



Managing private and public adaptation to climate change

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ABSTRACT

Adaptation to climate change is already being delivered by public and private actors, yet there has been little analysis of the relationships between the providers and beneficiaries of adaptation. This paper reviews the type of actors that are supplying adaptation services and their motivations. We then focus on a specific, under-explored case of adaptation: that of privately provided adaptation public goods and services, the realization of which is contingent on the individual management of private goods and private risks. Following the work of Olson (1965) we find that the benefits of the privately provided adaptation public good do not necessarily accrue back to the (same) individuals who are the providers. The characteristics of this particular form of public good pose specific institutional challenges. In this paper we: 1) explore the characteristics and defining features of these privately provided adaptation public goods; 2) argue that this form of adaptation provisioning is increasingly recognised as a feature in climate change adaptation (and/or social transformation) problems; 3) review existing cases of effective/ineffective management of these public goods; and 4) outline the institutions that may be required to facilitate the management of these public goods for adaptation.

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1. Introduction

We know that the management of private capital can have negative externalities. There are many examples of private actions that create negative public externalities in relation to climate change. Individuals buying air-conditioners for homes, offices or cars to keep their occupants cool in hot weather contribute to increase greenhouse gas emissions and thus potentially exacerbate the impacts of climate change on others (Isaac and van Vuuren, 2009). Less often discussed, but also well-known, is the fact that individual actions can generate (accidentally or deliberately) adaptation public goods.

Climate change adaptations are the processes and actions that enable people to cope better with increasingly challenging weather and climatic conditions. Adaptations may involve the development or adoption of a technology, or it can involve building capacity such as improved risk management or knowledge enhancement (West and Gawith, 2005). In this paper, we argue

that inadequate attention has been given to the identification and understanding of the providers and beneficiaries of adaptation and the motives of adaptation providers. Such attention is necessary to ensure that policy instruments designed to encourage adaptation are effective.

More specifically, we argue that there exists an underexplored arena of climate change adaptation in which individual managers of private capital are taking private actions that in turn create adaptation benefits for a broader community. In these particular cases, the costs of adaptation are perceived to be borne by the individual, while the benefits may not be tangible or directly accrue to that individual. In essence, individuals are called upon to take action for a greater collective good, to which they may only have an abstract relationship, if at all. We argue that this special case of adaptation – which we refer to as ‘privately provided adaptation public goods’ – has been neglected in the conceptualization of the adaptation process, yet is a critical component of action at the boundaries of the private and public spheres. While there is widespread recognition that the reality of governance is far more complex than the private/public divide challenged by Ostrom (1996) – see for example, Lemos and Agrawal (2006) – there has been very little explicit attention to characterize the nature of the public–private collaboration that adaptation is increasingly

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entailing, and the institutional arrangements that can best facilitate its realization (Eakin and Lemos, 2006).

2. Adaptation goods: public and private roles

The interplay between private and public action, costs and benefits in the realm of adaptation can be characterized as activity in four domains (see Fig. 1), each entailing specific institutional arrangements and challenges: public provision of adaptation goods for public benefit; public provision of adaptation for (largely) private benefit; private adaptation for private benefit; and finally – and what interests us here – (largely) private provision of adaptation goods for public benefit. We describe each of these domains briefly below.

We acknowledge that this typology is a caricature of the real process of adaptive action. Each domain of action is in essence a ‘fuzzy’ category with degrees of public and private interaction and co-production. Nevertheless, there are some adaptation goods in which either public or private action is typical and expected; there are others in which some degree of co-production is not only desired but also necessary.

2.1. Public provision of adaptation goods – for public benefit

The need for and conditions in which government intervention is required to support adaptation is one of the more common cases discussed in the policy literature. The expected threats to public infrastructure and public goods (national security, social welfare, economic productivity) associated with climate change (e.g., rising sea levels, drought), coupled with the contractual obligation of governments of democratic nations to protect their citizens from unreasonable harm, has led to planning exercises and expenditures of public funds on adaptation activities. The gains from these investments are non-rival, and non-payers cannot be excluded from enjoying the benefits. An example is the UK government’s investment in the Hadley Centre which produces freely available climate models and data for public use in climate change adaptation planning (UKCIP, 2003).

2.2. Public provision of adaptation goods – for (largely) private benefit

Climate change will have differential impacts across a population, revealing varying sensitivities and capacities to cope with change. The benefits of individual adaptation are also often temporally diffuse and challenging because of the up-front investment required for implementation. Governments can play a variety of roles in mediating these distributional inequities and uncertainties by providing subsidies to individuals to encourage actions that will be in their benefit (e.g., offering tax breaks for the adoption of energy- or water-saving technologies; subsidizing the provision of insurance; investing in informational campaigns and

decision support systems that enhance individual innovation and risk management). The adaptations are non-rival in consumption (e.g., as long as the public investment is sustainable, the enjoyment of the adaptation support by one individual does not detract from that of others), however, because actions are implemented in the private sphere, anyone who does not enter into the adaptation support program will not benefit from the actions taken by those who did. Examples of action in this domain include the UK Thames Barrier 2100 Project – a barrier system designed to protect London from flooding (Lavery and Donovan, 2005), while this is paid for by UK taxpayers, residents outside of London are not expected to directly benefit.

