

# **COMPARATIVE IRRIGATION STUDIES: THE ÓRBIGO VALLEY OF SPAIN AND THE COLCA VALLEY OF PERÚ**

David W. Guillet

## **1 INTRODUCTION**

The relation between irrigation and human organization has provided a test of several theoretical paradigms in anthropology and related social sciences. Today, scholars have turned their attention to questions surrounding the rather large residue of irrigation systems tending to be small in scale, indigenous and long-lasting, and local in scope and in knowledge. The issues that guide scholarly inquiry on irrigation and human organization concern the social and political forms which organization for irrigation leads, the forces behind their emergence, and the relation between water management and household production. The sustainability and potential for intensification of water management systems is of particular import today as demographic growth increases the need to feed growing populations.

One question not being addressed in the current literature is posed by considering the respective environmental settings of the small-scale and large-scale irrigation systems discussed in the literature. Many small-scale systems are located in mountainous regions of the world such as the Philippines, Himalayas, Bali, Alps and Andes. The majority of the large-scale irrigation systems, on the other hand, are found in relatively flat, lowland areas usually with access to rivers for irrigation (e.g. coastal Peru, Mesopotamia, China, Egypt, Mexico and the U.S). A large body of geocological, historical, and ecological anthropological research has shown the need to take into consideration environmental variables in explaining the specificities of human organization in mountains. The uniqueness of environment-culture interactions has been shown for a range of montane agro-ecological systems, including: mixed agro-pastoral production [Alpwirtschaft], vertical control of a maximum of ecological zones [verticality], sectoral-fallowing, common herding, and common pasturing. This research suggests that an environmental focus on small-scale irrigation organization in mountains would yield significant returns.

A second question necessarily asked of any irrigation system is the nature and effect of its interaction with external political agents. The impact of external political agents on irrigation systems is of particular import today as states, faced with the need to feed growing populations, increasingly intervene in local water management by codifying and updating water laws, expanding agricultural ministries to implement the new laws, charging agricultural universities and research stations with finding better ways to transport, allocate and distribute water, training extension agents to acquaint farmers with the new laws and procedures, and designing ways to resolve conflicts. The efficacy of these managerial innovations is a much discussed aspect of contemporary irrigation theory and policy.

Substantive questions of the impact of external political agents on irrigation systems raise, in turn, important theoretical and policy issues associated with recent work in common pool resource (CPR) institutions and institutional analysis. Institutional analysis examines economic problems from a perspective of individual

choices, institutions and transaction costs. Institutions define the opportunity set within which choice is made but individual choice, aggregated into collective action, creates the institutional structure. Transaction costs represent the costs of obtaining the information on which individuals can base their decisions. Institutions represent, among other things, collective means to lower and manage transaction costs. CPRs are created to solve, through collective action, problems of free-riding, commitment, institutional innovation, and the monitoring of individual compliance with sets of rules (OSTROM 1990).

Institutional analysis offers innovative and powerful analytical tools to address many current issues in irrigation research. One example of its promise is its approach to an important relationship between irrigation, water property rights, and social organization, first noted by Leach in a study (LEACH 1961) of the village of Pul Eliya in then Ceylon. In the institutional economics literature, this relationship is treated as a subset of a larger set of questions concerning the structure of property rights, its origins, and the consequences for social interaction flowing from a particular structure of property rights. In taking up an institutional approach to the relationship, Coward suggests (1986) that the activities of water users in creating and maintaining their irrigation facilities establishes property relationships which become an important basis for collective action. This approach brings theoretical insights into irrigation organization in culturally diverse, but environmentally similar, mountain areas such as the Andes (GUILLET 1992) and the Himalayas (COWARD 1990).

