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Promoting Spatial Coordination in Flood Buyouts in the United States: Four Strategies and Four Challenges from the Economics of Land Preservation Literature

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Abstract: Managed retreat in the form of voluntary flood-buyout programs provides homeowners with an alternative to repairing and rebuilding residences that have sustained severe flood damage. Buyout programs are most economically efficient when groups of neighboring properties are acquired because they can then create unfragmented flood control areas and reduce the cost of providing local services. However, buyout programs in the United States often fail to acquire such efficient, unfragmented spaces, for various reasons, including long administrative timelines, the way in which buyout offers are made, desires for community cohesion, and attachments to place. Buyout programs have relied primarily on posted price mechanisms involving offers that are accepted or rejected by homeowners with little or no negotiation. In this paper, we describe four alternative strategies that have been used successfully in land-preservation agricultural–environmental contexts to increase acceptance rates and decrease fragmentation: agglomeration bonuses, reverse auctions, target constraints, and hybrid approaches. We discuss challenges that may arise during their implementation in the buyout context—transaction costs, equity and distributional impacts, unintended consequences, and social pressure—and recommend further research into the efficiency and equity of applying these strategies to residential buyout programs with the explicit goal of promoting spatial coordination.

Keywords: Adaptation; Buyouts; Land preservation; Mechanism design; Agglomeration bonus; Reverse auction; Target constraint; Equity.

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Introduction

Managed retreat is the purposeful relocation of residents and infrastructure away from very hazardous areas. Though flood-prone communities in the United States have historically prioritized other strategies (e.g., levees, beach nourishment, home elevations) (Kousky 2014), numerous analyses have noted the potential of managed retreat to phase out risk-prone real estate development (e.g., Titus 1986, 1991; GAO 2020a). The 2018 US National Climate Assessment observed that retreat is likely to be "unavoidable" in some areas under all but the most conservative projections of sea level rise (Jay et al. 2018), which is expected to affect between 4 million and 13 million Americans by the year 2100 (Hauer et al. 2016).

Voluntary flood buyout programs have become the most common form of managed retreat in the United States. Under these programs, the government offers to purchase properties damaged by flooding, coastal storms, or other hazards, and property owners decide whether to sell or stay (e.g., Binder and Greer 2016; Siders 2019; Fraser et al. 2003). FEMA has funded buyout programs since 1989 and spent roughly $4 billion to support the acquisition of more than 45,000 homes (GAO 2020b). Other agencies, including the US Department of Housing and Urban Development (HUD), USACE, and USDA, also fund buyouts, and some buyouts are funded by state or local initiatives.

Buyouts can be a significant tool for reducing flood risks and long-term public expenditures. Buyouts also affect a range of household and community outcomes such as social justice, ecosystem service benefits, community connections, place attachment, mental health, and cultural heritage (e.g., Koslov et al. 2021; Binder et al. 2019, 2020; Dannenberg et al. 2019; McNamara et al. 2018; Simms et al. 2021; Siders et al. 2021; Atoba et al. 2021; Tate et al. 2016; BenDor et al. 2020).

However, buyouts have often fallen short of their theoretical potential to achieve economic goals and reduce risk. The problems include implementation delays that can increase the economic burden on participating households and reduce homeowner willingness to participate (Weber and Moore 2019), complex governance systems that increase administrative costs for local governments (Curran-Groome et al. 2022), differences of opinion over what

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fair adaptation entails and at what scales it should be addressed (Cooper and McKenna 2008; Craig 2019), and a failure to account for ecological costs and benefits during decision-making processes (Atoba et al. 2021). Local governments can be an impediment to offering buyouts, considered a "first hurdle," because they have significant discretion as to whether buyouts are offered (Miao and Davlasheridze 2022) and frequently raise concerns that buyouts will have a negative effect on the local economy and on property tax bases specifically (Salvesen et al. 2018; BenDor et al. 2020). These concerns are particularly apparent when the properties acquired through a buyout program are distributed in a "disjointed pattern that does little to protect environmental assets" (Atoba et al. 2021, p. 229). This fragmented pattern is sometimes called checkerboarding, and it may make it difficult for local governments to use land effectively for flood management or to reduce public services and maintenance costs (BenDor et al. 2020; Zavar et al. 2016). Fragmentation may be especially apparent in communities with low acceptance rates by homeowners.

BenDor et al. (2020) demonstrate that the economic costs of buyouts may be reduced by strategies that reduce fragmentation. Spatially coordinated buyouts may improve these outcomes by enabling the creation of floodplains or wetland restoration, which generates ecosystem services like flood hazard mitigation (FEMA 2011, 2015a; GAO 2020b). Spatially coordinated buyouts may also generate infrastructure and cost savings by reducing or eliminating the need for public services in a hazardous area (BenDor et al. 2020).

We hypothesize that some of the inefficiencies in cost and spatial distribution of buyout programs arise, in part because of the way in which buyout offers have been structured and the nature of the financial incentives these offer mechanisms provide to property owners. Buyout administrators most often offer to purchase properties at "fair market value," based on either a predisaster or current appraisal. Frequently, there are differences between government determinations of the objective "fair" market values of homes and the personal value owners place on them, and these differences may lead property owners to reject buyout offers. The value homeowners place on their property and their willingness to accept a buyout are influenced not only by their knowledge of the market and their financial situation but also by social considerations, such as whether their neighbors are also relocating, how long they have lived in their neighborhood, and how strongly they are attached to the location (e.g., Robinson et al. 2018; de Vries and Fraser 2012; Fraser et al. 2003; Zavar et al. 2015). Buyout offer mechanisms that account for these variations may be better able to reduce fragmentation and realize the risk reduction and cost savings potential of buyout programs.

In this paper, we present four strategies explored within the economics literature on land preservation or conservation acquisitions and discuss their potential to increase net benefits by improving the spatial distribution of floodplain buyouts: (1) agglomeration bonuses, (2) reverse auctions, (3) target constraints, and (4) hybrid approaches that combine the first three. Table 1 presents some key similarities and differences between the flood buyout context and that of agricultural land preservation. Specifically, Table 1 highlights that the objective of land preservation is to retire parcels of agricultural land in perpetuity (or through a long-term contract), often for environmental benefits. Providing many of the desired environmental benefits requires contiguous conservation; therefore, much of the agri-environmental literature focuses on how to design programs and policies that reduce fragmentation (Nguyen et al. 2022). Techniques used in land preservation have not, to our knowledge, been explored in the floodplain buyout literature or commonly applied in practice (beyond the examples we detail in what follows). Our goal in presenting them here is to explore the potential for greater experimentation (theoretical, empirical, and applied) in how buyout offers are made by connecting insights from the literature related to floodplain buyouts and land conservation. We also highlight four challenges that might arise in applying these strategies in a buyout context: (1) transaction costs, (2) concerns related to equity and distribution of benefits and costs, (3) unintended consequences that arise from perverse relocation incentives, and (4) social pressure with respect to the voluntary nature of buyouts.

