International Journal of the Commons
Vol. 12, no 1 2018, pp. 60–81
Publisher: Uopen Journals
URL:http://www.thecommonsjournal.org
DOI: 10.18352/ijc.772

ISSN: 1875-0281

Resource asymmetry and property rights in agricultural drainage systems: Implications for collective action

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Abstract: Scholarly work on examining how property rights affect incentives for collective action in common-pool resource management has benefited immensely from the property-rights analytical scheme proposed in the seminal work of Schlager and Ostrom (1992). Here we apply this scheme to agricultural drainage systems, conceptualizing them as a common-pool resource held in a private property ownership regime and exhibiting asymmetric dilemmas. We propose a property rights analytical scheme to suit the asymmetry of incentives in drainage systems, while examining how drainage management institutions allocate bundles of property rights and how property rights interact to affect incentives for collective action. Unlike Schlager and Ostrom (1992), we find that property rights are not cumulatively bundled, and that having land held in private decouples use rights from physical access rights. In addition, the existence of complementary institutional mechanisms, one landowner-driven and the other government-driven, can provide collective action incentives.

Keywords: Agricultural drainage systems, collective action, institutions, property rights, resource asymmetry

Acknowledgements: The authors would like to thank the many people who agreed to be interviewed for this research. This research was funded by USDA National Institute for Food and Agriculture under Award #2012-51130-20255.

1. Introduction and rationale

Natural resource management often poses collective action dilemmas. Nobel laureate Ostrom's (1990) pioneering work on understanding collective action in a variety of natural resource management contexts, such as forests, irrigation systems, and fisheries, showed that local resource users can sometimes overcome such dilemmas by devising property rights and acting collectively to successfully manage a resource. Property rights define who has access to the resource, how much can be harvested, who can manage, and how rights can be transferred (Schlager and Ostrom 1992).

A plethora of collective action studies have investigated patterns of property rights and institutions of collective action for irrigation systems (Fujiie et al. 2005; Totin et al. 2014), fisheries (Schlager 1994; Kanchanaroek et al. 2013) and forests (Agrawal and Ostrom 2001; Roy et al. 2012). Such institutional analysis has usually focused on common-pool resources (CPRs) which are held by the community, i.e. under a common-property regime. Less is known about common-pool resources which are held in a private property (land) ownership regime. Additionally, property rights literature typically examines resources without spatial asymmetries (Janssen and Rollins 2012). In an asymmetric dilemma, the relative positions of resource users at the head and tail of the system generates asymmetric access to the resource (Ostrom and Gardner 1993). Such physical arrangement of resource users affects their incentives for collective action. An agricultural drainage system is an example of a resource exhibiting an asymmetric dilemma, where multiple landowners own land parcels (a private property ownership regime) but not the drainage system, which is a common-pool resource. Due to resource asymmetry, landowners may have different preferences over potential actions and outcomes in drainage management based on the spatial location of their private property, which may lead to a "free-rider problem", the core problem in a collective action situation (Ostrom 1990). Property rights can help individuals to overcome such free rider problems (Ostrom 2004).

Water as a desired "good", for irrigation, has long been studied by collective action scholars using institutional analysis (Fujiie et al. 2005; Totin et al. 2014), yet excessive water that is drained to allow crop production has not (Scheumann and Freisem 2002; Schleyer 2009). Like many other natural resources, management of agricultural drainage systems often involves more than one landowner, and thus requires cooperation and collective action among them. However, the coordinated management of drainage systems often proves to be difficult because of conflicting interests of landowners, leading to collective action dilemmas of joint investment and removal of excess water. Examining the rich interplay between property rights and institutions[1] can help us understand the diverse

[1] Institutions are "enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as by the physical world" (Crawford and Ostrom 1995).

incentives that participants face in a collective action dilemma, and thus understand the conditions conducive to collective action (Ostrom 2003).

Using agricultural drainage systems, in this study, we highlight two major aspects of generating collective action for drainage management: landowners' spatial asymmetry and property rights. Whereas resource asymmetry provides a starting point for conceptualizing spatial location of landowners' private property with respect to the drainage system, we investigate in detail the institutional mechanisms for constructing and maintaining agricultural drainage systems in the Western Lake Erie Basin (WLEB) region of Ohio. Specifically, for our detailed analysis, we examine how property rights of access, withdrawal, management, exclusion, and alienation are defined for drainage management institutions[2] and subsequently impacts incentives for collective action (Schlager and Ostrom 1992; Ostrom 2009). The overarching questions of this study are: (1) How can we conceptualize property rights for agricultural drainage systems? and (2) How do institutions interact with property rights for promoting collective action of joint investment and removal of excess water for agricultural drainage systems? The study follows a comparative case-study design (Yin 2009). We find that unlike fisheries and other commonly studied CPRs such as self-organized irrigation systems and forests, property rights are not cumulatively bundled for drainage systems, and that having land held in private decouples use rights from physical access rights.

2. Study context

Our rationale for selecting the WLEB region of Ohio as the study context was both practical and theoretical. Drainage management is a challenge across the world, making it a topic of relevance for both practice and policy (Abdeldayem et al. 2005). Paradoxically, however, drainage has become a 'forgotten factor' in international water discourse as a theme and a concern (Scheumann and Freisem 2002; Abdeldayem et al. 2005; Tollefson et al. 2014). Scholars argue that unlike irrigation management, for which institutional arrangements abound, institutions for managing agricultural drainage are lacking (Scheumann and Freisem 2002; Schleyer 2009). The agricultural landscape in Ohio, however, presents a contrast, where the first agricultural drainage laws were passed in 1841 (Atherton 1999). These laws granted local offices and landowners several mechanisms to organize and fund the design and construction of drainage projects (ODNR 2009). The rich institutional setting thus provides an apt context to investigate resource asymmetry and property rights. Although states across the Midwestern United States vary with respect to the details of institutional mechanisms for drainage management, basic approaches are shared widely across the Midwestern agricultural landscape.

