4850, while the upper-end value of €522 produces a value of just over €11,000 for how much can be considered as affordable. [Aerts \(2018\)](#) presents an estimate that flood-proofing costs for a representative German household could be \$22,237 in 2011. Adjusting for inflation between 2011 and 2013, this produces an estimated cost of €17,324. This, in turn, has an annualised cost of about 82 EUR per month.

Overall, the first two income classifications are present in floodplains and will require assistance to adapt. The third income group is likely to need assistance if they are expected to both adapt their living environment and to purchase insurance. This is especially relevant if there are credit market imperfections that limit their potential to buy measures with relatively cheap loan financing. For group 4 onwards, it is much more likely that they will be able to bear the burden placed upon them. In this approach, vouchers and loan-like financing are suitable mechanisms for addressing the burden placed on these residents.

4.2. Libertarianism

Once calculated, 11 % of the respondents were awarded a score of at least 2 on the information seeking aspect of libertarian index presented in [section 3.2.2](#) (the first bullet point), which means about 89 % of the sample would require support to be able to make informed decisions and choices. Over 50 % of the sample was informed by at least 2 informational avenues, only 7 % would be completely informed. A similar finding also occurs for perceived individual responsibility, in that over half of the population can be perceived as disagreeing with this statement. Therefore, this represents a potentially easy avenue for support, which can be through increased disclosure requirements for living in a floodplain and a reminder to proactively act and limit flood risk where possible according to the German Federal Waters Act relevant in our study area. However, it must be acknowledge that a score of at least 2 (i.e., two information avenues) is an arbitrary threshold as if we required all 4 information avenues to be achieved then the support rate would increase to 93 %.

For the perceived costs indicator, most of the population finds the protective measures that they are familiar with as being rather expensive. However, under the libertarian approach, it is not the government's role to directly address this issue. Rather, the best role for the government in this conceptualisation would be to correct market imperfections that would inhibit action (e.g., the correction of credit market imperfections).

¹ Eurostat variable ilc_di04.

4.3. Egalitarian & capabilities

In this indicator, the higher the score, the more limited the capability to adapt is assumed to be. A lower capability to act as identified by this indicator is not necessarily because of the intrinsic characteristics of a specific trait, but also because of social expectations and constructions which lead to overall limitations. Under this approach, we take a further prioritization approach where top 30 % of respondents are those who should be prioritised for help (i.e., the top third when respondents are ranked according to facing the highest barriers to adaptation). In assuming that the threshold value to be considered as requiring help is to be in the top 30 % of indicator values, this means a score of at least 0.29 on the capability index was required. The average index value for individuals below that threshold was 0.2, and 0.51 above it. This is quite a clear difference between these two groups; however, our use of the top third being prioritised is an arbitrary threshold that was determined as reasonable by the authors before conducting the empirical analysis as part of the wider thought experiment. In practice, this threshold of where to draw the line between those who need help and those who do not should be done as part of a wider consultation process (e.g., it may be considered to follow an approach more similar to the prioritizing approach where we start with the individuals displaying the highest barriers and then move onto individuals who are ranked lower) with the objective of co-designing a suitable threshold to maximise the thresholds social acceptability. In this framework, the proposed instrument would simply be for the government to provide and install the required flood adaptive measures. This can be considered like activities in several countries whereby houses can be insulated for free (for the resident). This overcomes the perceived lack of capacity for those who cannot fully act.

4.4. Prioritarian

The results of the prioritarian framework produce various rankings, whereby those at the top of them should receive prioritised aid. However, while this is very simple, what indicators of absolute (e.g., reported damage), relative (e.g., damage normalised to income or property values), or potential damage (e.g., using the property value to indicate maximum potential loss) are used to construct them is important. The ranking produced is highly sensitive to the definition of damage used. This is shown in [Table 3](#) where the indicators produce highly different rankings as compared to using raw damage ranking as a baseline comparison (e.g., a person was ranked first in terms of raw damage suffered, but 10th in terms of relative damage resulting in a difference of 9 places in the prioritisation order). While some respondents were ranked at the same position under multiple different indicators of damage, the smallest average difference in rankings was nearly 6 places and the highest 16 (e.g., under one scheme a person was ranked as 6th, but under another was ranked 22nd).

