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Operational definitions of inequality, deprivation and vulnerability in social and environmental justice research

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Abstract

Purpose – This study addresses the persistent conceptual ambiguity in defining and measuring social disparities, such as inequality, deprivation and vulnerability, which hinders effective social justice research and policy interventions. The aim of the present study is to propose a clear and precise conceptual framework to facilitate the standardized operationalization of these concepts across research and policy contexts.

Design/methodology/approach – An interdisciplinary literature review was undertaken, encompassing environmental studies, sociology, geography and related fields. The study examined and compared existing definitions, measurement methods and applications of inequality, deprivation and vulnerability. Variations in indicators, spatial scales and disciplinary approaches were systematically assessed. Insights were synthesized to propose coherent operational guidelines that accommodate diverse research contexts while maintaining conceptual clarity.

Findings – The analysis reveals persistent variability and interchangeability in the use of these core concepts, which undermines comparability across studies. A core set of conceptual domains and operational guidelines is proposed, highlighting how these concepts can be operationalized in ways that respect disciplinary, spatial and methodological contexts. These findings provide a foundation for more consistent measurement, guiding research-informed policy development and the improvement of social welfare systems.

Originality/value – The article contributes a theoretically grounded framework for clarifying social justice concepts, synthesizing divergent disciplinary indicators to provide practical guidance for researchers and policymakers, thereby strengthening the link between conceptual clarity and actionable social policy aimed at reducing social disparities.

Keywords Social justice, Inequality, Deprivation, Vulnerability, Social disparities, Equity policy

Paper type General review

1. Introduction

1.1 Conceptual ambiguity in social and environmental justice research

In recent decades, social justice has become a central analytical concern across sociology, geography, environmental studies, public policy and public health. However, despite growing awareness of social disparities in contemporary society, there remains a persistent conceptual ambiguity in the terminology used to describe and analyze social disadvantage, undermining the effectiveness of policies and interventions (Brown, 2017; Cole, 2016; Mayrhofer, 2025; Salvatore, 2007). Terms such as deprivation and vulnerability, together with related concepts of social disadvantage, are frequently used with overlapping meanings or without consistent analytical distinctions across disciplines (Brown *et al.*, 2017, p. 499; Busumtwi-Sam, 2008, p. 22).

This lack of conceptual clarity is particularly problematic in social and environmental research, where the distribution of environmental risks and benefits is closely intertwined with pre-existing social conditions (Kaplinsky, 2008). Exposure to hazards such as heatwaves,

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flooding, air pollution or resource scarcity is not evenly distributed across populations but is shaped by structural inequalities, material living conditions and differential capacities to respond and recover (Cutter *et al.*, 2003). As a result, the precise conceptualization of social disadvantage, specifically through the distinct yet interrelated lenses of inequality, deprivation and vulnerability, directly influences how environmental injustice is identified, measured and addressed.

At the theoretical level, these conceptual challenges are closely linked to broader debates on social justice. Early influential approaches, particularly associated with Rawls (1999), emphasized fairness in the allocation of rights and resources. While influential, this distributive approach has been criticized because focusing primarily on the allocation of resources may overlook how social relations, institutional arrangements and structural inequalities influence individuals' ability to benefit from those resources (Young, 1990; Pogge, 2005).

To address this limitation, Sen's entitlement and capability framework introduced a decisive shift by emphasizing that justice depends not only on the distribution of resources, but also on the structural conditions that determine individuals' entitlements, that is, their legitimate ability to access and use resources (Sen, 1982, 1985, 1999). From this perspective, justice must be evaluated in terms of people's real freedoms and opportunities to achieve valued ways of being and doing (Sen, 1992; Nussbaum, 2000). Building on these developments, contemporary social justice research increasingly adopts multidimensional perspectives that integrate redistribution, recognition and structural disadvantage (Fraser, 2009; Fraser and Honneth, 2003; Wolff and De-Shalit, 2007). In applied fields, particularly environmental justice, Schlosberg (2007) expanded this multidimensional perspective by arguing that justice involves not only the equitable distribution of environmental goods and burdens, but also social recognition, meaningful participation in decision-making, and the real capacity of individuals and communities to achieve well-being and flourish.

This article adopts a multidimensional understanding of social justice, in which justice is not limited to the equitable distribution of resources, but also includes the structural conditions, capabilities and opportunities that enable individuals and communities to achieve well-being and respond to environmental risks (Sen, 1992; Fraser, 2009; Schlosberg, 2007).

Despite this theoretical evolution, empirical research continues to struggle with the operationalization of these multidimensional perspectives. In practice, studies frequently conflate structural inequalities, material deprivation and vulnerability to harm within overlapping or inconsistent analytical categories. This conceptual imprecision is especially limiting in environmental and climate justice research, where robust assessment of social vulnerability and deprivation is essential for designing equitable adaptation and mitigation policies. In response to these measurement challenges, recent empirical research has increasingly incorporated novel spatial data, sociodemographic indicators and computational methods to better characterize and map economic and social disparities (Suel *et al.*, 2019; Garbasevschi *et al.*, 2023).

In response to these challenges, this article examines the operational definitions of inequality, deprivation and vulnerability within interdisciplinary social and environmental justice literature. It addresses the following research question: how do existing empirical approaches conceptualize and measure these overlapping dimensions of social disadvantage, and what are the implications of their inconsistent use for comparability across studies? By systematically examining how inequality, deprivation and vulnerability are applied in empirical research and translated into indicators and composite measures, this article clarifies their analytical boundaries and identifies sources of conceptual and operational ambiguity. In doing so, it provides a more coherent foundation for the assessment of social and environmental disparities and for the development of more policy-relevant approaches. The aim is to strengthen conceptual clarity and improve the analytical foundations required for more coherent and policy-relevant assessments of social and environmental disparities.

