

Who Should Pay for Climate Adaptation?: Public Attitudes and Financing of Flood Protection  
in Florida

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**Abstract**

An investigation of public support for coastal adaptation options and public finance options in Florida, evaluated stakeholder judgments and how they changed through a participatory engagement process. The study found that public finance mechanisms that imposed fiscal burdens on those who directly benefit from hazard reduction were rated as more acceptable than others. Significantly, visualizations and data on local economic damage and return on investment of potential adaptation options further increased acceptability ratings. Whether development fees can be rationalised as part of permission for development and to mitigate its impact is a legal matter in the USA (called rational nexus). One concern of this paper is to explore options for such fees to cover climate adaptation. This raises issues over the potential conflict with the community-wide and intergenerational nature of long-term adaptation. We also explore the relevance of environmental attitudes using the New Environmental Paradigm scale and political party affiliation. Results have implications for infrastructure improvements that require public approval for financing.

**Key words:** participation, climate change, adaptation, public finance, environmental attitudes

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## **1. Introduction**

Adapting to climate change is one of the greatest ethical challenges of our time (Gardiner 2006, 2011; Jamieson 2003, 2008; Tremmel 2013). Recent analysis has clarified that appropriate responses will provide practical solutions that balance creativity of novel approaches with recognition of political realities (e.g., Shockley and Light 2016). To make each strategy more stable, they should also focus on well-being and be sensitive to context and place (Shockley 2014). They should further integrate a strong precautionary principle if the risks of climate change are to be fully accounted for (Hartzell-Nichols 2014). While human induced climate change is a global problem, action to adapt is more a local issue (Schreurs 2008, van Aalst et al 2008, Ayers and Forsyth 2009, Funfgeld and McEvoy 2011, Haasnoot et al. 2012).

These observations point toward needs to ethically address the question of who pays for and who benefits from each adaptation strategy. In coastal communities of the United States of America (U.S.), weather- and water-driven hazards have heightened attention about communities' abilities to adapt to increased frequencies of major storms and hurricanes (e.g., Leiserowitz et al. 2015, Lee et al. 2015). This concern has led to new studies on how communities evaluate risks (Akerlof et al. 2016), construct deliberative processes in support of adaptation options (Merrill et al. 2012, 2014; Michael Baker International, 2015), and how governance processes and stakeholder values and perceptions impact adaptation planning (Measham et al. 2011, NCCARF 2010, Preston et al., 2011). Visualization tools such as those created by U.S. National Oceanic and Atmospheric Administration and Climate Central are being used by planners and officials to define and deliberate on local risks to sea level rise and flooding with community stakeholders. However, research is needed that links tools and approaches with the social, economic and regulatory context of public finance at the local level. Implementation of major resiliency improvements will require large public investment, incentives, and/or leveraging of private investment (IPCC 2014). At the same time, the issue

of climate change is charged with conflicting value positions (cf. Nisbet and Myeres 2007) and no issue in American public policy is less charged with fundamental conflicts over economic efficiency as a value than the question of who should pay for public goods, like community safety (Nelson and Moody 2003).

The challenge of finding fiscal mechanisms to implement to resiliency improvements is not new (OECD 2003). For example, the impact fee mechanism for pay-as-you-go funding, of needed public improvements, by the investors whose developments will benefit, is an approach that rapidly expanded in its extent and variety of uses in the U.S. since the 1980s. The expanding application of development impact fees brought with it an important legal and economic principle known as the “rational nexus” test (Nelson and Moody, 2003). It holds that funds exacted from a private developer by the public must be used to meet a need related to the development, such as new facilities or services that will benefit and/or are triggered by the new private activity (i.e., has a rational nexus of benefit and/or causation associated with that activity). For example, a new housing development may result in the need for increased school capacity that can justify an impact fee, whereas charging the developer to build a public facility somewhere else is unlikely to meet the legal requirements in the U.S.