An alternative ranking scheme could be similar to that of [section 4.3.](#), and investigating who remains in the top 30 % of people impacted regardless of how observed flood impacts are measured. Under this ranking approach 55 % of respondents, they were in the same group under all different approaches. 16 % are only located in the high impact group once, 11 % twice, 4 % thrice, and 15 % 4 times; therefore, making this version of the indicator into a binary of the top 30 % is far less sensitive to the indicator of damage used. This renders it slightly more tractable for determining who should receive prioritised support in adaptation afterwards. However, in all cases, homeowners are slightly biased due to their potential to suffer damage to both the building and its contents for which they are responsible. For this framework, all the discussed measures may be suitable.

4.5. Cross-comparison of results

[Table 4](#) presents the cross-correlations of the rankings of respondents across the different definitions of 'affordability'. The following observations are made. Firstly, the correlations are low, with high p-values, implying that there is little connection between a person's place under each definition. Arguably, this is not a surprising result because each of the definitions has a different objective, and they don't necessarily overlap in practicality. A further observation maybe that that different combinations and questions used to generate the indicators could plausibly be changed as we were constrained to an existing survey designed for a different purpose. Rather a bottom-up or consensus driven approach to defining the questions and items used to define the thresholds. Secondly, while the correlations are low, an expected pattern can be observed. For instance, the prioritarian and proportionality outcomes are negatively correlated much as the egalitarian and the libertarian outcomes. A negative correlation between the prioritarian and proportionality outcomes could be expected as proportionality places a larger emphasis on those with lower incomes, while the prioritarian framework is based on damaged suffered it will in effect place the emphasis on those with higher asset values. Similarly, the negative correlation between the egalitarian and the libertarian outcomes is also plausibly expected. This is because the questions used in the libertarian approach implies that those most informed are also not those the egalitarian identifies as requiring additional support.

5. Discussion

5.1. Implications of the different ethical policies

Each of the different definitions generates different empirical frameworks to operationalise that concept to be measurable based on very different driving assumptions behind each concept. We would argue that this is a necessary reflection of the varying complexities of each of the concepts; as a social justice issue, there is no universally correct answer. While the different ethical driving forces can limit the various empirical frameworks' inter-concept comparability, this is not the case for intra-concept definitions. For instance, proportionality could be measured using differences in housing expenses not exceeding a certain value, or the expenditure itself must

fall below a certain percentage of disposable income, but the concept of needing to keep expenditure below a certain percentage of income is not a directly relevant consideration. Therefore, it can be argued that a direct comparison across the concepts and definitions is possible within concepts as it is more likely that we can have a suitably consistent data set to explore the relevant aspects.

We were unable to fully empirically operationalise and measure how these different concepts could render very different results and implications for disaster management. We were unable to do so because while the proportionality concept can be readily measured using the standard academic surveys or publicly accessible statistics, the others, especially for the egalitarian, require much more detailed knowledge of the respondents that can be tailored to be suitable for the flood risk domain. In comparison to this, the libertarian is simple and attractive within the push towards the conceptualisations in which flood risk management is moving, e.g., [Kuhlicke et al. \(2020\)](#) or [Lucas and Booth \(2020\)](#). The libertarian definition proposed was an extreme *laissez-faire* approach, but one that fits within the narrative of many different aspects of government-led flood risk management, where in effect an increasingly strong role for private action can be seen as privatising the responsibility for flood risk ([Lucas and Booth, 2020](#)). Under this conceptualisation, the only required response to ‘unaffordability’ is to provide more risk information, flood education, and better advertising of possible measures to allow those at risk to make the most informed choice. For example, [Attems et al. \(2020\)](#) investigates the German Hochwasserpas, which provides property-owners with a “flood risk” label similar to that of the EU Energy label, but focused upon the protection level of the individual property. Though, while such a measure would be a potential libertarian intervention, [Attems et al. \(2020\)](#) note that in practice simply providing information didn’t always help as for those who had an implementation knowledge gap lost their motivation to install property-level protection measures. Though, this could be taken to be an indication that libertarian conceptualisation does not go far enough in managing risk as there is still a remaining information asymmetry that needs to be closed. This could be more easily achieved under the egalitarian approach which takes this informational basis as the starting point but would also seek to actively develop the property-owner’s ability to act, rather than assuming their capacity to act successfully.