Overview of Current Buyout Processes

Buyout programs are administered by state and local governments and often demonstrate significant variation as local officials tailor programs to their preference. Despite these variations, these programs also share commonalities based on federal guidelines, most often from FEMA or HUD. Under this approach, which we refer to as the FEMA method, local governments make posted price offers that are fair, transparent, and equitable (FEMA 2015b). Fair compensation has most often been interpreted to mean the predisaster fair market value of a home as determined by an independent appraiser. However, fair compensation could be defined in other ways, such as replacement value: the cost the owner would have to pay to purchase a similar property nearby. Even when fair market values appear to be objectively fair, individual owners often vary in terms of their subjective valuations of their properties based on preferences for remaining in their neighborhoods versus relocating [see Frimpong et al. (2019) and the next section]. Nevertheless, under the FEMA method, as illustrated in Fig. 1, the price is generally fixed by the government or a third party rather than the homeowner or through negotiation, and the posted price offer can be accepted or rejected by the property owner. We use this FEMA method as a baseline to compare alternative practices from other land-acquisition contexts, though we also recognize that buyout programs are conducted in a variety of ways and that there can be considerable variation in how homes are valued (e.g., practitioner

Table 1. Differences in functions of voluntary land preservation and voluntary coastal acquisition programs

Characteristic	Voluntary land preservation program	Voluntary flood-buyout program
Purpose	Retire parcels of agricultural land in perpetuity (or through a long-term contract) to provide public benefit through provision of ecosystem services	Retire parcels of land in perpetuity to boost flood resilience and decrease infrastructure expenditures (e.g., roads, utilities)
Buyer	Government (e.g., USDA, state agencies)	Government (local or state, through funding from, e.g., FEMA, HUD)
Seller	Rural landowner	Homeowner
Type of land	Agricultural land, forest land	Residential
Potential challenges	Low participation, high cost, fragmentation, inequality	

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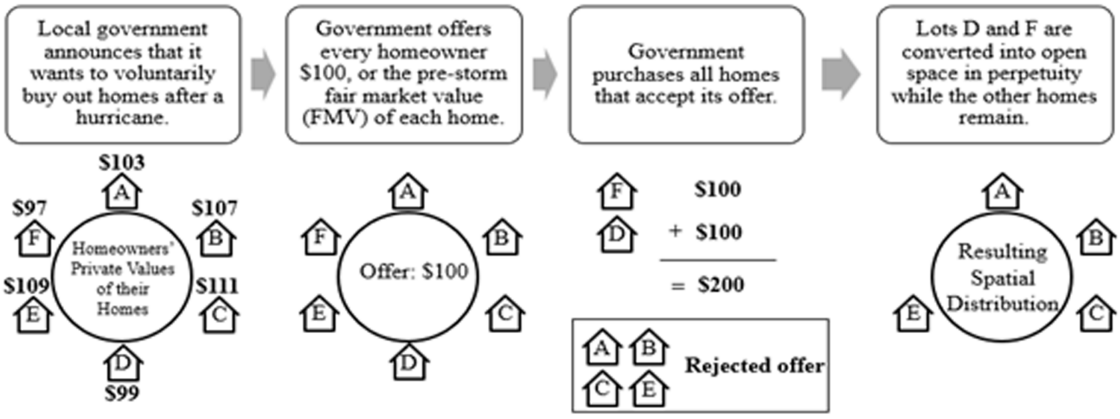

Fig. 1. Example of FEMA method coastal buyout program that uses a posted price offer mechanism (all numbers in thousands).

consideration of pre- or poststorm valuation) (Siders and Gerber-Chavez 2021).

Homeowner Acceptance Rates

Several factors have been shown to play important roles in homeowner acceptance rates within buyouts: timing, prices, communities, and homeowner perceptions. For example, homeowners are more likely to accept buyout offers that can be completed before repairs must be made (de Vries and Fraser 2012). However, buyouts often take several years to complete (Weber and Moore 2019). During that time, owners must continue to pay mortgages, flood insurance premiums (if they were required to carry insurance), and property taxes, even if they cannot physically live in their primary residence and are paying for a secondary residence. These obligations can rapidly become financially untenable under buyout processes, which can last 2–5 years (Weber and Moore 2019). Offer prices also have a significant effect; for example, Frimpong et al. (2019) found a positive relationship between prices offered and rates of acceptance. Seebauer and Winkler (2020), however, noted that considering only economic factors means ignoring important emotional and social dimensions of relocation decisions. Individuals' attachments to their communities (Lewis 2012; de Vries and Fraser 2012) and neighborhoods (Frimpong et al. 2019) affect the value they place on their homes. Residents may have "a strong sentimental attachment to or family history associated with the home and/or neighborhood" (BenDor et al. 2020, p. 14). Their strong desire to remain in their homes might also relate to a perceived aversion to encountering hardship while finding another home or establishing strong community attachments in new neighborhoods (Kick et al. 2011; Fraser et al. 2003; Binder et al. 2019). Many residents do not want to be "left behind" by neighbors who decide to sell, so they are more likely to accept buyouts when they know or believe that their neighbors will sell (Ando and Reeser 2022; Fraser et al. 2003; Lewis 2012; de Vries and Fraser 2012). In addition, homeowners' willingness to accept buyout offers increases as their perceptions of flood risks and hurricane risks increase (Robinson et al. 2018; Ando and Reeser 2022; Fraser et al. 2003; de Vries and Fraser 2012; Kick et al. 2011).

Incentives to Promote Buyout Program Participation

Local, county, and state governments have implemented various types of incentives in buyout programs to maximize participation, encourage residents to relocate locally (to retain the tax base), and motivate groups of residents to relocate to avoid fragmentation.

For example, when New York implemented a buyout program following Hurricane Sandy in 2012, the state initially offered three financial incentives: an additional 10% for properties located in extremely high-risk areas, an additional 5% to residents who relocated within New York City, and an additional 10% to owners whose neighbors participated in a cluster (this last incentive was later eliminated) (GOSR 2015; Binder and Greer 2016). Notably, a 2019 assessment of residents' moves found that most had relocated in New York City (McGhee et al. 2020), but it was not clear how much the incentive versus residents' desires to remain close to jobs, schools, family, and familiar locations had contributed to their choices.

Following Hurricanes Katrina and Rita, the Louisiana Office of Community Development implemented a buyout in which homeowners forfeited up to 40% of the buyout price if they chose to relocate outside of Louisiana (Greer and Brokopp Binder 2017; Program 2009). The effect of this disincentive has not yet been evaluated in terms of resulting risk exposure and social vulnerability for participating homeowners.

