Implicit Sustainable Development Theories Obscure Disproportionate Impacts from Climate-related Extreme Events: Example from Hurricane Michael and Housing Losses on Florida's Forgotten Coast

Chad Stephen Boda (chad.boda@LUCSUS.lu.se)
Lund University: Lunds Universitet

Murray Scown
Utrecht University: Universiteit Utrecht

Turaj Faran
Lund University: Lunds Universitet

Research Article

Keywords: Climate Change, Capital Theory, Human Development, Loss and Damage, Disproportionality, Disasters

Posted Date: May 13th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-512844/v1

Implicit sustainable development theories obscure disproportionate impacts from climate-related extreme events: example from Hurricane Michael and housing losses on Florida's Forgotten Coast

Chad S. Boda[1]*, Murray W. Scown[2], Turaj Faran[1]

[1]Lund University Centre for Sustainability Studies, Lund, Sweden; [2]Copernicus Institute of Sustainable Development, Utrecht University, Netherlands

*Corresponding author: chad.boda@lucsus.lu.se, +46730344243, LUCSUS, Lund University, Box 170, SE-221 00 Lund, Sweden

Abstract

A central challenge for sustainable development (SD) is how societies are to avoid, minimize or address impacts from anthropogenic climate change. However, competing perspective on "what should be sustained" lead to widely different understandings of what mitigation, adaptation and loss and damage entail and how best to approach them. We provide a novel conceptual and empirical comparison of two contrasting SD-based theoretical approaches to the study of impacts from climate-related extreme events: Capital Theory and Human Development. We use our analysis of immediate residential property value and housing capacity impacts caused by Hurricane Michael in Gulf County, Florida, to demonstrate how the theory used to assess and interpret impacts greatly affects the identification of whom and where is considered to be objectively "most impacted". From our comparative analysis and discussion, we conclude that, while currently underutilized, Human Development is the more advanced approach to SD oriented climate-impact research and policy when compared to Capital Theory.

Keywords

Climate Change; Capital Theory; Human Development; Loss and Damage; Disproportionality; Disasters

1. Introduction

Evidence is mounting that anthropogenic climate change (CC) is already causing geographically uneven and socially disproportionate harms in different places around the world (IPCC, 2018). However, the kinds of impacts considered relevant to CC policy and practice, e.g., economic vs. non-economic (Serdeczny et al., 2018), tangible vs. intangible (Tschakert et al., 2019), and at what scale remains contested terrain. The way evidence of impacts is interpreted by researchers and policy makers will have important implications for where and whom is considered "most impacted", and thus for what is considered a prudent policy response to address climate-related impacts when they occur (Thomas et al., 2020). In the context of Sustainable Development (SD), addressing this question means clarifying "what should be sustained" when attempting to avoid, minimize or address impacts from CC.

Sustainable Development (SD) offers a fully comprehensive, integrative and coherent approach to understanding and addressing anthropogenic climate change-driven impacts (Boda et al., 2020). Multiple theories of SD are (implicitly) informing research and practice in this area, each with a unique set of core concepts, evaluative criteria, informational requirements and related policy prescriptions (Boda et al., 2021). Two of the main approaches include: 1) Capital Theory, a utilitarian economic theory that prioritizes maintaining a society's aggregate productivity through its capital stocks; and 2) the capabilities approach

to Human Development, a non-utilitarian welfare theory that prioritizes improving the substantive freedom (i.e., capabilities) available to individuals in society, starting with the least-well-off. Outside, or rather, between, these two approaches, a third unique body of work exists that emphasizes numerous heterogeneous ways in which CC impacts may manifest, which has been labelled the "wish-list of valid concerns" (Boda et al., 2021). While the spectrum of ideas that make up this body of work are not as internally coherent as the main two approaches, its most notable and consistent characteristic is a concern with the place- and cultural-specificity of many impacts from CC (see, e.g., Tschakert et al. 2017; Barnett et al, 2016). This leads some of its proponents to develop extensive lists of different types of impacts from CC that are supposedly incommensurable (e.g., Tschakert et al., 2019). How best to handle measurement and monitoring of heterogeneous impacts from CC remains an important topic of contention in loss and damage circles, though it is essential if a catalogue of climate-related harm is ever to materialize (Otto et al., 2020). The current study, as explained below, maintains a focus on comparing the two main approaches; however, when discussing the advantages of the capabilities approach to Human Development in particular, we argue that it also provides a satisfactory resolution to the on-going "wish-list" debate over how best to conceptualize, measure and ultimately address the heterogeneous impacts from CC.

It is well-known that there are differences in how competing theories conceptualize, measure and seek to address development related challenges (see, e.g., Greig et al., 2007, Ch. 11). Broadly speaking, economic-based approaches have dominated scholarship on the assessment of loss and damage from climate change (McNamara and Jackson, 2019; Boda et al, 2021). However, recent developments in the area of Disaster Risk Reduction (DRR) have argued for impact assessment approaches that disaggregate impacts and highlight the most vulnerable, with some explicitly championing a capabilities approach to impact assessment (Ton et al., 2020; Gardoni and Murphy, 2008; 2009). Still, use of the capabilities-based Human Development approach even within DRR studies remains scarce (Ton et al., 2020). In the context of climate-related impacts relevant for the Paris Agreement and loss and damage research, the explicit implications of adopting such varying approaches in interpreting disproportionality and differences in severity have not been empirically researched.

Empirical evidence is required to understand the comparative advantages and disadvantages of competing DRR or loss and damage approaches at the broader level of development strategies and priorities, not only at the level of appropriate metrics and tactics within DRR. Indeed, DRR itself needs to be situated; that is, while DRR is indispensable as a tool box for avoiding, minimizing and addressing risks from CC, it generally lacks orientation regarding how such activities as mitigation, adaptation and addressing loss and damage from CC contribute to broader normative development strategies, which theories of SD provide (see Boda et al., 2020). These levels, however, are of course intertwined. Theoretically speaking, the development strategy one adheres to should determine what the appropriate tools and metrics for assessment are, which in turn will guide recovery responses. However, empirically, there are very few studies assessing the same event from two different development approaches, and discussing in what ways the assessments differ and how this could impact post-event response priorities (for exceptions see, e.g., Gardoni and Murphy, 2010). More evidence of the advantages and disadvantages of competing SD approaches to CC-impact studies will furthermore help clarify the consequences for CC-impact researchers, and the policies that flow from this research, of adopting, implicitly or explicitly, a particular approach.

We here empirically assess the impacts of Hurricane Michael to Gulf County's (Florida, USA) residential properties through three different analytical impact indicators (total property value losses, proportional property value losses, and loss of residential units or newly vacant residential properties), which we apply to parcel-level property data collected by the Gulf County Property Appraiser before and after the hurricane. We then interpret the results from the perspective of two contrasting approaches to SD, namely Capital Theory and the Human Development approach. We discuss how these competing perspectives lead to different appraisals of what defines a "highly impacted" area, as well as how they have the propensity to skew towards certain types of information and thus the properties and people represented by this information. We conclude with a reasoned and comparative appraisal of the two approaches, favoring the capabilities approach to Human Development. We argue that the capabilities approach to Human Development provides means for handling heterogeneous impacts from CC consistently, without resorting to either reductionist unitary metrics or to extensive lists of supposedly incommensurable impacts.

2. Materials and methods

2.1 Hurricane Michael, a limits-breaching event

Hurricane Michael made landfall in the Florida Panhandle on October 10, 2018 as the strongest storm of the 2018 hurricane season and the strongest ever to make landfall in October in the United States. It was also the only category 5 storm on record to make landfall along this region of Florida, affectionately known as the "Forgotten Coast". More than two years later, many communities impacted by the storm are only beginning the process of long-term recovery.

The best science available suggests that the scale and type of impacts seen in the wake of Hurricane Michael are indicative of what will become more likely in a climate-changed world (Patricola and Wehner, 2018; IPCC, 2018). By this, we mean impacts that exceed a variety of local hard and soft "limits" to adaptation (Barnett et al, 2015), the culmination of which then lead to widespread damages. Post-hurricane analysis showed that storm surge reach 9-14 feet (2.7-4.3 m) above ground level in the hardest hit areas along the coast, easily topping the natural height of the local barrier fore-dune system that normally acts as a protective barrier against the impacts of coastal storms (Beven et al., 2018.). A rapid damage survey conducted by Prevatt and Roueche (2019) showed that the breaching of this height limit lead to catastrophic flooding and extensive damage to coastal infrastructure and residences. Hurricane Michael wind speeds also breached other important hard limits, leading to extensive damage. Prevatt and Roueche (2019) also found that wind speeds exceeded the physical limits of many structures in the impacted area, though with important divergences. Homes with certain building characteristics, e.g., construction year and material types, were correlated with particular degrees and types of damage, with older homes generally fairing worse than newer houses in terms of wind damage, the former being less likely to have adopted current construction standards. These same wind speeds also exceeded the physiological limits of regional crops and forest species, e.g. longleaf pines (*Pinus palustris*) (Zampieri et al., 2020), toppling hundreds of square miles of timber resources and protected forest, and destroying thousands of acres of vegetable crops across Florida, Georgia and Alabama (Avila, 2019).

