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Robustness and vulnerability of community irrigation systems: The case of the Taos valley acequias

Michael Cox [a,*], Justin M. Ross [b]

[a] Workshop in Political Theory and Policy Analysis, Indiana University, 513 North Park Street, Bloomington, IN 47408, USA
[b] School of Public & Environmental Affairs, Indiana University, 1315 East Tenth Street, Bloomington, IN 47405, USA

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ABSTRACT

Traditional economic and policy analysis theory has emphasized the implementation of private or public property rights regimes in order to sustainably manage natural resources. More recent work has challenged this approach by examining the strengths and weakness of common property governance of such resources. This paper contributes to this literature by analyzing the acequia irrigation communities in northern New Mexico. Through statistical analysis, we find that the acequias' ability to maintain collective-action as estimated by a critical performance function, crop production, is aided by water sharing agreements and access to groundwater, and that it is hampered by property rights fragmentation and urbanization.

1. Introduction

Traditional economic theory and policy analyses have long forecast the destruction or exhaustion of Common-Pool Resources (CPRs), such as forests and fisheries, unless they are governed by an external authority that is capable of imposing an idealized private or public property-rights system on those who use the resource [13,15]. As scholars later began to question these assumptions, attention turned to exploring the conditions under which groups of users can successfully manage a resource using common property rights systems [1,10,22].

Irrigation systems are one example of a CPR that is managed as common property by decentralized user groups in many regions around the world. The persistence of such systems over time has created several puzzles [21,29]. First, how do such communities resolve collective-action problems inherent in managing irrigation systems over time? Second, how have their organizational adaptations to past disturbances affected their abilities to adapt to novel disturbances in an increasingly interconnected world?

Exploring how common property systems function contributes to a larger research program in environmental and institutional economics, which studies how different property rights systems affect the management of the natural environment. By raising or lowering transaction costs, different institutional property arrangements may ameliorate or exacerbate collective action problems such as externalities, information asymmetries, and principal-agent problems inherent in social systems managing natural resources [7,8,14]. Coase [6], for instance, emphasized situations where assigning property rights, particularly private property rights, can improve an environmental or natural resource problem. Following the theoretical trends, government programs assigning property rights to a natural resource have primarily done it on the individual level, particularly in fisheries management in the form of individual quotas or similar

* Corresponding author. Fax: +1 812 855 3150.
E-mail addresses: miecox@indiana.edu (M. Cox), justross@indiana.edu (J.M. Ross).

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mechanisms [17]. Understanding how and when common property systems function with respect to various resource systems is important in identifying the conditions under which they may have comparative advantages or disadvantages with respect to other property right systems that might be implemented through public policy.

This paper addresses this issue by analyzing 51 acequia irrigation communities in Taos valley of northern New Mexico. These systems have operated for hundreds of years in a harsh environment, and as such offer potential lessons regarding the effective management of collective-action problems faced by other community-based CPR management systems, as well as for governments that might impose a particular property rights arrangement onto a CPR. The complexity of the acequia system requires a variety of methodologies and data sources. On-site in-depth interviews and content analysis of historical documentation were conducted, and remote sensing imagery and geographic information systems were employed to generate data that would enable a regression analysis.

This paper tests two basic types of hypotheses: first, which social and biophysical features of the acequias allow the residents to maintain collective-action over time? Secondly, what disturbances to the acequias are affecting their ability to maintain collective-action over time? Their ability to successfully engage in collective action is estimated in this study by a remotely sensed estimate of crop production, known as the Normalized Difference Vegetation Index (NDVI). NDVI is not an indicator of economic performance. Rather, it can be used as a proxy for collective action because in traditional irrigation systems like the acequias, producing agricultural products in an arid environment still requires high levels of collective action.

The main findings of this study are: (1) acequias perform better when they have access to alternative sources of water via groundwater and water sharing agreements; (2) acequias within municipal boundaries and those whose land property rights have become more fragmented are performing worse; and (3) small- to medium-sized acequias perform better than larger acequias.

2. Background

The empirical model used in hypothesis testing is derived in part from the existing empirical and theoretical work that has been done on similar systems, as well as some features specific to the acequias in Taos valley. The intention of this section is to provide the relevant background on these acequias as well as the literature on common property and collective action.

2.1. Common-pool resource management and collective action

An irrigation system is an example of a CPR that is finite, exhaustible, and which would incur high exclusion costs to limit access. The characteristics of CPRs lead to at least two types of collective-action problems: those of resource appropriation and provision [23]. A collective-action problem is a dilemma for user communities due to a divergence between individual and community-level interests. In these situations, the pursuit of individual gain can be collectively harmful, and it may be difficult for users to self-organize and act collectively in pursuit of common interests. It is this problem that has historically convinced many scholars and policymakers of a need to implement entirely private or public property regimes to manage CPRs.

An appropriation problem can result in the overconsumption of an exhaustible resource, such as water, when an individual benefits from personal consumption at the expense of the community and the condition of the resource. This is a special case of a negative externality, and is reflected in the commonly observed upstream–downstream relationship in irrigation systems whereby an upstream user can impose externalities on downstream neighbors by consuming a large proportion of the available water. A provision or public good problem can result in underprovision of the infrastructure needed to appropriate a resource, such as irrigation headworks. This is essentially a positive externality that can occur when it is difficult to exclude non-contributors from benefiting from, or free-riding on, the efforts of contributors. Individuals may then enjoy the benefits of others' provision without contributing, which lowers their incentive to contribute themselves. Both types of problems need to be resolved to sustain CPR management systems.

Much of the literature on CPR management has focused on common property regimes, where individuals' rights to the resource are contingent upon their continual adherence to community rules and norms. A variety of factors have been hypothesized and verified as contributing to the robustness of cooperation among users facing the social dilemmas posed by CPRs [1,22,23]. These include: (1) institutional arrangements and property rights; (2) characteristics of the user groups such as their size or heterogeneity; (3) levels of social or economic connectivity within and between user groups, as well as between them and their external political and economic environment [28,29]. An important aspect of the explanations offered by this literature is that features supporting collective-action do so because they either increase the benefits of cooperation or they lower the costs involved in maintaining cooperation. Implicit in these explanations is a model of human behavior that is governed at least to some extent by self-interest, and which takes particular courses of action only if the benefits of doing so exceed the costs.

One factor from this literature tested in this analysis is the effect of group size. Theory indicates that small- to medium-sized groups may be better able to maintain the cooperation needed to manage an irrigation system than larger groups [23]. The primary mechanism behind this relationship is that transaction costs involved in monitoring and enforcing