New Jersey's ongoing Blue Acres buyout program does not offer direct financial incentives beyond the offer price but eases the financial burden of relocation for participants in other ways. For example, the Blue Acres staff negotiated with lending companies and ultimately organized more than $2 million in support for loan forgiveness programs and short sales for owners who owe more than their homes are worth (FEMA 2015a; Spidalieri et al. 2020). Blue Acres also partners with local nonprofit organizations that support residents with funding for attorney and appraiser fees and other costs associated with buyouts and moves (FEMA 2015a).

Harris County, Texas, in recognition of the difficulty of finding and affording new housing around the Houston area after a buyout, provides two relocation incentives. Residents who relocate outside of the 100-year floodplains are eligible to receive down-payment funds of up to 120% of their annual median income for a home; they must reside in that home for at least 2 years to be eligible (Harris County Community Services Department 2017). Residents who relocate outside 100-year floodplains may also qualify for an additional lump sum of up to $19,779 if they agree to move outside Houston but remain in Harris County (Harris County Community Services Department 2020).

In North Carolina, Charlotte-Mecklenburg Storm Water Services offers residents the option to sell the land beneath eligible homes and relocate the buildings to areas outside the floodplain. The homeowner would bear the cost of purchasing new parcels of land, but the township would pay the cost of physically relocating

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the structures (AECOM 2012). This option may be especially attractive to residents who are strongly attached to the physical structures of their homes, although it has not yet been used in practice (CMSWS 2015).

These types of supports and incentives may increase participation rates (and thereby decrease spatial fragmentation), but they may also have unintended consequences (discussed subsequently in the section "Four Implementation Challenges"). An experimental approach to testing both incentives and the overall mechanism may provide evidence for effective buyout program design that minimizes unintended consequences.

Is There a Better Way?

Programs designed to preserve agricultural lands, forested areas, and wildlife habitats have much in common with programs designed to convert residential areas to open space to control flooding (Table 1). Consequently, strategies that have been used in these agri-environmental contexts might increase the economic efficiency of flood buyouts. In land-preservation programs, government entities and nonprofit organizations seek to convert privately owned lands from current uses such as agriculture, active forestry, and housing to open space, thereby preserving environmental resources that generate public benefits. Unlike flood buyouts, these land-preservation programs may result in a private entity continuing to own the land, with only the use of the land restricted. Nevertheless, the two sets of programs face similar challenges, including low rates of participation, budget constraints, and fragmented acquisitions. For example, Parkhurst et al. (2002) designed an economic experiment to study preservation acquisitions and found that 100% of the scenarios that did not include a spatial incentive or communication between neighbors led to fragmentation.

Researchers have tested numerous combinations of approaches in preservation to promote the acquisition of contiguous properties, including agglomeration bonuses (Parkhurst et al. 2002; Parkhurst and Shogren 2007, 2008; Banerjee et al. 2012, 2014; Banerjee 2018; Fooks et al. 2016), reverse auctions (Latacz-Lohmann and Van der Hamsvoort 1997; Reeson et al. 2011; Schilizzi and Latacz-Lohmann 2007; Otto et al. 2020; Arnold et al. 2013; Fooks et al. 2015; Duke et al. 2017; Messer et al. 2017), and target constraints (Fooks et al. 2016; Parkhurst and Shogren 2007; Otto et al. 2020; Duke et al. 2015). Table 2 presents an overview of these strategies and the challenges associated with implementing them. We review the potential for these strategies to improve buyout programs designed to control flood damage and recommend additional research and experimentation in order to support future decision making by flood buyout programs aiming to improve economic efficiency through spatial coordination. Which of these four strategies will perform best in the context of flood buyouts is an empirical question, and the answer likely differs based on the context in which the strategy is applied and the goals of individual programs and communities. More experimentation in this area may contribute evidence on the efficient design of flood buyout programs. In addition, we subsequently raise four possible implementation challenges that need to be considered by local governments seeking to improve spatial coordination using these strategies.

The remainder of this paper presents four strategies of implementing mechanisms for improving the net benefits generated by flood buyout programs and four challenges associated with these mechanisms. Fig. 2 summarizes the expected changes in benefits and challenges under each strategy relative to the status quo, or FEMA method (posted price). We focus on five key program outcomes, including contiguity of acquired parcels (with three nested outcomes related to infrastructure, ecosystems, and community-level risk reduction), purchase cost savings per house, homeowner welfare, community welfare, and homeowner hazard risk reduction. We use the terms *homeowner* and *community welfare* holistically to refer not only to financial benefit and risk reduction but also to less tangible considerations such as place attachment,

Table 2. Summary of four strategies and four challenges for coastal home buyout programs that are derived from the economics literature on land preservation and the flood-buyout literature

Category	Topic	Description
Strategies	Agglomeration bonuses	Agglomeration bonuses are additional bonus payments made when neighbors coordinate with one another and jointly agree to accept their respective buyout offers. They can increase beneficial spatial coordination between neighbors at an additional cost that is borne by the buyer.
	Reverse auctions	Reverse auctions feature a single buyer, such as a government buyout program, who obtains offers from multiple sellers and accepts the lowest offer(s). This mechanism may effectively lower overall costs, though one needs to be alert to rent seeking or collusion, especially when the auction has few participants.
	Target constraints	Target constraints impose a minimum level of cooperation or participation required for the buyouts to go forward. Target constraints can minimize fragmentation in flood-buyout programs without imposing additional costs on program administrators.
	Hybrid approaches	Combining financial incentives and market mechanisms can create synergistic effects that further alleviate fragmentation and decrease the program costs borne by the buyer.
Challenges	Transaction costs	The additional costs to a program, e.g., paperwork, administration, and search costs. Transactions costs can limit a buyer's ability to scale a buyout program and can decrease sellers' willingness to participate.
	Equity and distributional impacts	Existing buyout programs are often targeted in low income communities, which can increase disparities in the local community. Future programs should develop a thoughtful approach to where and how buyouts are proposed.
	Unintended consequences	Incentives within flood-buyout programs can have unintended consequences and should carefully account for the short- and long-term impacts on disadvantaged communities.
	Social pressure and voluntariness	Target constraints and agglomeration bonuses may place social pressure on reluctant residents and turn technically voluntary buyouts into programs that feel like coercive displacements. More research is needed to understand how to frame these strategies to homeowners to foster spatial coordination without creating the perception of coerciveness.