The exceeding of these hard limits led to damages on a scale that further exceeded important soft limits in the affected communities, in particular financial limits. Storm damages far exceeded the budgetary

capacities of highly impacted city and county governments, in a state where local financial capacity for ecological restoration, climate adaptation and disaster preparation and response is highly uneven and often severely lacking (Boda and Jerneck, 2019; Boda, 2018). In the aggregate, Hurricane Michael was registered as a "billion dollar" disaster according to the National Center for Environmental Information, with $25.5 billion in damages (NOAA, n.d.). Similarly, the Em-Dat database registered the storm as causing $16 billion in damages. However, the distribution of these effects was highly uneven. Large portions of the total damage amounts came from agricultural and forestry impacts resulting from high wind speeds (FDACS, 2018), as noted above. A smaller but no less significant portion of these reported impacts comes from structural damages, including devastating impacts to commercial and residential properties and debris clearance costs. The National Hurricane Center's final synopsis of Hurricane Michael noted that Gulf County was among the three hardest hit counties in terms of structural damages, along with Bay County to the west, and Jackson County to the north, with Gulf County affected the most in per capita terms (Beven et al., 2018).

2.2 Study area – Gulf County

Gulf County is located in the Northwestern "Panhandle" region of Florida in the southeastern United States (Figure 1). Gulf County is a predominantly rural county with a population of just over 13,500 residents. Per capita income is just over $21,000 while median household income is around $44,000. Roughly, 20% of Gulf County's population lives in poverty (*U.S. Census Bureau*, n.d.). As previously mentioned, it was among the most heavily impacted counties on a per-capita basis by Hurricane Michael (Beven et al., 2018).

2.3 Analysis of housing impacts

We focus on housing impacts for three main reasons. First, research has consistently shown that damage to housing is both a common and deeply significant impact occurring as a result of tropical cyclones and other natural disasters (Comerio, 1997; Zhang and Peacock, 2009). Second, in the context of the United States, housing is commonly a major source of wealth for many households, and losses in its value can have significant implications for household financial security, even inter-generationally (Wolff, 2016). Finally, having access to adequate housing is a crucial conversion factor for many other essential social capabilities, including securing income-generating employment and maintaining physical and mental health (Winston and Pareja Eastaway, 2008). The question of adequate and affordable housing is widely viewed as central to managing future climate risks, recognizing that the housing question, particularly in developing countries, will interact with and be exacerbated by increasing climate hazards (e.g., heat waves, tropical cyclones), generally impacting the least-well-off most severely (IPCC, 2018). Of course, a focus on housing certainly does not capture all significant impacts, including those that may affect the most vulnerable residents, such as elderly, people with disabilities, and low-income renters (Ton et al., 2020). Because of this, we are not claiming to reveal all the important differences between Capital Theory and Human Development approaches when it comes to impact of climate-related extreme events. Our claim is more modest but still important. We show, using housing as an example, how the concepts and metrics in these competing approaches promote either exclusion or inclusion of impacts on particular portions of the population, which clearly has implications for *inter alia* recovery policy at a variety of scales.

We analyze housing impacts using three different impact indicators. First, we analyze *total* residential property value losses (i.e., aggregate monetary damages). This is taken as an indication of the *quantitative* severity of residential property damages; that is, the higher the total monetary damages, the higher the impact severity. Second, we analyze *proportional* residential property value losses (i.e., monetary damages as a percentage of total property value). This is taken an indication of the *qualitative* severity of residential property damages; that is, the higher the proportion of total property value lost, the higher the impact severity. Third, we analyze the loss of residential units (i.e., newly vacant or lost residential properties). This is taken as an indication of the severity of impacts to housing *capacity*; that is, the higher the percentage of residential units lost, the higher the impact severity. We note here that just because an indicator is itself numerical, does not imply it cannot represent qualitative characteristics (see, e.g., Tabandeh et al., 2017). We evaluated these indicators at the parcel level, then analyzed them at two scales: the county level and the intermediate "neighborhood" level. Parcels are the smallest spatial units of land delineated in the study area (Figure 1), with more than 18,000 discrete parcels across the entirety of Gulf County in 2019. Our second spatial scale of analysis, the neighborhood level (Figure 1), is a grouping of census blocks around six neighborhoods of high-density residential properties. These neighborhoods were identified using a combination of 1) county zoning maps to narrow the geographic focus to residential zonings only, 2) visual identification of higher density residential areas using parcel data in ArcMap, and 3) the author's pre-knowledge of Gulf County and its distinct residential neighborhoods.

Insert Figure 1

Housing losses were evaluated using the parcel-level property appraisal data from the Florida Tax Authority. Property appraisal data for 2018 and 2019 provide records of parcel value and land use and property type before and after Hurricane Michael. We confirmed with the state property appraiser that a parcel-by-parcel damage survey was conducted and recorded after the storm, and that tax information contained in the property appraisal data is the most comprehensive measure of Hurricane Michael's immediate impact on residential properties. It is still quite possible the survey under-valued some property damages due to the practical limitations of the post-storm valuation process (e.g., external observation vs. internal damages). The property appraisal data were made spatially-explicit by joining them to the 2019 shapefile of county-wide parcel boundaries.

We analysed all parcels in Gulf County categorized as residential in 2018. We included all parcels with any of the three residential base strata used by the Tax Authority (Table 1). We used the base strata to identifying the specific zoning of parcels as residential. We also observed the active strata to determine if parcels were actively being used for residential purposes. We then analysed for 2019 the same parcels that were categorized as residential according to their 2018 base strata, which were identified in the 2019 data by the unique parcel identifier. Only those parcels whose unique identifier matched between the 2018 and 2019 appraisal data, as well as the 2019 shapefile, were retained. A total of 6731 residential parcels were analysed for the entire county, but two were removed for block- and neighborhood-level analyses because of non-matching spatial data.

Insert Table 1

Monetary values of all residential parcels in 2018 and 2019 were obtained from the "just value" recorded in the property appraisal. We adjusted "just value" by the "just value change" also recorded in the appraisal data, which reflects any adjustment made to an initial property valuation upon a subsequent valuation. Monetary losses (or gains) were calculated for each parcel as the change in adjusted just value from 2018 to 2019. We then calculated these parcel-level losses (or gains) as a proportion of the 2018 property value. One outlier was removed (parcel ID 03178-110R) whose 2018 just value change (from a second 2018 appraisal) reduced the parcel value by over 95%, but the parcel's 2019 value was back to within 75% of the first 2018 appraisal. These changes could not meaningfully be in interpreted in relation to the storm damage, and so this parcel was removed. Finally at the parcel level, we calculated the total number of residential units lost from 2018 to 2019 as the difference in total units within all parcels analysed from 2018 to 2019.

Next, we aggregated parcel-level assessments to the census block level. We used the 2018 TIGER/Line shapefile (U.S. Census Bureau, 2018) for census blocks and the 2019 parcel boundary shapefile to spatially-join parcels to census blocks. The use of 2018 census blocks was to align with demographic statistical data during the year of the storm, while the use of 2019 parcels was to align with losses and damages experienced after the storm. We aggregated 2018-2019 changes in property value for all parcels within each block and in the total number of active residential units within each block. We then excluded all blocks with a net gain in parcel value from further analyses, in order to focus on the distribution of losses. A total of 463 blocks were analysed further. The magnitude of monetary and housing capacity losses at the block level were then used in the calculation of neighborhood level impacts.

We compared how housing impacts from Hurricane Michael would be evaluated differently through the three indicators (absolute monetary losses, proportional monetary losses, housing capacity losses). We analysed the rank-order of blocks according to each measure of losses because the absolute measures of monetary losses are extremely skewed. In this approach, blocks with a low rank through a particular lens can be considered to have sustained smaller losses when compared to a block with a high rank through the same lens. If the three indicators yield similar evaluations of impacts, one would expect the rank-order of blocks to lie close to the 1:1 diagonal when two indicators are plotted against each other. Large deviations from the expected 1:1 relationship (residuals) indicate blocks where, for example, proportional value losses are much greater than total value losses, relative to other block, or vice versa.

Finally, we focused on the six neighborhoods (Figure 1) in order to assess intermediate-level patterns in housing losses throughout the county. These include the two main cities of Port St. Joe and Wewahitchka, North Port St. Joe and "St. Joe Beach" (both distinct neighborhoods within greater Port St. Joe), as well as the unincorporated communities of Cape San Blas and Highland Views. These areas are all zoned as residential, mixed commercial-residential or municipal. Within these zones, the neighborhoods were spatially bounded based on geographic proximity rather than formal municipal boundaries to maximize the number of parcels captured in the neighborhood analysis. All statistical analyses were performed in R and all spatial data processing performed in ArcGIS. Additional informational sources were also collected to complement the primary analysis of housing data, including damage surveys conducted by academic, state and private institutions.

3. Results

3.1 Parcel-level impacts

Our analysis reveals that 85% of residential parcels in Gulf County sustained some degree of monetary value loss between 2018 and 2019. These gross monetary losses totaled more than $250 million. Median property value in the county dropped by 19%, from $139,400 in 2018 to $112,500 in 2019. Almost 60% of residential parcels (n = 4013) lost $10,000 or more in value, while 6% (n = 416) lost half of their 2018 value or more. Just over half of all properties lost between $1 and $30,000 in value (Figure 2A) and two-thirds lost between 0% and 30% of their 2018 value (Figure 2B). The largest absolute monetary loss sustained by a single property was $2.15 million and six properties lost all of their value and more (i.e., by incurring a negative property value in 2019). Only 12% of properties gained value from 2018 to 2019, and 3% did not change in value.

Insert Figure 2

In terms of housing capacity lost, our analysis shows that 17% of active residential units (n = 1186) were lost following Hurricane Michael. These losses include 194 active units that became vacant from 2018 to 2019, as well as 992 units active in 2018 that disappeared in 2019. Additionally, loss of residential units does not imply a monetary loss in property value from 2018 to 2019 (e.g., if a multi-unit property was converted to a single-unit property with greater value). However, our qualitative assessment suggests the actual impact to housing capacity is much higher when considering some residential units are still occupied but in squalid condition due to storm damage.