The institutional paradigm provides, in addition, innovative analytic tools to investigate the efficacy of managerial innovations made by the state in local irrigation. Three influential models of common pool resources, Hardin's tragedy of the commons, the prisoner's dilemma game, and Mancur Olson's logic of collective action, all lead to a prediction that users of common pool resources will not cooperate to achieve collective benefits and justify a policy recommendation that external government authorities should impose solutions. Institutional analysis rephrases the issue as one of the conditions under which external agents facilitate or hinder the resolution of common pool resource problems. Institutional models of CPRs refrain from recommending external intervention; rather they suggests principles under which common-pool problems can be solved by voluntary associations (OSTROM 1990). Institutional models of CPRs thus have appeal for anthropologists who cite examples from the ethnographic record of small-scale groups able to successfully manage communal lands and forests, irrigation systems and fisheries through collective action. Ostrom has suggested, in this regard, a set of "design principles" helping to account for the success of long-enduring CPR institutions, including: clearly defined boundaries, collective-choice arrangements, congruent rules, conflict-resolution mechanisms, graduated sanctions, minimal recognition of rights to organize, and for CPRs that are part of larger institutions, the nesting of the aforementioned activities in multiple layers of nested enterprises. She advocates research to test these and other design principles in explaining the persistence of successful CPRs (OSTROM 1990: 88ff.).

## 2 RESEARCH OBJECTIVES, METHODS AND SOURCES

This research seeks to produce generalizations concerning the causes of organization for irrigation, to interpret historically the varying outcomes of state intervention in local irrigation, and to assess the efficacy of alternative forms of state intervention in irrigation. One goal will be to test an hypothesized association bet-

ween mountain environment and irrigation organization in a Spanish community. The hypothesis derives from the author's research in Peru and can be stated as follows. Mountain environments are characterized by patchy hydrology in which «each site in a mountain range is hydrologically unique, due to the almost infinite ways in which the meteorological and terrain controls may vary» (ALFORD 1985: 360). Microenvironments provided with the moisture, productive soils, and frost-resistance necessary for agriculture are intermittent and discontinuous in distribution. In addition, canals tend to be short, flow volumes low and service areas restricted in such environments. In these settings, one finds irrigation clusters as building blocks of irrigation organization --- small clusters of fields, water sources and landowners who share the local knowledge necessary to manage water in these microenvironments and reduce the transaction costs of information. The proposed research will evaluate the hypothesized association through an intensive ethnographic and historical study of a Spanish mountain irrigation system and its inclusion as one of a set of four cases of small-scale and large-scale irrigation to be compared systematically.

A second goal is to investigate the effect of the Water Law of 1985 and the new regional water authority (Consejo de Agua) on the institutional form of the local irrigation system and to compare it with three other cases described below. Current research suggests that rather than bending to the will of a dominant state, farmers in small-scale irrigation communities negotiate a set of «working adjustments» based on their use of formal and informal resources (e.g. the courts, mass mobilization, and «the path of quiet resistance»). In investigating the implementation of the laws and reforms in question, then, as a process of formal and informal negotiation, I will gather data on actors, arenas, resources, strategies and tactics.

The last goal will be to evaluate the effect of state intervention in the irrigation system of the Spanish mountain community in terms of the extent to which it hinders or facilitates the resolution of problems of free-riding, commitment, institutional innovation, and the monitoring of individual compliance with sets of rules. It will then be compared with three other cases described below. This research objective will contribute to determining the efficacy of alternative forms of state intervention in irrigation and to testing the design principles put forward by Ostrom (1990: 88ff) in explaining the persistence of successful CPRs.

A variety of ethnographic and historic methods will be used to address these objects. Ethnographic methods of interviewing and participant-observation will be used to survey irrigation systems. These systems possess a variety of informal structures of authority associated with main canals and irrigation community charters and formally recognized irrigation communities, the Comunidad de Regantes as called for by the 1879, and continued under the 1985, Water Laws. Research will be directed during the initial phase of the project toward understanding the range and scope of this diversity. Data will be collected on the characteristics of each irrigation system: size in irrigable area; number of irrigators; geographical boundaries; mechanisms for obtaining information on system states, methods for monitoring compliance; definition of water rights; sanctions for infractions by users; and, the selection, motivation, monitoring, rewarding and sanctioning of the performance of agents. The ordenanzas for each system, a useful source of information on authority structures, will be collected.