[2] For clarity, we would like to remind the reader that "rights" are the product of "rules" (Schlager and Ostrom 1992). In the Ohio context, drainage management institutions have a set of rules which specify which users have certain property rights.

Over 7.4 million acres of cropland in Ohio benefit from drainage systems, making it an important agricultural practice (ODNR 2008). Four institutional mechanisms have been provided for establishing and maintaining drainage systems, referred to as 'group drainage improvement'. By definition, the term "group" refers to the fact that such improvements concern more than one landowner. The drainage improvement is either in the form of constructing new drainage ditches or laying down main drainage tiles,[3] or in the form of maintaining the existing drainage system. Most of the times, it is either one landowner, or a group of landowners, who identify a drainage management issue, such as eroding drainage ditch banks, and approach either the county Soil and Water Conservation District (SWCD) or the County Engineer's Office (CEO). After looking at the issue, the official can then make recommendations to the landowner, or the group of landowners, about which institution to use. The decision about which institution to choose rests with the landowners.

In this study, we focus on the two most commonly used mechanisms for drainage collective action in Ohio: Mutual Agreement and County Petition.[4] Mutual Agreement (MA) is used when landowners agree to voluntarily provide a group drainage improvement and are willing to pay the cost of construction. County Petition is filed with the county commissioners (CCs), either by a benefitting landowner, or multiple benefitting landowners, in order to have a group drainage improvement, which is then financed, constructed, and maintained via assessments on benefitting landowners in the watershed. Key similarities between the two mechanisms are that both involve more than one landowner and they are both provided under the Ohio County Ditch Law. There are several key distinctions between the two mechanisms, as summarized in Table 1.

Table 1: Comparing the two institutions for agricultural drainage systems in Ohio.

Key distinctions	Mutual Agreement	County Petition
Level of govt. involvement	Minimal	Maximum
Scope	To construct a group drainage improvement	To construct and provide future maintenance for a group drainage improvement
Nature of involvement of landowners	Voluntary (disagreeing landowners in the watershed cannot be forced to contribute)	Non-voluntary (disagreeing landowners in the watershed can be forced to contribute)

[3] Drainage tiles are perforated pipes made of clay, cement or plastic, which help remove excess water from soil subsurface. These tiles are installed below the surface of agricultural fields. Main drainage tiles (also called a "water collector" in other contexts) run across multiple properties draining water eventually into a ditch.

[4] The other two institutional mechanisms are Conservation Works of Improvement and Conservancy District Improvement.

3. A primer on property rights in common-pool resource management

A property right is the right to undertake a particular action or actions in relation to a specific domain, which in this case is a drainage system (Schlager and Ostrom 1992). Commonly referred to as "bundles of rights," these rights can be conceptualized as five categories: access, withdrawal, management, exclusion, and alienation (see Table 2).

Property rights are especially important in natural resource management as they offer incentives to the users, give them necessary authorizations and control, and reinforce collective action (Meinzen-Dick and Knox 1999). Property rights are often described as a bundle of rights, working together to affect individual behavior. For example, in a study of inshore fisheries Schlager (1994) found that having the rights of access, withdrawal, management and exclusion together allowed fishers to keep others from invading their inshore fisheries and encouraged investment. Similarly, in irrigation systems, Tang (1994) found that having the rights associated with access, withdrawal, management, and exclusion was crucial for long-term management of the resource. A cumulative and nested bundling of property rights facilitates comparison of bundles held by different resource users, and subsequent understanding of how property rights endowments affect behavior (Galik and Jagger 2015). For example, since claimants (see Table 2) hold management rights, they face stronger incentives than authorized users to invest in natural resource collective action (Schlager and Ostrom 1992).

Whereas Schlager and Ostrom (1992) classify bundles of rights as either use rights (access and withdrawal) or decision-making rights (management, exclusion, and alienation), such bundles of rights have also been grouped as *usus* rights to use the resource; *usufructus* rights to derive income from a resource; and *abusus* rights to change the resource (Meinzen-Dick 2014). Similarly, Schlager and Ostrom (1992) identify rights originating among users as *de facto* rights (in practice), and rights granted and enforced by a government as *de jure* rights (in form). Property rights and collective action are interdependent, which is particularly clear in the case of common-pool resources, where holding rights in the

Table 2: Bundles of property rights (Source: Schlager and Ostrom 1992).

Property right	Description	Bundles of property rights
Access (P1)	The right to enter a defined physical property	Authorized user (P1 + P2)
Withdrawal (P2)	The right to obtain the "products" of a resource	
Management (P3)	The right to regulate internal use patterns and transform the resource by making improvements	Claimant (P1 + P2 + P3)
Exclusion (P4)	The right to determine who will have an access right, and how that right may be transferred	Proprietor (P1 + P2 + P3 + P4)
Alienation (P5)	The right to sell or lease the right of management, exclusion, or both	Owner (P1 + P2 + P3 + P4 + P5)

resource reinforces collective action among members, and collective action is needed to manage the resource (Meinzen-Dick et al. 2004).

Recognizing the complex relationships among institutions, property rights and collective action, this study argues that the incentive of a right holder to contribute in an agricultural drainage collective action dilemma is driven by their physical arrangement with respect to the resource, and most importantly, the bundles of property rights that indicate a users' claim to the resource.