2.3. Private adaptation – for private benefit

Adaptation actions taken by an individual or private entity accrue benefits directly back to the adaptor, and others are excluded. Private actors’ adaptations might include insulating homes, installing double glazing, buying sandbags, or relocating out of an area prone to flooding. For each of these examples there are clearly defined property rights and the adaptations are rival in consumption (whereby assets acquired for adaptation by one individual or group are not available for the same purposes by others¹).

2.4. Private adaptation – for public benefit

Finally, there is the case of private action that generates adaptive benefits in the public sphere. In this case, the benefits of individual or private action do not directly accrue back to the individual, or are so diffuse in space and time as to be intangible and abstract. Here, the space in which the adaptation occurs is an emergent property of numerous individuals taking action which either intentionally or inadvertently provides a public service. There are clearly defined features of this type of public good. First, unlike common property resources, the benefits gained from private action are non-rival. Second the benefits are non-excludable – they accrue to anyone living in or near the area where adaptation outcomes are realized. Third, the public adaptation good may not accrue at the location where the private action is taking place. Fourth, the benefits are likely to accrue to others but, in many cases, not the individual provisioning the adaptation service and may actually imply risks and costs to the “adapting” actor. In all cases the adaptation public goods only materialize through the participation of numerous private resource users/ managers; the adaptation is thus dependent on the coordination and commitment of private actors. The incentive for individual action, while essential (otherwise the adaptation does not exist), is thus ambiguous.

In the next section, we describe some emergent cases of climate-related adaptation that raise issues about this particular domain of adaptation, and then outline considerations for improved institutional arrangements.

3. What are these privately provided adaptation public goods?

We now outline several cases in which a public adaptation good is the product of individual private action. We use Table 1 to show the unique aspects of privately delivered adaptation public goods, describing first the private resource being managed, e.g., a home, land, a farm; the characteristics of the actor managing

		Beneficiaries	
		Private	Public
Providers	Private	e.g. buying sand bags to limit home flood damage	e.g. urban flood risk reduction via intentional rural flooding
	Public	e.g. grants for house insulation to reduce cold / heat stress	e.g. global climate models; “Em-dat” hazards database

Fig. 1. Domains of adaptation.

¹ Recent work on successful adaptation suggests that any adaptation which limits others’ ability to adapt is maladaptive (Barnett and O’Neill, 2010). This is an issue of consumption externalities and requires specific policy measures to address it – this is beyond the scope of this paper.

Table 1
Examples of the characteristics of privately created adaptation public goods.

Description of resource owner and resource	Privately funded adaptation	Cost to the resource owner	Public good created	Beneficiaries of private adaptation	Source
Smallholder farmer and smallholder farms (México)	Managing coffee plantations for vegetation complexity	Potentially lower coffee yields and enhanced management costs	Landslide risk reduction/soil stability Enhanced wildlife habitat/ biodiversity	Public sector (reduced landslide damage to public roads and infrastructure)	Philpott et al. (2008)
Landholders of rural farmland (Europe)	Removing barriers to riparian flooding	Lost use of productive land, harvest losses, increased land management costs	Flood risk reduction Reduced damage to downstream/ urban infrastructure, property and economic activity	Urban property owners and public infrastructure providers (government)	Posthumus et al. (2008); Johnson and Priest (2008); Howgate and Kenyon (2009); Erdlenbruch et al. (2009)
Urban home owners (UK)	Plant gardens with grass instead of pave/deck	Loss of use of paved area/culturally less acceptable	Flood risk reduction Better water drainage of area More extensive habitat for wildlife	Other residents in the area gain flood risk reduction	White (2008); City of Edinburgh Council (2008); Royal Horticultural Society (2006); Wild et al. (2002)
Home owners (Caribbean)	Emptying outdoor water receptacles to avoid stagnant water collecting to prevent spread of mosquitoes	Time and effort to check water receptacles are emptied	Public health/ disease control Reduced risk of mosquito vector borne disease	Wider community Public health providers	Fochs and Chadee (1997); Nathan (1993); Rawlins et al. (2008)

that resource; and the resource owner. Second we describe the privately funded adaptations and costs to the resource owner. Third, we show the benefits from managing the resource and the group to whom the benefits flow. Finally we describe the nature of the public good created, i.e. whether a true public good, a common pool resource, or a positive externality.

These cases are diverse, and, with a few exceptions, typically have not been framed as concerns of public–private institutions for risk abatement. For example, evidence from Chiapas suggests that farmers' management of vegetation complexity has an influence on landscape-scale risk of landslides (Philpott et al., 2008). In that study, less vegetation complexity had no statistical influence on the vulnerability of coffee harvests to torrential rainfall but was significantly associated with the occurrence of landslides along roads that transect coffee farms. The adaptive benefit of individual action (increasing vegetation complexity on farm plots) would appear to be primarily at the landscape scale (a scale of presumed public concern in relation to ecosystem services and public infrastructure), rather than in terms of the household farm economy.

Flood control policy is another area in which there is emergent recognition of the need for private action to create adaptation public goods. Erdlenbruch et al. (2009), for example, describe efforts in France to reduce flood risk at the basin scale through Flood Prevention Action Plans. Private rural landholders are requested to participate in actions designed to increase the risk of flooding on their properties through modifying embankments or vegetation with the aim of creating a public good: reduced vulnerability to flooding in densely populated urban zones. Similar policies are being considered in Scotland and England. In Scotland, a policy of "Sustainable Flood Management" aims to encourage farmers and other landowners to enhance the capacity for flood storage on their private lands in order to reduce the public expense of flood disaster (Howgate and Kenyon, 2009). In Yorkshire, the UK's "Making Space for Water" policy (DEFRA, 2005), which is also designed to enhance flood water capture on rural lands, runs counter to farmers' production strategies that have entailed land use intensification, mechanization and river channelling. In this latter case, while farmers were cognizant of differential impact of flooding between downstream and upstream land uses, they were generally unwilling to alter successful production strategies to create a social benefit in which they would not partake (Posthumus et al., 2008).