1.2 Rationale for concept selection

The selection of inequality, deprivation and vulnerability is grounded in the analytical needs of contemporary social research, particularly within environmental and climate justice. These fields require conceptual tools capable of capturing how structural conditions, material living standards and exposure to environmental risks jointly shape uneven social outcomes across populations and territories (Otto *et al.*, 2017). Despite the diversity of terms used in the literature, these three concepts consistently emerge as central because they allow for a systematic and complementary understanding of socio-environmental disadvantage (Kruize *et al.*, 2014).

From an environmental perspective, inequality, deprivation and vulnerability represent three interconnected but distinct analytical dimensions. Inequality captures the structural and distributive patterns through which environmental goods and burdens are unevenly allocated across groups and spaces. Deprivation refers to the material conditions that determine access to essential resources and services, shaping everyday living standards and the capacity to withstand environmental stressors. Vulnerability introduces a forward-looking dimension, reflecting differential exposure, sensitivity and adaptive capacity in the face of environmental, social and economic shocks.

The combined use of these concepts is therefore functional rather than arbitrary. Together, they allow for the integration of structural disparities, lived material conditions and differential capacities to respond to environmental risks within a single analytical framework. This is particularly relevant in environmental and social justice research, where risks such as heatwaves, flooding, pollution or resource scarcity interact with pre-existing social disparities to produce uneven impacts (Yenneti *et al.*, 2016).

2. Methods

2.1 Scoping review approach

To address the conceptual fragmentation of social justice and disparities in empirical research, this study employs a scoping review methodology. This approach is particularly suitable for mapping heterogeneous and interdisciplinary bodies of literature, identifying conceptual gaps, and synthesizing theoretical and operational frameworks across disciplines. The review follows the methodological framework proposed by Arksey and O'Malley (2005) as well as the updated recommendations by Westphaln *et al.* (2021). The process involved defining a research question: How have the concepts of inequality, deprivation and vulnerability been conceptualized and operationalized in empirical research addressing social and environmental justice?

2.2 Search strategy and data sources

A literature search was conducted across interdisciplinary databases, including Scopus and Web of Science. Search strings included combinations such as: ("social justice" OR "environmental justice") AND ("inequality" OR "vulnerability" OR "deprivation") AND ("composite index" OR "composite indicator" OR "multi-indicator"). To ensure a comprehensive historical mapping of the literature and avoid selection bias, no publication date restrictions were applied.

2.3 Inclusion and exclusion criteria

To ensure a robust conceptual framework, as suggested by the literature on theoretical synthesis, the following criteria were applied:

Inclusion: (1) Peer-reviewed theoretical frameworks on social and environmental justice; (2) empirical studies that operationalize inequality, vulnerability or deprivation through composite indices or multi-indicator measures; (3) articles published in English; (4) studies published up to May 2025.

Exclusion: (1) Empirical studies relying exclusively on single indicators (e.g. income alone, education level alone) without constructing composite or multidimensional indices of inequality, vulnerability or deprivation. (2) Theoretical works that do not engage with social justice or distributive frameworks relevant to health or spatial analysis. (3) Studies that do not explicitly operationalize inequality, vulnerability or deprivation, even if they address related topics (e.g. general health outcomes without a distributive or justice-oriented framework).

2.4 Synthesis of results

The selected literature was analyzed using a thematic synthesis approach, focusing on how scholars navigate the tension between abstract normative theories of justice and their empirical operationalization. This process enabled the identification of key challenges, including conceptual inconsistencies, variability in indicator selection and difficulties in translating multidimensional constructs into standardized metrics. At the same time, it highlighted emerging strategies for bridging the gap between theory and measurement, particularly through the development of composite indices that integrate dimensions of inequality, vulnerability and deprivation.

3. Critical approach to the concept of inequality

This section examines the concept of inequality, tracing its evolution from traditional economic indicators to a multidimensional framework. Subsection 3.1 addresses its theoretical definitions, contrasting resource-based approaches with capabilities and entitlement frameworks. Subsection 3.2 details its operationalization through key primary metrics and synthetic indices, such as Gini, Atkinson and Theil, highlighting their applications and analytical scope.

3.1 Inequality: concept and perspectives

Across disciplines as varied as economics, sociology, environmental sciences, geography and public health, inequality is generally defined as the unequal distribution of and access to resources and opportunities among individuals or groups within a society (Graham, 2004; Mattison *et al.*, 2016). The term "inequality" typically refers to the unequal distribution of a variable, with the degree of inequality being determined by the extent to which the distribution deviates from an equal distribution. Consequently, social inequalities appear across multiple domains, including economics resources, health outcomes and social mobility (Clark *et al.*, 2022; Gilbert, 2017).

Consequently, the term "inequality" can also be used to describe a situation in which one population group is unable to access the same level of health, education or income as another (Domínguez-Berjón *et al.*, 2014). Likewise, inequalities are associated with social positions or statuses within a group or society (Mattison *et al.*, 2016). They are shaped by the social context surrounding individuals and require comparison between two or more groups to identify and quantify potential discrepancies between different variables that may contribute to inequalities (Duncan *et al.*, 2014). Inequality, therefore, transcends mere income disparity to be defined as a stratified structure in which social origin persistently conditions personal achievements and final well-being (Araki, 2025).