In order to explore the contribution that environmental variation makes to diversity in traditional irrigation systems, data will be collected on climatic (hydrology, sunlight, temperature, wind); edaphic (topography, soils) and biotic (flora,

fauna, disease types) variables. The results of this phase of the research will include a map of the region showing the distribution of traditional irrigation systems with their canal networks and service area. A database of environmental and institutional information on each system will be assembled. A variety of maps are available at scales of 1:25,000 (topographic) and 1:50,000 (topographic, crop, geologic, soils) which will be used in conjunction with planos parcelarios to map the systems.

A second dimension of the traditional irrigation systems, aside from their organization, is their performance. The dimension of performance that is of interest in this project is related to transaction costs. The ability of authority structures to resolve free-rider problems, ensure individual compliance and commitment, and define and measure water shares will be studied. Performance measures may come from case studies and records of litigation.

The Comisarías de Aguas, within the Ministerio de Obras Públicas, carry out important functions with respect to Comunidades de Regantes. They: (1) enforce the requirements that irrigators constitute themselves as Comunidades de Regantes where specified by law; (2), instruct and process applications for the formation of a Comunidad de Regantes and once accepted, bring the ordenanzas before the Ministerio for their approval; (3) grant concessions of water for irrigation, when the quantity is less than 20 liters/second and for industrial uses when the potential is less than 500 caballos de vapor. Larger quantities require approval of central organs of the Ministerio; (4) resolve appeals against decisions of the Sindicatos de Riego or the Juntas Generales de las Comunidades, where administrative channels have been exhausted; (5) exercise the function of canal police (policía de cauces); (6) approve the expansion of the irrigable area of the comunidades when there is no increase in the water source involved; (7) monitoring the processes for the removal of irrigators from their communities, etc. The records of the Comisarías de Aguas may be useful for providing light on system performance.

The organization and performance of these systems will be investigated in detail. In addition, research will address individual water use decisions, transaction costs, and the cultural knowledge appropriate for decision-making and institution-building in the domain of water. Conflicts, or the lack of conflicts, between the legal code of the state and informal management rules will be examined. Questions will include: how are rights to use the resource set by the community? How are these rights maintained and reinforced? Are there any existing social ties among the members of the community that influence reinforcement? What would be the benefits of establishing a collective management system for the resource in question (e.g. as opposed to privatizing the resource)? What are the costs of such a system (e.g. as opposed to privatizing the resource)?

Communal water management systems, in order to be effective, must be able to respond to change. Farmers modify cropping patterns in response to shifts in consumption, market incentives, and the desire for higher yields; the incorporation of New World crops such as maize and potatoes required subtle modification to water management. New irrigation technology (e.g. electric water pumps) displaced the old (water wheels, noria) forcing managerial adjustments. Ground water is pumped in excess allowing salt water infiltration in coastal areas and evoking managerial intervention. Precipitation declines, reducing available surface water. Communal water management systems must have the flexibility to adjust their subsystems of water transport, allocation and distribution accordingly. Excessively rigid resource management principles may present stumbling blocks and themselves have to undergo modification leading to institutional change. Robust CPR regimes are suffi-

ciently flexible to adjust to short term changes and contain mechanisms to allow efficient institutional changes to occur. Change in the principles of managing scarce and valuable resources always occurs within a political context which can hinder or facilitate individual innovation.