There are other examples of vulnerability derived from the absence of the privately provided public good. Recent research in the UK has shown a growing tendency of British householders to pave their gardens, or cover them in wooden decking instead of traditional grassy lawns (City of Edinburgh Council, 2008; Royal Horticultural Society, 2006; Wild et al., 2002). The shift towards paved gardens is driven by many factors (White, 2008), however there are various implications of this individual action, some significant in terms of adaptation to changing rainfall regimes. As more absorptive land is covered with hard non-porous surfaces, roads and drains are more likely to experience higher levels of run-off after heavy precipitation (Dietz, 2007). There has not yet been any action taken to address this issue, but if the trend continues some form of individual action – e.g., modification of private land – may be needed to generate the adaptation public good of flood risk reduction.

Another example of the absence of the privately provided public good relates to public health in the tropics. Mosquito larvae thrive in stagnant water. In tropical countries, during rainy seasons, rain water accumulates in plant pots, wheelbarrows, and other household or garden receptacles, where mosquito larvae then grow (Arunachalam et al., 2010). If individual households do not regularly dispatch the stagnant water, mosquitoes can thrive and mosquito-borne disease can spread. There is no guarantee that the individual who thoroughly checks their premises and empties stagnant water vessels will avoid mosquito-borne disease – although they will likely gain the benefits from fewer bites due to a lower mosquito population around their home. However, if enough individuals participate in such practices there is likely to be collective reduction in risk of mosquito transmitted disease (Fochs and Chadee, 1997). Across the Caribbean, public health officials visit homes to remind residents to check and empty possible water containers during the rainy season – on the assumption that education and knowledge support private benevolence (Nathan, 1993). Yet there remains a persistent lack of participation by some parts of society (Rawlins et al., 2008) – revealing a variable willingness by private actors to freely provide a public good.

From this set of examples we can determine that privately provided adaptation public goods are supplied through two main delivery pathways: accidental and deliberate provision actors (see Fig. 2). Accidental provision can occur as a by-product of other actions, i.e. positive externalities of private actions carried out for

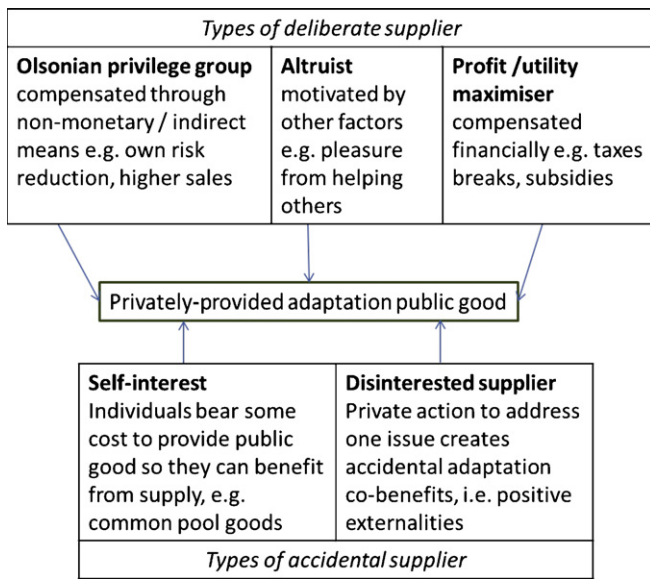


Fig. 2. Forms of privately provided public goods and motivations for supply.

purposes that have little or nothing to do with the supply of adaptation public goods. For example, if an individual household adopts a rainwater harvesting system, pressure on national water infrastructure, or shared groundwater resources is reduced, thereby providing more resources for other people. Or, an individual may choose to invest their own time to clear a public drain outside their own home to minimise flood risk to their own property – but others benefit from this.

Deliberate provision is likely to occur through action by one of three types of actors: i) individuals who value the goods more than the cost of supply and who therefore supply the goods to others, i.e. an Olsonian privilege group²; ii) altruists who are motivated by other factors such as helping other people; iii) profit or welfare maximising actors who are induced to provide the goods (we will consider the inducements in the following section). The rest of this paper considers only the deliberate provision of public goods. Accidental providers are likely to continue to supply the public good as it is either at no cost to themselves, or at an acceptable cost. We are more interested in those who are not yet supplying the public good, and the incentives they may require to do this, hence we focus on the deliberate provision of adaptation public goods.

As we describe in detail below, the need to harness private action to create adaptation public goods poses specific institutional challenges that are only beginning to be understood. In part this is because there are surprisingly few empirical studies of privately funded public goods (Kotchen and Moore, 2007). Moving forward with this particular form of adaptation requires better knowledge about the institutional context: namely, who are the (private) resource users, what are the resources they manage, and what role does that management have in realizing adaptation at broader scales? Further, what benefits and costs are entailed in adaptation efforts? Who bears these costs and gains the benefits, and what rules and regulations govern adaptation management? We need to understand these elements to ensure that the appropriate policy

² These groups are named after Mancur Olson's work on collective action (Olson, 1965). He showed that a public good may be provided by small 'privileged' groups if they can benefit from its provision. A frequently used example is the private provision of a street light by a shop owner where the street light is directly outside the shop. The shop owner is likely to increase custom, but (s)he is happy to allow others to benefit from the light without additional reward.

instruments can be designed to ensure adequate provisioning of these public goods.