Historically, the study of inequality was heavily confined to econometric models and income-related metrics (Allison, 1978; Cowell, 2011). This approach has been predominantly adopted by economists, using measures such as the Gini index and the Lorenz curve to quantify disparities (Pagli, 1975). However, recent economic crises and periods or recession have highlighted the limitations of measuring inequality exclusively through economic variables, reinforcing the understanding of inequality as a multidimensional phenomenon (Lang and Lingnau, 2015). As Sen (1992) fundamentally argued, social justice should not be evaluated merely in terms of the distribution of resources, but also in terms of individuals' capabilities to

achieve valued ways of being and doing. From this viewpoint, justice depends on what individuals are actually able to do and be with the resources available to them. This suggests that social stratification is determined by "entitlements," the legitimate rights to access basic goods and shaped by the social context (Leicht, 2020).

Consequently, this perspective challenges traditional measures that rely solely on minimum income cut-offs. Therefore, nowadays, inequality is usually assessed as a multidimensional phenomenon that can be measured by indices such as the UNDP's Human Development Index (HDI), which – in addition to income – includes also life expectancy and educational attainment, or the Multidimensional Poverty Index (MPI), which encompasses education, infant mortality, nutrition and quality of life as measured by access to different basic goods and services (Dean, 2016; Slay *et al.*, 2014). In contemporary societies, inequality can also be measured in terms of labor occupation, differentiating between different categories of workers, as the type of labor occupation and work performed produces social stratification (Leicht, 2020; Xie *et al.*, 2016).

3.2 Operationalizing inequality: from primary metrics to synthetic indices

The operationalization of inequality in social and applied research has relied on a wide range of indicators that seek to capture socioeconomic disparities at both the individual and contextual levels (Domínguez-Berjón *et al.*, 2014). Previous reviews have shown that the most commonly used measures are simple socioeconomic indicators, such as per capita income, employment status, educational attainment, occupation and access to resources. Demographic variables, including nationality and country of origin, are also frequently incorporated as markers of social differentiation (Aamodt *et al.*, 2023; Lloyd, 2010; Xiao *et al.*, 2018).

Regarding the indices employed for the measurement of inequalities, the majority are related to socioeconomic status (SES). Composite indicators such as SES include simple indicators such as family composition, educational attainment, proportion of the population employed in each economic sector, unemployment rate or proportion of population in each work status group (Chakraborty *et al.*, 2020; Sacre *et al.*, 2023; Tello *et al.*, 2005). In addition, less common variables include access to vehicles and neighborhood issues such as crime and overcrowding (Coulter and Clark, 2019; Suel *et al.*, 2019).

Inequality has also been widely used in the context of income inequality at the macro level in both developed (Atkinson, 1995; Roine and Strömberg, 2025) and developing country groups (Fabrizio *et al.*, 2017; Lustig, 2018). Additionally, spatial and environmental research incorporates contextual variables such as population density (Duncan *et al.*, 2014; Lelo *et al.*, 2019) and overcrowding indices, a metric for assessing domestic spatial inequality (Lalloué *et al.*, 2013).

To measure income inequalities, researchers often rely on summary indices that capture the overall distribution of resources or outcomes. Among the most widely used measures is the Gini coefficient. The Gini coefficient, originally developed by Corrado Gini in 1912 (Ceriani and Verme, 2012), provides a summary measure of overall inequality, ranging from 0 (perfect equality) to 1 (maximum inequality), and has been applied to income, health and other social outcomes. However, while the Gini coefficient offers a statistical snapshot of overall inequality, it has limitations in identifying where inequality is most pronounced within the distribution.

In contrast, the Atkinson index (Atkinson, 1970) introduces a normative dimension through a sensitivity parameter that allows researchers to assign greater weight to parts of the income distribution. A higher sensitivity parameter makes the index more responsive to inequalities affecting those at the lower end of the income scale. Thus, Atkinson's approach moves beyond pure statistics to incorporate social justice, specifically prioritizing the position of the most disadvantaged groups (De Maio, 2007).

While the Gini and Atkinson indices describe the magnitude and ethical weight of inequality, the Theil index (Theil, 1967) serves as a diagnostic tool to uncover its structural

origins. One of the main strengths of the Theil index is the ability to decompose total inequality into "within-group" and "between-group" components, providing insight into its structural sources. The Theil index can reveal whether inequality is primarily concentrated within the general population or if it is driven, for example, by systemic gaps in gender, educational attainment, or geographic location. However, unlike the Gini coefficient, the Theil index lacks a universally accepted benchmark for interpreting the meaning of specific values (Tian *et al.*, 2021).

Among the inequality indices focused on these thematic areas, the Gender Inequality Index (GII) stands out for capturing the loss of human development due to gender-based disparities in empowerment and labor market participation (UNDP, 2025). Additionally, the Duncan Segregation Index (Duncan and Duncan, 1955) is frequently employed to quantify spatial or occupational separation between social groups, highlighting territorial inequalities.

Despite their widespread use, inequality indices have been criticized for reducing complex social realities to single numerical representations. Although these measures facilitate comparison across populations and territories, they may obscure the multidimensional and structural nature of inequality and vulnerability, particularly when detached from their broader social, political and territorial contexts.

4. Deprivation: exploring different approaches to deprivation

Section 4 explores deprivation and multidimensional applications across social and spatial research. Subsection 4.1 establishes theoretical boundaries, distinguishing material and social dimensions from income poverty. Subsection 4.2 analyzes operationalization through composite metrics like the Index of Multiple Deprivation, while addressing methodological challenges related to factor analysis and spatial resolution.

4.1 Defining deprivation

The term deprivation refers to the inability to satisfy a basic need due to a lack of material resources (Guillaume *et al.*, 2016). Deprivation can also limit the ability of certain demographic groups to live their daily lives under adequate conditions (Townsend, 1987). Initially developed in the United Kingdom by Holtermann (1975) and later by Townsend (1987), the concept has been widely adopted in the medical and geographical fields to analyze how socioeconomic contexts impact health outcomes (Domínguez-Berjón *et al.*, 2008).