An additional challenge is that, in the context of a changing climate, community protection and long-term adaptation are public goods, which raises concerns over ‘free riders’. The conventional solution to the free rider problem in the context of American public finance (and the fundamental utilitarian values underlying it) has been to seek funding through general taxation. However, climate adaptation further aggravates the tension between satisfying the rational nexus test and a general need for providing a public good through a tax and budget approach, because some potential payers benefit by deciding to be located where they will be more vulnerable to hazards than others. (This dynamic at a national scale is one reason why the National Flood Insurance Program faces bankruptcy). Even considering the problem of free riders, however, entire communities will benefit from many successful

adaptation options in terms of economic resiliency and avoided economic disruption. Thus, imposing costs of adaptation *only* on those who have placed themselves at greater risk may actually be inefficient in both economic and engineering senses. For example, “storm water utility” fee mechanisms are a means to pay for the area-wide nonpoint pollution and flood mitigation needs that have become a national priority. However, this approach has often faced vehement opposition as a “rain tax,” especially in cases where municipalities have not built a strong value-based case for the benefit and need (Beierle et al. 2013). Striking a better balance among these problems may need to be a hallmark of future methods of value-based environmental finance. The present study addresses these needs by helping identify the degree to which communities expect that the benefits of climate adaptation-related fees will accrue to individuals who pay for them.

Scientists have been frustrated by the perceived failure of what they judge as better scientific information to enhance public understanding and support for mitigation and adapting to long-term environmental change. Neo-classical economics’ efficiency principle—and real political pressures—militate against imposing collective burdens for systematic but unevenly distributed threats. This study examines the intersection of those two dimensions. The focal research questions were:

1. Does provision of information on future risks and responses (including modest collaboration in defining what responses to analyse) change prior beliefs about risk and response;
2. Are there any systematic differences in the acceptability of and preferences among different means of paying for risk reduction among choices that violate economic efficiency to varying degrees (e.g. broad taxation versus beneficiary-pays)?; and

3. Can differences in preferences be attributed to fundamental value differences held about humans and the natural world, given that climate change risks seem to tap such divisions?

## **2. Case Study Design and Conduct**

This paper reports on the Florida case study carried out as part of an international applied research project called “Metropole”. This engaged with three coastal communities, one in each of Brazil, the United Kingdom and the U.S. The overall aim was to understand how economic and environmental values might make stakeholders more or less likely to support adaptation planning and public finance mechanisms to pay for preparing for combined threats of sea level rise and hurricane storm surge. The study model embodied principles promoted by the National Academy of Sciences as “sustainability science” (Kates 2011; Clark and Dickson 2003), and included technical modelling of storm surges and flooding due to sea level rise (see Appendix I). Information provided to study participants made use of the Coastal Adaptation to Sea Level Rise (SLR) Tool (COAST) model (Catalysis Adaptation Partners, 2015) to show visualizations of SLR, infrastructure impacts, and costs/benefits for adaptations (see Figure 1). Part of this participatory modelling protocol used in community planning projects includes polling the stakeholders on the parameters as to how much risk reduction to analyse (e.g., to what level to elevate buildings in the study area). We worked with staff at Broward County and the cities of Ft. Lauderdale, Dania Beach, and Hollywood, Florida. Partners defined a joint study area, which included over 10,000 residential, commercial and industrial property parcels in these densely developed communities located directly on the Atlantic Ocean and Inter-coastal waterway. The research team and local government managers reviewed the estimated SLR/flood risks and the local hosts selected two adaptation actions to model: 1) flood proofing, including elevating commercial and residential buildings; and, 2) a two-phase voluntary buyout program to

remove properties from risks. These choices were tailored to reflect the most realistic and potentially useful combination of actions in this study area.

In partnership with municipal government planning officials two linked public workshops were organised with affected citizen stakeholders and decision makers. In the first workshop, the participants reviewed initial information on future threats of damage and loss to their community and helped choose two adaptation responses. These were then modelled and costed by the research team and used for comparison with a “no action” scenario. In the second workshop participants reviewed the results.

