

Who Should Pay for Climate Adaptation? Public Attitudes and the 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

Environmental Values **27** (2018): 535–557.

© 2018 The White Horse Press. doi: 10.3197/096327118X15321668325957

Submitted 31 October 2016; accepted 12 February 2018

\$REMOTE_ASSR = IP address
Mon, 01 Oct 2018 17:12:28 = Date & Time

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, visualisations and data on local economic damage and return on investment of potential adaptation options further increased acceptability ratings. The question of whether a development fee for adaptation or any other public purpose supported by private funds is a legal issue that depends on a test called the rational nexus. One concern of this article is to explore options for such fees to cover adaptation to climate change. This raises issues about 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' (NEP) scale and political party affiliation. Results have implications for infrastructure improvements that require public approval for financing.

KEYWORDS

Participation, climate change, adaptation, public finance, environmental attitudes

INTRODUCTION

Adapting to climate change is one of the greatest ethical challenges of our time (Gardiner 2006, 2011; Jamieson 2003, 2008; Tremmel 2013). Adaptation responses should focus on well-being and be sensitive to context and place (Shockley 2014), and 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 (Ayers and Forsyth 2009; Funfgeld and McEvoy 2011; Haasnoot et al. 2012; Schreurs 2008; Van Aalst et al. 2008).

These observations point towards the need to ethically address the question of who pays for and who benefits from each adaptation strategy. In coastal communities in the United States, weather- and water-driven hazards have heightened attention about communities' abilities to adapt to increased frequencies of major storms and hurricanes (e.g. Lee et al. 2015; Leiserowitz 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 (MBI 2015; Merrill et al. 2012, 2014) and how governance processes and stakeholder values and perceptions impact on adaptation planning (Measham et al. 2011; Preston et al. 2011). Visualisation tools such as those created by the US National Oceanic and Atmospheric Administration

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

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 the leveraging of private investment (IPCC 2014). At the same time, the issue of climate change is charged with conflicting value positions (e.g. Nisbet and Myeres 2007) and no issue in US public policy is more 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 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 United States 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). This 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 (that is, there is 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 legal requirements.

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 locate where they will be more vulnerable to hazards than others.¹ Even considering the problem of free riders, however, entire communities will benefit from many successful adaptation options in terms of economic resiliency and the avoidance of 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 area-wide non-point pollution and flood

1. This dynamic at a national scale is one reason why the National Flood Insurance Program faces bankruptcy.

mitigation needs that have become a national priority. (In recent years national and local attention to water pollution control has shifted from ‘point sources’ like factory discharges to non-point water pollution from rainwater and such-like generated off-site and absorbed by the soil. This has become more of a concern with the increase in impervious surfaces in the landscape from development.) 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. Neoclassical 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. We pursue three focal research questions. First, 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? Second, are there any systematic differences in the acceptability of and preferences for different means of paying for risk reduction among choices that violate economic efficiency to varying degrees (for example, broad taxation versus payments by beneficiaries)? And third, can differences in preferences be attributed to fundamental value differences held about humans and the natural world, given that climate change risks seem to be related to such divisions?

CASE STUDY DESIGN AND CONDUCT

This article reports on a 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 United States. 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 US National Academy of Sciences as ‘sustainability science’ (Clark and Dickson 2003; Kates 2011) and included the technical modelling of storm surges and flooding due to sea-level rise (see Appendix). Information provided to study participants made use of the Coastal Adaptation to Sea Level Rise (SLR) Tool (COAST) model (CAP 2015) to show visualisations of SLR,

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

infrastructure impacts and costs and benefits for adaptations (see Figure 1). Part of this participatory modelling protocol used in community planning projects includes polling the stakeholders on the parameters of how much risk reduction to analyse (for example, to what level to elevate buildings in the study area). We worked with staff at Broward County and the cities of Fort 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: first, flood proofing, including elevating commercial and residential buildings; and second, a two-phase voluntary buyout programme to remove properties from risk. These choices were tailored to reflect the most realistic and potentially useful combination of actions in the study area.



Figure 1. Sample 3D visualisation used to depict relative real-estate dollar losses in the study area under a future sea-level rise and storm-surge scenario. Source: GEI (2015).