Deprivation is commonly operationalized along two dimensions: social status and material deprivation. The former refers to the collective and individual capital of a population, including social support, community resources and cultural levels (Duque *et al.*, 2021). In contrast, material deprivation refers to limited or insufficient access to essential goods and services, such as education, employment opportunities and adequate housing (Sánchez-Cantalejo *et al.*, 2008; Schuurman *et al.*, 2007). Deprivation manifests as a cumulative convergence of disadvantages across multiple interconnected domains, spanning labor market exclusion, precarious housing conditions and a lack of social integration (Mogin *et al.*, 2025). In this sense, deprivation can also be conceptualized as a continuum rather than a binary condition, ranging from mild to severe forms depending on the accumulation and intensity of unmet needs across different domains (Gordon, 2002).

Beyond objective measures, the conceptualization of deprivation also includes relative deprivation, emphasizing the role that subjective feelings and perceptions play in living conditions. Such findings highlight that social deprivation can be assessed not only through material or social scarcity but also through individuals' subjective experience (Whelan and Maître, 2007). In this context, it is important to clarify the distinction between deprivation and poverty, as these terms are often confused. Poverty generally refers to the lack of income or financial resources needed to achieve a minimum standard of living. However, from a macro-structural perspective, poverty is not merely a ranking of individual financial failures, but a

relational structure where the lack of resources is often a consequence of opportunity hoarding by more powerful groups (Calnitsky, 2018). In contrast, deprivation encompasses a broader spectrum of unmet needs, which may be material – for example, lacking a bathroom or car – or social, such as limited access to education or healthcare (Townsend, 1979). Townsend emphasized that, while poverty is primarily an economic condition, deprivation reflects the outcomes of that condition in everyday life, often across multiple domains (Townsend, 1987). Therefore, while poverty can lead to deprivation, deprivation can also occur when income levels exceed poverty thresholds but other essential needs remain unsatisfied (Dunn, 2023). This approach was adopted by other authors, such as Sen (1976), who argued that poverty should be evaluated not only in terms of income level, but also in terms of what people can or cannot do and be compared to other members of their community.

4.2 Composite variables and indices

The concept of deprivation was initially applied within public health research to operationalize the relationship between social conditions and population health outcomes (Guillaume *et al.*, 2016; Zhang *et al.*, 2021). Early contributions include Carstairs and Morris (1989), who operationalized area-level deprivation through indicators such as overcrowding, male unemployment, low social class and lack of car access in Scotland, England and Wales. These early frameworks established a fundamental methodological principle in deprivation research, highlighting that the definition of disadvantage critically depends on both variable selection and weighting decisions.

Among the most widely used indices is the Index of Multiple Deprivation, originally developed in the United Kingdom to capture multiple dimensions of disadvantage through domains such as income, employment, health, education, housing, environment and crime (Noble *et al.*, 2006). This framework has been tailored into specific national variants, including the English, Welsh and Scottish IMDs. In the English Indices of Deprivation (IoD2019), income (22.5%) and employment (22.5%) domains reflect their foundational role in the structure of disadvantage, followed by Education and Health (13.5% each), and Crime, Housing and Environment (9.3% each) (Leeser, 2016). Furthermore, the IoD2019 framework includes specialized supplementary indices to measure age-specific vulnerability: the Income Deprivation Affecting Children Index (aged 0–15) and the Income Deprivation Affecting Older People Index (aged 60+).

Deprivation studies have also been applied in the United States, where the Index of Multiple Deprivation is widely used and includes variables such as median income, education, tenure, individuals with limited English proficiency, household overcrowding, single-person households, households without a personal vehicle and number of health and recreational facilities per 1,000 persons (Eibner and Sturm, 2006). Another study conducted in the United States employed a less prevalent index, the Standardized Neighborhood Deprivation Index. This index included percentage of men working in managerial and professional occupations, overcrowded housing, poverty, female-headed households with dependents, households receiving public assistance and households with an annual income of less than $30,000. Additionally, it considered the level of education below the high school level and the percentage of unemployed individuals (Messer *et al.*, 2006).

Most deprivation indices are calculated using Exploratory Factor Analysis, while others, such as the Pobal HP Deprivation Index, use Confirmatory Factor Analysis (Haase *et al.*, 2012). More recent studies have employed additional deprivation indices, including the Social Deprivation Index (SDI), a metric that encompasses unemployment, a monthly household income below USD 250, lack of education, single-person households, single marital status, never having been married and under-tenancy (Wong *et al.*, 2008). In Europe, the European Deprivation Index was developed using census data from France, Italy, Portugal, Spain and England, with an innovative approach that combines different variables based on the specific deprivation circumstances in each country (Guillaume *et al.*, 2016). Furthermore, Butler *et al.*

(2013) demonstrated that a composite social deprivation index provides a more robust analysis of health-related disparities than traditional, single-variable metrics, reinforcing the necessity of multidimensional approaches in geographical research.

Indices are tailored to specific spatial contexts, such as VANDIX in Canada (Bell *et al.*, 2007), DANDEX in Denmark (Meijer *et al.*, 2013) and Pobal HP in Ireland (Haase *et al.*, 2012). In Spain, research on deprivation has also concentrated on the spatial determinants of health, resulting in the creation of synthetic deprivation indices (Benach and Yasui, 1999; Duque *et al.*, 2021; Sánchez-Cantalejo *et al.*, 2008). Common variables include unemployment, manual labor proportion, immigration or ethnic minority status, dependency ratio, low education and low household income, with occasional inclusion of single-person households, marital status and car ownership. Data are typically sourced from censuses and general health surveys.