4. Conceptualizing asymmetric resource dilemmas in agricultural drainage systems

To conceptualize resource dilemmas in agricultural drainage systems, a useful point of comparison is irrigation systems. An irrigation system brings water to land for human use, typically to grow crops. In irrigation systems, resource users face two kinds of related collective action problems: (1) joint investment in the resource system and (2) the allocation of water, i.e. the "resource units", from the system (Tang 1989). Allocation of resource units from an irrigation system poses an "asymmetric common-pool resource dilemma" (Janssen and Rollins 2012). In such a dilemma, the relative positions of resource users at the head and tail of the system generate asymmetric access to the resource (Ostrom and Gardner 1993). The resource users who are uphill and physically nearer to the source of water are called the "head-enders" and those who are downhill and physically farther from it are called the "tail-enders" (Ostrom and Gardner 1993). Within the group of users, head-enders have little incentive to maintain the irrigation system, and their ability to access the water is less dependent on the actions of other users, compared to tail-enders.

In the schematic representation (Figure 1), landowner 1 (L1) to landowner 16 (L16) represent a group of users benefitting from an irrigation system, which is comprised of a main irrigation canal and multiple distributary canals. Within the group of head-end users, L4 and L8 are in a preferred position since they are not only uphill and physically close to the canal, but also get to withdraw water before any other user in the group. Once water flows beyond their property, they have little incentive to contribute towards the maintenance of the irrigation system. This is an asymmetric resource dilemma, where the physical arrangement of resource users affects their incentives for collective action.

Similar to an irrigation system, a drainage system faces the collective action problem of joint investment, but instead of water allocation, the collective action problem here is to remove excess water from the cropland. Drainage systems also exhibit an asymmetric resource dilemma wherein the relative positions of resource users generate asymmetric incentives to provide the resource. In a given drainage area, which drains into a drainage ditch, users who have the ditch running over their property, by virtue of being physically near the resource, can be considered to be "near-landowners". The second group of resource users are those who do not have the ditch on their property, but being in the drainage area, are deriving drain-

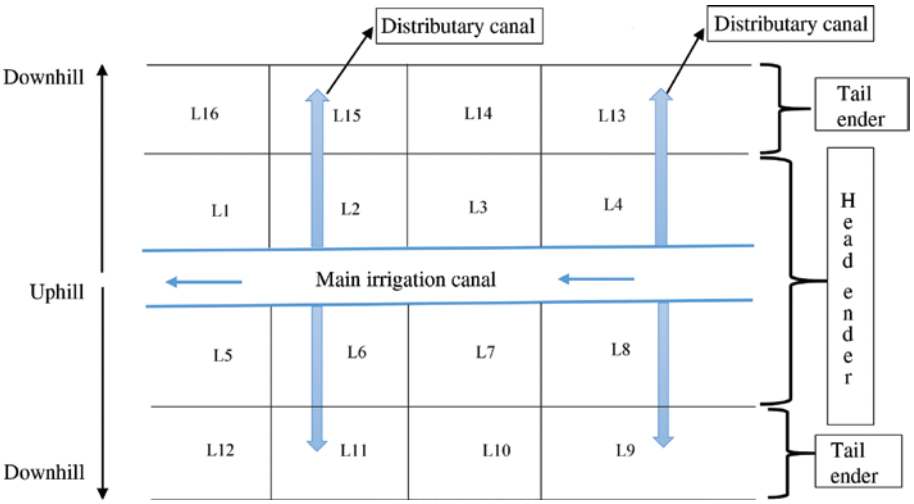

Figure 1: A schematic representation of users along an irrigation canal.

age benefits from it. By virtue of being uphill of the near-landowners and physically distant from the resource, they can be considered to be "far-landowners" (see Figure 2).

Constructing and maintaining drainage systems typically involve more than one landowner. However, given the greater physical distance from the resource itself, and reduced likelihood of being affected by flooding, far-landowners may

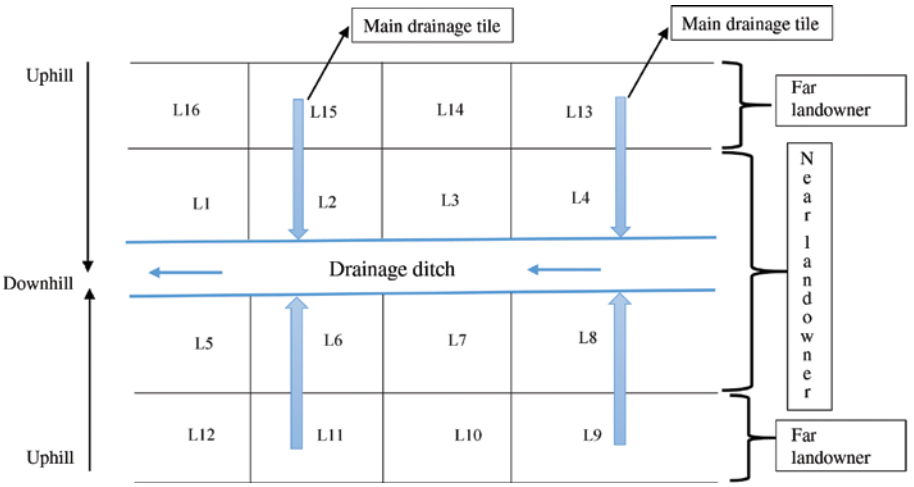

Figure 2: A schematic representation of users along a ditch.

not perceive as much benefit as near-landowners to maintain the drainage system.[5] In contrast, a near-landowner faces flooding risks if the drainage system overflows, which increases his incentive to contribute towards the maintenance of the drainage system.