Prior to the workshops, municipal partners conducted outreach to recruit participants via personal email invitations, posting meeting announcements to newspapers, planning and community listserves, and verbal outreach from local officials. At workshop one, 50 participants completed the first survey before project-specific information was presented. Before the start of the second workshop, new participants completed the same questions on demographic and risk experience. At the conclusion of workshop two, panellists (returning participants) and new attendees were again polled on adaptation actions, perceptions of barriers and funding mechanisms. We collected surveys from 12 panellists and 18 new participants. Because of the small numbers, we do not report comparisons of panellists’ versus new participants’ demographic characteristics for workshop two.

Survey participants identified their prior hazard exposure, their attitudes and beliefs about risk and local government risk reduction priorities, and demographic information about themselves including political party affiliation. They rated the comparative acceptability of various public finance methods to pay for risk reduction. In addition, they completed the 10-question version of the New Ecological Paradigm (NEP) value scale (Dunlap and Van Liere 1978; Dunlap et al. 2000). The NEP was selected for use as a compact means to ascertain fundamental values regarding the balance between natural processes and human activities that impact nature. We also considered, but did not use, the Post-Materialist Values scale,

which consists of as few as six question items (Inglehart, 1977; Inglehart and Flanagan, 1987). Both scales examine the deep-seated divisions between those who support traditional positions on societal organization and behaviour versus post-industrial and environmentally-oriented stances, such as supremacy of human technology versus its risks and limitations and nature to be commanded versus protected. The virtue of these two scales along with their ease of use with respondents is that they have been employed in hundreds of instances over more than four decades and on a multi-nation basis. For example, Pierce et al. (1987) used the NEP to investigate differences and commonalities in environmental positions of publics in Japan versus the United States. We judged that the NEP is more suited to understanding value-based reasons for differences in public positions on paying for climate adaptation than Inglehart's Post-Materialist Values scale because the latter focuses on structural issues of governmental authority and control and economic supremacy versus human freedom and choice. By contrast, Milbrath (1984: 21) has pointed out that the NEP taps deep values of:

“high valuation of nature, their sense of empathy which generalizes compassion toward other species [...] and generations, their desire to carefully plan and act so as to avoid risks to humans and nature, their recognition that there are limits to growth to which humans must adapt, and their desire for a new society that incorporates new ways to conduct our economic and political affairs.”

While the two value measures are related, the NEP is a more direct gauge of orientations relevant to the climate change problem: the NEP is an appropriate gauge of values that would support recognizing human impacts and limits on global resilience, or rejecting such limits in favor of human latitude to do as we wish. Finally, given the long use of the NEP, we know something of its limitations, in particular that on average, respondents to the NEP scale over many studies tend to have at least slightly pro-environmental value scores (Clark et al. 2003).

Workshop one was held on January 29, 2015, in the City of Hollywood, and workshop two on March 26, 2015 in the adjacent City of Dania Beach. During workshop one,

participants learned about model inputs including real estate data/property values, sea level rise curves, and depth-damage functions. Participants broke into small groups led by experienced facilitators to review maps, visualizations, and supplemental material. After the discussions we gave attendees keypad polling devices to reduce participant influence and asked them to address three issues:

- 1) define the height of the flood proofing and elevation actions to be modelled (modal response 8 feet);
- 2) estimate the percentage of property owners in the impacted areas that would participate in the proposed programs to flood proof and elevate structures (modal response 75%); and
- 3) estimate a percentage that would participate in voluntary buyout programs on short-term (five years; modal response 50%) and long-term horizons (thirty years, modal response 75%) horizons.

We used the participant-influenced parameters to calculate the benefit-cost results for the modelled adaptation actions. We calculated damages from one-time storm events and cumulative expected damages over time both under no-action scenarios and according to the two proposed adaptation actions. We presented the results at the second workshop and showed visualizations of avoided damages under each adaptation scenario and comparisons of risk-mitigation efficiencies of the scenarios versus taking no action. (Example materials are shown in Figure 1 and Table 1. Technical specifications of this analysis are summarized in Appendix I.) After we presented the information/visuals, stakeholders separated into small facilitated groups to discuss expected costs of the funding the actions and the expected avoided damages from cumulative storms and flooding under low and high sea level rise scenarios through the year 2060. For the elevate and flood proof strategy we calculated \$1.3 billion in avoided damages under the low sea level rise scenario, and \$1.8 billion in avoided damages under the high sea level rise scenario (see Table 1). Cost estimates for elevating and