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 e-mail invitations, posting meeting announcements in

newspapers, planning and community listservs, and verbal outreach from local officials. At the first workshop, fifty 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 the second workshop, panellists (returning participants) and new attendees were again polled on adaptation actions, perceptions of barriers and funding mechanisms. We collected surveys from twelve panellists and eighteen new participants. Because of the small numbers, we do not report comparisons of panellists' versus new participants' demographic characteristics for the second workshop.

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 a ten-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 have an impact on nature. We also considered, but did not use, the 'post-materialist values' scale, which consists of as few as six questions (Inglehart 1977; Inglehart and Flanagan 1987). Both scales examine the deep-seated divisions between those who support traditional positions on societal organisation 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 has pointed out that the NEP taps into people's

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. (Milbrath 1984: 21)

While the two value measures are related, the NEP is a more direct gauge of orientations relevant to the problem of climate change. The NEP is also an

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

appropriate gauge of values that would support recognising human impacts and limits on global resilience, or rejecting such limits in favour 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).

The first workshop was held on 29 January 2015 in Hollywood, and the second two were held on 26 March 2015 in adjacent Dania Beach. During the first workshop, participants learned about model inputs including real-estate data and property values, sea-level rise curves and depth-damage functions. Participants broke into small groups led by experienced facilitators to review maps, visualisations 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, or 2.4 metres);
2. estimate the percentage of property owners in the impacted areas that would participate in the proposed programmes to flood proof and elevate structures (modal response: 75 per cent);
3. estimate a percentage that would participate in voluntary buyout programmes on short-term and long-term horizons (five years: modal response 50 per cent; thirty years: modal response 75 per cent).

We used participant-influenced parameters to calculate the cost–benefit results for the modelled adaptation actions. We calculated damages from one-time storm events and cumulative expected damage 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 visualisations of avoided damage under each adaptation scenario and comparisons of risk-mitigation efficiencies of the scenarios versus taking no action.² After we presented the information and visuals, stakeholders separated into small facilitated groups to discuss the expected costs of funding the actions and the expected avoided damage from cumulative storms and flooding under low and high sea-level rise scenarios up to 2060. For the elevated 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 those buildings not elevated or flood proofed today ranged from \$57 million to \$117 million. When these costs were compared to cumulative avoided damages, cost–benefit

2. Example materials are shown in Figure 1 and Table 1. Technical specifications of this analysis are summarised in the Appendix.

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 cost–benefit ratio, every dollar spent today to elevate and flood-proof buildings would save about \$31 by 2060.

Table 1. Cost–benefit results for sea-level rise

Strategy	Avoided damages (\$ Millions)		Cost–benefit ratios	
	Low SLR	High SLR	Low SLR	High SLR
Elevate and flood proof	1258	1791	10.78	15.35
Voluntary buyouts	208	178	0.39	0.34

Notes: Two adaptation strategies under high and low sea-level rise scenarios (3.3 per cent discount rate). Table presented at the second workshop.

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. Cost–benefit 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 characterised by high educational attainment and was predominantly middle-aged or older. Some 87 per cent of attendees were White, 11 per cent African American and almost 90 per cent had household incomes above the national median (about \$63,000). Participants included community leaders, representatives from homeowner associations, elected officials and staff from local and regional planning organisations. 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.

A high proportion of participants had experience with the five coastal hazards they were surveyed about: high winds; extensive flooding; storm surge;

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

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). A high percentage expressed serious concern about the impact of the five hazards on their town within the next ten years: on a scale of 1 (not concerned) to 5 (highly concerned), between 51 and 68 per cent of participants gave a score of 5 to each of the five hazards. Large percentages were also highly concerned about potential impacts on their own households within the next ten years (28 to 46 per cent scoring 5 across the five hazard categories). Other levels of concern (such as ‘somewhat concerned’, ‘concerned’, and ‘moderately concerned’) were more mixed across hazard categories for impacts on 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 or coastal erosion.