In the schematic representation (Figure 2), landowner 1 (L1) to landowner 16 (L16) represent a group of users benefitting from a drainage system, which is comprised of a drainage ditch and multiple main drainage tiles. Once water drains from the property of a far-landowner he has little incentive to contribute towards the maintenance of the drainage system downhill. Within the group of far-landowners, L9 and L13 are in a preferred position since they are not only uphill and physically distant to the ditch, thus at low risk of flooding, but also water drains from their property before the property of any other user in the group due to slope of the land. Once water drains from their property, they have little incentive to contribute towards the maintenance of the drainage system. Thus, just like irrigation systems, drainage systems exhibit an asymmetric resource dilemma, as a result of which the physical arrangement of resource users affects their incentives for collective action.

Comparing irrigation versus drainage systems, thus, allows for emergence of some important similarities as well as contrasts (see Table 3).

5. Conceptualizing property rights in agricultural drainage systems

In this section, we apply Schlager and Ostrom's property-rights analytical scheme to drainage systems situated in a private property regime and identify how property rights affect incentives for collective action. Specifically, we conceptualize

Table 3: Comparative analysis of two asymmetric resource dilemmas.

Attributes	Irrigation	Drainage
Resource system (RS)	Main irrigation canal + distributary canals	Drainage ditch + main drainage tiles
Resource unit (RU)	Allocated water	Drained water
Type of collective action problem	Joint investment and water allocation	Joint investment and removal of excess water
Resource user distribution	Head-enders and tail-enders	Near-landowner and far-landowner
Incentive structure for maintaining RS	Head-enders: little incentive Tail-enders: high incentive	Near-landowners: high incentive Far-landowners: little incentive
Preferred position of resource user	Uphill, physically near, i.e. to be a head-ender	Uphill, physically distant, i.e. to be a far-landowner

[5] We would like to acknowledge that far-landowners would have a relatively higher incentive to maintain the system in a low gradient topography, since lack of maintenance downstream would affect drainage efficiency upstream.

property rights in drainage systems, and how their presence or lack thereof, may act as a barrier for collective action.

In drainage systems, the right of access (P1) indicates whether or not a resource user has the right to enter a drainage ditch. This right would also translate to the right to physically access the main drainage tile/distributary canal (see Figure 2). Near-landowners, i.e. users who have the ditch running over their property, will have this right. This is because drainage ditches are considered private property. Under the Ohio Common Law, the owner of the land beside the ditch also owns the land beneath it. If two different landowners own the land on each side, each owns the land to the center of the ditch. Even among near-landowners, a resource user may physically access only the section of the drainage ditch that is on his property. Far-landowners, who derive benefit from the ditch do not have the right to physically access the ditch, however, they can physically access the section of the main drainage tile that runs through their property. A complex interplay between asymmetric distribution of resource users and right to the land (private property ownership), thus restricts physical access to the drainage infrastructure. This may act as a hindrance for landowners in perceiving the need for drainage improvement.

The classic understanding of the right of withdrawal (P2) is rooted in the idea that a resource user obtains the "products" of a resource. For example, a forest is the resource and a resource user obtains a tangible product in the form of timber. However, in drainage systems users do not "withdraw" anything tangible. They simply "use"[6] the drainage system to obtain the benefit of improved drainage. This right would thus pertain to the water[7] (Meinzen-Dick 2014), not with the commonly studied goal of obtaining it, but getting rid of it. Within a given drainage area, the right to use the system depends on the drainage management institutions.

Regulating internal use patterns (P3) pertains to determining how, when, and where "resource units" can be harvested from a resource. However, given the nature of the resource under consideration, where "resource unit" is often a function of the natural gradient of the land and flow patterns, it is very difficult to regulate use patterns among near and far-landowners. Whereas management is conducive to the idea of managing the internal use patterns of users when they are harvesting something, for drainage systems the right of management should be conceptualized as the decision making right of maintenance of the infrastructure (Meinzen-Dick 2014). However, the right of access complicates exercising

[6] Meinzen-Dick (2014) identifies withdrawal (P2) as a "consumptive use". In drainage systems, consumptive use would translate into a group of resource users consuming the physical space for water to drain.

[7] A legal institution, the "Reasonable Use Doctrine" is often used by the courts in Ohio when dealing with conflicts related to drained water. As per this doctrine, 'no landowner shall unreasonably increase or decrease the flow of surface water drainage onto adjoining lands, or unreasonably divert or alter the natural water course'.

maintenance right, since the lands on which drainage systems are located are privately owned. In other words, exercising the right of maintenance (right to the infrastructure) requires first exercising the right of access (right to the land).

In a recent application of the property-rights analytical scheme by Schlager and Ostrom, Meinzen-Dick (2014) defined exclusion (P4) as the right to determine who can use the resource and how that right may be transferred. Drawing upon extant scholarly understanding of the right of exclusion, three conceptual clarifications are important for analyzing drainage systems. First, since using a drainage system does not require users to physically access it, Meinzen-Dick's (2014) conceptualization of excluding use is more conducive to drainage systems than is Schlager and Ostrom's (1992) conceptualization. Second, since using a drainage system does not require taking any action by a user at the time of use,[8] we conceptualize the right of exclusion as excluding use without contributing. Third, since transferring exclusion rights is already considered as part of the right of alienation (see Table 2), in order to avoid redundancy and to aid conceptual clarity, we do not include it in our conceptualization of the right of exclusion for drainage systems.

In drainage systems, the right to maintain and the right to exclude pertain to the infrastructure. Unlike commonly studied natural resource management contexts, in drainage systems, resource users do not "sell" or "lease" their rights (P5) in exchange for money or any commodity, but simply "grant" their rights of maintenance and exclusion, either to other resource users or the local government agency. However, "granting" either or both of these rights comes into conflict with right to the land, i.e. private property ownership.