flood proofing 75 per cent of the buildings not elevated or flood proofed today ranged from \$57 million to \$117 million. When these costs were compared to cumulative avoided damages, benefit-cost ratios ranged from 11 (low sea level rise scenario and high cost estimate) to 31 (high sea level rise scenario and low cost estimate). These represent long-term savings in the form of damage reduction for every dollar spent today. For example, under the best benefit-cost ratio, every \$1.00 spent today to elevate and flood-proof buildings would save ~\$31 by 2060.

### **3. Results**

For the voluntary relocation strategy we calculated over \$200 million in avoided damages under the low sea level rise scenario and nearly \$180 million in avoided damages under the high sea level rise scenario. Cost estimates for purchasing half of the properties vulnerable to sea level rise by 2030 and 75 per cent of the properties vulnerable to sea level rise by 2060 ranged from \$351 million to \$526 million. Benefit-cost ratios from these numbers ranged from 0.3 (high cost estimate and high sea level rise scenario) to 0.6 (low cost estimate and low sea level rise scenario). All ratios were less than one, meaning the modelled action would provide no long-term savings in the form of building damage reduction alone.

Fifty people (53 per cent men, 47 per cent women) attended the first workshop. The group was characterized by high educational attainment, was predominantly middle-aged and older, 87 per cent were White, 11 per cent African American and almost 90 per cent had household incomes above the national median household income (about \$63,000).

Participants included community leaders, representatives from home owner associations, elected officials and staff from local and regional planning organizations. The group consisted of equal proportions of local government, state, and federal agency staff (4 to 1 local), and formal and informal citizen leaders (elected, appointed and interest group leaders) with 20 per cent self-identifying as “other.” Their reported political affiliations were: 52 per

cent Democrats, 13 per cent Republicans and 35 per cent Independents. The enrolment of registered voters in Broward County in 2015 was 50 per cent Democrats, 22 per cent Republican and 22 per cent Independent.

High proportions (72–94 per cent) of participants had experience with the five coastal hazards they were surveyed about (i.e., high winds, extensive flooding, storm surge, rising sea levels, and coastal erosion). More individuals indicated that they had personal experience with high winds (94 per cent), coastal erosion (86 per cent), and extensive flooding (84 per cent) than with storm surge (72 per cent) and rising seas (74 per cent). Higher percentages expressed serious concern about impacts of the five hazards, for their town within the next ten years, 51–68 per cent scored 5—on a scale from 1 (not concerned) to 5 (highly concerned). Large percentages were also highly concerned about potential impacts to their own households within the next ten years (28–46 per cent scoring 5 across the five hazard categories); other levels of concern (i.e., somewhat concerned, concerned, and moderately concerned) were more mixed across hazard categories for impacts to their own households. More than a quarter of participants indicated they were not concerned at all about impacts to their households from storm surge, sea level rise, and coastal erosion.

Table 2 presents the 10-item NEP using a five-point scale from 1 (strongly disagree) to 5 (strongly agree)—the mid point 3 was designated as “undecided”. Thus a perfect score on pro-environmental values would be 50 (i.e., strong agreement with the positively phrased odd-numbered items and strong disagreement with negatively phrased even-numbered items). Conversely, a value score of 10 would represent more anti-environmental values and an undecided respondent on all items would have a score of 30. Some, but not all, of the non-pro-environmental statements about the human role in modifying the environment are ones that might be consistent with support for climate risk adaptation. For example, on the NEP item about human ingenuity to solve problems, belief in the ability to adapt could be

consistent with the belief that the Earth's systems are also fragile—and that adaptive action is needed in an era where just “leaving the Earth alone” is no longer a rational option.