Our analysis of the 5668 residential parcels that suffered monetary loss in value revealed that many properties sustaining very high proportional damages remained active residences (Figure 3A). Of the 413 parcels that lost more than half of their value from 2018 to 2019, 84 remained active residential in 2019, including 10 properties that lost more than 75% of their value (Figure 3A), indicating that some residents in Gulf County are living in properties worth only a fraction of their pre-hurricane value. When visiting Gulf County in March 2020, Boda observed the continued widespread use of plastic tarps and other temporary fixes to residential properties in, for example, (North) Port St. Joe and Highland Views. In other locations, such as St. Joe Beach, large portions of the coastal residential areas remain cleared, with only concrete foundations remaining of the properties destroyed in Hurricane Michael. The vast majority (91%) of parcels that lost value and became vacant in 2019 sustained losses of more than $10,000 (Figure 3B), yet almost a quarter of vacancies occurred with losses less than 25% of their 2018 value and as little as 0.3% (Figure 3B), perhaps indicating residents who relocated after the storm without having personally sustained significant property damage.

Insert Figure 3

3.2 Neighborhood-level impacts

Neighborhoods differed greatly in terms of total value, proportional value and housing capacity impacts (Table 2). Net parcel losses across neighborhoods range from $1.2 million (Highland View) to $68 million (Cape San Blas), while proportional losses across neighborhoods ranged from 7% in Highland View to 24% in St. Joe Beach. Average change in parcel value had a wide range from almost $4,677 in North Port St. Joe to almost $75,000 in Cape San Blas. Average proportional change in parcel value ranged between 1% and

22%. Residential unit losses ranged from 6% of the housing units in Port St. Joe to 30% in St. Joe Beach. St. Joe Beach and Highland View sustained by far the highest percentage loss of housing units of all neighborhoods.

Insert Table 2

3.3 Differences among indicators

Our results show that the three indicators used give very different pictures as to the distribution and magnitude of impacts. If the lenses were to give equivalent evaluations of impacts, one would expect the rank-order to be similar when assessed through each indicator, which is not the case in Gulf County (Figure 4). Large monetary losses do not necessarily imply large proportional losses or losses in housing capacity (i.e., percent of units lost within a block), and vice versa.

The uneven distribution of impacts throughout Gulf County become even clearer when comparatively ranking the six neighborhoods along the three lenses used to assess losses and damages (Figure 4). High value properties in Cape San Blas dominate the monetary loss rankings, while less than 10% of housing units were lost in this neighborhood (Table 2). In contrast, Highland View sustained comparatively low monetary losses per parcel overall, but had massive losses of housing units. North Port St. Joe and Wewahitchka are clustered largely in the upper left corner of Figures 5A and 5C, implying that, while the total monetary damage in these communities was relatively little in comparison to other neighborhoods, e.g. Cape San Blas, they still experienced devastating impacts to property, as reflected in high proportional loss rankings (Figure 4C), as well as in direct housing capacity, as reflected in high percent unit losses (Figure 4A). Certain neighborhoods, such as Port St. Joe and St. Joe Beach, show a distribution indicative of high housing capacity losses across parcels that sustained all levels of total or proportional monetary losses (Figure 4A and B). Port St. Joe and St. Joe Beach also show a less skewed relation between total loss rankings and percent loss rankings than lower-income parts of the county; e.g., North Port St. Joe and Wewahitchka (Figure 4C).

Insert Figure 4

4 Discussion

4.1 Housing impacts from the perspective of Capital Theory

Capital Theory approaches SD from a utilitarian perspective and aims to sustain aggregate utility over time, generally indicated by the level of per capita income. It thus emphasizes that SD is development that maintains a society's overall productive capacity (i.e., stock of productive capital), as this is considered the driver of economic growth (Solow, 1991). Monetary metrics and cost-benefit analysis are necessary tools used to monitor and evaluate capital growth over time. It should be noted that, while Capital Theory is not concerned with the *precise* distribution of wealth in society, it is not completely negligent of the issue. Rather, Capital Theory relies on the assumption that a well-functioning market economy will provide the most efficient (and least coercive) mechanism for distributing aggregate social wealth within society (Solow, 1989).

From this perspective, housing is understood primarily as a "stock of capital" that can be invested in or divested from depending on the rate of return on investment. Housing stock in this view is substitutable with other productive industries, and investing in housing stock is (economically) rational when it leads to growth in overall economic production (e.g., GDP). In this way, the most relevant information for understanding Hurricane Michael's impacts to housing in Gulf County is to focus on the more than $250 million in county-wide aggregate property value losses. When it comes to the disproportionate distribution of these monetary damages, and thus the identification of "most impacted" areas within the county, the focus will be on those areas with the highest monetary losses. In other words, the most impacted areas from the perspective of Capital Theory are those with the largest quantity of property value lost, which are highly affected by the pre-existing relative value of a given property.

Cape San Blas and St. Joe Beach (respectively) show up as the first and second most impacted neighborhoods from this perspective, with their collective impacts amounting to just over half (54%) of the total losses county-wide. Other areas with lower total monetary losses, even if they have high proportional or capacity losses, are ranked comparatively lower due to their more marginal importance for capital stock restoration. This includes, for example, the entire neighborhoods of Wewahitchka, North Port St. Joe and Highland View, which when combined amount to a total of $7 million in damage, or a mere 3% of countywide damages.

With its focus on *aggregate* monetary damages, the other analytical indicators we used to assess impacts on housing in the county are not relevant from the perspective of Capital Theory. More precisely, the significance of proportional value losses and the loss of housing unit capacity are considered to already be sufficiently represented in the aggregation of monetary losses. However, Prevatt and Roueche (2019), in their post-disaster rapid assessment, suggest that disproportionate impacts from Hurricane Michael at the parcel level result from a combination of hazard exposure and, importantly, housing quality and age. Older or lower quality homes, which may be ranked quite low in monetary value terms, were in fact heavily impacted by both storm surge and wind damages, with obviously important implications for the individuals living in these houses. Capital Theory offers little insight into how to deal with such qualitative disproportionality in impacts. Its propensity to focus, albeit unwittingly, on damage to more expensive properties leads to a neglect of cases of proportionally more severe damaged properties if they are relatively low in monetary value.

4.2 Housing impacts from the perspective of Human Development

Human Development approaches SD from a non-utilitarian position, focusing on addressing objective deprivations in contrast to maximizing aggregate social utility measured in monetary units. Development is thus viewed as the process by which individuals are empowered to pursue lives they have reason to value, rather than as the process of capital accumulation (see Sen, 2001). The freedom of individuals to live meaningful lives is a factor of a person's capability set, that is, the substantive opportunities becoming available to the person. Free persons can combine their different capabilities to achieve different functioning states (i.e., different lifestyles). Sustainable development, from this perspective, is thus development that expands people's substantive opportunities (capabilities) to live valuable lives, and it draws on a wide variety of informational sources to monitor and evaluate this process of capability expansion.

From this perspective, housing is understood primarily as a basic necessity (often called a "conversion factor") for a wide variety of essential capabilities, including maintaining health and employment. Interpreting housing impacts in this perspective implies understanding them as leading to the *deprivation of individual capabilities.* The most relevant information, then, is not the aggregate monetary losses as in Capital Theory, but the disaggregated impacts on individual capabilities to continue to lead valued (e.g., healthy) lives, which clearly includes being adequately housed. Thus, the most pertinent information is regarding the *qualitative* severity of damage to a particular residential property/neighborhood (e.g., proportional value losses), including the over-all capacity to accommodate citizens with residential units (e.g., housing capacity losses). An interest in qualitative disproportionality, however, does not preclude the possibility of assessing these impacts using quantitative data, as we have done here via proportional value losses. When it comes to the disproportionate distribution of impacts, the capabilities approach aims to focus on those residents who are the least well off, recognizing that there are qualitatively different kinds of capability deprivation connected to pre-existing inequalities in capability sets and functioning achievements (Gardoni and Murphy, 2009), including, for example, differences in housing quality.

The difference between proportional and total losses that we have shown is instructive. Our results reveal that impacts viewed through the lens of proportional monetary losses (an indication of the *qualitative* severity of impact to a property) highlight different highly-impacted areas than those under Capital Theory (which emphasizes *quantitative* severity). North Port St. Joe, for example, sustained very high levels of proportional property value loss, even though it ranks relatively low in terms of total damage levels. This is, first, an indication that many houses in North Port St. Joe were severely damaged in the storm (even if they did not become vacant) and, second, that the high proportional losses represent the potential for a major hit to intergenerational wealth in an already low-income community. The importance of recognizing the qualitative difference between total and proportional damages, and their implications for low-income households, has been noted by other climate-impact researchers as well (van der Geest, 2018).

Comparing high value losses and high housing capacity losses brings out further important differences. Many places with lower levels of monetary damage (i.e., low property values to begin with) experienced high levels of housing units loss, for example North Port St. Joe and Highland View, implying a significant loss in the ability to house residents. From this capabilities perspective, areas with high proportional losses *and* high vacancy rates, as seen for example in St. Joe Beach as well as North Port St. Joe and Highland View, could be considered potential deprivation hotspots.

4.3 Identifying the "high impact" areas: which SD approach is best?

Interpretation of the different impact indicators leads to very divergent assessments of which neighborhoods in Gulf County were "most impacted" by Hurricane Michael (Table 3). Reviewing this provides a good opportunity for discussing the comparative advantages and disadvantages of the two competing SD approaches.