Our conceptualization of property rights in agricultural drainage systems is presented below (see Table 4). Note that text in italics indicates adaptation of Schlager and Ostrom's conceptualization of property rights to suit the asymmetry

Table 4: Property rights in agricultural drainage systems.

Property right	Description	*Property right pertains to…*
Physical access (P1)	The right to enter a defined physical property	*Infrastructure (conflicts with right to the land)*
Use (P2)	The right to obtain the "products" of a resource *system*	*Drained Water (a product of using the resource system)*
Maintenance (P3)	*The right to maintain the resource system*	*Infrastructure*
Exclusion (P4)	*The right to determine who will have a right to use the resource system without contributing*	*(use of) Infrastructure*
Alienation (P5)	The right to *grant* the right of *maintenance*, exclusion, or both	*Infrastructure (conflicts with right to the land)*

Adapted from Schlager and Ostrom (1992) and drawing on insights from Meinzen-Dick (2014).

[8] In contrary, taking an action at the time of use would correspond to, for example, a resource user harvesting timber from a forest.

of incentives and the private property (land) ownership of the common-pool resource[9] of the agricultural drainage system.

6. Research method and data collection

The study follows a comparative case-study design (Yin 2009) to illustrate the property rights concepts described above. Comparative case studies are well suited for understanding complex phenomena in real-world settings, where many factors are potentially important (Yin 2009). In this study, our two cases are the two institutional mechanisms existing for drainage in Ohio: Mutual Agreement (MA) and County Petition (CP). Selection of these two cases allows comparison of a case with minimal involvement of government agencies and no dissenting landowners (MA) to a case with maximum involvement of government agencies and dissenting landowners (CP). The five property rights P1–P5 are the key variables of interest.

To understand how P1–P5 affect collective action, we rely on data from interviews and documents. Data collection included in-depth interviews with key informants.[10] In the study, key informants were those most closely involved with functioning of the drainage management institutions: county engineers, deputy engineers, drainage technicians, and district technicians. These individuals spend their careers interacting with landowners regarding drainage issues and are familiar with both the institutional mechanisms and landowners' reactions to them. A snowball sampling technique was used to identify knowledgeable informants (Patton 1990). We conducted interviews with 16 government agents involved in the two institutional mechanisms: Mutual Agreement and County Petition. These interviews were conducted in-person during December, 2014–January, 2015. Systematic qualitative techniques including coding, pattern matching, and synthesis were used to analyze the collected data. Quotes and short vignettes were instructive. This allowed for synthesis of interpretations and identification of themes that cut across cases (Miles and Huberman 1994).

[9] Given that drainage systems are held in a private property ownership regime, they could also be viewed as anti-commons, wherein multiple users have the right to exclude others from using the resource (Heller 1997; Buchanan and Yong 2000). In the absence of an effective privilege of use, such resources are characterized by underuse – a tragedy of the anti-commons. However, as explained in this section, drainage systems are amenable to conceptualizing the right of exclusion as excluding right to use (drain) without contributing. Although a resource user, by virtue of private property right, can restrict physical access to the drainage system, s/he cannot exclude a non-contributing user from using the drainage system. As a result, drainage systems are not characterized by underuse – a defining feature of anti-commons, but by collective action problems of joint investment and removal of excess water. Moreover, as our analysis indicates (see Tables 5 and 6), for one of our cases, the lack of right of exclusion impacts collective action. Multiple users holding the right of exclusion, in contrast, characterize the anti-commons.

[10] Key informants are people with firsthand knowledge of the events being studied who provide factual information about the organization from an insider perspective (Hardy and Koontz 2009).

Document analysis provided additional data. Analysis of Ohio Revised Code (ORC) chapters 6131 and 6137 focused on understanding Mutual Agreement and County Petition mechanisms. Specifically, this analysis provided an understanding of the main provisions of the Ohio drainage laws.

7. Results

In this section we describe the institutional mechanisms for drainage improvement and how property rights are defined within each mechanism. Subsequently we examine the role of variables P1–P5 in affecting incentives for collective action in drainage management. But first it is important to note that, although different, the two mechanisms are not necessarily mutually exclusive over time. Interviewees said that landowners often attempt to create a mutual agreement project, with less government involvement, and if they cannot generate enough support for this voluntary mechanism then they may attempt to create a county petition project.

7.1. Property rights in mutual agreement (MA) and county petition (CP) projects

In both MA and CP projects (described above in the Study Context section), landowners who have the drainage system on their property have the right of physical access (P1), but only to the section of the drainage system on their property. Consequently, a far-landowner will still have to seek permission from a near-landowner owner to be able to physically access a drainage ditch. However, given that MA projects involve a group of landowners working together to fix a drainage issue, it is possible that even far-landowners are able to physically access the ditch, as a de facto right (in practice) although not de jure right (in law). If a drainage issue originates on someone's property, and if the property owner disagrees with carrying out the improvement, others in the group do not have a right to access his property. This aspect was captured very well by an interviewee, who said, *"If a landowner doesn't want another landowner to come through his property the project is off a mutual agreement. Even if he says he is not going to pay, you cannot go across his property without his permission."* In CP projects, however, when the viewing of the project is held, the CCs (County Commissioners), officials from the CEO (County Engineer's Office), and anybody in the watershed have de jure rights to physically access the drainage system and look at the drainage issue. Subsequently, if the project is approved, and the drainage improvement is provided, the improvement is put on permanent maintenance. Because the CEO is assigned the role to maintain the improvement, it has the right to access the drainage system in order to carry out maintenance activities such as spraying, bank repairs, etc.