Table 2 shows means for the NEP items with a tilt towards high NEP scores (as originally conceived by Dunlap and Van Liere 1978) especially for those items that have to do with agreeing that natural systems are fragile, deserve protection and that human impacts have been negative. However the group mean is equivalent to a scale score of “undecided” for two items (4 and 6) that have to do with the ability of humans to manage our interactions with natural systems and natural resources in a resilient manner. This is important because one of the goals of the workshops was precisely to explore stakeholder perspectives on how to adapt. The average of these means was 3.8 with a standard deviation of 0.7—i.e., more than two thirds of the group scored above a neutral score of 3.0. Only one-fifth had a mean score of 3.1 or less.

One of the main survey questions asked participants to review 16 prototypical coastal adaptation planning actions and identify which ones they thought their local government should implement, and when. The actions included structural mitigation measures (e.g., seawalls), actions regarding public infrastructure (e.g. protecting or relocating facilities), actions regarding private property both in terms of public investment (e.g., in property buyouts), land-use policy regulations (e.g., restricting rebuilding) and nature-based solutions. The timeframes for each action were: “now,” “10 years,” “25 years,” “100 years,” “never,” or “unsure.” The modal response of Pre-Workshop 1 participants was to prioritize action now, and second most frequent choice was 10 years, for 14 of 16 options. Responses of returning panellists remained consistent for most options.<sup>1</sup>

The survey included two questions related to public finance: 1) agreement with the need to raise fees or taxes; and 2) a multi-item question that asked participants to rate the level of acceptability (1-5 Likert scale) for six existing public revenue-raising mechanisms

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<sup>1</sup> Similar patterns emerged in the other Metropole case studies (Reynolds et al. 2017).

typically available to county or local government. While these are largely conventional revenue mechanisms, considering them for application to long-term climate adaptation is novel. Also, as evidenced by participants' overwhelming opinions that such actions need to occur within 10 years, it can be assumed participants were evaluating the funding tools as a concrete possibility, not a distant abstraction.

When asked "Do you agree or disagree with the following statement: Implementing projects to reduce potential impacts of climate-related hazards in our community should be a local or regional government priority, even if it will require a slight increase in taxes or new fees?", 56 per cent strongly agreed and 27 percent agreed somewhat. This is important context for understanding responses to the next set of questions, which focused on the *methods* of funding. Table 3 also shows responses to a question about the relative acceptability of six funding mechanisms and the frequency of responses to the specific choices about level of acceptability for each action. The mean score is also shown for each method, as another aid to comparison, based on scaling the choices from 1 (not acceptable) to 5 (totally acceptable).

The approaches that received the lowest relative ratings of acceptability would all impose general or population-wide fiscal burdens. These approaches were: property taxation, sales tax surcharges and utility (water) billing surcharges. These methods assume justification for general revenue. By comparison, the two approaches that received the highest acceptability were both mechanisms that apply to those who would directly benefit from the actions taken. In the case of low-interest loans, the public would make it possible for property owners to amortize their own investments through underwriting. In the case of special benefit district assessments—a long-standing practice in local public finance—the revenues raised are tied to the need to address the risks to a defined set of property owners. The next most highly accepted method—bonding—did not specify the source of repayment but involves long-term amortization of investment.

A special question on finance, included upon request of project partners, asked participants to take a straw vote on a current bonding issue. The question asked, “If a referendum was put on the 2016 ballot to create a Community Resiliency Bond (a long-term loan) that would generate \$100 million by 2036 to support multiple adaptation projects, how likely would you be to vote for it?” Nearly 48 per cent responded that they “Would Vote For It”. Another 21 per cent said it was “Very Likely.” Some 8.3 per cent said their vote was “Moderately Likely,” and 12.5 per cent said it was only “Somewhat Likely.” Finally 10.4 per cent reported that they, “Would Not Vote For It,” with two missing responses.