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	Mechanisms			
	Agglomeration Bonus	Reverse Auction	Target Constraints	Hybrid Approaches
Goals/Benefits				
Contiguity (including infrastructure savings, ecosystem services, and community hazard risk reductions)	↑	↔	↑	↑
Purchased cost savings per house	↓	↑ or ↓	↔	↑ or ↓
Homeowner welfare	↑	↑ or ↓	?	?
Community welfare	?	?	?	?
Homeowner hazard risk reduction*	↑	↔	↑ or ↓	↑ or ↓
	(a)			
Challenges				
Transaction costs	↑	↑	↑	↑
Burden to program administrator	↔	↑	↔	↑
Lack of transparency to the public	↑	↑	↑	↑
Equity/Distributional impacts	?	?	?	?
Unintended consequences	?	?	?	?
Social pressure	↑	↔	↑	↑ or ↔
	(b)			

Legend: All expected changes are expressed relative to the FEMA status quo of posted price offers to homeowners. ↑ denotes an increase relative to the status quo while ↓ denotes a decrease. ↔ indicates that there is no ex ante reason to expect a difference in outcomes relative to the status quo. ↑ or ↓ highlights ambiguity in possible outcomes as a function of program implementation. ? denotes instances in which the existing literature is insufficient to determine the directional impact of the proposed strategy.

Notes: * The predictions regarding homeowner hazard risk reductions assume that homeowners on average move to a place that is less exposed to flood risk than their original home. However, as we discuss in the section on perverse relocation incentives, this is not always the case in practice.

Fig. 2. Benefits and challenges of alternative procurement mechanisms compared to status quo FEMA approach (posted price).

community cohesion, and emotional well-being (de Vries and Fraser 2012; Binder et al. 2019, 2020; Koslov et al. 2021). In the next section, a subsection will introduce each of the four strategies and their goals and benefits [Fig. 2(a)]. The following section provides a subsection for each challenge [Fig. 2(b)]. The paper concludes with a summary of our findings and directions for future research and highlights some important areas for future work in determining the effect of acquisition mechanisms (denoted by a question mark in Fig. 2).

Four Strategies from Agriculture Preservation to Increase Buyout Efficiency through Improved Spatial Coordination

This section identifies four distinct strategies to promote spatial coordination (summarized in Table 2) that are worth further investigation in the flood buyout context. The strategies are drawn from the economics literature on land preservation and relate to agglomeration bonuses, target constraints, reverse auctions, and hybrid approaches. Although we argue that these tools are worth investigating for their application to flood buyouts, we also highlight four challenges related to their implementation that arise from the land-preservation and flood buyout literature. The challenges are related to concerns regarding transaction costs, equity and distributional implications, the possibility of perverse relocation incentives, and the social pressure that must be addressed when assessing potential tools to use in flood buyout programs.

Agglomeration Bonuses and Coordination

Strategy 1: Agglomeration bonuses can increase beneficial spatial coordination between neighbors at an additional cost to the buyer.

Agglomeration bonuses (also called network bonuses) are additional payments made when neighbors coordinate with one another and jointly agree to accept their respective buyout offers. Although agglomeration bonuses increases the overall cost per home acquired, they can be an effective tool to encourage coordination and generate more spatially efficient outcomes. An example of a hypothetical agglomeration bonus in conjunction with a posted price offer is shown in Fig. 3. Research in environmental preservation found that agglomeration bonuses alone can increase spatial coordination by up to 62% (Parkhurst et al. 2002), and larger bonuses further increase spatial coordination among neighbors (Banerjee 2018).

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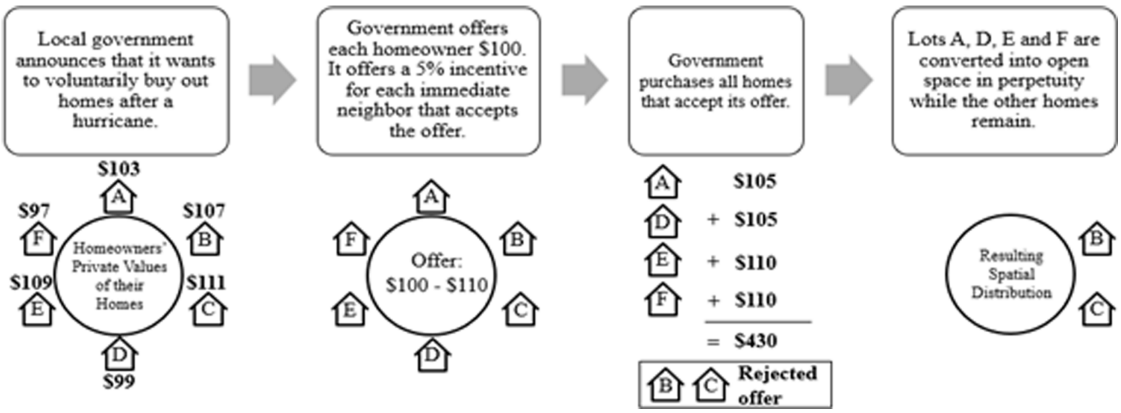

Fig. 3. Example of a coastal buyout program that offers a posted price offer plus an agglomeration bonus (all numbers in thousands). Homes that coordinate with one adjacent neighbor receive $105, whereas homes that coordinate with both adjacent neighbors receive $110.

Fig. 3 reflects the benefits of increased contiguity suggested by the literature: agglomeration bonuses provide financial incentives for coordination, thereby generating infrastructure savings, ecosystem service benefits, and hazard risk reductions at the community level. The additional payment creates additional program costs but also increases homeowner welfare and reduces hazard risk (when the homeowner relocates to a place that has less flood risk than their original home). Predicting the impact of agglomeration bonuses on community welfare beyond increased contiguity cobenefits will require additional research, as will nonfinancial elements of homeowner welfare, such as place attachment. Assuming that homeowners will, on average, move to a place that is less exposed to flood risk than their original home, the implementation of an agglomeration bonus will provide hazard risk reductions through increased participation.

In terms of behavioral interventions, additional research has shown that combining an agglomeration bonus with direct, nonbinding communication with others (known as cheap talk) increases neighbor coordination more than a bonus alone (Parkhurst et al. 2002). In the study, cheap talk was simulated in an economics laboratory setting; participants were told that they could communicate with other members of their group between experimental rounds. This finding is significant because direct communication naturally occurs between neighboring homeowners. Buyer transparency also influences decision-making. For example, providing experiment participants with information about the decisions of their direct (Banerjee et al. 2014) and indirect (Banerjee et al. 2014; Banerjee 2018) neighbors proved effective in establishing a so-called new normal that boosted participation and spatial coordination. The effect is likely to be particularly pronounced in tight-knit communities: Banerjee et al. (2012) found that small, intimate groups sustained spatial coordination longer than large groups.

As previously noted, New York's buyout program used to offer a 10% agglomeration bonus (Binder and Greer 2016). Its effect on spatial agglomeration is unclear because it was eventually discontinued, thereby raising another concern: Can cheap talk between real world neighbors and agglomeration bonuses lead to social coercion, in which neighbors pressure other neighbors to accept buyouts in order to obtain the bonus? Researchers have already started to investigate the extent to which such social pressure occurs in the absence of agglomeration bonuses. The extent to which bonuses increase these concerns represents a potential challenge that merits additional research and is discussed in greater detail in an upcoming section "Equity and Distributional Impacts."