Table 2. NEP scores

	NEP item	Mean	SD	n
1	We are approaching the limit of the number of people the Earth can support	3.35	1.33	48
2	Humans have the right to modify the natural environment to suit their needs	3.45	1.40	48
3	When humans interfere with nature it often produces disastrous consequences	3.83	1.15	48
4	Human ingenuity will insure that we do not make the Earth unliveable	3.10	1.22	48
5	Humans are seriously abusing the environment	4.24	1.13	49
6	Earth has plenty of natural resources if we just learn how to develop them	2.94	1.27	50
7	Plants and animals have as much right as humans to exist	4.23	1.09	47
8	The balance of nature is strong enough to cope with impacts of modern industrial nations	3.96	1.22	48
9	Despite our special abilities, humans are still subject to the laws of nature	4.75	0.56	48
10	The so-called ‘ecological crisis’ facing humankind has been greatly exaggerated	4.18	1.12	48

Table 2 presents the ten-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 (that is, 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, regarding 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 – that is, more than two-thirds of the group scored above a neutral score of 3, and only one-fifth had a mean score of 3.1 or less.

The aim of the methodology was to survey participants on their values and preferences before they learned more from the workshop, and then to re-survey them after they had seen results that they also helped parameterise. One of the main survey questions asked participants to review sixteen prototypical coastal-adaptation planning actions and identify which ones they thought their local government should implement and when. The actions included structural mitigation measures (such as seawalls), actions regarding public infrastructure (for example, protecting or relocating facilities), actions regarding private property both in terms of public investment (such as property buyouts), land-use policy regulations (such as restricting rebuilding) and nature-based solutions. The time frames for each action were: 'now', '10 years', '25 years', '100 years', 'never' or 'unsure'. The modal response of pre-workshop 1 participants was to prioritise action now, and the second most frequent choice was for implementation within 10 years for fourteen of the sixteen options. Responses of the second workshop's returning panellists remained consistent for most options.

The survey included two questions related to public finance: the first concerned agreement with the need to raise fees or taxes; and the second was a multi-item question that asked participants to rate the level of acceptability for six existing public revenue-raising mechanisms typically available to county or local government.³ 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 rather than a distant abstraction.

3. The second question used a 1 to 5 Likert scale.

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

Participants in both workshops were 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?’ In response, 56 per cent strongly agreed and 27 per cent agreed somewhat. This is important contextual evidence for understanding responses to the next set of questions, which focused on 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 the 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).

Table 3. Acceptability of funding mechanisms

Funding Methods	Acceptability level					Mean	SD
	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)		
Create a new county-wide resiliency fund based on property taxes	18.8	12.5	31.3	16.7	20.8	3.1	1.4
Develop a special district assessment (on) properties in areas designated highly vulnerable	10.4	12.5	29.2	18.8	29.2	3.5	1.3
Issue a bond (long-term borrowing) to finance public infrastructure improvements	8.3	25.0	20.8	14.6	31.3	3.4	1.4
Create a low-interest loan programme for flood-proofing and elevating residences	4.2	10.4	20.8	35.4	29.1	3.8	1.1
Add a flood resiliency surcharge on monthly water utility bills (e.g. specific to storm-water drain improvements)	31.2	20.8	10.4	16.7	20.8	2.8	1.6
Raise the local sales tax slightly (law in Florida 0.5 to 1 cent per dollar)	33.3	22.9	18.8	10.4	14.6	2.5	1.4

Notes: Local adaptation action (mean based on acceptability scale of 1=not at all; 2=somewhat; 3=moderately; 4=highly; 5=totally). n=48

The proposed climate adaptation 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. 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 amortise 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 amortisation 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 was, ‘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, while another 21 per cent said it was very likely that they would vote for it; meanwhile, some 8.3 per cent said their vote was moderately likely, 12.5 per cent said it was somewhat likely and 10.4 per cent reported that they would not vote for it (there were also two missing responses).

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 the 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 ten items which have been standardised into four groups around a mean of 0 and standard deviation (SD) of 1. For the sake of comparison of judgments about the funding mechanisms, the standardised scores were then broken into four groupings above and below the mean. The –2 and +2 groups are those responses where the individual’s NEP score is more than one standard deviation above or below the mean; the –1 and +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

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

Table 5, followed by the rank order of acceptability for the six mechanisms in that grouping.⁴

Table 4. NEP score versus funding mechanism

Funding mechanism	NEP standard deviation grouping							
	-2		-1		+1		+2	
	SD	Rank	SD	Rank	SD	Rank	SD	Rank
Property-tax-based fund	1.9	3	3.3	4	3.6	2	2.9	2
Special district assessment	2.9	2	3.7	2	3.4	3	3.7	1
Long-term bonding	3.0	1	3.7	2	3.6	2	2.6	3
Low-interest loans for elevation and/or flood-proofing	3.0	1	4.4	1	3.9	1	3.7	1
Flood resilience surcharge on water bills	1.5	4	3.4	3	3.3	4	2.6	3
Raise local sales tax from \$.005 to \$.01	1.2	5	2.8	5	3.1	5	2.1	4
n	9		10		18		7	