#### 4. Analysis

##### *Influence of Environmental Attitudes*

As noted, the political and environmental values of participants were skewed towards the Democratic and pro-NEP side, yet there is still a question: Are preferences for funding approaches a function of pro-environmental values (or lack of them) or are they reflective of other ideas about efficient and acceptable funding principles? This is an important question because funding of action can be stymied by values. Environmental values are sometimes viewed to be invariant (Feldman 1988; Rokeach 1973), but even when values do not change in the short term, other principles of acceptable and feasible policy may allow for devising workable means. Additionally, values are subject to long-term change and the existence of such a shift is the basis of value frameworks like the NEP.

Table 4 shows the NEP scores averaged across all 10 items which have been standardized into four groups around a mean of zero and standard deviation (SD) of one. For the sake of comparison of judgments about the funding mechanisms the standardized scores were then broken into four groupings above and below the mean. The -2 or +2 groups are those responses where the individual’s NEP score is more than one standard deviation above or below the mean. The -1 or +1 groups are those that scored up to one standard deviation

above or below the mean. Average acceptability scores for each of the six adaptation funding mechanisms are reported for each of those groups descriptively in Table 5, followed by the rank-order of acceptability for the six mechanisms in that grouping. (Note that four of the 50 observations are lost due to missing data on the NEP or non-responses to funding questions from workshop one participants).

Those who scored in the lowest group on the NEP scale consistently had lower acceptability scores for most funding mechanisms (Table 4). The pattern was mixed for the next two (-1 and +1 SD) groupings, with the -1 group marginally lower on the three least preferred methods and somewhat higher on the three more preferred. The -1 grouping was equivalent to a neutral to slightly pro-NEP position on the scale given the mean. The +2 SD group was the least consistent with this pattern. The small numbers and nature of this set of respondents (non-random and self-selected) did not allow for meaningful testing of these relationships. However, the rank-ordering of preferences (shown in parentheses) shows a strong and consequential pattern: although the lowest NEP group distinctly rated acceptability of all funding approaches lowest on the scales (suggesting at least some influence of more extreme anti-environmental values, which would require a much larger and randomized sample to confirm), the rank-ordering across the four groups was similar. This reflects a pattern of preference that, as discussed, has rational explanations grounded in basic issues of designing acceptable and efficient public finance policies and tools.

Analysis by political party affiliation shows a similar result (Table 5.). The general order of types of preferred mechanisms was similar among all parties. Democrats and Independents rated the acceptability of all funding methods consistently higher than Republicans.

Table 6 shows a slightly different analysis of funding preferences. Responses to the funding questions are broken down by how participants scored on the NEP scale (either above or below the NEP mean of about 3.8). Note again that a mean of 3.8 represents a

moderate bias towards pro-environmental values and only a few of the workshop two participants scored at a neutral 30 or below. Thus, the two groups above and below the mean of 3.8 are labelled as having either a High or Low-to-Moderate pro-NEP values bias. As Table 6 shows, those with the lower pro-NEP bent score the acceptability of all (except one) of the funding choices lower on average than those in the high pro-environmental bias group. However, the rank-order of funding options is again substantially the same between the two groups; benefit-aligned cost options scoring higher than general taxation/fee options. This further suggests that fiscal values interacted with the pro-environmental values to create a two-level set of preferences, where the general implication could be stated this way: “If we have to do it, let’s apply a just burdens framework within a core American social ethic.”

#### *Do Participatory Processes Influence Preferences?*

We focused on two questions in our analysis: 1) How did panellist preferences change as a result of the participatory COAST process in terms of adaptation actions and financial options? and 2) Were there differences in preferences solely because some panellists attended only the second workshop? These questions help us to explore: 1) preferences for adaptation action and financing methods and 2) the extent to which the participatory process used might modify these preferences.

Table 7 compares how panellists and new participants rated the acceptability of seven adaptation funding choices at the end of the COAST process. Note that the local option for a sales tax of one-half to one cent was replaced at our study partners’ request with a similar, but generalized “local option surtax” item. Another financing action was “Public funding of V-zone buyouts” (i.e., funding for purchase of real estate in parts of town particularly vulnerable to flooding from storm surge). This was perhaps the most controversial action and funding option proposed. Percentages judging each action as “Highly Acceptable” or “Totally Acceptable” were similar between panellists and new attendees, and rank order of

preferences were consistent between the two groups as well. This further confirms that there was a consistent fiscal value at work based on the rational nexus as explained earlier. Levels of acceptability largely followed the same pattern of preference for benefit-based mechanisms versus general taxation but there was one consistent change (noted in Table 6) among both groups: support significantly increased for water-bill-based fees to increase flood resiliency, such as for storm water management. This may indicate increased awareness of the community-wide benefits of such infrastructure and the justification for general burdens to pay for it.