Reverse Auctions

Strategy 2: Reverse auctions may effectively lower overall costs; however, reverse auctions may increase program vulnerability to rent seeking or collusion when the auction has few participants.

In standard auctions, a seller obtains bids (offers) from multiple buyers and accepts the highest one. In reverse auctions, a single buyer, such as a government preservation program, obtains offers from multiple sellers and accepts the lowest offer(s). Thus, instead of trying to estimate a property's fair market value, reverse auctions give sellers the opportunity to state their private willingness-to-accept price for the land (see Fig. 4, which outlines an example of a reverse auction program).

The literature in economics and preservation on the effectiveness of reverse auctions in laboratory and field settings is rich. In fact, the 2020 Nobel Memorial Prize in Economic Sciences was awarded for work on the design and function of reverse auctions (Royal Swedish Academy of Sciences 2020). Latacz-Lohmann and Van der Hamsvoort (1997) first demonstrated the value of using reverse auctions in preservation programs to improve their economic efficiency (obtain the greatest public benefit from the available budget). Their results suggested that competitive bidding could outperform fixed-rate payments and increase a program's cost-effectiveness, providing greater benefits for the same expense.

Reverse auctions are already used in many different contexts, including government finance, public utilities, preservation programs, water rights, carbon markets, and private property sales, and have been widely used by several US federal programs. For example, USDA's Conservation Reserve Program (CRP) has used a type of reverse auction since 1986 to enroll land to convert from agriculture to vegetative cover such as grasses and trees. In 2017, the CRP enrolled more than 24 million acres using a large-scale reverse auction process (Wallander et al. 2021).

One concern associated with auctions is the potential for so-called rent-seeking behavior by homeowners. Rent seeking describes instances in which individuals attempt to gain excess profit by bidding (offering) more than their true private value. In the example of a reverse auction shown in Fig. 4, rent seeking is present when potential sellers submit bids that exceed their actual private valuations of their land. If all bidders seek additional rents, all of their offers will exceed their true valuations, and the winning sellers will receive more than their true valuations for their properties. Banerjee et al. (2015) and Fooks et al. (2016) found that rent seeking was generally present in all auction scenarios. Furthermore, rent seeking increased when subjects were aware of the spatial goal of

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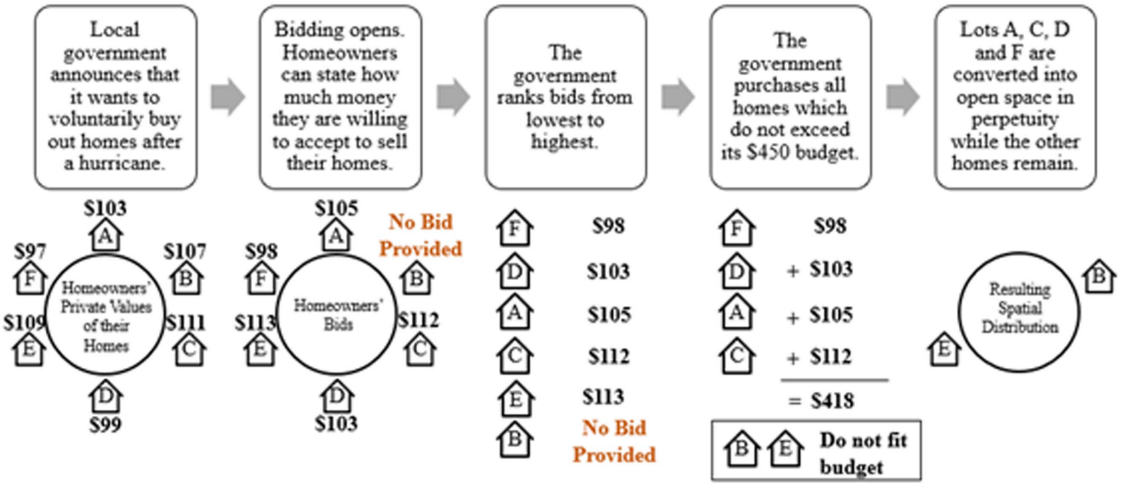

Fig. 4. Example of coastal buyout program that uses a reverse auction (no agglomeration bonus) and has a budget of $450 (in thousands).

an auction; in those cases, they knew that their parcels were critical to avoiding fragmentation and could demand to be paid a higher price. These findings suggest that transparency about the spatial goal of an auction can be detrimental to auction efficiency.

Messer et al. (2017) noted that another challenge can arise with government-run reverse auctions where public information is given, such as budgetary allocations for the program. In a situation with repeated interactions, participants in laboratory auction experiments increased their rent seeking in situations where they were aware that the government buyer had more money to spend and lowered their bids when they were told the government had less money (thereby creating a more competitive auction).

Yet another concern regarding reverse auctions is that residents generally are not familiar with this type of mechanism for selling property. Consequently, agencies can benefit from following iterative auction procedures in which participants complete several rounds and implementation only occurs in the final round. This iterative approach allows bidders to learn how the auction functions, which can increase participation and lead to more efficient bidding. On the other hand, successive auctions over several rounds can create opportunities for participants to learn how to collude and coordinate their bids, which can ultimately increase the cost of acquiring the lands. Reeson et al. (2011) used an experiment to evaluate an iterative auction procedure and found that efficiency increased with rounds, suggesting that the benefit of learning was greater than any disadvantage arising from collusion. Another interesting finding by Banerjee et al. (2015) is that participants reduced their bids (e.g., bid closer to their true values) when they knew that their neighbors had won in a previous round. Thus, though collusion is possible, carefully designed iterative auctions can provide an incentive for competitive offers.

Although the land-conservation literature indicates that reverse auctions have the potential to increase economic efficiency by securing the greatest public benefit, Fig. 2 notes that there is no ex-ante reason to believe that they will increase overall contiguity in the context of home buyouts. There is further ambiguity if implementing a reverse auction might increase or decrease overall per-home costs. A reverse auction mechanism has the potential to increase homeowner welfare for those willing to accept an offer that is slightly above the posted price and to decrease homeowner welfare for those who receive less than the status quo posted price. Future research can assess the potential benefits of a reverse auction on community welfare. As with contiguity, there is no ex-ante reason to believe that reverse auctions would change overall homeowner risk reduction.

Target Constraints and Provision Points

Strategy 3: Target constraints can minimize fragmentation in flood buyout programs without imposing additional costs on program administrators.

Land preservation buyouts sometimes need to acquire a specific number of adjacent parcels (e.g., to restore a wetland or reduce public infrastructures in high-risk areas). Below those thresholds, the programs cannot achieve their goals. This threshold has been addressed using target constraints (also called provision point mechanisms) that impose a minimum level of cooperation or participation required for the buyouts to go forward.