A further significant area of debate concerns the spatial scale of analysis in the context of deprivation. The majority of deprivation indicators are constructed at the area level, designed to reflect the collective socioeconomic disadvantage experienced by residents within specific geographical boundaries, such as neighborhoods or districts (Mogin *et al.*, 2025). For example, the Townsend score is traditionally applied at the level of enumeration districts (EDs) to identify areas with high concentrations of deprived households (Townsend, 1987). This localized approach is critical for capturing the multidimensional nature of deprivation, as focusing on small-area units allows researchers to identify spatial clusters of disadvantage that are typically masked by aggregate national statistics. However, Openshaw and Taylor (1979) demonstrated that variability and inconsistency can arise because area-based measures are often artificially defined and subject to change. This leads to the Modifiable Areal Unit Problem (MAUP), which Schuurman *et al.* (2007) identify as a fundamental challenge in studies of deprivation. The MAUP suggests that the choice of spatial scale directly influences results, specifically through the scale effect (Manley *et al.*, 2006), whereby aggregating data from multiple neighborhoods can mask extreme values through averaging. As a result, this loss of granularity may misrepresent the true level of deprivation in individual areas.

To overcome the constraints of spatial aggregation, recent literature suggests that analyses should not be restricted to a single spatial scale. Authors such as Flowerdew *et al.* (2008) propose the use of synthetic zones, rather than relying on arbitrary census boundaries. Therefore, the robustness of an indicator depends on its ability to remain consistent across different levels of aggregation, thus ensuring that public policy interventions do not mask concrete realities.

5. Vulnerability: an approach to environmental vulnerability and social vulnerability

Section 5 examines vulnerability within environmental and social contexts, focusing on susceptibility to external hazards and systemic risk. Subsection 5.1 grounds the concept in political ecology and institutional resilience, establishing clear distinctions from inequality and deprivation. Subsection 5.2 reviews major operational frameworks – such as the Social Vulnerability Index (SoVI and SVI) – and discusses indicator selection across micro, meso and macro scales.

5.1 Vulnerability: what it is and why it matters

The concept of vulnerability has traditionally been applied to the study of the impact of natural disasters. In this context, the United Nations Office for Disaster Risk Reduction (UNDRR) defines vulnerability as "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard." Fundamentally, vulnerability refers to the condition in which individuals are more susceptible to harm due to a lack of resources and/or skills (Bergstrand *et al.*, 2015; Davino *et al.*, 2021). Furthermore, the term "social vulnerability" is used to describe socioeconomic disparities that arise from a range of

factors, including demographic, social, cultural, economic, political and institutional differences. These factors are related to the ability of individuals and communities to cope with and recover from hazards (Park and Xu, 2022; Santos *et al.*, 2022). Many definitions of social vulnerability share a common denominator focus on susceptibility to hazards and the capacity for resilience or mitigation of their effects (Bergstrand *et al.*, 2015; De Oliveira Mendes, 2009; Holand and Lujala, 2013; Karanja and Kiage, 2022; Mah *et al.*, 2023; Martin, 2015; Park and Xu, 2022). Furthermore, Mah *et al.* (2023) extend the concept of social vulnerability to encompass technological hazards and extreme events in addition to natural hazards. From the perspective of environmental studies, social vulnerability is related to both environmental inequality and ecological resilience (Landry *et al.*, 2020).

Following the tradition of political ecology proposed by Blaikie *et al.* (2004), vulnerability cannot be understood in isolation, but rather as the result of "root causes" linked to the unequal distribution of power and resources. This approach aligns with Adger's (2006) conceptualization of social vulnerability, which emphasizes the susceptibility of individuals and communities to harm from external stresses, as well as the role of adaptive capacity, resilience and institutional conditions in shaping their ability to respond. From a social justice perspective, vulnerability can be understood as reflecting unequal entitlements and constrained capabilities, whereby exposure to risk is mediated by individuals' actual capacity to respond and recover (Sen, 1992; Fraser, 2009; Schlosberg, 2007).

International organizations like the United Nations (UNDP, 2014) and ECLAC (CEPAL, 2002) utilize vulnerability to guide development and humanitarian policies, focusing on the defenselessness of specific groups. The UNDP (2014) refined this through the concept of "human vulnerability," which describes the erosion of individual capabilities when facing shocks, from abrupt disasters to long-term environmental shifts, by integrating structural dimensions, such as intersecting constraints of gender and ethnicity, with life-cycle dynamics that account for increased susceptibility during childhood or old age. Ultimately, the UNDP asserts that analyzing vulnerability demands triadic precision: identifying what groups are vulnerable to, the underlying reasons why and who specifically is most affected.

Theoretical models often conceptualize vulnerability through two constituent elements: the biophysical impacts on a given space and the intrinsic social dimensions of the population (Chambers, 1989; Ge *et al.*, 2019). Other studies have used vulnerability as a concept associated with risk and hazard, including hazard, socioeconomic patterns and associated decision-making over time (Holzmann *et al.*, 2003; Karanja and Kiage, 2022). In this context, while some authors have conceptualized the hazards underlying vulnerability as primarily natural (Holand and Lujala, 2013; Reckien, 2018), others have adopted a more multifaceted conceptualization (Spielman *et al.*, 2020; von Szombathely *et al.*, 2023).