While it could be argued that mechanisms such as the Hochwasserpas aim to change behaviour by informing and encouraging the implementation of property-level measures; there is also the potential that it reinforces a wider shift responsibility for different levels of flood risk management. There is a much more significant degree of nuance in how responsibilities and burdens must be allocated, and the different power dynamics within society must be accounted for rather than simply assuming that the decisions people make from their constrained optimisation discussions are the socially correct choices. This can be especially relevant as, for example, in the UK, where it is predicted that socially vulnerable individuals will have new locations in (potential) floodplains ([Rözer and Surminski, 2021](#)) who may not be able to act until more tangible needs have been met.

Therefore, the egalitarian approach offers the most potentially nuanced aspect from a resilience-building/vulnerability reduction aspect; however, this approach potentially faces a much more transaction-cost-heavy approach as a greater deal of more detailed information may be needed to calculate the indicator, which may not exist in a single location. It is quite possible, therefore, that this definition cannot be systematically made at the level at which many of the resources for support are distributed. For example, one could also consider this egalitarian approach to be based on enhancing the behavioural drivers of action. However, [Kuhlicke et al. \(2023\)](#) notes the huge range of approaches and inconsistency in how different researchers have approached vulnerability and adaptation behaviour. This also raises a further question, especially in the light of social inequalities and power dynamics, as to whether we build such an indicator from an external viewpoint or will the process of developing such an indicator externally result in the missing of important contextual information because it does not account for local power relationships and contexts, and how barriers to successfully adapting are expressed.

Considering this, the proportionality definition is the simplest to employ consistently using predetermined indicators and agreed-upon thresholds and indicators (e.g., federal poverty lines in the United States that accounts for household composition, or the European Union’s housing cost overburden threshold of expenditures larger than 40 % of disposable income). Moreover, this can be conducted independently of the individual in question, for example, government tax/benefits records can be used to identify who could need support. This can be refined with the flood maps that must be produced as part of the EU flood directive (or similar policy initiatives) to further refine this to areas that can be flooded in addition to the areas that can be directly identified as flooded (e.g. using the Copernicus rapid disaster mapping system). Moreover, in countries such as Germany or the Netherlands where local governments have records of which properties are owner-occupied or rented, this allows further targeted information to be provided in line with what they can be expected to conduct. For example, renters might need help with contents insurance, while building owners can receive help for wet flood-proofing a building; however, this might have to be combined with a tailored building-level consultation to work out what measures are best suited for individual complexities rather than a single uniform suggestion (in line with the Hochwasserpas approach). This does entail additional costs as not all measures are equally effective and or suitable for all properties. However, to successfully act upon this, we are effectively bounded by the transaction costs of trying to develop a monitoring and reporting structure where losses can be reported, or estimated, in comparison to the capacity of the household to bear with them. The more complex this process, the less attractive it will become, especially from a political perspective, where it can increase the lag between a person requesting help and being officially offered help. For instance, this is a known problem with post-disaster insurance payments, as in some cases, slow, difficult insurance pay-outs can be worse than if no insurance help was provided ([Pontirakul et al., 2017](#)). Moreover, these additional brings us back closer to the approach suggested by the egalitarian conceptualisation.

5.2. Interaction with risk reduction

There is an additional overall perspective to consider when investigating the “additional” burden generated by an increasing expectation of adaptation; this is that potentially it can be considered that by promoting more adaptation actions by private households, the overall social burden created by flood risk is reduced (i.e., that flood risk and potential impacts are reduced). It can,

therefore, be argued that the collective burden is reduced which could result in a “net reduction” in the overall burden. As such, as with any policy intervention, there are winners (e.g. fewer ad-hoc taxes to finance post-disaster compensation) and losers (e.g. greater expenditure on adaptation) when an action aiming for an overall societal improvement is attempted.

Though it must be acknowledged, that there is a degree of similarity to related ‘common goods’ problems, where both individual and collective actions can jointly or independently reduce the negative burden (e.g., greenhouse gas emissions). However, a novel difference between examples such as greenhouse gas emissions is that there are examples of flood risk management where actions taken to lower the negative impacts increases the risk for another one, e.g., levees can protect one area but worsen downstream or upstream flood risk (Liao et al., 2023), an outcome known as ‘risk harm’ (Chan and Liao, 2022). Consequently, while not the focus of the current paper, a relevant discussion is not only whether individual (e.g., property-level floodproofing) or collective (e.g., levees, natural flood management) measures are fairer from a social justice point of view, but equally important it is to consider which one is more effective in terms of risk reduction and how it fits within the wider social justice perspectives discussed above.