A target constraint can be used in flood buyouts to establish a minimum number of adjacent homeowners that must agree to participate. Fig. 5 reconsiders the hypothetical buyout programs in Figs. 3 and 4, which implemented an agglomeration bonus and a reverse auction, respectively. Suppose that we impose a target constraint in each setting that mandates the participation of at least three adjacent homes. The hypothetical outcome under the program with an agglomeration bonus would still go through in the presence of this type of target constraint because there are four adjacent homes (D, E, F, and A) that are willing to participate, resulting in environmental benefits in the form of contiguous wetlands and increased flood resilience. By contrast, the reverse auction buyout example generated two sets of two adjacent homes (C and D, and F and A) that are willing participants, which would not satisfy the target constraint. In this case, all residents would stay, and the target constraint mechanism would avoid the implementation of a spatially inefficient program that would have cost $418,000 and resulted in fragmentation.

The preceding examples demonstrate the need for thoughtfully constructed target constraints, which have been tested in the land-preservation literature. Messer et al. (2005), using an economic experiment, showed that successful implementation of provision point mechanisms depends in part on (1) the level of the threshold established; and (2) the existence of a mechanism by which subjects can privately signal their desire to contribute to other participants. Messer et al. (2008) subsequently tested the efficiency of a provision point mechanism that included the option to receive a refund of contributions to the public good at the end of rounds.

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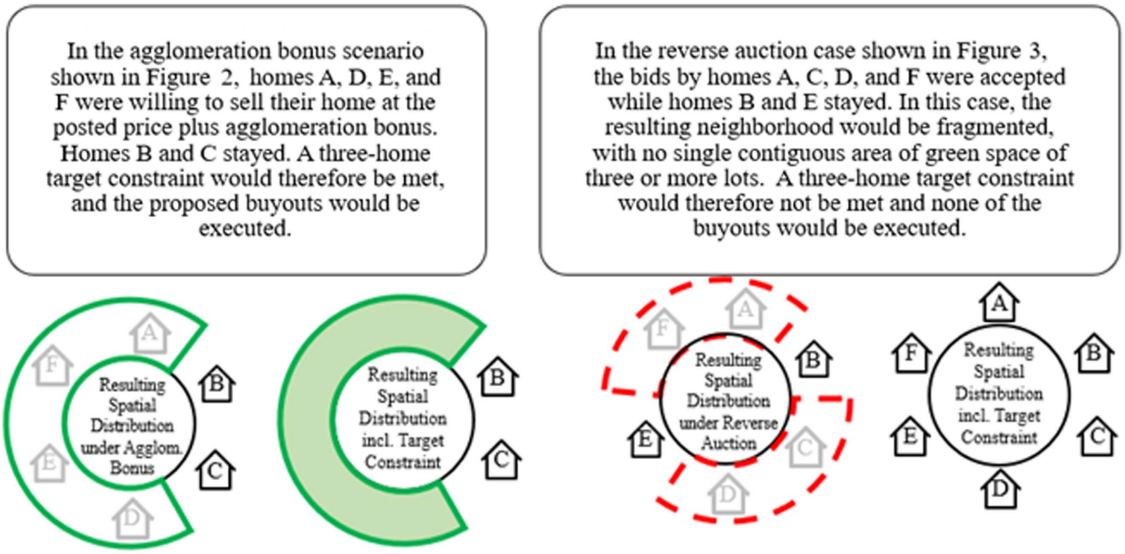

Fig. 5. Outcome of hypothetical coastal buyout programs if three-home target constraint is imposed.

Under this mechanism, all participants had to contribute at the beginning of the round and were given the option to ask for a full or partial refund of their contributions before the round ended. The participants were aware that a minimum threshold had to be attained to implement the program; if their collective contributions did not meet the threshold, everyone received a 100% refund, and the public program was canceled. In this case, the provision point refund mechanism consistently led to successful implementation: overall, the design achieved implementation 90.9% of the time (Messer et al. 2008). These results highlight the potential effectiveness of introducing target constraints into flood control programs to minimize fragmentation. As with agglomeration bonuses, the potential exists for neighbors in a flood buyout context to exert social pressure on one another to participate or not participate. We further discuss the effects of this approach on communities in the "Equity and Distributional Impacts" section.

Fig. 2 indicates that, by design, target constraints increase contiguity by only permitting contiguous buyouts. However, the other outcomes of interest are either ambiguous or require further research.

Hybrid Approaches

Strategy 4: Combining financial incentives can create synergistic effects that further alleviate fragmentation and decrease the program costs for the buyer.

A related stream of research has tested the efficiency of using several strategies in combination. For example, Fooks et al. (2016) tested a process involving a reverse auction with an agglomeration bonus, with a budget constraint (a maximum amount of money the buyer can spend), and with spatial targeting (a process that allows the buyer to place additional value on properties that are adjacent to parcels of land that are already protected or are about to be protected). They found that the addition of an agglomeration bonus increased the overall acceptance rate of bids but decreased the spatial contiguity of the resulting acquisitions and, therefore, of the environmental benefit they provided. Introduction of spatial targeting, on the other hand, improved the overall outcome, and combining spatial targeting and an agglomeration bonus increased the number of bids and ensured that the selection of parcels provided significant environmental benefits. Otto et al. (2020) tested reverse auctions with and without a provision point mechanism and found that provision point reverse auctions yielded significantly lower bids. Schilizzi and Latacz-Lohmann (2007) tested reverse auctions that incorporated either a budget constraint or a target constraint against a posted price mechanism and found that both combinations outperformed the posted price program in one-shot settings. They found, however, that the reverse auctions provided no such advantage with repeated rounds, again suggesting that it will be important for flood buyout programs to consider whether they will employ one-shot auctions in a community.

Four Implementation Challenges

This section identifies four distinct challenges that merit careful consideration and experimentation before local governments decide where and how to apply the four strategies proposed in the preceding discussion. Our four proposed strategies are intended to generate a greater net social benefit. Specifically, the use of these agglomeration bonuses and reverse auctions has the potential to provide more compensation to buyout participants than the fair market value of their home (especially if the home is at high risk or has endured repetitive loss and is therefore considered a high-value buyout to the government) and to be particularly beneficial to owners of properties with low market value (due to their high risk or to historical practices that have led to property devaluation).

However, flood buyouts also have a humanitarian purpose: to protect residents. Their overall success must consider the financial well-being of the participants and other emotional, social, and health outcomes. This requires explicitly addressing how buyout tools affect the long-term well-being of the residents involved. We have four main concerns, which are discussed at length in what follows: (1) transaction costs can decrease participation rates and make programs more difficult to scale; (2) buyout programs are commonly implemented in low income communities which can increase disparities in the local community; (3) some relocation incentives may have unintended consequences, driving residents to relocate to areas of equal or even greater economic and flood risk; and (4) agglomeration bonuses and target constraints, particularly when coupled with information exchange, may place social

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pressure on reluctant residents and even turn technically voluntary buyouts into programs that feel like coercive displacements.