The main distinction between vulnerability and inequality is that vulnerability encompasses not only the unequal distribution of a variable but also external factors, thereby representing a consequence or impact of a phenomenon (Chambers, 1989; Downing, 1990). In social policy, this distinction is vital for resource allocation, as it allows for the prioritization of groups based on their specific level of defenselessness (Mayrhofer, 2025). The term vulnerable is applied to a society or group of people when several conditions necessary to resilience are lacking or inaccessible (Ge *et al.*, 2019). These concepts are interrelated, and several factors may contribute to vulnerability, including socioeconomic differences and poverty (Brooks *et al.*, 2005). Cutter *et al.* (2003) propose that social vulnerability is a result of social inequalities, as well as the characteristics inherent to communities and the built environment. Consequently, social vulnerability is not merely dependent on individuals' or households' characteristics but is also shaped by spatial dynamics (Davino *et al.*, 2021). For instance, vulnerability to environmental stress or hazard has been associated with population socioeconomic characteristics and educational attainment (van der Land and Hummel, 2013). Research has also examined relationships between social vulnerability and the availability and diversity of urban tree species, particularly in areas with higher proportions of tenants, low-income residents and people aged over 65 years (Landry *et al.*, 2020). Furthermore, social

vulnerability can be measured through specific demographic and socioeconomic indicators that increase exposure to risk or reduce adaptive capacity. Examples of these indicators include low educational attainment, low income, chronic physical or mental illness, job insecurity, low-skilled employment, physical disability, housing deprivation, overcrowding and language barriers. These conditions tend to exacerbate vulnerability, particularly among ethnic minorities, people living alone, single-parent households and non-native language speakers (Baró *et al.*, 2019; Davino *et al.*, 2021; Frigerio *et al.*, 2018; Ribot, 1995; Martin, 2015; von Szombathely *et al.*, 2023; Yenneti *et al.*, 2016).

Groups that share certain characteristics – such as low income, limited education or insecure housing – tend to be more socially vulnerable, as they are more exposed to hazard and have a reduced capacity to avoid or mitigate harm (Martin, 2015), as well as to social exclusion (Arthurson and Baum, 2015). Nevertheless, vulnerability is not an inherent condition of individuals, but rather a contextual and relative phenomenon. Moreover, there is no consensus on the standardization of variables to measure vulnerability, as this is dependent on the specific research objectives, the geographical location of the study and the study scope under investigation.

5.2 Vulnerability indicators: factors and dimensions

The Social Vulnerability Index (SoVI), developed by Cutter *et al.* (2003), is one of the most widely used frameworks for operationalizing vulnerability. Initially developed in the United States, it has been widely applied in international contexts (De Oliveira Mendes, 2009; Holand and Lujala, 2013; Frigerio *et al.*, 2018; Spielman *et al.*, 2020; Park and Xu, 2022; Santos *et al.*, 2022). SoVI is predominantly employed in the field of hazards, yet it lacks variables specifically pertaining to natural disasters and their associated risks (Mah *et al.*, 2023). Furthermore, efforts have been made to integrate these diverse indices into a unified index, such as the Place-based Vulnerability Index (PVI) (Piegorsch *et al.*, 2007).

Building on this tradition, the Social Vulnerability Index (SVI) developed by Flanagan *et al.* (2011) provides a more standardized and policy-oriented operationalization. The SVI categorizes vulnerability into four critical domains: (1) socioeconomic status, (2) household composition and disability, (3) minority status and language and (4) housing and transportation. A primary strength of the SVI is its reliance on a high-resolution geographic scale, specifically the census tract level.

The operationalization of vulnerability is inherently scale-dependent, as the selection of indicators varies according to the spatial resolution of analysis. In Downing (1990) study of vulnerability to famine, three levels of analysis were established: macro, micro and micro-individual. At the macro level, which can range from a country to a city or neighborhood, one of the dimensions can be geographical (violence in the neighborhood) or institutional (lack of access to services and resources). The indicators for this level of analysis can be the number of muggings or the number of facilities in the neighborhood. The micro level analysis focuses on the purchasing power of the household, which is measured by the average net income per household. The micro-individual level refers to the individual and may encompass demographic characteristics such as age, gender or other individual characteristics, as outlined by Downing (1990). In the medical field, these dimensions are represented at the micro level by individual factors and lifestyles, at the meso-level by social relations and the community and finally, at the macro level, by associated with socioeconomic, cultural and environmental conditions (Dahlgren and Whitehead, 1991).

In contrast, macro-global perspectives redefine the concept through systemic development assets – such as GDP, governance and gender equity – exemplified by the Global Data Lab Vulnerability Index (Smits and Huisman, 2024) or the study by Birkmann *et al.* (2022) that uses the Global Risk Index and the Index for Risk Management at the global level. Ultimately, the choice of indicators must be tailored to the scale of the study, as micro-scale indices

prioritize social fabric and immediate responsiveness, while these broader frameworks emphasize institutional fragility.

However, a more nuanced approach, pioneered by Chambers (1989), emphasizes the need for simple, participatory methods that allow individuals to analyze their own conditions and identify priorities. This perspective shifts the focus toward vulnerability indicators centered on household assets, such as net assets, labor capacity, dependency ratios and food security, alongside exposure to external shocks and stresses.

In addition to the field of natural disasters, prior research has investigated the relationship between social vulnerability and the capacity of communities to adapt to environmental inequalities. This includes studies on the unequal distribution of urban forests (Landry *et al.*, 2020) or the impact of heat waves (Arthurson and Baum, 2015). Besides, vulnerability has been applied in health research (Mah *et al.*, 2023) and in studies of exposure to hunger (Downing, 1990).

6. Discussion and implications

This review makes three main contributions to social and environmental justice literature. First, it clarifies the conceptual boundaries between inequality, deprivation and vulnerability, which are often used interchangeably in empirical research. Second, it proposes a functional framework that explains how these concepts interact across temporal and analytical dimensions. Third, it provides guidance for their operationalization in empirical research and policy design.

6.1 Interrelations between inequality, deprivation and vulnerability

Our findings suggest that inequality refers to the uneven distribution of resources and opportunities across different individuals or groups within a society. This unequal distribution creates a social structure where some groups have greater access to essential resources than others. Inequality can be defined as a structural condition of society, which is related to class and social composition.