There were also differences in attitudes towards public spending, reflected in responses to the question which assesses agreement about the need to increase fees and taxes to address climate impacts. Almost twice the proportion of panellists (64 per cent) “Agreed Strongly” as compared to new participants (36 per cent). However, while another 27 per cent of the panellists “Agreed Somewhat” with this spending question, twice as many (53 per cent) of the new group “Agreed Somewhat.” On the question of an imminent (2016) Community Resiliency Bond vote for \$100 million that would be spent by 2036, 36 per cent of both groups chose “Would Vote For.” But where 27 per cent more of the panellists chose “Very Likely Would Vote For,” only an additional 9 per cent of the new group chose that level of support. Eighteen (18) percent of both groups said they would not vote it. Although the panellist group was highly self-selected, it is not possible to conclude that the entire collaborative process is the reason for the somewhat deeper support for these votes among the panellists versus the new participants.

The third major category of questions was designed to assess normative beliefs. We asked participants to choose three reasons (from nine) of why *others in their community* might not support local adaptation action. The reasons were derived from often-cited barriers of informational, psycho-social, institutional and economic factors (Adger et al. 2009, Eisenack et al 2014, Gifford, Kormos and McIntyre 2011, Lorenzoni et al. 2007, Moser and

Ekstrom 2010, Wolf et al. 2009). The top three barriers chosen by workshop one attendees were: lack of knowledge about future consequences (68 per cent); expected opposition to new taxes/fees (60 per cent); and, climate change/sea level rise are distant issues (50 per cent). Uncertainty of scientific data was cited by 34 per cent. Other issues were cited at low levels (4 to 26 per cent): including denial, distrust of media, low confidence in local government, and concerns about the economic impacts.

Table 8 compares responses of three subgroups: 1) returning panellists before workshop one; 2) returning panellists after workshop two; and 3) new attendees after workshop two. Similar to workshop one, participants in each group chose: lack of knowledge, and cost opposition over other reasons. Panellists had significant pre/post shifts. “Lack of knowledge” increased from 42 to 84 percent and “opposition to new taxes/fees” increased from 50 to 67 per cent, while “climate change as a distant issue” decreased dramatically from 67 to 17 per cent. There was a slight decrease in “scientific uncertainty” from 33 to 25 per cent. These shifts appear to reflect their increased understanding of local impacts, risk timeframes and scale of costs, as discussed in the workshops.

New attendees were similar to panellists, choosing “lack of knowledge” (60 per cent) and “opposition to new taxes/fees” at 50 per cent. However, they also chose “denial” at 58 per cent (more than double the all workshop one and panellists), and more chose “concerns about real estate investment” and “scientific uncertainty” (both at 40 per cent) -- higher than panelists pre/post. While the datasets are small, the patterns offer interesting insights for facilitating deliberative discussions to draw out perceived normative beliefs and enhance communications to support reflection.

## **5. Conclusions**

Our results indicate a consistent pattern between pro-environmental values and higher acceptability of public investment in coastal climate adaptation. They also show that across

largely all NEP scores, there was consistent ordering of choices about how to pay for adaptation costs according to a rational nexus of benefit distribution. This is consistent with recent research showing that for individuals acting to address climate change, it is not essential to cultivate biospheric values or the love of nature (Howell 2017). Our results also reflect that participatory modelling may modestly encourage willingness to support action. However, this highly engaged group of experienced citizen leaders and staff judged that feasible and acceptable new financing mechanisms may need to be aligned between distribution of marginal fiscal benefits and burdens. This is practically useful for conceiving of the next generation of community-level environmental finance tools that will be required to meet the task of adaptation.