4. Institutional mechanisms to encourage private provision of adaptation public goods

Motivating private actors to produce adaptation public goods under the conditions outlined above poses specific institutional problems. In the adaptation case we are interested in, the development of effective institutions is challenged by:

- the cognitive and physical distance of specific natural resource users to the public adaptation good: the private property managers who engage in adaptations are likely not to directly benefit from the adaptation they collectively create.
- The intangible, statistical and uncertain nature of the good itself: reduced risk of landslides, flood damage, or disease is typically only evident over time and at an aggregated temporal and spatial scale. Private actors must weigh specific quantifiable costs of their individual actions against an uncertain outcome.
- Resource users may be well-organized and collaborative (e.g., farmers participating in producer associations), yet their collective interests may not be in line with the beneficiaries of the public adaptation good (e.g., urban middle class who have purchased flood plain properties), and thus their organization and identity may work against the goal of adaptation.

Insights into this problem of appropriate institutions can be gleaned from prior research on the 'co-production' of public goods and services and co-management of resources. Ostrom (1996), for example, discusses development advantages of involving beneficiaries of a public service – education, for example, – in the process of service production. She argues that motivation and specific incentives to collaborate, trust among and between all collaborating parties, and accountability are all critical components for effective co-production.

The case of private production of adaptation public goods is a special case that is not completely congruent with examples of co-production and co-management. In the cases of co-production described by Ostrom (1996), the "regular" service provider (of education, for example) is capable of moving forward with the service provision without the participation of private actors. The creation of the public adaptation good we are interested in, however, is entirely dependent on the actions of individual private actors. In both co-production and co-management, the private actors are assumed to share some of the benefits from the service being produced (co-production) or resource system being managed (co-management). As we showed in Fig. 2, this is sometimes the case with accidental supply (e.g., in the case of externalities, or common-pool resources), but in other cases this assumption does not hold.

Nevertheless, some general principles from this literature are likely to apply to the adaptation case. To act in ways that create significant public adaptation benefits, private actors must be motivated to take actions that either go beyond or even contradict their self-interest. Such action may in part be motivated through economic transactions that compensate individual property owners for loss and risk associated with their actions, and in part by supporting a social contract between private actors and the presumed beneficiaries of the public adaptation service. As with service co-production and resource co-management, achieving sufficient private participation in provisioning of adaptation public goods will also demand trust and cooperation among private actors and between such actors and the public organizations interested in realizing the adaptation benefit.

In the next section, we draw from the cases listed in Table 1, and the suppliers identified in Fig. 2, and consider what would

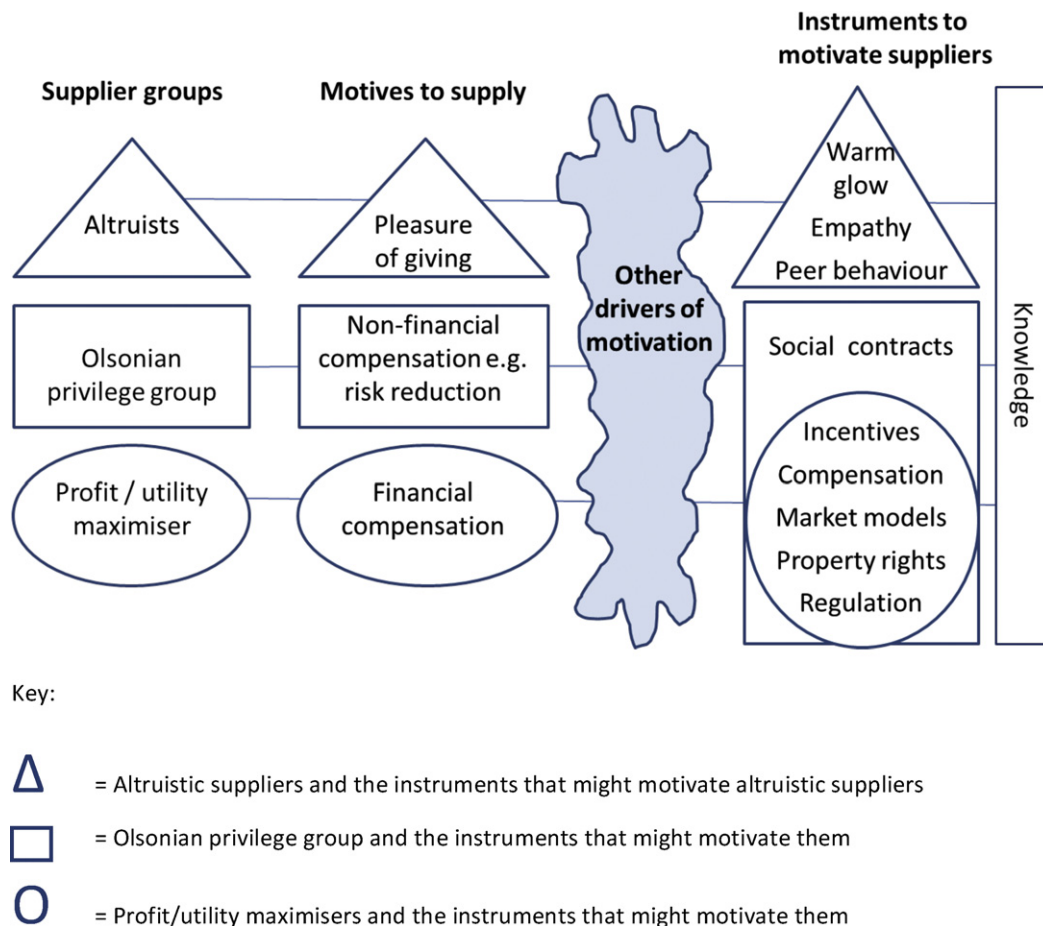


Fig. 3. Supplier groups and instruments to motivate supply.