In both MA and CP projects, everybody in the drainage area has the right to use (P2) the benefit of improved drainage. However, what is interesting from a collective action point of view is that in MA projects, landowners have the capability to choose whether they want to contribute to the project or not. For example, an interviewee mentioned, *"If you are in a drainage area, and the*

group decided to let you off the project and not pay for it, but that's still where you are going to drain [i.e. obtain the benefit of improved drainage]*."* Having the right to use the drainage system without the obligation to contribute towards the improvement can be characterized as free riding. In CP projects, however, the CEO distributes the cost (for both construction and maintenance) across the benefitting landowners. This means that near-landowners as well as far-landowners must pay in the form of annual assessments. For example, an interviewee mentioned, *"We have got drainage maps which show boundary lines to each particular channel. So, if you are in, you are in, and if you are out, you are out."* From the perspective of property rights, a county petition procedure helps tie the right to drain with the obligation to pay annual assessments, thus promoting collective action.

In MA projects, the right of maintenance (P3) rests with the individual landowner. Once a project has been done, i.e. an issue has been fixed, the individual landowner has the right to maintain his section of the drainage system. This individual level holding of the right of maintenance acts as a deterrent for promoting collective action. For example, one of our interviewees said, *"In a county petition project, the maintenance is ongoing, irrespective of change in ownership of the land. But if ownership of land changes* [in a mutual agreement project]*, it becomes difficult to keep maintaining the system."* The mutual agreement procedure legally (de jure) provides for payment of maintenance costs for a year by the benefitting landowners, followed by an annual assessment for future maintenance. However, in practice (de facto), interviewees consistently indicated the absence of any such provision for future maintenance. One noted that a MA is a "handshake" agreement, where maintenance rests with the individual landowner. In CP projects, the right of maintenance (P3) rests with the CEO. Users do not have the right to make any changes in the drainage improvement. Once a petition is approved and an improvement is constructed, the CEO obtains a permanent easement for maintenance purposes. Unlike a MA project, wherein change in land ownership makes it difficult to maintain an improvement, in a CP project, the maintenance is ongoing regardless of land ownership. This in turn, may act as a factor which promotes collective action.

In MA projects, a near- or far-landowner who is in the same drainage area, but decides to not pay his share of the cost of the improvement, cannot be excluded from his right to use (P4). Thus, although the group of landowners who decide to cooperate and work towards an improvement are able to decide the size of the project, when it comes to drawing resource units, they are not able to exclude other potential beneficiaries, given the natural (as well as interconnected, tiled) flow of water downhill. In MA projects, no legal right exists to allow a landowner to force another landowner to make payments for the ditch. In CP projects, landowners do not have the right to exclude anyone else in the watershed from their right to drain into the improvement without contributing. This decision rests with the CEO. The physical boundary of a project is driven by the drainage area and determined by the CEO. Hence, the CEO has the right to exclude someone from

deriving drainage benefits without paying towards the improvement. By virtue of having this right, the CEO is able to ensure that there are no free riders in the project. So, unlike MA, where the right to use without having the obligation to pay for the improvement may allow for free riders in the group, in CP projects, the CEO is able to ensure that there are no free riders.

The right of alienation (P5) refers to the right to sell or lease the right to exclude use (P4) and/or the right of maintenance (P3). Every landowner involved in a given MA project holds the right to maintain the section of the drainage system on his property, and hence "grant" this right to others. In contrast, landowners do not hold the right to exclude use (P4) of the resource, as uphill landowners will drain naturally or through main tiles into the ditch. As mentioned earlier, once the ownership of the land changes, the new owner is under no obligation to maintain his part of the drainage system, making it difficult to maintain the interconnected system. The resulting uncertainty about the maintenance of the drainage improvement was described by an interviewee, who mentioned, *"You can get something fixed and done under mutual agreement, but if say after 15 years go by…what's going to happen? Who is going to be in-charge? If I am a mile away from the ditch, am I going to go there and maintain that ditch?"* In CP projects, the right of alienation (P5) does not rest with landowners. Both the right to exclude use without contributing and the right of maintenance rest with the CEO. This may encourage other users in the watershed to act collectively for drainage improvement in the future, since there is a security that the improvement will be maintained, and that there won't be any free riders in the group.

To sum up, while property rights allocation under MA project seems to hinder collective action towards joint investment and maintenance of drainage systems, property rights allocation under CP projects facilitates collective action by ensuring that all users deriving benefit from a given drainage improvement jointly invest in the system and contribute towards its maintenance.

7.2. Cross-case comparisons

Comparing across the two cases reveals patterns in the incentives provided by the five key property rights (P1–P5; see Tables 5 and 6).

Since both the cases have a legal backing in the Ohio County Ditch Law, they represent bundles of de jure rights (Schlager and Ostrom 1992). However, as shown in Table 5, these two cases vary with respect to property rights held by the local government agency. Whereas for MA projects, the local government agency does not hold any property rights, for CP projects, the local government agency does hold property rights. Specifically, the CP mechanism gives the local government agency the right to physically access the drainage system (P1), maintain the drainage system (P3), and exclude non-paying beneficiaries from using by forcing all beneficiaries to contribute through assessments (P4).

Table 5: Comparing agricultural drainage system property rights across the two cases.

Case	Property right holder	Bundles of property rights
Mutual agreement	Near-landowner	P1[i] + P2 + P3 + P5[ii]
	Far-landowner	P1[i] + P2 + P3 + P5[ii]
	Local government	None
County petition	Near-landowner	P1[i+iii] + P2
	Far-landowner	P1[i+iii] + P2
	Local government	P1[iv] + P3 + P4

Notes: P1: Physical Access; P2: Right to use (drain); P3: Right to maintain; P4: Right to exclude use without contributing; P5: Right to alienate.