Long-term bonding and enabling private borrowing to meet future needs over time enjoyed consistent support as a middle-ground between general taxation and fee-for-service approaches. Amortized approaches may be a strong opportunity, both politically and rationally, to raise funds to manage the shifting environment. Direct public funding of public improvements such as flood gates, seawater pumps or elevated road segments is one kind of action to consider.<sup>2</sup> Another approach is to use bonding to unlock self-interested private investment and its power. How these approaches can amplify investment impacts requires sustained planning and further research. To date, the nation's approaches to adaptation finance are piecemeal, state-by-state and locality-by-locality, with conflicts between cities and counties. To help address this in the future, results from this study underscore the importance of connecting sources of prospective adaptation funding with individuals who will benefit from the action.

Importantly, benefit from taxes or fees that are imposed to adapt to future hazards may be a violation of the efficiency test that most public policy in the U.S. is constantly

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<sup>2</sup> In fact, these approaches were undertaken by the City of Miami Beach (Flechas and Staletovich 2015).

challenged to meet (e.g., the national health insurance debate). Yet at the same time, dealing with future impacts of climate-enhanced hazards clearly requires we confront both inter-generational distributions of benefits and costs and also the problem of free riders across time and space (i.e., people who benefit from a publically provided good or service without paying full costs of that good or service). Such justified public investments are exemplified by the military and warfare where security over-rides other political constraints, or in the case of emergencies such as the Great Depression. However, such situations are national in scope, and although human induced climate change is a global phenomenon, much action to adapt must occur locally. Results from this study help identify how to accomplish this, by clearly demonstrating a local preference that those who will benefit from potential adaptation actions should be the ones that pay for the action.

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## **Appendix 1.**

Technical model inputs included a digital elevation model of Broward County obtained from the University of Florida GeoPlan Center (2014) and referenced in feet in the North American Vertical Datum of 1988 (NAVD88). Mean Higher High Water (MHHW) was the base reference upon which storm surge and sea level rise were added. The NOAA tide station at the Bahia Yacht Club in Ft. Lauderdale (NOAA 2014) reported MHHW at an elevation of 4.57 ft. The DEM for Broward County had elevations referenced in NAVD88 (ft), MHHW value was therefore converted to NAVD88 by subtracting 4.20 ft from 4.57 ft (Fig. 2), giving a base value of 0.37 ft. The digital elevation model was then lowered by 0.37 ft to reflect MHHW being at zero elevation. Two sea level rise curves were used to calculate amounts of damage to buildings over time (Southeast Florida Regional Compact 2011). Storm surge values that the model used to inundate parcels each year in the multi-decade scenarios were derived from FEMA Flood Insurance Rate Maps and Flood Insurance Study reports (2014). These documents provide heights for storms of various strengths, typically including 10-, 50-, and 100-year recurrence intervals (that is, storms that have a 10%, 2%, and 1% chance of occurring in any year). These heights were used to create exceedance curves for different sub-areas so that cumulative damage estimates could be calculated in a hydrologically variable, non-bathtub format. For one-time damage estimates, heights for today's nuisance flood (1.05 ft) and Hurricane Wilma (6 ft) were used. A parcel map layer was provided by personnel from the Broward County Property Appraiser Network. Each property in the layer contained an attribute for assessed building and land value, use code and construction year. Because local ordinances required buildings to be elevated after 1978, construction year was used a proxy for which properties had elevated buildings. All buildings constructed since 1979 were assumed to have first floor elevations 8 ft above grade. Use codes were identified to determine whether a building was commercial or residential. These uses were then

matched with depth damage functions for building types outlined by Gulf Engineers & Consultants (2006) for the US Army Corps of Engineers. Costs of flood proofing and elevation actions were secured from earlier projects in collaboration with engineering firm Parsons Brinckerhoff, in a review of internet contractor websites. Costs of the voluntary buyout action were based on per-parcel market values of real estate in the study area. A 3.3% discount rate was applied for all scenarios to reflect anticipated economic growth during the scenario period.