motivate the different suppliers to provide adequate delivery of the adaptation public goods (see Fig. 3). We draw from the typology of tools to manage ecosystem services from Salzman (2005). Salzman (2005), Jack et al. (2008) and others identify the range of institutional arrangements that exist for managing complex goods. Salzman refers to these as: prescription, persuasion, property rights, penalties and payments. However, we take these ideas forward by clustering them according to the supplier-type they may motivate, namely: instruments that encourage altruism, instruments that support the emergence of Olsonian privilege groups, instruments that motivate profit or welfare maximisers, and instruments to motivate all suppliers. We consider each of these caricatures of supplier-types in turn.

4.1. Instruments to motivate altruistic provision of adaptation public goods

The challenge of influencing individual behaviour for the common good is complicated by our lack of knowledge about what drives ethical behaviour. Research shows that individuals are willing to pay for environmental goods and services even though they might never benefit directly from their existence (Spash et al., 2009). There is also empirical evidence of people preferring to act in society's best interest rather than their own (Berglund and Matti, 2006; Dobson, 2003). Research on sustainable consumption and socially conscious consumerism suggests that the main drivers of this behaviour are feelings of satisfaction, and the presence of empathy. These are considered below.

Environmental economic studies have identified that charitable giving (or other pro-environmental behaviour) can induce a 'warm

glow', i.e. a feeling of satisfaction (for example, Andreoni, 1990; Cooper et al., 2004; Kahneman and Knetsch, 1992), which encourages further charitable giving. Peer attitudes and behaviours also shape the way we behave (environmental sociology literature summarised in Jackson, 2004). Research on consumer motivations for participating in 'sustainable' food chains reveals that consumers envision solidarity with others and connectivity to place through their food purchases, namely with farmers within or near-by their community (Hinrichs, 2000; Winters, 2003). While such exchanges are embedded with social and environmental meaning, they are, however, ultimately economic transactions in which consumers acquire desired food stuffs to satisfy their needs. Indeed, despite attempts by governments to encourage pro-environmental behaviour, many schemes which rely on individuals acting in the public interest have not been as well-supported as expected (Whitmarsh and O'Neill, 2010).

Empathy is evident in existing cases of private provisioning of public adaptation. For example, Howgate and Kenyon's (2009) study of rural landowner's willingness to participate in new flood management policies in Scotland demonstrated that while distrusting of the implementing agencies, the landowners expressed empathy with downstream residents at risk of flooding and understood the potential social benefits that the new flood policy might bring, revealing a foundation for collaborative action. In the Yorkshire analysis of rural landowners' willingness to participate in flood control, landowners distinguished between investments to eliminate negative externalities of their farming practices (controlling pollution or erosion, for example) that they perceived as their moral responsibility and investments that would provide a social service, such as flood control for downstream

communities. While they felt strong social obligation to engage in the former, they were less motivated to engage in the latter without formal monetary compensation (Posthumus et al., 2008). In this case other instruments may be necessary.

4.2. Incentives to motivate profit/welfare maximisers and Olsonian 'privilege' groups

Self-interested suppliers, driven by monetary (profit-maximisers in Fig. 2) or non-financial (Olsonian groups) imperatives, may be encouraged to deliver adaptation public goods by compensation or incentives, by market models, by regulation, or by adjustment of property rights. There are additional incentives that could be used to motivate Olsonian groups – discussed below – but first we consider the general incentives for self-interested suppliers and the opportunities associated with each of these.

To address spatial and social inequities concerning where and to whom the risks of harm from climate change and the benefits of adaptation accrue, compensatory payments or economic incentives for action hold obvious appeal. Such transfer payments and incentive programs are already in wide use in climate change policy. In the area of greenhouse gas mitigation for example, there are an increasing number of examples of institutions designed to induce private action to create public mitigation goods. In the UK, the Energy Savings Trust, a quasi-governmental body, is coordinating programs aimed at encouraging home owners and businesses to reduce their greenhouse gas emissions thereby contributing (although arguably very indirectly and in a miniscule way) to a reduction in the likely impacts of climate change (The Energy Saving Trust, 2009). The UK government supports the Trust's activities by providing small grants for consumers to change their behaviour e.g., to insulate their lofts, install cavity wall insulation or double glazing, or change their energy consumption patterns.

The appropriateness of transfers of public resources to induce individual action is sometimes controversial, however, when private benefits clearly accrue to the individuals taking the action. In relation to the implementation of the "Making Space for Water" flood policy in urban areas of the UK, Johnson and Priest (2008) describe how under this policy urban households at risk are now required to undertake all reasonable action to prevent or minimize flooding on their own land, and thus presumably reduce public costs of flood protection and disasters. Lack of economic incentives limit households' willingness to take such action, yet there is also public resistance to the idea that public money be provided for individual-scale measures, particularly if such measures enhance individual property values in at-risk areas.