[i]Physical access restricted to the section of drainage system on a landowner's property.

[ii]Both near- and far-landowners continue to hold alienation rights pertaining to maintenance but not exclusion from use.

[iii]Both near- and far-landowners in the watershed can physically access the section of the drainage system with drainage issue during the viewing stage of the project.

[iv]A local government agent has the right to physically access the area with drainage issue in order to conduct surveys, assess the problem, and if the project is approved, to carry out maintenance activities.

As is evident in Table 5, bundles of property rights are not the same across the two institutional mechanisms. For MA projects, landowners do not have the right of exclusion (P4), because they cannot exclude a non-contributor from using the resource. However, they have physical access to the section of the drainage system on their property (P1), right to drain (P2), right to maintain the drainage system on their property (P3), and right to alienate their maintenance right (P5). Thus, unlike Schlager and Ostrom's (1992) conceptualization of progressive bundles of property rights (see Table 2), our analysis for mutual agreement project demonstrates that property rights may not always exhibit such progression (see Table 5).

For CP projects, landowners neither have the right to maintain (P3) or exclude (P4), both of which are granted to the local government agency by the petitioning landowners. Since landowners don't have either P3 or P4, they cannot alienate these rights (P5). Thus, for CP projects, the agency becomes a property right holder, holding the rights of physical access (P1), maintenance (P3), and exclusion (P4). Since landowners have the right of physical access (P1) and use (P2), in a county petition project they can be described as "authorized users", as defined by Schlager and Ostrom (1992) (see Table 2). Their property-rights analytical scheme conceptualizes property rights as progressive bundles of rights (see Table 2); our analysis corroborates their conceptualization for landowners in CP projects. However, such progressive bundling of property rights does not hold true for the local government agency in CP projects (see Table 5).

As our results demonstrate, different drainage management institutions allocate different bundles of property rights to resource users as well as the local government agency, which in turn has implications for collective action. Specifically, for drainage institutions, property rights interact with each other to affect collective action.

As described above, the right to benefit from using improved drainage (P2) rests with all landowners in the drainage area (see Table 5). However, whereas the voluntary nature of the arrangement allows for potential free riders to be present in a MA project, in CP projects, the local government agency is able to make sure that there are no free riders in the group. They do so by enforcing P4: every user is required to pay their fair share based on the benefit they are drawing from the improvement. While this leads some resource users to question the cost-benefit distribution, it nevertheless may encourage users to work collectively, and thus promote collective action. In contrast, the absence of an enforcing agency in MA projects may deter users from working collectively towards drainage improvements, and hence discourage collective action. Thus, the interplay of P2 and P4 becomes a crucial factor in either encouraging or discouraging collective action. Additionally, the interplay of private land ownership and P3 has implications for collective action (see Table 6).

The above analysis of allocation of bundles of property rights across the two cases (Mutual Agreement and County Petition) leads to the conclusion that for a given case, near and far-landowners have the same bundles of property rights (see Table 5). Additionally, as shown in Table 6, the interplay among property rights is critical. Moreover, property rights interactions are more conducive to collective action in CP projects.

Table 6: Property right interactions in drainage systems.

Case	Property rights interactions	Implications for collective action (+, −)
Mutual agreement	Absence of P4 impacts P2	(−) Since it is difficult to exclude anyone in a given drainage basin to exercise his "right to drain", in the absence of an authority to force everyone to contribute, all landowners[a] in a drainage basin can exercise P2 regardless of their contributions. This increases the likelihood of free riding; decreases the likelihood of collective action.
	Private land ownership impacts P3	(−) If a landowner sells his land, the new owner is under no obligation to maintain his part of the drainage system. This reduces certainty of future benefits and thus decreases the likelihood of collective action.
County petition	Presence of P4 impacts P2	(+) Local government agency draws the boundary of a group drainage improvement, based on the drainage area; everybody who benefits from the improvement, pays for it. This decreases the likelihood of free riding; increases the likelihood of collective action.
	Private land ownership does not impact P3	(+) Change in land ownership does not impact maintenance of the drainage system; local government agency maintains it through a permanent easement. This increases certainty of future benefits and thus increases the likelihood of collective action.

Notes: Sign inside parenthesis indicates expected impact on collective action: (+) Helps; (−) Hinders. PR: Property Right; CA: Collective Action; P1: Physical Access; P2: Right to use (drain); P3: Right of maintenance; P4: Right to exclude use without contributing; P5: Right to alienate.
[a]However, near-landowners will have an interest in regular maintenance of the system, given that they would want to avoid flooding risk.

8. Discussion

Extant scholarly work on collective action problems often focuses on common-pool resources (CPRs) held by a community under a common-property regime. However, an agricultural drainage system is a common-pool resource which in many places is held in a private property (land) ownership regime. Additionally, property rights literature rarely examines resources which exhibit an asymmetric resource dilemma. Agricultural drainage systems are an example of one such resource. In this study, examining drainage management institutions and how each of these institutional mechanisms allocates bundles of property rights leads to several new insights.

The first insight pertains to the theoretically important interactive nature exhibited by the two institutional mechanisms examined in this study. Rather than finding that one type of institution is always better than the other, it is evident that they are complementary. Whereas MA (Case 1) provides a landowner-driven institutional mechanism to give a first attempt at generating collective action, if that fails, CP (Case 2) acts as a government-driven institutional back-up to facilitate collective action. This resonates with Ostrom's design principles encouraging users to develop their own rule making (including cost allocation for projects) but if this fails then there should be an outside government entity available. While Ostrom's design principles see this outside entity as important for conflict resolution (Ostrom 1990, 2009), this case suggests another role for the outside entity: to provide an alternative institutional arrangement in case the MA is not successful. Thus, a theoretical argument can be made to consider the role for government beyond just existing as a conflict resolution venue. Rather, a key government role may be to supply an alternative institution for stakeholders to generate collective action. This insight is in line with studies of collaborative environmental management describing the complementarity of community-driven efforts and government resources (Koontz et al. 2004).