Both individual and collective measures can be cost-effective methods for reducing flood risk when deployed in the situations that correspond best to their characteristics, when purely considered in terms of the monetary damage prevented (Kuhlicke et al., 2020). However, the measures clearly operate at different scales. For instance, mobile flood barriers as an individual will fail against inundation depths much smaller than that of a levee or flood wall due to hydrostatic pressures, while examples of natural flood management such as retention areas or forested areas (Thaler et al., 2023) while effective against a range of floods are most effective for small scale flooding (Dadson et al., 2017).

Expanding out from this concept to that of proportionality and how this approach would deal with ‘risk harm’. Proportionality would use a similar threshold-approach, we quantify the risk burden generated by flooding and how this must be below a certain level. This could be a certain multiplier of income or asset values, or similar to a Dutch approach that the probability of loss of life due to flooding may not exceed 1/100,00 per year (ENW, 2017). In this later example, a disproportionate burden from a risk management would be if as a result someone now suffered from a higher mortality probability. This would require either a change in the original investment or further risk reduction activities to return the mortality probability to what is deemed to be an accepted threshold. The egalitarian & capabilities approach would be similar, in that if the increase in risk is within the capability of those negatively impacted to address. Prioritarian Framework places the emphasis on those with the highest risk, so if the negative impacts are accounted for the order which the next investments will change to account for the potentially new rankings. While under a strict libertarian perspective, people should be informed of the consequences of a protective investment and the rationale for the investment despite potential negative consequences. Once this information has been provided, those negatively impacted have the autonomy to “vote with their feet” if required or engage in a process of bargaining to establish a suitable compensation arrangement, e.g., see Machac et al. (2018). These different perspectives can also be expected to have wider social implications as the prioritarian framework for instance, if using absolute rather than relative risk/damage levels. The focus on monetary damages might create situations where less wealthy communities end up with lower levels of protection overall. We make no judgement on the ethical implications of this potential ‘risk harm’ but rather a brief consideration of how risk managers may respond. The cost-benefit analysis (CBA) is based on the damage assessment, which means high-income communities/families have the higher risk of losses; where usually the vulnerable are presented with lower expected losses simply because the value of their assets is lower (Thaler et al., 2018, Siders, 2019, Ciullo et al., 2020). Moreover, the CBA driving flood risk can also be used to mask subjective value decisions and considerations with a cloak of objectivity to create useful rhetorical instruments for sidestepping ethical issues (Siders, 2019). It still has a general value in metric decisions through the centrally valid idea that resources should be allocated to where they are most socially useful, but care must be taken to define what is “socially useful”, conditional on the transparency of the decision-making process that accurately reflects the local situation.

6. Conclusion

Given the nature of flood risk generation and the increasing influence of climate change, disaster risk reduction, flood risk management, and climate change adaptation, a greater focus on social justice and equity concerns is required. This is because the generation and alteration of natural hazard risks are fundamentally unfair and are increasingly combined with an expectation that people must act to protect themselves within wider flood risk management paradigms. We explore the potential that different social justice and ethical concepts can have on how we approach the expectation that people must act in line with their capabilities and social expectations. In doing so, we find that the different definitions of affordability as informed by different underlying ethical principles produce very different understandings of how they should be receiving help to adapt to the threat posed by disaster risk. The main implication of this finding for disaster and climate risk management is that it is a non-trivial decision as to which of the indicators should be used and how they are defined and empirically measured to guide policy. There is relatively little agreement across the studied approaches, which will have non-trivial impacts or who will be targeted, and the scope and nature of resources required to suitably remove the burden placed upon those who are expected to adapt. This is a required consideration as not everyone in society has an equal capacity to act, and policymaking in this area should not assume that there is such an equal capacity. How this burden is defined and measured needs to be part of a wider conversation about the roles expected of different stakeholders within flood risk management. There will be overlaps between some groups of people within the survey, resulting in certain groups of people being getting support from different justice theories. It is also possible that governments are using more than one justice concept in their decision-making process, seeking to strike a balance across the different priorities of each definition. While our study was focused upon potential disaster risk management implications, the interaction between social justice and resource prioritisation is a topic which touches on many fields, e.g., transport, pollution reduction, energy, etc., that contribute to achieving a more sustainable (and as such disaster and climate resilient) society.

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.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary material

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