Transaction Costs

Challenge 1: Transaction costs can limit a buyer's ability to scale a buyout program and decrease sellers' willingness to participate.

Evaluating the cost-effectiveness of a buyout program requires accounting for the program's transaction costs or any of the additional costs incurred from the program, including the administrative burden, the costs to the homeowners of time, making a decision, and effort to enroll. The large transaction costs associated with flood buyout programs can dramatically reduce participation, which can lead to greater fragmentation and limit programs' effectiveness practically and financially. Potential sellers also incur transaction costs in terms of finding and moving to new locations and losses of community and attachment.

The agency incurs transaction costs when planning, implementing, and supporting the program (McCann and Easter 2000). These costs typically increase, sometimes dramatically, with the complexity of a program and can strain program resources, particularly when programs are small and have few staff members. One study estimated that buyouts cost roughly $8,000 to $14,000 per property in administrative costs (Curran-Groome et al. 2022). Research on land-preservation programs has shown that transaction costs contribute substantially to the full cost of programs and policies (McCann et al. 2005).

High transaction costs for sellers (real and perceived) can influence their willingness to participate. Sellers' transaction costs have been identified as a key barrier to participation in preservation programs in general (McCann and Claassen 2016), especially in programs that use reverse auctions (Rolfe et al. 2018; Palm-Forster et al. 2019). Low participation rates reduce the pool of bids made, which limits the agency's options and can result in less cost-effective acquisitions. Over time, sellers' real and perceived transaction costs can decline as they learn more about the program. Identifying ways to streamline the program also encourages participation, particularly when new program features are first introduced. Ando and Reeser (2022) found that homeowners had a positive willingness to pay for bundling buyout and insurance to reduce the time between a natural disaster and either an insurance payout or buyout.

In the context of flood buyout programs, increased transaction costs would limit funds for the buyouts in general and for incentives to increase contiguity in particular. As shown in Fig. 5, compared to posted price buyouts, the alternative mechanisms likely involve higher transaction costs for agencies and potential participants. Therefore, agencies face tradeoffs between the benefits of incorporating incentives, such as agglomeration bonuses, reverse auctions, and target constraints, versus their increased costs and complexities. Agencies must weigh the full benefits and costs of changing their programs, including consideration of the transaction costs associated with such changes.

Equity and Distributional Impacts

Challenge 2: Existing buyout programs often target low-income communities, which can increase disparities in the local community.

Reverse auctions have been effective in preservation settings because competition among sellers drives down offer prices while retaining an ability to account for the factors under consideration by a homeowner other than market value. This is beneficial for government buyers, who want to maximize their purchase power and the resulting social benefit, but it can be detrimental to individual sellers. Theoretically, rational sellers do not choose to sell at prices that harm them financially. However, in flood buyouts, sellers can feel that they have no viable financial alternatives. When a home has been substantially damaged by flooding, the owners can be required to rebuild according to updated building codes and elevation requirements, which can be prohibitively expensive since government assistance typically covers only a portion of the cost (de Vries and Fraser 2012; Binder and Greer 2016). An owner who feels obliged to sell because the risk of a hazard has become intolerable is coerced not by the buyout program but by the broader context (e.g., historical development patterns, investments in flood management and infrastructure, housing availability, rates of sea level rise and coastal erosion, building codes). Whether reverse auctions benefit or harm residents or make them feel coerced must therefore be evaluated as one factor within a larger context influencing owner decisions.

In addition, the decision on where to offer buyouts merits careful consideration. Flood buyouts are generally controversial, in part because they are often implemented in low-income neighborhoods and might be seen as a way of trying to displace members of these communities (Tate et al. 2016; Mach et al. 2019; Elliott et al. 2020; de Vries and Fraser 2012). Numerous studies have found that low-income communities frequently are at greater risk of flooding than high-income communities, have few protective measures in place, and find it more difficult to recover after a disaster (Martinich et al. 2013; Atteridge and Remling 2018; Buchanan et al. 2020; Howell and Elliott 2018). Consequently, program administrators sometimes purposefully focus on low-income communities when establishing buyouts (Siders and Gerber-Chavez 2021). Programs funded by HUD may even be required to spend 50% to 70% of the funds in low- and moderate-income neighborhoods.

Before reverse auctions are used in flood buyout programs, policymakers may consider their effects on the relative distribution of buyouts across socioeconomic groups, especially if buyouts are proposed in low-income communities. A good approach to investigating such effects would be to conduct economic and behavioral experiments to assess whether and how much reverse auctions decrease purchase prices and how owners' incomes and past experiences with flooding affect their willingness to sell at a loss. This would also require research on how the outcomes of buyout programs vary across income levels and purchase prices: how these factors affect where people move and how they fare financially thereafter. We note in Fig. 2 that the existing literature is insufficient to determine the directional impact of these strategies on equity. Finally, research is needed to explore how reverse auctions can be combined with other incentives such as down payment assistance and even income adjustments to offset potential harm created by reduced purchase prices (and how hybrid approaches affect the overall cost of a program).

Unintended Consequences

Challenge 3: Incentives within flood buyout programs can have unintended consequences, including short- and long-term impacts on disadvantaged communities.

As previously noted, financial incentives can be used to encourage buyout participants to relocate locally to retain a community's population and, thus, its property tax revenue. However, these incentives can also induce residents to relocate to another flood-prone area or to areas that present greater risk in terms of crime, poverty, and housing quality. For example, McGhee et al. (2020) studied 323 New York households that relocated following Hurricane Sandy and found that 20% of the households relocated to areas that were at risk of flooding and 95% moved to neighborhoods with higher poverty rates, which has been shown to reduce the future

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earning potential of children (Chetty and Hendren 2018). Similarly, Loughran and Elliott (2019) conducted a study of 1,782 Harris County, Texas, buyouts between January 2000 and August 2017; they found that roughly 9 out of 10 homeowners relocated within the metropolitan area, and that Hispanic and Black homeowners were significantly more likely to relocate locally (within the metro area) compared to White homeowners. These patterns raise concerns about the potential unintended consequences of incentivizing local relocation. Residents who chose to remain in the New York City or Houston metropolitan areas, for example, may have had to compete with each other for housing and likely would have faced inflated prices, effectively limiting their options and increasing the rate of racially segregated neighborhoods. Further research to understand how relocation incentives affect residents' decisions and long-term well-being is important for future evidence-based policymaking.

Social Pressure and Voluntariness

Challenge 4: Target constraints and agglomeration bonuses may place social pressure on reluctant residents and turn technically voluntary buyouts into programs that feel like coercive displacements. More research is needed to understand how to frame these strategies to homeowners to foster spatial coordination without creating the perception of coercion.