In turn, deprivation emphasizes unmet needs due to a lack of essential resources, opportunities or capabilities necessary for a decent quality of life. This includes unmet basic needs that directly affect individuals' well-being. For example, pre-existing inequalities can intensify deprivation, limiting access to housing, healthcare or education.

Vulnerability, by contrast, is not primarily a distributive concept. Rather, it refers to the susceptibility of individuals or groups to harm, although this susceptibility is often shaped by pre-existing structural inequalities. Closely linked to resilience, vulnerability reflects a group's capacity to cope with, adapt to and recover from hazards or adverse situations.

However, vulnerability can also exacerbate existing inequalities, as those most vulnerable are less able to cope with the impact of a hazard, and the time required to recover from such an event can serve to prolong existing inequalities. These distinct concepts are interrelated, often acting as both causes and consequences of social processes that produce unequal outcomes.

As with vulnerability, the opportunities to cope with or adapt to hazards are also influenced by inequality and deprivation, as well as by a range of social and contextual factors, including livelihoods, community structures, social networks, household composition, gender, age, ethnicity, historical context and physical and mental health. These factors shape both the degree of vulnerability, the extent of deprivation and the distribution of inequalities, highlighting the complex interactions between inequality, deprivation and vulnerability in social justice research.

Together, these insights allow us to propose an integrated and nonlinear conceptual framework that clarifies the dynamic and multidirectional relationships between the three concepts. As Figure 1 illustrates, inequality may operate as the structural root of social injustice, representing systemic and historically embedded disparities in the distribution of

wealth, opportunities and power across axes such as race, class and geographical location. However, these baseline asymmetries do not follow a strictly sequential or unidirectional trajectory toward deprivation and vulnerability.

Instead, the framework captures a recursive system driven by mutually reinforcing feedback loops and exogenous shocks. While structural inequality generates ongoing material deprivation, exogenous shocks interact directly with pre-existing conditions. As Sen (1999) illustrates through the concept of entitlement failures, sudden environmental or socioeconomic shocks can directly trigger acute deprivation irrespective of prior distributive states. In turn, accumulated vulnerability is not merely a passive layer of impact or a future risk state; as a dynamic process of accumulated strain (Chambers, 1989; Hinkel, 2011), vulnerability actively materializes into further material deprivation by depleting community coping capacities and asset bases during and after adverse events.

Consequently, deprivation materializes in the uneven capacity of certain groups to access essential goods and services – such as adequate housing, healthcare, education and meaningful social participation – acting both as an outcome of structural disparities and as an active catalyst that heightens exposure and deepens systemic inequalities. Rather than treating vulnerability merely as a passive, resultant layer of impact or a static future risk state (UNDP, 2014), our framework incorporates these multidirectional mechanisms to directly address the critique by Hinkel (2011), who argues that operational models must explicitly specify how variables dynamically combine to measure potential future harm. The process is inherently cyclical: external impacts and vulnerability-driven deprivations reinforce mechanisms of cumulative disadvantage (DiPrete and Eirich, 2006), perpetually feeding back into the structural roots of inequality and trapping marginalized groups in a self-perpetuating cycle of injustice.

While rooted in social justice literature, this framework directly informs environmental and climate justice by showing how structural inequalities drive uneven exposure to ecological hazards. By framing exogenous shocks as direct triggers of acute deprivation, it

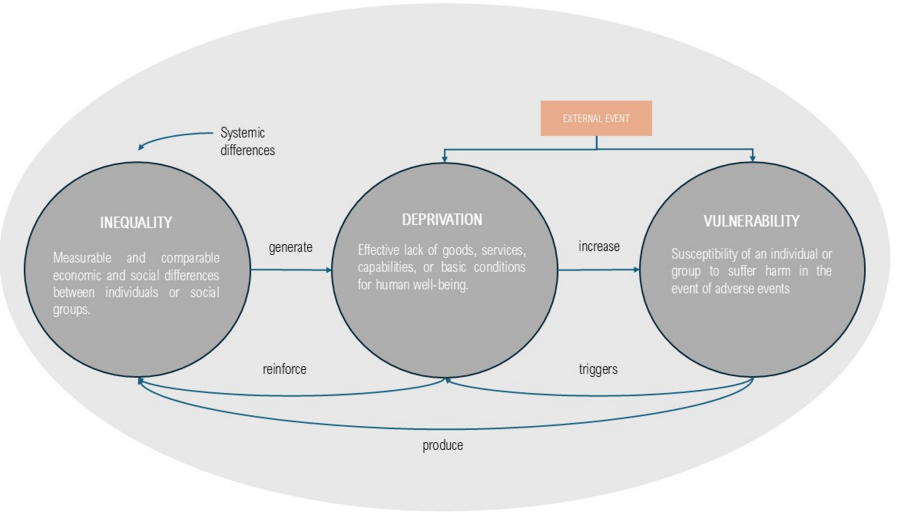

Figure 1. Conceptual framework of the relationships among inequality, deprivation and vulnerability in social justice research. Source: Authors' own work

demonstrates that environmental justice remains inseparable from broader socioeconomic conditions.