To study irrigation system performance and its response to change, a knowledge base of cases of actions take by the irrigation authorities will be assembled, whenever possible. Transcriptions of the minutes of canal offtake and irrigation community meetings, combined with informant explication, have proven in previous research to be an excellent source of data on water distribution principles and practices, and, when assembled over time, to offer valuable insights into the ability of the system to handle short term change. By analyzing transcripts of water management meetings over the course of an agricultural season, one can construct a model of the communal response to a serious drought, a method used by the author in his Peruvian research (GUILLET 1992) and by Glick to show systemic response to a drought in Valencia in the summer of 1413 (GLICK 1970:132-145).

Reconstructing the history of state interventions in irrigation is facilitated by rich archival resources. While some material on the history of state interventions in local irrigation is available in regional histories (e.g. RUBIO RECIO 1955), the bulk of primary data will come from oral history and personal, parish, consejo, municipal, provincial, and national archives. In each of the historical periods addressed in this study, the effect of water legislation, bureaucratic intervention and other agrarian policies such as subsidies and credit tied directly or indirectly to irrigation, on local irrigation will be investigated.

The archival resources that will be used to investigate the period of consejo water management prior to 1879 are various. Early concessions of water such as a grant made in 1315 by «el Infante don Felipe, hijo del rey don Sancho (IV), y su esposa dona Margarita» to the Cabildo of Astorga of the waters of the rio Orbigo to irrigate the village of Santa Marina del Rey (RODRÍGUEZ LÓPEZ 1907: II: 314) will help delimit the water management entities in question. Subsequent conflicts (pleitos) over water shed light on management principles, water rights and obligations. Such conflicts could be caused for a number of reasons: spring floods (avenidas) leading to shifts in the course of rivers, the construction of a new canal or mill, or differences between mill owners and irrigators. The documentary record associated with plietos is extremely rich and includes powers-of-attorney (poderes), testimony, sentences, agreements (convenios) and cartas ejecutorias. These documents can be found in several locations. Many are the archives of parishes and formal and informal village irrigation associations. Others associated with cases appealed to higher courts may be consulted in the ecclesiastical archives, the Archivo General de Simancas and the Archivo de la Chancilleria de Valladolid. The notary protocols kept in regional archives are a rich source of poderes and convenios.

Archives of senorial families such as the Archivo de los Condes de Luna in León is of especial interest, in this regard. It contains useful information for documenting irrigation system operation, ownership patterns and transfers during the Middle Ages which form the historical basis for contemporary population settlement and irrigation organization. A catalog to the archives was published by César Álvarez Álvarez and Jose A. Martín Fuertes in 1977.

The Catastro de Ensenada is an important complementary source to the pleito documentation for the 18th century. Together with various remurios, delimitaciones, apeos and foros, scattered throughout the documentary record, these materials can be used for reconstructing the location of canals (presas), dams (puertos), mills, place



names and other geographical markers for the study of irrigation. Madoz's *Diccionario geográfico-estadístico* is an obvious source for the mid-nineteenth century for villages of the region.

Some material is occasionally encountered in the archives of the numerous monasteries established during the repoblacion. Late in the period, one begins to see incipient special-purpose irrigation institutions emerging in concejo and wider administrative units. Notary protocols housed in the Archivo Histórico Provincial in Leon contain copies of contracts, court cases, and other documents associated with irrigation systems.

The impact of the 1879 national water law (*Ley de Aguas*) and other administrative reforms which transferred authority over water from concejos to the Gobernador Civil at the Provincial level, and through appeals to his decisions, to the Ministerio de Obras Publicas in Madrid is accessible to the scholar through a number of sources. The archives of ayuntamientos and juntas vecinales contain *Libros de Acuerdos, Ordenanzas, Memorias* and other documents useful for reconstructing rural and urban water management. The published *Ordenanzas* of each *Comunidad de Regantes* are another useful source. The Archivo General in the Ministerio de Obras Públicas y Transportes in Madrid contains materials on public works from the older Ministerio de Fomento for the mid-late nineteenth through the early twentieth centuries. One can find concessions of water made to local irrigation communities, ayuntamientos, grain mills and other industrial users; litigation over water rights; provision of urban potable water and drainage systems; various projects and plans to defend villages against spring floods. The *Registro de Aprovechamientos* in the Ministerio de Obras Públicas y Transportes is basic for reconstructing the time and spatial sequence of water concessions since the late 19th century. Other materials from the Archivo de Fomento are housed in the Archivo General de la Administracion in Alcalá de Henares.