Capital Theory comes with strong technical advantages. One of the most immediate is that it is the appropriate fit for much of the current practice in the areas of DRR, CC adaptation and loss and damage, where economic-based assessment and policy rules the game (see, e.g., McNamara and Jackson, 2019; Boda et al. 2021). Its focus on economic concepts, metrics and financial risk reduction policies results in a degree of relative decisiveness and comprehensiveness that some argue may be essential for

operationalizing climate-impact research in the existing political climate (Roberts et al., 2017), or including "stakeholders" such as the private sector (Surminski and Eldridge, 2015). Historically, the kind of strict reductionism inherent in Capital Theory has proven appealing to policy makers in relation to a wide variety of environmental and development concerns (Porter, 1996). A serious downside of Capital Theory, however, is that its focus on aggregate monetary losses has the potential to draw attention away from the worst off areas. For example, it is practically impossible for low property value neighborhoods like North Port St. Joe (average parcel loss of $4,677) to be identified as the "most impacted" areas under this perspective, as they simply do not have the property wealth to compare quantitatively with places like Cape San Blas (average parcel loss of $74,872).

Insert Table 3

On the other hand, the Human Development approach, as we see it, has important distinct substantive advantages over Capital Theory. While Capital Theory is primarily concerned with aggregate monetary losses and must convert all relevant impacts into this unitary metric, the Human Development approach does not ignore the importance of monetary losses, but incorporates it as one relative factor potentially affecting capabilities. That is to say, one should take note of monetary losses not in its absolute magnitude (á la Capital Theory), but in terms of the contribution that this magnitude makes relative to the overall human capabilities of its proprietors. Relative figures such as proportional losses are instead preferred as they allow some meaningful comparability between lower property value areas like North Port St. Joe and high property value ones like Cape San Blas in terms of qualitative severity of impacts. This is because the Human Development approach is concerned with the lost use-value of property, not only the exchange value. The Human Development approach's interest in the qualities of impacts facilitates the inclusion of all properties, irrespective of value, that experienced severe immediate impacts. This is reflected in for example the ranking of St. Joe Beach (largely high property values) as highly impacted from both perspectives, as it was ground zero of the hurricane and experienced near complete devastation (Prevatt and Roueche, 2019) and thus high proportional and housing capacity losses, in addition to high total value impacts. At the same time, North Port St. Joe and Highland View (low to middle value properties) take the place of Cape San Blas as "most impacted" under the capabilities approach, due to higher levels of proportional and capacity impacts. This attention to the qualitative heterogeneity of impacts points towards another important advantaged afforded by the Human Development approach to climate-related impact studies, which we elaborate in the following section.

4.4 Opportunities and challenges for a Human Development approach to climate-impact research and policy

There are many important capabilities not well captured by the kind of value-focused housing impacts we analyzed here, which might reasonably be expected in the aftermath of any extreme event. These include, for example, access to adequate nutrition, environmental quality concerns, or loss of community belonging, which affect many of the most vulnerable people including homeless, people with disabilities, children, elderly and low-income renters. These kinds of so-called "non-economic" impacts have been much discussed in research on the impacts from anthropogenic climate change, particularly in loss and damage circles. One of the main bones of contention regards what metrics are appropriate when accounting for non-monetary impacts. Some argue non-economic or intangible impacts from CC cannot or should not be quantified or made comparable due to their being derived from particular cultural and geographical contexts, which renders them incommensurable (Tschakert et al., 2017). The answer to this

question from within Capital Theory, of course, is to require all relevant impacts be converted into monetary metrics, thus rendering them commensurable (Dilley and Grasso, 2016), for which there are many standard tools (Preston, 2017). However, a focus on capabilities does not necessitate or preclude quantification, nor require the use of any unitary metric, but rather draws on a dashboard of relevant indicators. The use of such an indicator dashboard under the Human Development approach is quite different from the elaboration of extensive lists of qualitatively different and presumably incommensurate impacts from CC (cf. Tschakert et al., 2019; also see the "wish-list" literature from Boda et al., 2021). Under the Human Development approach, the commensurability of the varying kinds of possible impacts from climate-related events is not denied, nor is it achieved via a unitary *metric*. Rather, the possibility of comparing the wide variety of qualitatively different possible impacts from CC is achieved through a unitary *concept* (i.e., capabilities) which coherently expresses relations among these varying kinds of impacts and their implications for peoples´ substantive freedoms and well-being (see Sen, 2001, Ch. 1). It is here that we note perhaps the most significant challenge for a Human Development approach to climate-related impact studies, in contrast to the merits of Capital Theory; namely, the difficulty of operationalizing a capabilities approach to Human Development in actual SD practice. For Sen, the indicators included in a dashboard should reflect a set of contextually-relevant capabilities, and the prioritization of these capabilities should, within the realm of reasonable possibility, be set through a process of open and reasoned public deliberation (see Sen, 1999). While his attempt to operationalize the capabilities approach lead Sen into the realm of ethics and theories of justice (see Sen, 2011), there are unquestionably other avenues open to exploration for its operationalization, which points towards fruitful further research.

5. Conclusions

In this article, we have provided empirical measurements of impacts to residential properties in Gulf County, Florida occurring from Hurricane Michael, a limits-breaching climate-related extreme event. In the aggregate, we reported widespread and devastating impacts, with nearly nine in ten of county-wide residential properties sustaining immediate value losses, and nearly 1 in 5 of total residential units rendered vacant or lost between 2018-2019. Our interpretation of these impacts through competing theories of SD show how they lead to dramatically different appraisals of where and whom is considered "most impacted". While Capital Theory is a highly operational approach compatible with much current practice, its emphasis on aggregate monetary losses has the potential to draw attention away from properties that experienced severe qualitative damages and towards high-value properties, with the possibility of overlooking those most in need. The Human Development approach's emphasis on qualitative impacts to housing as a factor in maintaining capabilities such as physical and mental health, in contrast, draws attention to areas where high percentages of residential properties were severely damaged (i.e., proportional monetary damages) and/or rendered unlivable (i.e., capacity losses). This helps draw attention to neighborhoods that experienced immediate and severe qualitative damages across the full spectrum of high to low property value neighborhoods. We furthermore note how the unitary concept of capabilities provides a resolution to the debate over how to conceptualize and measure heterogeneous impacts from CC in a coherent, consistent and integrative way. Operationalizing the Human Development approach in practice, however, remains a major challenge. We conclude from our comparative analysis and discussion that the capabilities approach to Human Development is promising

as a more comprehensive and human-centered approach to SD oriented climate-impact research and policy when compared to Capital Theory.

Declarations:

Funding: Swedish Research Council FORMAS

Conflicts of interest: None

Availability of data and material: Data available upon request from corresponding author

Code availability: Code available upon request from corresponding author

References:

Avila, L. A. (2019). The 2018 Atlantic Hurricane Season: Another Catastrophic Year for the United States. *Weatherwise,* 72(4), 14–21. https://doi.org/10.1080/00431672.2019.1612201

Barnett J, Tschakert P, Head L, Adger WN (2016) A science of loss. Nat Clim Chang 6:976

Barnett, J., L. S. Evans, C. Gross, A. S. Kiem, R. T. Kingsford, J. P. Palutikof, C. M. Pickering, and S. G. Smithers. (2015). From barriers to limits to climate change adaptation: path dependency and the speed of change. *Ecology and Society* 20(3): 5. http://dx.doi. org/10.5751/ES-07698-200305

Beven, J. L., Berg, R., and Hagen, A. (2018). National Hurricane Center Tropical Cyclone Report: Hurricane Michael (AL142018).

Boda, C.S. (2018). The entrepreneurial Sunshine State: Neoliberalism, growth management and environmental conservation in Florida, *Journal of Urban Affairs*, 40:6, 838-862, DOI: 10.1080/07352166.2017.1413287

Boda, C.S., Faran, T., Scown, M., Dorkenoo, K., Chaffin, B.C., Nastar, M., Boyd, E. (2021). Loss and damage from climate change and implicit assumptions of sustainable development. *Climatic Change*. 164: 13

Boda, C.S., Scown, M., Faran, T., Nastar, M., Dorkenoo, K., Chaffin, B.C., Boyd, E. (2020). Framing Loss and Damage from climate change as the failure of Sustainable Development, *Climate and Development*, DOI: 10.1080/17565529.2020.1851640

Boda, C.S., Jerneck, A. (2019). Enabling local adaptation to climate change: towards collective action in Flagler Beach, Florida, USA. *Climatic Change* 157, 631–649. https://doi.org/10.1007/s10584-019-02611-6

Comerio, M. C. (1997). Housing Issues after Disasters. *Journal of Contingencies and Crisis Management*, 5(3), 166–178. https://doi.org/10.1111/1468-5973.00052

Dilley, M., and Grasso, V.F. (2016). Disaster reduction, loss and damage data, and the post-2015 international policy agenda. *Environmental Science and Policy*, 61, 74–76. https://doi.org/10.1016/j.envsci.2016.04. 002

FDACS. (2018). Hurricane Michael's Damage to Florida Agriculture. Florida Department of Agriculture and Consumer Services.

Gardoni, P. and Murphy, C., (2008). Recovery from natural and man-made disasters as capabilities restoration and enhancement. *International Journal of Sustainable Development and Planning*. Vol. 3, No. 4, 317–333

Gardoni, P. and Murphy, C., (2009), Capabilities-Based Approach to Measuring the Societal Impacts of Natural and Man-Made Hazards in Risk Analysis, *Natural Hazards Review*, 10(2), 29-37

Gardoni, P. and Murphy, C., (2010), Gauging the societal impacts of natural disasters using a capability approach, *Disasters*, 34(3), 619-636

Gardoni, P., and Murphy, C. (2009). Capabilities-Based Approach to Measuring the Societal Impacts of Natural and Man-Made Hazards in Risk Analysis. *Natural Hazards Review*, 10(2), 29–37. https://doi.org/10.1061/(ASCE)1527-6988(2009)10:2(29)

Greig, A., David Hulme, and Mark Turner (2007). "Challenging Global Inequality: Development Theory and Practice in the 21st Century". Palgrave Macmillan.