6.2 Practical application and policy guidance

A key challenge identified in the review is that attempts to conceptually separate inequality, deprivation and vulnerability may themselves introduce artificial distinctions. In practice, empirical studies frequently blur these boundaries, either by combining indicators across concepts or by using them interchangeably. This raises the question of whether inequality, deprivation and vulnerability reflect distinct social processes or different analytical lenses applied to similar underlying phenomena, as summarized in Table 1. Crucially, this conceptual ambiguity is not merely a terminological issue but reflects deeper theoretical tensions within the field of social justice. Distributive approaches such as those associated with Rawls (1999) emphasize equality in resource allocation, while capability-based frameworks developed by Sen (1992) and Nussbaum (2000) highlight the importance of conversion factors and real freedoms. In parallel, recognition-based theories and environmental justice theories (Bullard, 1993; Fraser and Honneth, 2003; Schlosberg, 2007) introduce nonmaterial dimensions, systemic exposure to hazards and institutional exclusion. The overlapping empirical use of inequality, deprivation and vulnerability reflects these unresolved normative tensions across both domains.

In studies addressing the impacts of natural disasters or environmental phenomena – such as urban heat islands, desertification or other climate-related events – vulnerability is a conceptually appropriate and widely accepted term. It is particularly relevant within the frameworks of climate justice and social justice, as it encompasses not only exposure to hazards but also the varying capacities of social groups to anticipate, cope with and recover from environmental stressors and climate-induced events (Otto *et al.*, 2017). For example, urban heat islands disproportionately impact marginalized communities, as pre-existing social inequalities exacerbate their vulnerability. Furthermore, the term should be employed in studies examining the consequences of alterations to the economic system, such as economic crises or recessions. Ultimately, vulnerability should be employed as a core framework in research investigating how demographic and social conditions dictate health outcomes, as it captures not only the current state of deprivation but also the diminished capacity of certain populations to anticipate, cope with and recover from external shocks.

The term deprivation is applicable when the study in question analyzes the impact of the lack of basic necessities of life, including economic resources, food, housing and healthcare. The term is also applicable to studies that analyze the lack of opportunities or social

Table 1. Comparative overview of inequality, deprivation and vulnerability

Concept	Approach	Temporal momentum	Common indicators	Social and environmental justice response
Inequality	Comparative	Structural/ Historical	Gini index, wage gaps, disparities in exposure to environmental	Redistribution and equity
Deprivation	Absence/Lack	Present/ Static	Poverty indices, material and service deprivation and lack of basic resources	Guarantee of social and environmental minimums
Vulnerability	Capacity/ Susceptibility	Prospective/ Risk	Environmental exposure and vulnerability indices	Social protection, climate adaptation and resilience

Source(s): Authors' own work

participation (academic, cultural, political, etc.) of the population from a perspective of social justice, redistribution of resources and social policies. Addressing deprivation is essential within climate justice discourse, as it underscores the need for equitable access to resources that empower communities to build resilience to environmental and social risks.

The term inequality should generally be employed when the study focuses on the analysis of differences in any socioeconomic characteristics, whether purely economic (income, purchasing power), demographic (gender, age, race) or social (religion, ethnicity, class, cultural level, education). This is applicable in most academic contexts, as it enables the description and characterization of disparate realities through comparison. Within the context of climate justice, inequalities reflect systemic and historical disparities that shape the uneven distribution of environmental risks and benefits across social groups (Harlan *et al.*, 2015). For example, lower-income groups or racial minorities are often more exposed to urban heat islands due to residential segregation and lack of green infrastructure. However, effective intervention requires prioritizing variables based on their specific weight in mitigating shocks. This may make assessing vulnerability more informative for intervention than measuring inequality alone: for instance, while disability is not a distributive inequality *per se*, it constitutes a state of heightened vulnerability when individuals lack the adaptive capacity to navigate institutional barriers.

Our research reveals a persistent paradox: while "deprivation" and "vulnerability" are theoretically broad, "inequality" remains primarily associated with income disparities in empirical practice. The overlap in their dimensions often leads to conceptual confusion. However, we propose that the distinction lies not only in the variables used but in their functional purpose. Following Hinkel (2011), social vulnerability should be operationalized as systemic susceptibility – a measure of the internal state of the social fabric before a hazard occurs.

While some frameworks include event-specific data (such as flood recurrence), we argue that the core of social vulnerability is contextual. It identifies the structural limitations of a system in its capacity to absorb shocks, regardless of their specific nature. In this sense, a vulnerability index differs from an inequality index by its prospective logic: it functions as a diagnostic of potential future harm rather than a mere description of current disparities. Conversely, measuring deprivation requires a focus on unmet needs and societal perceptions of social minimums (Pornet *et al.*, 2012). By combining these measurable indicators with context-specific qualitative insights (Patulny *et al.*, 2007), researchers can better align theoretical definitions with empirical metrics. This synthesis enables targeted public policies that address the specific causal mechanisms of social fragility, moving beyond one-size-fits-all interventions.

7. Conclusion

In light of the increasing visibility of social injustices and the persistent challenges in addressing them, this study contributes to the field of social justice by providing a clear and consistent framework for the use of inequality, vulnerability and deprivation. Unlike previous studies that treat these terms interchangeably, our analysis demonstrates that they represent distinct but interrelated layers of a systemic process.

As demonstrated, inequalities refer to differences that emerge from the comparison of populations, which may ultimately lead to the disadvantage of specific groups. Deprivation should be used to describe the lack of material and social resources, opportunities or capabilities necessary to meet essential needs within a particular social group. Vulnerability, on the other hand, describes the susceptibility of a population to harm in the face of adverse events or shocks, reflecting its capacity to anticipate, cope with, adapt to and recover from them.

This review synthesizes the multidimensional nature of these disparities to provide a standardized lexicon for social justice research. By clarifying these boundaries, it highlights

how precise terminology is a prerequisite for equity-oriented policies designed to address intersecting vulnerabilities and the structural constraints embedded within the social fabric. Moreover, this framework guides future studies toward a more coherent and rigorous operationalization of social justice, ensuring that interventions are accurately targeted to mitigate systemic issues faced by diverse populations across varying spatial contexts.

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