Table 5. Political affiliation versus funding mechanism

Funding mechanism	Political Affiliation					
	Republican		Democrat		Independent	
	NEP SD	Rank	NEP SD	Rank	NEP SD	Rank
Property-tax-based fund	2.5	3	3.3	4	3.0	3
Special district assessment	2.2	4	3.7	3	3.6	1
Long-term bonding	3.0	2	3.7	2	3.1	2
Low-interest loans for elevation and/or flood-proofing	3.2	1	4.1	1	3.6	4
Flood resilience surcharge on water bills	2.2	4	3.3	5	2.3	4
Raise local sales tax from \$.005 to \$.01	2.2	4	2.8	6	2.3	4
n	6		24		16	

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

4. Note that four of the fifty observations are lost due to missing data on the NEP or non-responses to funding questions from participants in the first workshop.

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 randomised 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 (see 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. Post-workshop adaptation-funding preferences by NEP value bias

Funding mechanisms	Acceptability			
	Low-moderate NEP bias		High NEP bias	
	Mean score	Rank	Mean score	Rank
Create a new county-wide resiliency fund based on property taxes	2.4	5	3.0	6
Special district assessment (on) properties in highly vulnerable areas	3.3	1	4.0	1
Long-term bonding to finance public infrastructure improvements	2.9	4	3.4	3
Low-interest loan programme for flood-proofing and elevating residences	3.0	3	3.8	2
Flood resiliency surcharge on monthly water utility bill for storm water	3.0	3	3.1	4
Create a local option surtax	3.1	2	2.8	7
Public funding to buyout at-risk properties in storm surge V-zone	2.0	6	3.1	5
n	7		16	

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 participants in the second workshop scored at a neutral 3.0 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, with 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

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

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: First, how did panellist preferences change as a result of the participatory COAST process in terms of adaptation actions and financial options? Second, were there differences in preferences solely because some panellists only attended the second workshop? These questions help us to explore preferences for adaptation action and financing methods, and the extent to which the participatory process used might modify these preferences.

Table 7. Adaptation-funding preference by attendance

Funding mechanisms	Rating of mechanism			
	Original panellist		New attendee	
	%	Rank	%	Rank
Create a new county-wide resiliency fund based on property taxes	33	5	27	5
Special district assessment (on) properties in highly vulnerable areas	67	1	73	1
Long-term bonding to finance public infrastructure improvements	42	4	36	4
Low-interest loan programme for flood-proofing and elevating residences	58	2	55	2
Flood resiliency surcharge on monthly water utility bill for storm water	50	3	45	3
Create a local option surtax	33	5	27	5
Public funding to buyout at-risk properties in storm surge V-zone	42	4	36	4
n	12		11	

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 either 0.5 cents or 1 cent per dollar (the two available options under Florida law) was replaced at our study partners’ request with a similar, but generalised ‘local option surtax’ item. Another financing action was ‘public funding of V-zone buyouts’ (that is, funding for the 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 the 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 fees based on water bills to increase flood resiliency, such as for storm-water management. This may indicate increased awareness of the community-wide benefits of this kind of 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. Meanwhile, 18 per cent 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 (out of 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 et al. 2011; Lorenzoni et al. 2007; Moser and Ekstrom 2010; Wolf et al. 2009). The top three barriers chosen by attendees at the first workshop 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 the media, low confidence in local government and concerns about the economic impacts.

Table 8 compares responses of three subgroups: returning panellists before the first workshop; returning panellists after the second workshop; and new attendees after the second workshop. Similar to the first workshop, participants in each group chose: lack of knowledge and cost opposition over other reasons. Participants who had been at both workshops (panellists) showed significant shifts between workshops. 'Lack of knowledge' increased as a choice from 42 to 84 per cent, 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

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

to 25 per cent. These shifts appear to reflect panellists' increased understanding of local impacts, risk time frames and scale of costs, as discussed in the workshops.