IPCC. (2018). An IPCC Special Report on the Impacts of Global Warming of 1.5 °C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways. Intergovernmental Panel on Climate Change (IPCC).

Lashley, J. G., and Warner, K. (2015). Evidence of demand for microinsurance for coping and adaptation to weather extremes in the Caribbean. *Climatic Change*, 133(1), 101–112. https://doi.org/10.1007/s10584-013-0922-1

McNamara, K.E., and Jackson, G. (2019). Loss and damage: A review of the literature and directions for future research. *WIREs Climate Change*, 10(2), Article e564. https://doi.org/10.1002/wcc.564

NOAA. (n.d.). U.S. Billion-dollar Weather and Climate Disasters, 1980 - present (NCEI Accession 0209268). Retrieved June 12, 2020, from https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0209268

Nordlander, L., Pill, M., and Martinez Romera, B. (2019). Insurance schemes for loss and damage: fools' gold? *Climate Policy*. https://doi.org/10.1080/14693062.2019.1671163

Otto, F.E.L., Harrington, L.J., Frame, D., Boyd, E., Cedervalle Lauta, K., Wehner, M., Clarke, B., Raju, E., Boda, C., Hauser, M., James, R.A., and Jones, R.G. (2020). Towards an inventory of the impacts of human-induced climate change. *Bulletin of the American Meteorological Society*, 101, E1972–E1979. https://doi.org/10.1175/ BAMS–D–20–0027.1

Patricola, C. M., and Wehner, M. F. (2018). Anthropogenic influences on major tropical cyclone events. *Nature*, 563(7731), 339–346. https://doi.org/10.1038/s41586-018-0673-2

Peacock, W. G., Van Zandt, S., Zhang, Y., and Highfield, W. E. (2014). Inequities in Long-Term Housing Recovery After Disasters. *Journal of the American Planning Association*, 80(4), 356–371. https://doi.org/10.1080/01944363.2014.980440

Preston CJ (2017) Challenges and opportunities for understanding non-economic loss and damage. *Ethics Policy and Environment* 20:143–155

Prevatt, D. O., and Roueche, D. B. (2019). Survey and Investigation of Buildings Damaged by Category-III, IV & V Hurricanes in FY 2018-2019 – Hurricane Michael. Project #P0091032.

Roberts, J.T., Natson, S., Hoffmeister, V., Durand, A., Weikmans, R., Gewirtzman, J., and Huq, S. (2017). How will we pay for loss and damage? *Ethics, Policy, Environment*, 20(2), 208–226. https://doi.org/10.1080/21550085.2017.1342963

Sen, A. (1999). The possibility of social choice. *American Economic Review*, 89(3), 349–378. https://doi.org/10.1257/aer.89.3.349

Sen, A. (2001). Development as freedom. Oxford Paperbacks.

Sen, A., (2011). The idea of justice. Harvard University Press.

Serdeczny, O.M., Bauer, S., and Huq, S. (2018). Non-economic losses from climate change: Opportunities for policy-oriented research. *Climate and Development*, 10(2), 97–101. https://doi.org/10.1080/17565529. 2017.1372268

Solow, R.M., (1986) On the intergenerational allocation of natural resources. *The Scandinavian Journal of Economics,* Vol. 88, No. 1

Solow, R.M., (1991) Sustainability: an economist's perspective. The eighteenth J. Seward Johnson lecture. Woods Hole Oceanographic Institution: Woods Hole, MA, USA.

Surminski S, Eldridge J. (2015) Observations on the role of the private sector in the UNFCCC's loss and damage from climate change work program. *International Journal of Global Warming* 8:213–230

Tabandeh,A., Gardoni, P., Murphy, C. (2017), A Reliability-Based Capability Approach. *Risk Analysis*. Vol. 38, Issue 2

Thomas, A., Serdeczny, O., and Pringle, P. (2020). Loss and damage research for the global stocktake. *Nature Climate Change*. https://doi.org/10.1038/s41558-020-0807-z

Ton, K.T., Gaillard, J.C., Adamson, C. et al. (2020). An Empirical Exploration of the Capabilities of People with Disabilities in Coping with Disasters. *International Journal of Disaster Risk Science*, 11, 602–614. https://doi.org/10.1007/s13753-020-00287-6

Tschakert P, Barnett J, Ellis N, Lawrence C, Tuana N, New M, ELRICK-BARR C, Pandit R, Pannell D (2017) Climate change and loss, as if people mattered: values, places, and experiences. *Wiley Interdisciplinary Reviews-Climate Change* 8

Tschakert, P., Ellis, N. R., Anderson, C., Kelly, A., and Obeng, J. (2019). One thousand ways to experience loss: A systematic analysis of climate-related intangible harm from around the world. *Global Environmental Change*, 55, 58–72. https://doi.org/10.1016/j.gloenvcha.2018.11.006

U.S. Census Bureau QuickFacts: Gulf County, Florida. (n.d.). Retrieved June 12, 2020, from https://www.census.gov/quickfacts/gulfcountyflorida

U.S. Census Bureau (2018). TIGER/Line Shapefiles and TIGER/Line Files Technical Documentation.

UNFCCC. (2020). Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on its second session, held in Madrid from 2 to 15 December 2019. Addendum Part two: Action taken by the Conference of the Parties serving as the meeting . United Nations Framework Convention on Climate Change.

van der Geest, K. (2018). Landslide Loss and Damage in Sindhupalchok District, Nepal: Comparing Income Groups with Implications for Compensation and Relief. *International Journal of Disaster Risk Science*, 9(2), 157–166. https://doi.org/10.1007/s13753-018-0178-5

Winston, N., and Pareja Eastaway, M. (2008). Sustainable housing in the urban context: International sustainable development indicator sets and housing. *Social Indicators Research*, 87(2), 211–221. https://doi.org/10.1007/s11205-007-9165-8

Wolff, E. N. (2016). Household Wealth Trends in the United States, 1962 to 2013: What Happened over the Great Recession? *The Russell Sage Foundation Journal of the Social Sciences*, 2(6), 24–43.

Zampieri, N.E., Pau, S. and Okamoto, D.K. (2020). The impact of Hurricane Michael on longleaf pine habitats in Florida. *Scientific Reports*, 10, 8483. https://doi.org/10.1038/s41598-020-65436-9

Zhang, Y., and Peacock, W. G. (2009). Planning for Housing Recovery? Lessons Learned From Hurricane Andrew. *Journal of the American Planning Association*, 76(1), 5–24. https://doi.org/10.1080/01944360903294556

Tables:

Table 1. Base strata categories of the Florida Tax Authority used to identify residential parcels in 2018.

Our category	Tax Authority Strata	Description
Residential	01	Residential property consisting of one primary living unit, including, but not limited to, single-family residences, condominiums, cooperatives, and mobile homes.
Residential	02	Retirement homes and residential property that consists of two to nine primary living units.
Residential	06	Improved commercial and industrial property (including multi-family residential with 10 units or more). Within this strata, only those parcels with 10 units or more included here.

Table 2. Parcel losses summarized for the six neighborhoods. Neighborhoods are ordered by average parcel value change. All dollar values given in current USD and all percentages given as % of 2018; all losses are indicated by negative sign.

Neighborhood	**No. of parcels**	**Net loss**	**% net loss**	**Average parcel value change**	**Average parcel value change (%)**	**% residential units lost**
Cape San Blas	906	$-67.83 mil.	-18%	$-74,872	-18%	-9%
St. Joe Beach	1266	$-66.27 mil.	-24%	$-52,344	-22%	-30%
PSJ (excl. Nth)	1254	$-35.12 mil.	-18%	$-28,010	-15%	-6%
Wewahitchka	362	$-2.99 mil.	-13%	$-8,264	-15%	-9%
Highland View	205	$-1.20 mil.	-7%	$-5,876	-1%	-23%
North PSJ	598	$-2.80 mil.	-11%	$-4,677	-13%	-10%
All other parcels	2137	$-61.27 mil.	-15%	$-28,670	-10%	-10%

Table 3: The top three most impacted for each indicator, interpreted by two theories of SD. The neighborhood positions represent the average ranks of all census blocks in each neighborhood against each indicator in Figure 4.