The second insight pertains to how we understand "bundles of property rights". Following Schlager and Ostrom (1992), property rights systems have been widely conceptualized and studied as containing cumulative bundles of five rights rather than a single right (Ostrom 2010). However, the five property rights are not necessarily held in a cumulative manner, i.e. as "progressive bundles of property rights", as is often the case in fisheries, and other commonly studied CPRs such as self-organized irrigation systems and forests (Tang 1994; Agrawal and Ostrom 2001). For example, the extant literature emphasizes how having the rights associated with being a proprietor (P1 + P2 + P3 + P4) is sufficient for encouraging users to contribute in a collective action dilemma (Schlager and Ostrom 1992; Schlager 1994; Tang 1994; Agrawal and Ostrom 2001). However, such cumulative and progressively stacked understanding of "bundles of property rights" does not fully apply to the drainage management institution of mutual agreement. As shown in Table 5, property right bundles are not strictly cumulative for mutual agreement projects. Instead, different institutional mechanisms (mutual agreement and county petition) allocate different bundles of property rights, and a landowner can hold the right of alienation (P5) without exclusion

(P4).[11] Thus, a cumulative understanding of property rights, as often is the case for CPRs, falls short[12] of understanding property rights in resource systems exhibiting an asymmetric resource dilemma combined with common-pool resource characteristics and private property ownership.

The third insight pertains to how individual property rights interact to affect collective action. Specifically, the right of exclusion (P4) interacted with the right to use (P2) and negatively affected collective action incentives in mutual agreement, as it increased the likelihood of free-riding (see Table 6). Similarly, the interaction between the right to the land, i.e. private property, and the right of maintenance (P3) negatively affected incentives for collective action in mutual agreement, as it reduced the certainty that the group drainage improvement will be maintained in the future (see Table 6). The existing CPR literature recognizes that the five property rights are independent of one another, but are often cumulatively held for common-pool resources (Schlager and Ostrom 1992; Ostrom 2010). However, given the non-cumulative stacking of property rights for drainage systems, it is important to understand which property rights interact, how they interact, and what implications such an interaction has for collective action.

9. Conclusion

The goal of this study was to examine how property rights are shaped by drainage management institutions, and subsequently impact incentives for collective action. Schlager and Ostrom (1992) provide a property-rights analytical scheme ranging from authorized user, to claimant, to proprietor, and to owner. Their work focused specifically on fisheries, which do not exhibit an asymmetric resource dilemma. In contrast, drainage systems in the Western Lake Erie basin of Ohio are characterized by asymmetries where users farther from the resource can use the resource (drain excess water) despite restricted physical access to the resource system, thus decoupling the direct link between use (P2) and physical access (P1). Such decoupling occurs due to the fact that unlike fisheries which are common-pool resources and held by the community, drainage systems in our study context are characterized by private property ownership alongside the common pool resource characteristics of drainage systems. Hence, landowners, by virtue of

[11] Schlager and Ostrom's (1992) property rights typology identifies P5 as the right to grant the right of maintenance, exclusion OR both. While it is true that landowners in MA projects do not have the right to sell/lease P4, they do have the right to sell/lease P3. Since the condition to have P5 is OR, the right to sell/lease P3 is sufficient for landowners in MA projects to have P5. Landowners' right to sell/lease P3 but not P4 in MA projects is a function of private property rights on which the drainage infrastructure exists. This further calls to attention the importance of the combination of private property and collective goods existing together in a resource system.

[12] We would like to remind the reader that we are not proposing a revision to the Schlager and Ostrom (1992) property rights typology. The nestedness of the typology allows for close examination of bundles of property rights that actors share and exercise in drainage management. However, as our analysis indicates, bundling of property rights is not strictly cumulative for drainage systems in our study context.

their land ownership, have physical access (P1) to the section of the drainage infrastructure on their property even as they are not able to exclude others from using the drainage infrastructure to drain their land.

By contrasting and comparing drainage and irrigation systems, this study demonstrates how physical arrangement of resource users with respect to the resource system affects their incentives to contribute in a collective action dilemma. In addition to the theoretical contributions, this study also has important management implications. For example, Table 3 could be used as a diagnostic tool by managers to understand the incentive structure in place and evaluate how that affects incentives for collective action in managing agricultural drainage systems.

As the property rights analysis indicates, drainage systems provide a rich foundation for advancing the theory of collective action. However, as much as this study provides conceptual clarifications and theoretical insights, it also leaves a number of questions unanswered. In particular, results raise several important questions and avenues for future research:

1. How can we curb free-riding behavior in collective action dilemmas where users can exercise use rights despite restricted physical access?
2. Does lack of cumulative bundles of property rights warrant special forms of institutional arrangements, including arrangements in which the government supplies an alternative institution for stakeholders to generate collective action?
3. Why do some landowners overcome collective action problems and agree to adopt a county petition institution that is enforceable and why do some landowners fail to do so?

Answering questions such as these will enable scholars and practitioners to better understand and manage resource systems that require users to work collectively. In particular, explaining institutional mechanisms is important for addressing collective action dilemmas involving common pool resources within a private property regime. Such mechanisms impact the incentives for overcoming asymmetrical resource dilemmas.

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