The justification for compensation is clearer in the case of rural landowners affected by this same flood policy, who are being asked to modify their properties to capture flood waters and reduce flood runoff. As articulated by the authors of the Yorkshire case of flood management, "farmers ... were quick to point out that it was inappropriate and inequitable to expect farmers to pay for 'improvements' for the benefit of others" (Posthumus et al., 2008: 795). In the case of the French Flood Prevention Action Plans, water management authorities charged with implementation had several compensation options available to them (Erdlenbruch et al., 2009). They could purchase land that would be exposed to an increased risk of flooding as a result of the policy, they could subsidize measures to reduce risk to specific built infrastructure on exposed property, or they could compensate landholders after each flood event or as a "once-and-for all indemnity" (Erdlenbruch et al., 2009). Challenges immediately arise in terms of defining the additional loss and risk that can be directly attributed to the policy implementation and what defines the limits of the public responsibility to the private landowner. In this latter case, with

the implementation of the Flood Action Plans, downstream urban residents may now have more access to private property insurance as their risk of flooding declines. Upstream agriculturalists, however, face more unmanageable and potentially uninsurable risk circumstances: their risk of flooding is no longer random, but at least partially attributable to public policy (Erdlenbruch et al., 2009). The study's authors suggest that for the plans to work effectively there should be a more direct mechanism of urban-rural compensation, as well as institutional coordination and subsidization of compensatory insurance schemes at higher spatial scales where risks are less likely to be covariate.

Creating a market for the public good is one option to ensure continued delivery of the public good. This is the premise of payments for ecosystem services (PES), in which private actors who participate in the production of 'intangible' services are compensated in market transactions for that production and the associated opportunity costs (Jack et al., 2008). For example, with the growth of voluntary carbon off-set markets, payments are being made to land managers for activities that enhance carbon sequestration (Turpie et al., 2008). Alternatively, resource owners are paid to desist from an action that is damaging a resource that generates public benefits, for example, payments for avoided deforestation in China (Liu et al., 2008). These payments are designed to compensate resource managers for the opportunity and transaction costs associated with the provisioning of ecosystem services, assuming that without such payments these goods would be underprovided (van Hecken and Bastiaensen, 2010).

While in most cases the existing private demand for services is insufficient to ensure the service provision, in other cases – carbon offset markets, for example, – the existence of private demand has been instrumental in the creation of PES markets. Bumpus and Liverman (2008) illustrate that carbon offset markets were initially created by non-state actors concerned with lack of public action on greenhouse gas mitigation. Thus, while in many cases the organization of private adaptation service provisioning may need to be incentivized by public sector actors, it is conceivable that as climate impacts increase in severity or frequency, the demand for adaptation service provisioning in one sector may increase to the point that a market for such services emerges as a response.

One challenge with payments for ecosystem services is that the marginal benefits of some service provisioning are not constant. In other words, there often exists a 'threshold effect': a certain degree of service provisioning is necessary before the benefits can be realized, challenging the design of incentives and market mechanisms. As indicated by Jack et al. (2008), incentives for habitat preservation would be far less complex and costly if simple assumptions could be made that every new unit of land dedicated to habitat preservation was equally important. In reality this is often not the case: for many species, minimum areas of land area are required before habitat benefits are gained, and habitats need to be connected to enhance species viability. For this reason, the value of any individual's action to preserve a piece of land for habitat is contingent on the actions of his or her neighbour, and the number of participants in the PES scheme. As a result institutional design of PES is frequently complex. The issue of non-constant marginal benefits is specifically applicable to the case of private provisioning of public adaptation, where we assume that a threshold of participants is required in order to achieve the adaptation outcome.

A more fundamental problem is associated with the 'non-excludable' nature of adaptation public goods created by private action. As with ecosystem services, individual citizens – the potential beneficiaries of public adaptation – may be reluctant to pay for a service that they could potentially enjoy as a free-rider, or for which they feel should be provided by a public agency (Jack et al., 2008). One difference with ecosystem services, however, is

that the public adaptation good is not simply underprovided in the absence of an appropriate incentive structure; it is not available at all. In the case of this form of adaptation good there might be more motivation for individuals (e.g., urban residents exposed to flooding) to be willing to participate as ‘buyers’ in some incentive scheme, as long as the value of the adaptation service can be demonstrated and quantified for them.

While payments for ecosystem services are designed to harness the best aspects of market incentives for public ends, typically the institutional arrangements entail the involvement of an intermediary – a government or non-governmental agency – to negotiate prices and purchases from resource managers in order to reduce transaction costs (Kemkes et al., 2010; van Hecken and Bastiaensen, 2010; Vatn, 2010). Government intervention may be necessary on the demand side to obligate beneficiaries to ‘pay’ for the generation of the ecosystem service in order to address the problem of free-riding (Jack et al., 2008), or to generate the demand for the service. Government, NGO or other intermediaries are also needed to certify transactions and maintain consumer confidence that the public aim is being met via the market-based transactions.

A final option to support the generation of public adaptation benefits from self-interested private actions comes from imposing use or management regulations on the private provider or reassigning property rights. For either case, there first needs to be recognition of the importance of the public good (hence the importance of learning, knowledge and motivation as discussed above), and in most cases, the explicit creation of the good. The second step involves ensuring the sustainable delivery of that public good. This might involve the creation of a market to provide the adaptation good (as described above), or regulation and/or the transfer of property rights could be used to force this provisioning.