The creation of the *Confederación Hidrográficas* in the 1920's to administer the hydraulic resources of the various watersheds and the construction of dams are major events in the contemporary history of Spanish irrigation. The Archivo General de la Administración in Alcalá de Henares contains important materials to reconstruct the hydraulic policies and actions of the Spanish state. The archives of the *Confederaciones Hidrográficas* of the Duero, Ebro and other rivers are essential for this period. Of seminal importance are the *Libro de Actas* of the *Comunidades de Regantes* formed largely in this century. They offer a detailed insight into the interactions between these irrigation communities and the various state agencies. Other archival sources which may prove useful for recent history, include the: *Delegación Provincial de Abastecimientos, Mapa de Abastos, Jefatura Agronómica y de Montes, Instituto Nacional de Colonización*, and the *Servicio de Concentración Parcelaria*.

### 3 THE RÍO ÓRBIGO

The valley of the río Órbigo in the province of León in northwestern Spain has been selected for intensive study. This river system originates in the confluence of the Omana and Luna rivers which descend the Cantabrian-Austurian mountains to eventually feed into the Duero river (TEIJÓN LASO 1948: 1949). Contemporary populations of the region trace their origins to settlements by small groups of people during the repopulation by Christian Spaniards after the expulsion of the Muslims (GARCÍA DE CORTÁZAR 1985). These settlements were established in suitable places along the river where diversion dams could draw water into open canals to irrigate

patches of fertile alluvial soils. During this period the Quiñones family established seigniorial dominion over the region (ÁLVAREZ ÁLVAREZ 1982). Ecclesiastical orders also established settlements (FERNÁNDEZ VARGAS 1980).

These settlements came to collectively manage the land, forests and other resources, including water, to which they had access. Local collective management was eventually institutionalized in the *concejo*, a tradition of Castillian communal life (CARLÉ 1968). The *concejo* persisted as local resource management vehicle through the late nineteenth century when it diminished in the face of administrative reforms (MANGAS NAVAS 1981). One of these reforms was the 1879 Water Law which called for the creation of special-purpose irrigation communities, *Comunidades de Regantes*. Many such communities were created in the *rio Orbigo* around the turn of the century, and later. Many, however, continued to operate along informal lines. The *Confederación Hidrográfica del Duero* formed in 1926 to manage irrigation throughout the greater *Duero* valley brought further state intervention in local water management. In 1952 the *Sindicato Central de Riegos del Embalse de Barrios de Luna* was created in anticipation of the completion of a large dam upstream of the *rio Orbigo* on the *rio Luna* in 1956. This dam changed the hydrology of the river, regularizing the flow of water to traditional irrigation systems and halting the seasonal imbalances that had led to flooding (*avenidas*) in the spring and abatement in August. It also brought water for irrigation to the heretofore rainfed *paramo* on the left side of the *rio Órbigo* (DE LLANOS Y SILVELA 1965). The new lands organized to receive the water released by the dam were organized directly through the *Sindicato Central*; the traditional irrigation systems incorporated into its administrative jurisdiction continued to operate through traditional forms (MOLINERO HERNANDO 1986). In the 1970's and later, most villages in the *rio Orbigo* went through a process of *concentración*, in which existing *minifundio*-sized plots were aggregated into larger-sized plots in order to achieve efficiencies of size and scale. Most recently, the creation of the autonomous *Junta de Castilla y León* and the Water Law of 1985 are producing as yet unclear impacts on traditional irrigation organization and performance.