Table 8. Barriers to local adaptation plans by participant type

Barrier to local adaptation plan	Pre workshop 1	Post workshop 2	After workshop 2
	Returnees (%)	Returnees (%)	First-timers (%)
Lack of knowledge – future hazards	42	83	60
Opposition to new taxes, fees to pay	50	67	50
Climate change a distant issue	67	17	10
Distrust media, news reports	17	0	20
Scientific data too uncertain	33	25	40
Local government lacks expertise to handle	17	17	8
Denial - Don't want to admit or move	25	25	58
Concern about real estate investments	17	0	40
Concern about tourism economy	8	8	30
n	12	12	10

Note: Barriers signify reasons others might not support local action.

New attendees were similar to panellists, choosing 'lack of knowledge' (60 per cent) and 'opposition to new taxes/fees' (50 per cent). However, they also chose 'denial' (58 per cent), a figure more than double that for all the participants and panellists of the first workshop, and more chose 'concerns about real-estate investment' and 'scientific uncertainty' (both at 40 per cent) – higher than panellists. While the data sets are small, the patterns offer interesting insights for facilitating deliberative discussions that draw out perceived normative beliefs and enhance communication to support reflection.

CONCLUSIONS

Our results indicate a consistent pattern between pro-environmental values and a higher acceptability of public investment in coastal climate adaptation. They also show that largely across all NEP scores there was a 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 a love of nature (Howell 2017). Our results also show that participatory modelling may modestly encourage willingness to support action. However, this highly engaged group of experienced citizen leaders

and city staff judged that feasible and acceptable new financing mechanisms may need to be aligned between the 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. Amortised 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.⁵ 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, vary 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 United States is constantly challenged to meet.⁶ Yet at the same time, dealing with future impacts of climate-enhanced hazards clearly requires that we confront both inter-generational distributions of benefits and costs and also the problem of free-riders across time and space (that is, people who benefit from a publicly provided good or service without paying the full cost of that good or service). Such justified public investment is exemplified by the military and warfare, where security overrides 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 for the idea that those who will benefit from potential adaptation actions should be the ones to pay for them.

5. In fact, these approaches were undertaken by Miami Beach (Flechas and Staletovich 2015).

6. See e.g. the national health insurance debate.

WHO SHOULD PAY FOR CLIMATE ADAPTATION?

ACKNOWLEDGEMENTS

Funding for this study was provided by the US National Science Foundation, grant number ICER 1342969 (Belmont Forum-G8 Initiative Collaborative Research: METROPOLE: An Integrated Framework to Analyze Local Decision Making and Adaptive Capacity to Large-Scale Environmental Change), for which the principal investigator was Frank Muller-Karger.

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WHO SHOULD PAY FOR CLIMATE ADAPTATION?

APPENDIX

Technical model inputs included a digital elevation model of Broward County obtained from the University of Florida GeoPlan Center 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 Fort Lauderdale (NOAA 2014) reported MHHW at an elevation of 4.57 feet.⁷ The digital elevation model for Broward County had elevations referenced in NAVD88 (in feet), and the MHHW value was therefore converted to NAVD88 by subtracting 4.2 feet from 4.57 feet, giving a base value of 0.37 feet. The digital elevation model was then lowered by 0.37 feet to reflect MHHW being at zero elevation. Two sea-level rise curves were used to calculate amounts of damage to buildings over time (SFRC 2011). Storm-surge values that the model used to inundate parcels each year in the multi-decade scenarios were derived from the federal flood insurance study report for Broward County (FEMA 2014). These documents provide heights for storms of various strengths, typically including recurrence intervals of 10, 50 and 100 years (that is, storms that have a 10 per cent, 2 per cent and 1 per cent 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 feet) and Hurricane Wilma of 2005 (6 feet) 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 as a proxy for which properties had elevated buildings. All buildings constructed since 1979 were assumed to have ground-floor elevations of 8 feet above ground level. 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 for the US Army Corps of Engineers (see GEC 2006). Costs for flood proofing and elevation actions were secured from earlier projects in collaboration with the engineering firm Parsons Brinckerhoff during a review of contractor websites. Costs of voluntary buyout action were based on per-parcel market values of real estate in the study area. A 3.3 per cent discount rate was applied for all scenarios to reflect anticipated economic growth during the scenario period.

7. For those unfamiliar with feet, 1 foot equals 0.3048 metres.