Lessons from environmental policy and management suggest that incentivizing private action for the production of adaptation public goods will require some form of regulation, in combination with other institutional tools. Citizens can be legally obligated to take actions needed to produce adaptation public goods or face penalties. In relation to the cases discussed above, regulation on exterior pavement area could reduce problems of runoff in cities affected by increasing storm intensity, or households could be penalized for having standing water on their property as an effort to control vectors. Compliance is enforced with monitoring (and thus is often expensive), but also (as discussed below) by appeals to the social contract of citizens to their neighbours and leadership.

A final option to support the private creation of public goods is the transfer of property rights from the individual to public or unitary ownership. In the case of flood management, for example, a government could offer to purchase at market prices land required to periodically receive flood waters in order to create a needed buffer for downstream populations (Morris et al., 2008). As discussed in Erdlenbruch et al., 2009, while such a transfer of rights solves some of the problems with participation and compliance, with rights also come costs and responsibilities. In the French case, municipal governments were reluctant to assume new and continual land management responsibilities in order to achieve their flood risk management goals.

Alternatively, rights could be unified or centralized (e.g., through a process of concessions to a specific resource manager) in order to reduce transaction costs and potentially enhance the efficiencies involved in adaptation efforts. Individual resource managers or actors whose collaboration is required to produce the adaptation good would lease or concede rights to a third party (e.g., a non-governmental or private entity) that would manage the resource and/or take the necessary actions to ensure that the adaptation was realized. In South Africa, a third-party government-funded agency (Working for Water) is serving as such an intermediary in the provisioning of ecosystem services (Turpie

et al., 2008). In the case of adaptation, the single third party would potentially be the recipient of “payments for adaptation services”, paying a concession to the resource owners. Such an arrangement might work in the few cases where the adaptation action required of resource owners does not impose significant risks or costs to them beyond the opportunity cost of time or labour.

4.3. Instruments specifically to motivate Olsonian privilege groups

A sub-group of self-interested suppliers are the Olsonian ‘privilege’ groups who derive greater benefit from the provision of a public good than the cost of providing it (Olson, 1965). In many cases, non-monetary or indirect compensation offsets the cost of provision. For example, the insurance industry may produce free publicly available flood risk maps to help homeowners check out flood risk on a property before they purchase or rent. This resource also acts as an effective public relations/communication tool that informs people at risk that their premiums are likely to rise; it also allows insurance companies to tighten insurance premiums in areas shown to be at more risk by the flood risk maps.

For this sub-group, to encourage Olsonian behaviour, incentives could be provided in the form of social contracts. Innovative social contracts that incorporate the needs and values of ‘distant populations’ are being used to garner support for voluntary private action that creates or supports the provision of public goods (O’Brien et al., 2009). Examples can be found in voluntary carbon markets whereby individuals pay money to a fund to offset their emissions of greenhouse gases. These payments go either to renewable energy projects or to projects that compensate others for the potential damage created by climate change (Bumpus and Liverman, 2008). Other examples can be found in the area of hazard management. In much of the US in the wildland-urban interface where wildfires pose significant risks to property at high public expense, private property owners are encouraged to clear brush around their homes to prevent fires from spreading. While motivation is driven by many factors, evidence shows that individuals participate as part of the social contract they figuratively sign when moving to the area (Moritz and Stephens, 2008). In these cases, the non-financial or indirect compensation to participants could be in the form of peer approval in the former case, or social acceptance by neighbours in the latter. This is not simply the ‘warm glow’ of altruism, as the individual or firm that signs up to a shared social contract can potentially gain social acceptance, respect, or recognition from peers or customers, or other non-financial rewards through their participation.

4.4. Instruments to motivate supply by all types of supplier

Consistent knowledge and attention to the means of communicating knowledge across levels is needed to facilitate dialogue and deliver complementarities of action across multiple layers of governance (Cash and Moser, 2000; Evans, 1996; Vogel et al., 2007). While information provision by itself is largely inadequate to induce risk-reducing action (see earlier example of mosquito control in the Caribbean, Rawlins et al., 2008), public information provision, required by regulation or encouraged through voluntary schemes, can influence the public discourse by raising awareness of individual responsibilities regarding public goods, with potential to motivate altruists or to encourage Olsonian groups to form. For example, the literature that examines private actions which create public benefits (e.g., charitable giving, green consumerism, and reduced greenhouse gas emissions) has illustrated the role of information and learning in influencing individuals’ choices (Ostrom, 1998; Smith et al., 1995).

Research on the provision, uptake and application of climate services (seasonal forecasts, weather information, disaster early

warning) has explored the knowledge environment, presenting evidence that action in the face of anticipated climate risk (conveyed through sources of technical and scientific information) is most likely when information users are actively involved in the process of learning, and knowledge formation (Buizer et al., 2010; Cash et al., 2002; Vogel and O'Brien, 2006). For example, in the case of farmers' participation in the UK "Making Space for Water" flood policy, lack of systemic knowledge was hypothesized to be an obstacle in farmers' willingness to participate. Posthumus et al. (2008) designed workshops supported by a visualization and decision-analysis tool, FARM, to help farmers and planners collaboratively understand the implications of their farming practices on pollution, water runoff and local hydrology. They found that FARM was "effective for stimulating constructive dialogue about a complex set of problems" (p. 790) and proved important for helping individual farmers understand the potential implications of changes on their personal property for flood risk at a broader spatial scale. In contrast, in the case of the proposed flood policy in Scotland, a lack of information regarding the specific costs and benefits of the flood policy for rural landowners and for society more broadly contributed to a lack of trust and confidence in the viability of the policy (Howgate and Kenyon, 2009). Co-production of knowledge therefore holds the potential to motivate profit maximisers to support regulation, reinterpretation of property rights, or explore ways of recovering financially from public good provision. However, it is not clear how well information provisioning works when the knowledge is characterized by high uncertainty. The benefits of individual actions for public adaptation may not be apparent until shocks and stress "make them visible", this may well be at a future (highly discounted) point in time.