In the United States, flood buyouts are almost exclusively voluntary due to FEMA and HUD regulations. Buyout administrators must provide potential participants with documents that clearly state that the buyouts are voluntary, that they can withdraw at any time, and that eminent domain and other forcible forms of eviction will not be used in the future if a property owner chooses not to participate (FEMA 2019). Nevertheless, some past participants felt that buyouts were coercive, either because it was not financially feasible to stay and rebuild (Binder and Greer 2016) or because they feared future flooding, disbanding of their neighborhoods, or a future lack of interest by the local government in providing services and maintaining infrastructures after numerous residents moved out (de Vries and Fraser 2012).

Several studies have found that property owners are more likely to accept buyout offers when they believe their neighbors will also accept (Ando and Reeser 2022; Fraser et al. 2003; Lewis 2012; de Vries and Fraser 2012). This sort of social pressure can increase the contiguity of parcels acquired by encouraging neighbors to relocate in groups. However, if group location is required to receive either the buyout or a financial incentive, holdouts may face significant social pressure to leave, particularly when residents are encouraged to communicate with each other about their plans. Any decision that has financial consequences for others tends to be extremely divisive (e.g., Hersher 2019). Residents who choose to accept buyouts can create future financial burdens on residents who stay in terms of additional taxes to maintain community services or a loss of services because of smaller tax bases. Residents who choose to remain can deprive their neighbors of agglomeration bonuses, reduce the effectiveness of the program by fragmenting purchases, and even force cancellation of the program.

To determine whether and how agglomeration bonuses and target constraints can be deployed in flood buyouts without causing undue social pressure and coercion, future studies may explore how various levels of bonuses affect social dynamics, for example, whether a relatively small bonus can achieve spatial coordination without applying pressure. Research may also further investigate mechanisms by which neighbors influence each other and the contexts in which such decisions are likely to be divisive or unifying. In Fig. 2, we note the potential for increased social pressure using agglomeration bonuses and target constraints relative to posted price buyouts. Ex ante, we have no reason to believe that reverse auctions would change the level of social pressure experienced by homeowners.

In addition to the four challenges identified in the preceding discussion, we note that, although our analysis has focused exclusively on property owners since they are the decision makers under current buyout policy, future programs will need to consider the role and well-being of renters as well (Dundon and Camp 2021).

Key Findings and Directions for Future Research

Our review suggests that improvements in contiguity and their nested outcomes are more likely to be achieved with agglomeration bonuses, target constraints/provision points, and hybrid approaches that incorporate these two strategies. Reverse auctions alone are unlikely to generate additional gains in contiguity, but they could be paired with agglomeration bonuses in a hybrid approach.

The amount of money spent on home purchases has direct implications for budget-constrained programs; therefore, many program administrators focus their attention on this type of metric. Any metric has its advantages and disadvantages: placing too much weight on cost alone without considering the benefits generated (which are often more difficult to measure) might decrease the effectiveness of a program. Compared to a posted price mechanism, purchase cost savings per house are not expected under any of the four strategies, though reverse auctions may generate cost savings in some cases. If individuals are willing to submit offers that are lower than the posted prices that would have been offered to them, reverse auctions could generate cost savings, but lower offers are not guaranteed. It could also be the case that offers higher than the posted price level are accepted due to the benefits generated by purchasing those homes. In such cases, net benefits could be higher than the status quo despite lower cost savings per house. Agglomeration bonuses will decrease cost savings for home purchases because more money is required to finance the bonuses. Ex ante, we have no reason to expect that the target constraint strategy would change the amount paid per house unless the approach was combined with agglomeration bonuses or reverse auctions in a hybrid strategy.

Homeowner risk reduction is determined by how much individual exposure to flood risk is reduced by the program; therefore, this metric is closely tied to the likelihood of receiving and accepting a buyout offer. Agglomeration bonuses are more likely to improve risk reduction because they increase the likelihood that someone will accept a buyout. Target constraints decrease the likelihood that any particular individual will receive a successful buyout because there is a risk that the target will not be met, so no buyouts will occur. We do not expect reverse auctions to change the likelihood of a buyout relative to posted price mechanisms.

Fig. 2 also notes that the increased complexity of the four strategies, relative to the posted price mechanism, may increase transaction costs and two nested challenges of burdens to program administrators and lack of transparency to the public. Increases in transaction costs can be offset by other gains, such as the public service savings and ecosystem service benefits from increased continuity; however, many administrators may care more about ease of program implementation rather than maximizing overall program net benefits. In cases where administrators accept higher transaction costs, they will have to identify resources to manage the increased complexity. Importantly, administrators will want to ensure that increases in participant transaction costs are minimized to avoid negative impacts on participation.

Programs may need to consider increases in challenges related to social pressures, which we expect to occur with agglomeration bonuses and target constraint strategies. In both of these cases, individuals may experience increased pressure from neighbors. If the pressure to accept a buyout does not align with their own private benefit–cost assessment, this pressure will reduce individual well-being. We do not expect increased social pressure to be generated by reverse auction mechanisms alone, but these pressures could exist under hybrid approaches that provide incentives for aligning group behavior.

Although the preservation literature helps us gain important insights about the direction of effects, Fig. 2 also highlights the many dimensions along which more research is needed. In particular, it is not clear how homeowner well-being and community welfare will change under these four strategies relative to the status quo posted price mechanism. Furthermore, we know little about the equity and distributional impacts of these strategies and the perverse relocation incentives that could be generated. Further research on strategies that have proven effective in the agricultural preservation context may contribute to improving spatial coordination in flood buyouts.

To date, buyout programs in the United States have relied on a limited set of financial incentives to promote participation and spatial coordination and to reduce agency overall costs. In some cases, those strategies have had harmful unintended consequences. Related research on preservation buyouts and easement programs offer promising insights into the effects of alternative strategies that can help to design effective flood buyout programs. We discussed four strategies in this article, which are largely motivated by the economics literature on land preservation and can be used to increase efficiency of buyout programs. Continued research on these strategies and their related challenges will further contribute evidence to balance economic efficiency and homeowners' well-being of buyout programs. Economic experiments in the laboratory or field are excellent tools for evaluating individual decisions and responses to potential policies and predicting the impacts of those decisions and policies, particularly when implementation costs are high (Harrison and List 2004; Messer and Allen 2018). Such research is also consistent with the Foundations for Evidence-Based Policymaking Act of 2018, which calls for a greater evidence base for informing federal policies. Moving forward, economic experiments can be used to test the potential of strategies such as agglomeration bonuses, reverse auctions, and target constraints to improve the economic efficiency of flood buyout programs and the social welfare of participants.

Data Availability Statement

No data, models, or code was generated or used during the study.

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