		Capital Theory	Human Development	
		Total Value	Proportional Value	Housing Capacity
Most impacted	1	Cape San Blas	St. Joe Beach	St. Joe Beach
	2	St. Joe Beach	North PSJ	Highland View
Least impacted	3	PSJ (excl. Nth)	PSJ (excl. Nth)	North PSJ

Figures and legends/text descriptions:

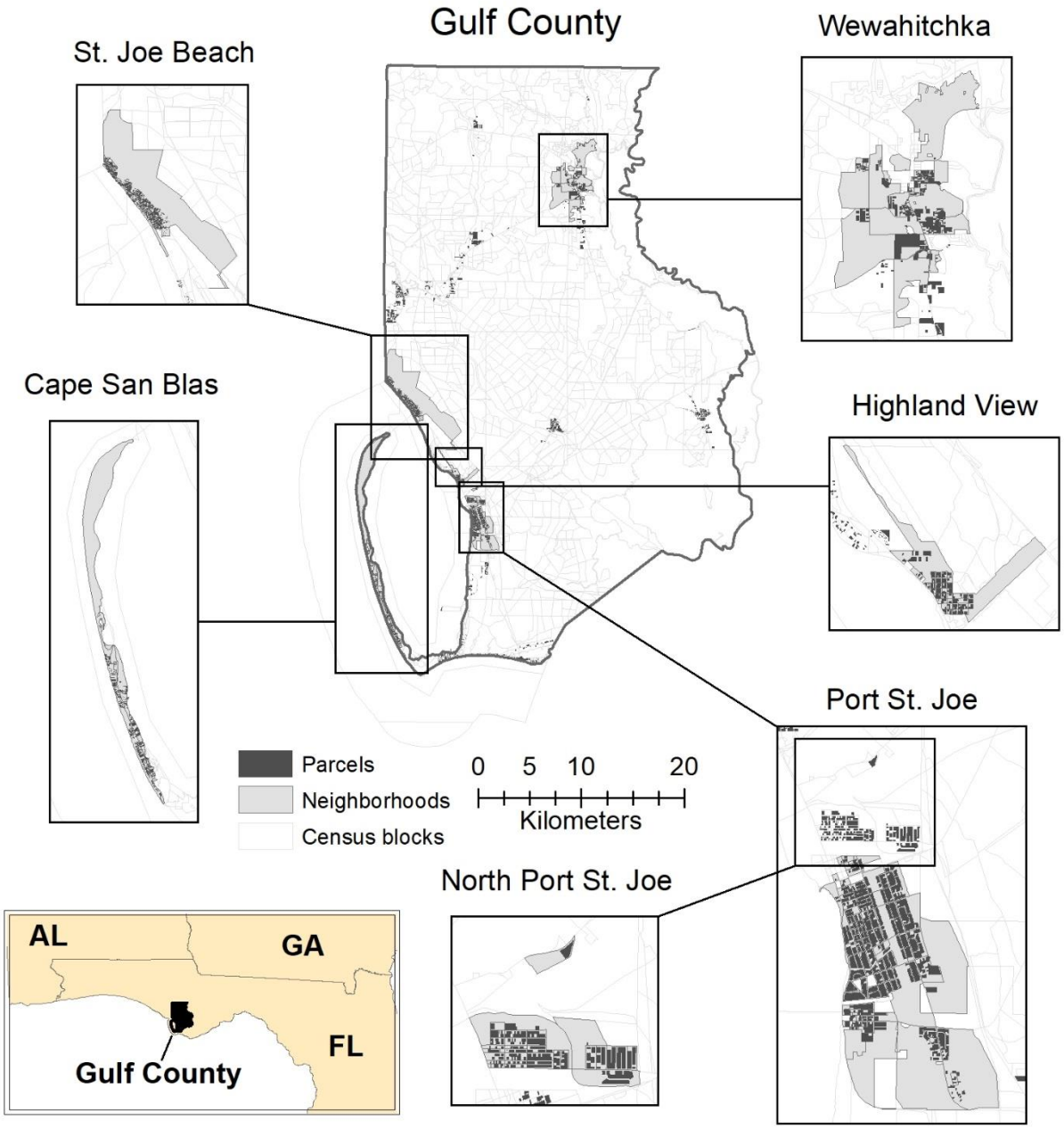

Figure 1. Spatial boundaries of Gulf County, residential parcels and six neighborhoods analysed. Dark grey filled shapes are all 2018 residential parcels in Gulf County. Light grey filled shapes are census blocks aggregated to analyse six neighborhoods, which are shown as insets. Bottom left inset shows location of Gulf County in the Florida Panhandle, USA. Note that North Port St. Joe was analysed separately from what we refer to as Port St. Joe, and what we label St. Joe Beach includes the Beacon Hill locality.

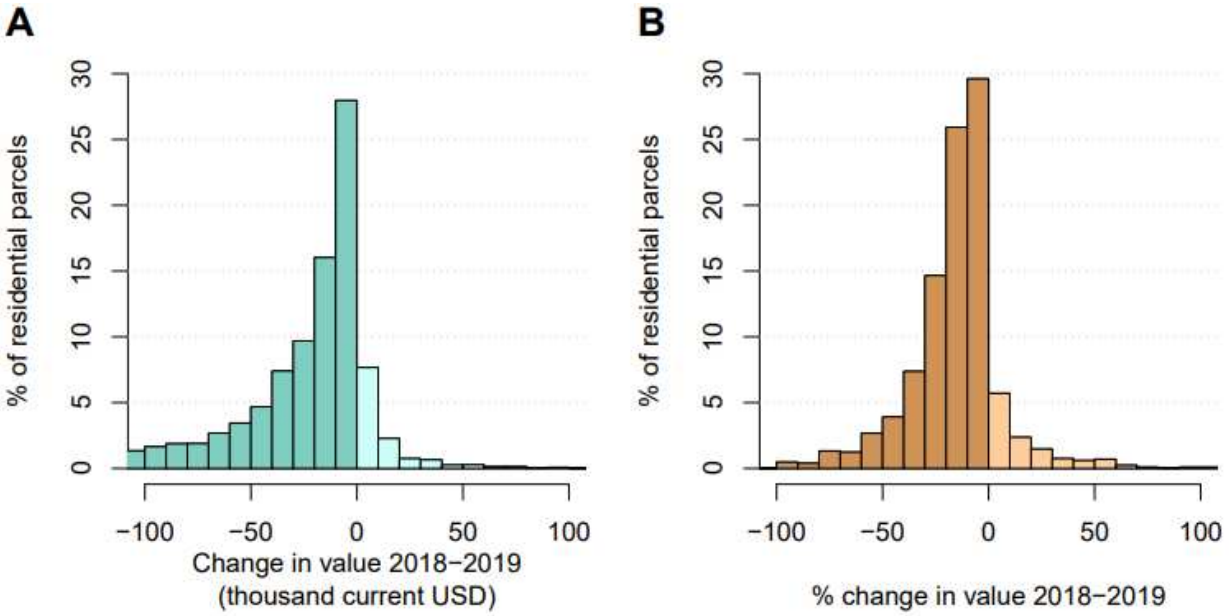

Figure 2. Percent frequency distributions of (A) total and (B) percentage changes in value from 2018-2019 for 6731 Gulf County residential parcels. Darker colour shades indicate parcels with net losses. NB horizontal axes are truncated and actual ranges were $-2.15 million to $0.42 million for (A) and -126% to 795% for (B), although only a tiny fraction of parcels had a change in value outside the ranges shown.

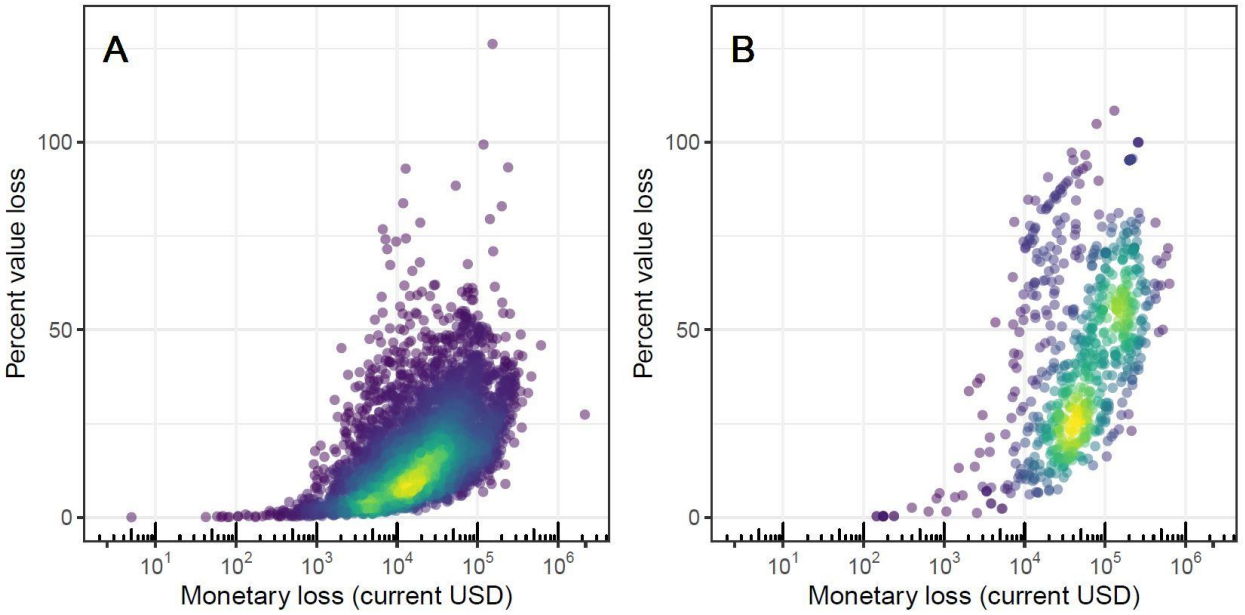

Figure 3. Absolute monetary losses compared to percentage losses for (A) the 4892 residential parcels in Gulf County that experienced a monetary loss in value but remained active; and (B) the 776 residential parcels that experienced a monetary loss in value and became vacant. Points are coloured by brightness according to increasing density in the plots.