The proliferation of institutional arrangements and experimental designs to address environmental and social externalities offers both tools and experience from which new institutional approaches for adaptation may emerge. Lessons from current experience indicate that there will be no silver bullet and each case of private provisioning of adaptation will create a unique set of parameters that will define the most appropriate type of policy intervention and institutional design. These lessons also suggest that a combination of policy interventions and tools will be needed, targeted to the type of supplier, relying on education and knowledge creation, strengthening of social contracts and formal mechanisms for compensation, risk sharing and equitable regulation.

5. Discussion and conclusion

Climate change adaptation as an explicit policy process is a new area of intervention and research, and as the demand for adaptation intervention accelerates, adaptation problem domains will emerge for which there has been little explicit research or policy attention. We have highlighted one such case: the potential growing need for private provisioning of a public adaptation good. While this "good" has many attributes that are similar to the subject of existing and developing environmental and social policy (e.g., common property management or ecosystem services), there has been very little explicit attention to this issue within the domain of adaptation policy and practice. A small but difficult set of cases are emerging that suggest that adaptation outcomes in some cases may be underprovided – or may simply never emerge at all – because of the public nature of the adaptation good, and the reliance on private actors for the goods' provisioning. As with other goods and services of this nature, this issue may require the development of specific institutional mechanisms and tools to support the realization of adaptive outcomes.

We have argued that privately provided adaptation public goods share three basic characteristics that affect the institutional mechanisms that might be used to regulate them. First, the provision of the good and the beneficiaries can exist at different

spatial scales and temporal moments, and in different geographic areas. This disconnects in space and time exacerbates uncertainty and creates a disjuncture over the distribution of rights and ownerships, costs and benefits. Second, there is not necessarily an immediate adaptation benefit from the private action: the public good is only emergent over time (and sometimes at aggregated scales); there can be a threshold effect where a minimum number of private actors are needed to provide the good; and the provision of the public good may be dependent on the continued behaviour of the multiple private actors. Third, individual and group interests are not necessarily congruent with the public interest, particularly where the service providers incur new risks and costs in the service provisioning and perceive few direct benefits. Where adaptation needs to be provided on a continuous basis and where there is both a high potential for and yet high uncertainty in the timing of occurrence of shocks to the system – from climate change or other stressors – these three characteristics make the delivery of this intangible public good extremely challenging.

Further complicating private-provisioning of public adaptation is the current political and cultural context, which, in western democracies, continues to emphasize state retrenchment. This means a smaller tax base and lower levels of government expenditure. Institutional mechanisms that require less government involvement may gain credibility and require further investigation. In this new era of austerity, options with low transaction and opportunity costs are preferable. Mechanisms based on payments for ecosystem services could be a credible option, particularly where benefits can be captured by the payees (Kemkes et al., 2010). Other institutions may be more appropriate where this is not the case, for example, where implementation costs are high for the resource owner.

Markets needed to deliver ecosystem services and those required to deliver privately provided adaptation public goods can be distinguished in part by the nature of the good in question. In the case of ecosystems there are very clear services provided – whether these are provisioning, regulating or cultural – that exist in both temporal and spatial scales – e.g., carbon sink capacity of a forest over a 50 years period. In contrast, the adaptation goods that we refer to appear far less tangible – they are risk reductions that change the probability of impact, for example, the likelihood of landslide or the chance of malaria spreading. Quantifying any reduction in risk is difficult not only because such a calculation depends on assumptions about the impact of actions taken by individuals, but also because the baseline condition (e.g., risk without the actions taken) is also changing in ways fraught with uncertainty. The adaptation actions that we describe here do not guarantee benefits to any one individual (e.g., a potential buyer), but they would aim to reduce risks to all, or at least to a broader population (e.g., a city's residents). Given the adaptation good is essentially concerning risk, the market for privately provided adaptation public goods would need to incorporate many characteristics of an insurance market. In some cases such a market might be appropriate, however, in other cases individuals cannot be guaranteed to receive the benefits they pay for, and thus it would be unlikely that such a mechanism would work. Hence for this underreported case of adaptation we need to consider other forms of institutional arrangements for delivery.

As with most environmental policy challenges today, the private provisioning of public adaptation demands complex governance, and will involve multiple actors and stakeholder groups in potentially innovative private-public partnerships. Mechanisms of governance of adaptation must be coupled with knowledge processes that identify the public adaptation need. Without this, it is difficult to assess the need for individual action, or to find ways to coordinate action at the appropriate scale. Ensuring adaptive outcomes in such circumstances will require a foundation of trust, common understanding and fairness. A combination of approaches

will undoubtedly be needed, in which social contracts among different populations are strengthened in public discourse, moral and ethical appeals are made to motivate individual collaboration for collective good, education and knowledge serve to situate individuals within broader systemic processes and outcomes, and specific incentives, rewards and penalties orchestrate individual action. Nevertheless, while we have the elements to move forward, to date this issue has been a neglected domain of climate policy.

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