Of the irrigation systems of the *rio Orbigo*, the *Presa de la Tierra* and the *Presa de Salvador* have been selected for intensive study. The *Presa de la Tierra* is one of the oldest, along with *Presa Cerrajera* and *Presa Forera*, of the *rio Órbigo*. From its *puerto* in the *termino municipal* of *Santa Marina del Rey*, it irrigates, through a complex system of main and branch canals, land in the villages of *Benavides*, *Gualtares*, *San Feliz*, *Villares*, *Moral*, *Hospital*, and *Villarejo del Orbigo*. The *Presa Salvador* system takes off water from the *rio Orbigo* within the *Termino Municipal* of *Santa Marina del Rey* and irrigates land within *Hospital de Orbigo*.

#### 4 COMPARATIVE IRRIGATION ORGANIZATION: PERÚ AND SPAIN

In order to support an hypothesis of an association between mountain environment and irrigation cluster organization, comparisons with a lowland, long-canal, irrigation system are necessary. I will employ a qualitative, holistic, comparison in which the Spanish mountain irrigation system will constitute one of a set of four cases. This research strategy is preferable to a variable-oriented and abstractly causal one, because the small number of well-documented mountain irrigation systems would make it difficult with multivariate statistical methods to arrive at an explanatory statement that conforms to statistical rigor. Moreover, the sensitivity of case-oriented comparative methodology to complexity and historical specificity overrides potential

limitations of limited generality and bias toward cases or coloring generalizations. Case-oriented research is particularly apt for addressing historical questions of state-locality relations where outcomes can result from multiple and conjunctural causes.

There will be two sets of paired comparisons; each set will contain a case from Peru and Spain with a long history of operation and interaction with a state. One set will represent mountain irrigation systems; the other, lowland irrigation systems characterized by long canals, high flow volumes and large service area. The Spanish mountain irrigation system will constitute one of the two cases of mountain irrigation; the other will be Lari in the Colca Valley of southwestern Peru. The lowland, long-canal irrigation systems will include the Ica Valley of coastal Peru and the Valencia huerta of Spain. The Ica and Valencia systems are quite similar in terms of long individual and total canal length, high flow volume and large service area. The Ica valley irrigation system is fed by a complex network of 25 major canals drawing water from the Ica river. The Achirana canal, the oldest and most important, provides water for about half (18,000 has.) of the cultivated area (37,000 has.) of the valley. In addition, around 500 wells now tap ground water reserves to supplement surface water sources (Oré n.d.: 5). The Valencia huerta contains 16,000 has. of land irrigated from 8 major canals taken off the Turia river and ground water from wells. Some canals are over 10 km. in length (MAAS AND ANDERSON 1978: 11-52).

Both river systems have experienced major intensifications of production and water use at a similar period in their history in this century. The cultivable area in Ica doubled during the period 1900-1930 in association with the shift to the cultivation of cotton for export. Valencia shifted to orange cultivation and grew at a prodigious rate (12.5 per cent per year) reaching a record level of production in 1930. In both cases, similar trajectories of improvements in hydraulic infrastructure provided the water for intensification: initially, through water pumped from ground water reserves and later through major state irrigation projects, the Choclococha reservoir project in Ica in the 1940's and 1950's and the Generalismo Reservoir in Valencia in 1950 (ORÉ n.d.; GLICK 1970:3).

The first step in the comparison will be to determine if all cases fall into the presence/presence or absence/absence cells of the 2x2 matrix. This would indicate initial support for an association of mountain environmental variables and irrigation cluster organization. Should this simple test of association be disproved, as typically happens because of causal complexity, other strategies are available for refining the argument such as identifying further conditions relevant to the outcome and isolating differences among instances of the outcome that may have been overlooked. The case-oriented method stimulates a rich dialogue between ideas and evidence and provide a basis for examining how conditions combine in different ways and in different contexts to produce different outcomes.