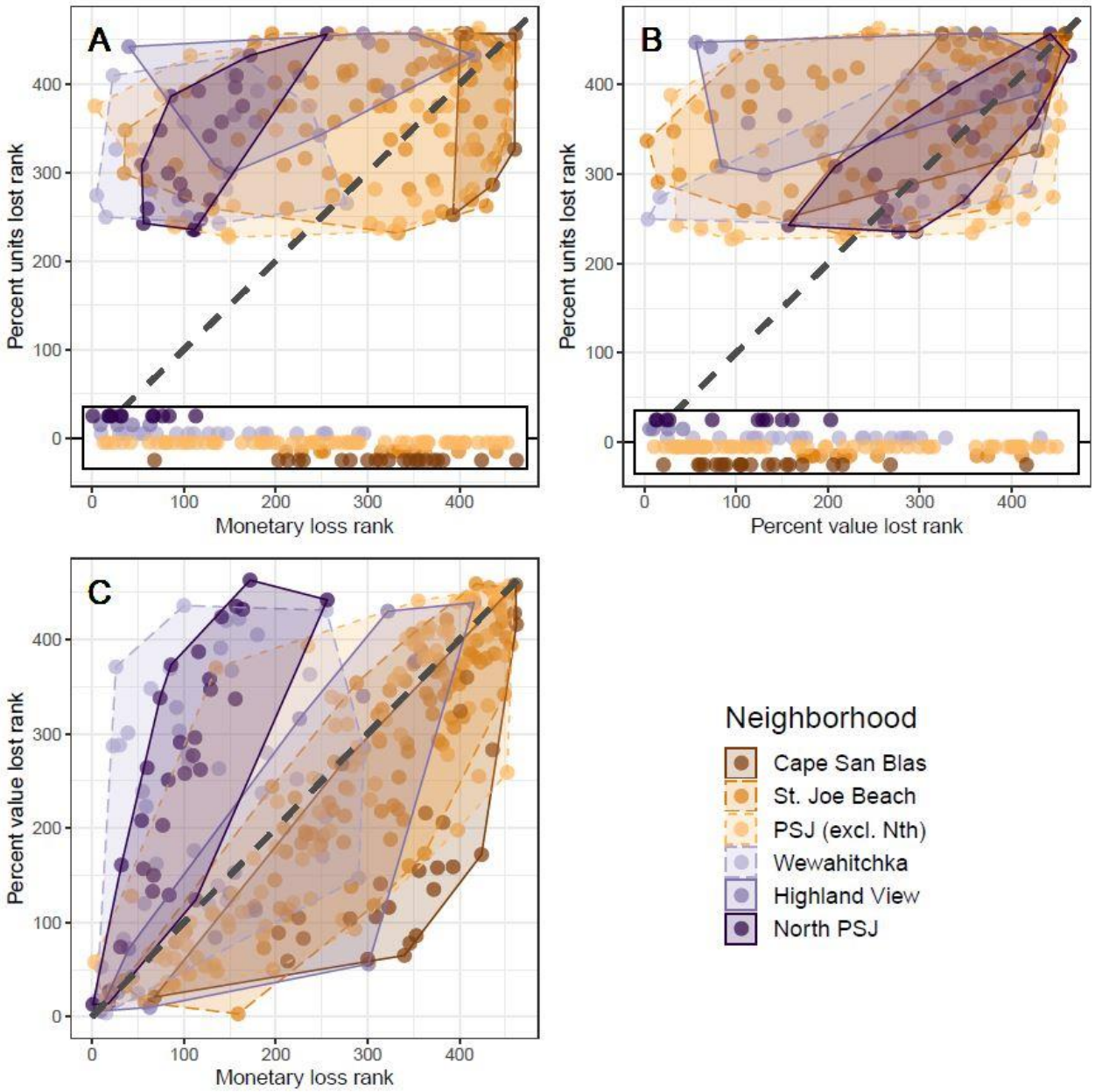

Figure 4. Comparison of the three lenses used to evaluate losses for the six neighborhoods. (A) Comparison of rank orders of neighborhoods by absolute monetary losses (x axis) and housing capacity losses (y axis). (B) Comparison of rank orders of neighborhoods by proportional monetary losses (x axis) and housing capacity losses (y axis). (C) Comparison of rank orders of neighborhoods by absolute monetary losses (x axis) and proportional monetary losses (y axis). Boxes along zero in panels A and B indicate those census blocks with no housing unit losses. Port St. Joe abbreviated to PSJ in legend. Note: census blocks outside the six neighborhoods shown in grey in Figure 1 are excluded here.

Figures

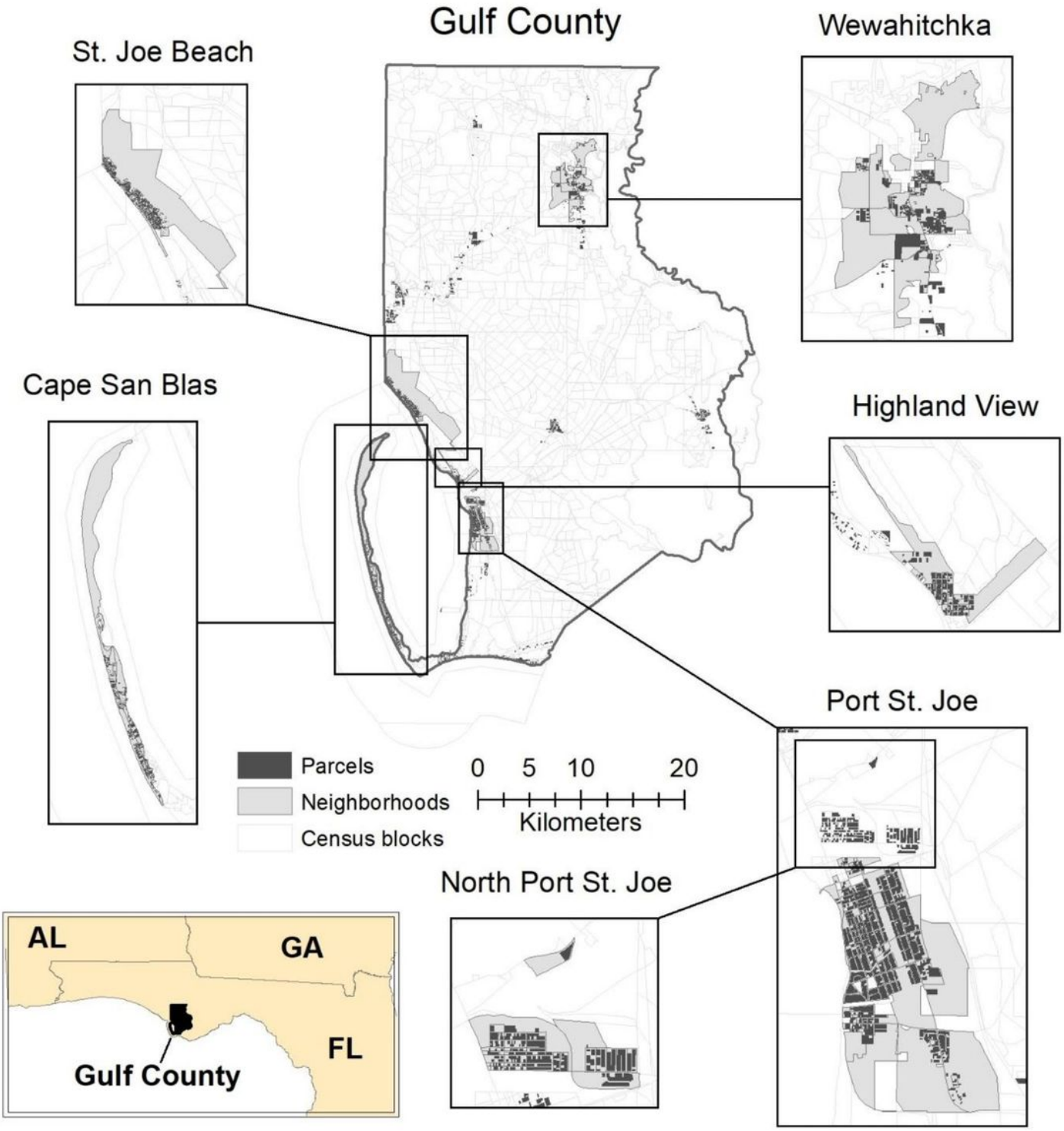

Figure 1

Spatial boundaries of Gulf County, residential parcels and six neighborhoods analysed. Dark grey filled shapes are all 2018 residential parcels in Gulf County. Light grey filled shapes are census blocks aggregated to analyse six neighborhoods, which are shown as insets. Bottom left inset shows location of

Gulf County in the Florida Panhandle, USA. Note that North Port St. Joe was analysed separately from what we refer to as Port St. Joe, and what we label St. Joe Beach includes the Beacon Hill locality. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

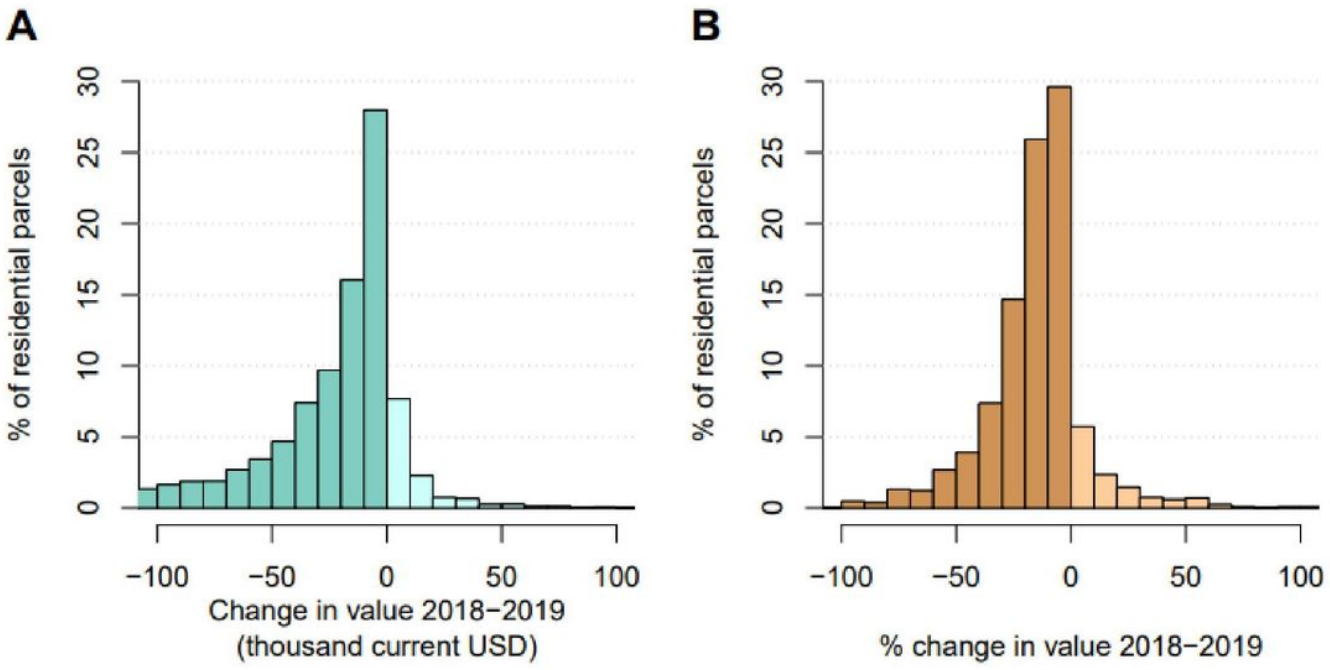

Figure 2

Percent frequency distributions of (A) total and (B) percentage changes in value from 2018-2019 for 6731 Gulf County residential parcels. Darker colour shades indicate parcels with net losses. NB horizontal axes are truncated and actual ranges were $-2.15 million to $0.42 million for (A) and -126% to 795% for (B), although only a tiny fraction of parcels had a change in value outside the ranges shown.

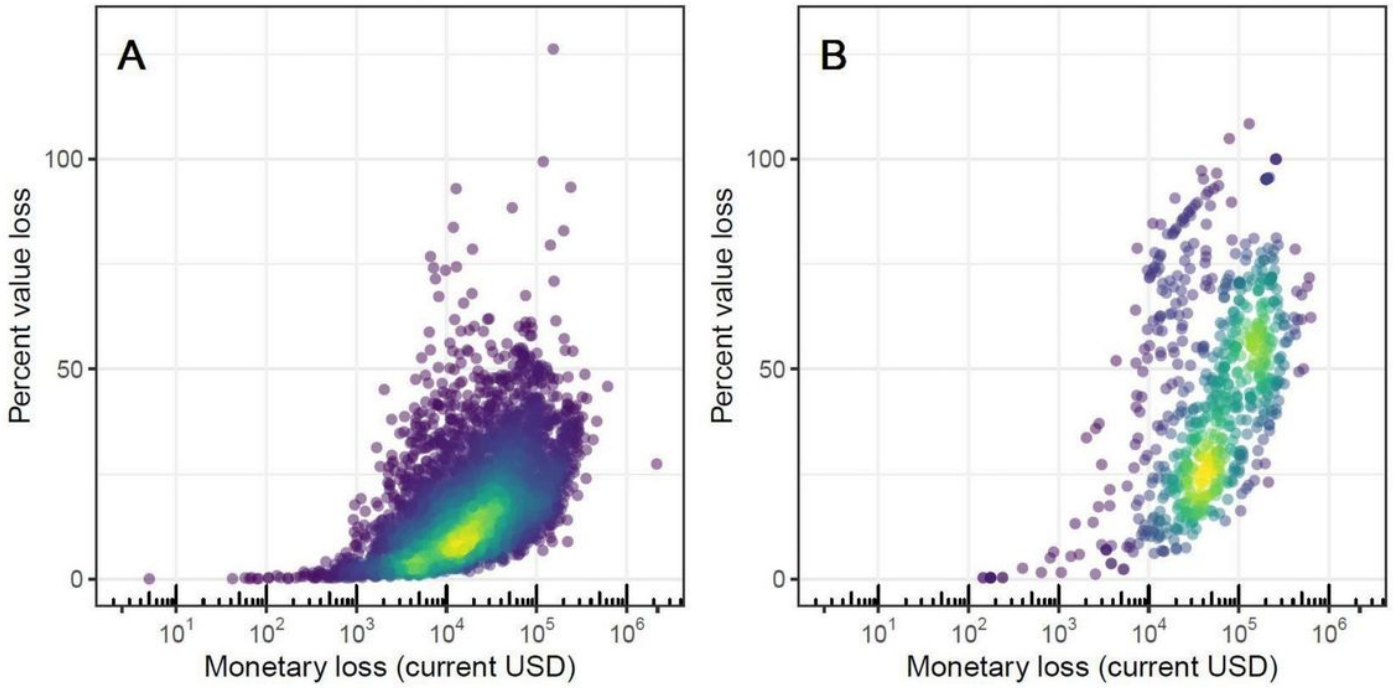

Figure 3

Absolute monetary losses compared to percentage losses for (A) the 4892 residential parcels in Gulf County that experienced a monetary loss in value but remained active; and (B) the 776 residential parcels that experienced a monetary loss in value and became vacant. Points are coloured by brightness according to increasing density in the plots.

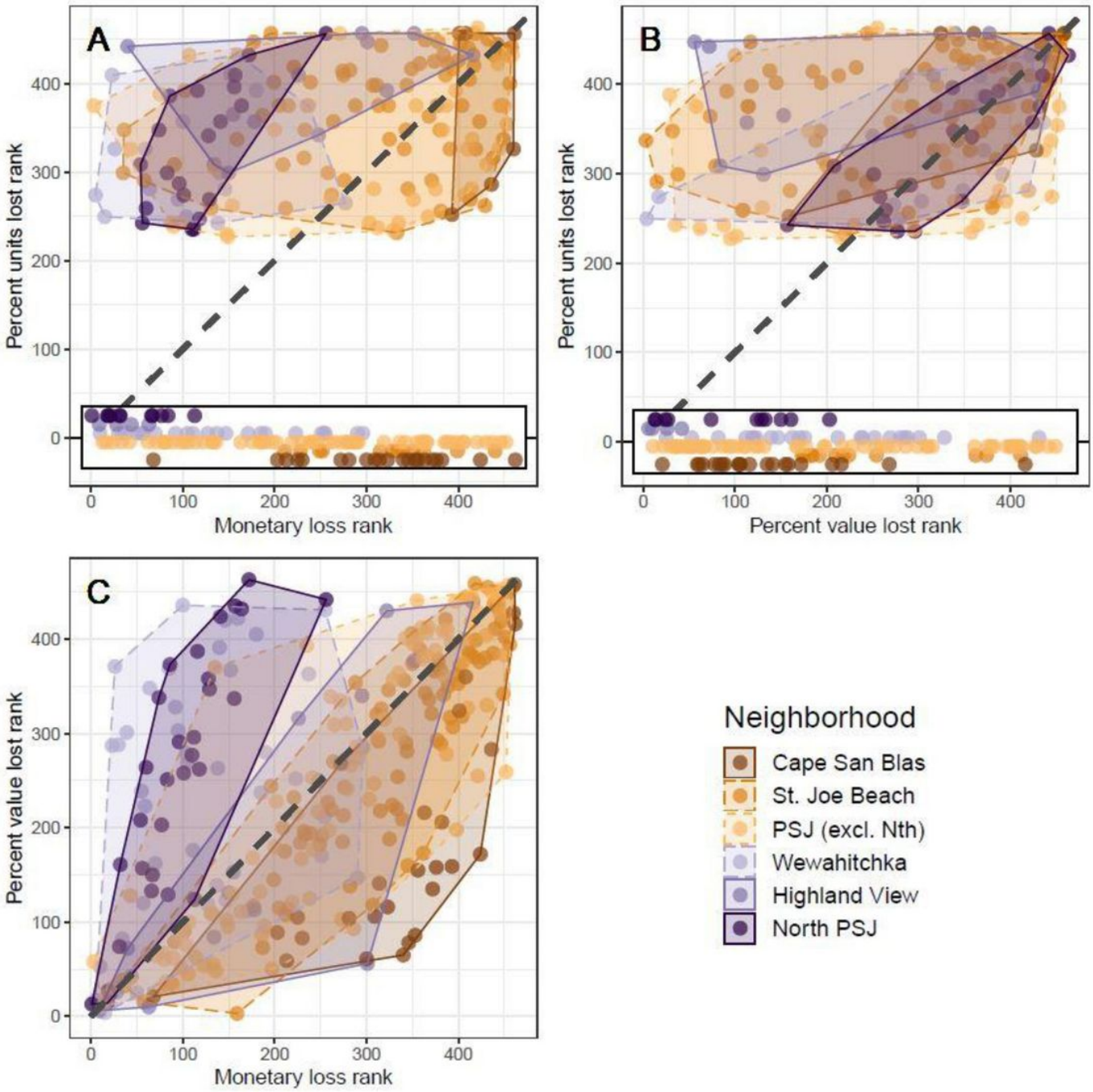

Figure 4

Comparison of the three lenses used to evaluate losses for the six neighborhoods. (A) Comparison of rank orders of neighborhoods by absolute monetary losses (x axis) and housing capacity losses (y axis). (B) Comparison of rank orders of neighborhoods by proportional monetary losses (x axis) and housing capacity losses (y axis). (C) Comparison of rank orders of neighborhoods by absolute monetary losses (x axis) and proportional monetary losses (y axis). Boxes along zero in panels A and B indicate those census blocks with no housing unit losses. Port St. Joe abbreviated to PSJ in legend. Note: census blocks outside the six neighborhoods shown in grey in Figure 1 are excluded here