The four-case comparison will also be used to evaluate the efficacy of alternative forms of state intervention in irrigation. Both Perú and Spain have embarked in recent years on a course of direct intervention in local irrigation. In Perú, the enactment by decree of the 1969 Water Law marked the first serious attempt by the state to intervene in highland water management, transferring the ownership of water to the state, creating a state-chartered irrigation organizational hierarchy linking local irrigation associations with the region; establishing a system of water taxation; and providing for direct state participation in key communal resource management decisions including water allocation. Of particular significance, historically, were the provisions to create new, and strengthen existing, local government-chartered irriga-



tion associations and link them to a hierarchy of canal and regional levels of water management (GUILLET 1992). In Spain, the 1985 Water Law incorporates ground water into the same juridical status of public good as surface water, requires that water concessions fit watershed management plans, allows the state to intervene in the case of drought or excessive exploitation of aquifers, and calls for administrative oversight of irrigator communities. New regional autonomous communities are given the power, in conjunction with the 1978 Constitution, to tailor these provisions to local needs and characteristics through new regional water management authorities [Consejos de Agua] (ABRIL ABADÍN 1986). A four-case comparative methodology will allow evaluation of the efficacy of these legal and administrative changes with respect to short-canal mountain irrigation systems and long-canal lowland irrigation systems.

These cases have been selected because they have been the subject of the detailed ethnographic and historical analysis necessary for the ends of the research. The Colca Valley, in which the village of Lari is located, is the best documented valley in the Andes in terms of the ethnography and history of irrigation. Aside from my own, three other thorough studies of Colca Valley irrigation systems are available (GELLES 1990; GUILLET 1992; TREACY 1989; VALDERRAMA AND ESCALANTE 1988). The Ica Valley is represented by a major study of the Achirana canal by a Peruvian sociologist, Teresa Oré (1990; n.d.) based on ethnographic and archival research, oral history and published reports by hydraulic engineers. Valencia is the subject of extensive study in the secondary literature (see MAAS AND ANDERSON 1978: footnote 1, p. 411). The study of Maas and Anderson (1978) is an excellent institutional analysis of the Valencia system through 1968; updating the changes in the last twenty five years will require a short period of archival and oral history research in Valencia.

## 5 BIBLIOGRAPHY

- ABRIL ABADÍN, Eduardo (1986) «Propiedad y disposición del agua para el uso agrícola». *Revista de Estudios Agro-Sociales*, 134: 9-37.
- ALFORD, Donald (1985) «Mountain hydrologic systems». *Mountain Research and Development*, 5:4: 349-363.
- ÁLVAREZ ÁLVAREZ, César (1982) *El Condado de Luna en la baja edad media*. León: Colegio Universitario de León. Instituto Fray Bernardino de Sahagún.
- CARLÉ, María del Carmen (1968) *Del concejo medieval castellano-leonés*. Buenos Aires: Instituto de Historia de España.
- COWARD, E. Walter Jr. (1986) «State and locality in Asian irrigation development». In: K.C. Nove and R.K. Sampath (eds.) *Irrigation Management in Developing Countries*. Boulder CO: Westview Press pp. 491-507.
- (1990) «Property rights and network order: The case of irrigation works in the western Himalayas». *Human organization*, 49:1: 78.
- DE LLANOS Y SILVELA, Luis (1965) «Así nació el embalse de Barrios de Luna». *Órbigo*, 1: 10-14.
- FERNÁNDEZ VARGAS, Valentina (1980) «El señorío eclesiástico leonés y su importancia en la economía de la zona en la Edad Moderna». *Tierras de León*, 40: 41-66.
- GARCÍA DE CORTÁZAR, José Ángel (1985) «Del Cantábrico al Duero». In:

- García de Cortázar, E. Portela, E. Cabrera, M. González and J.E. López de Coca: *Organización social del espacio en la España medieval. La Corona de Castilla en los siglos VII a XV*. Barcelona: Ariel, pp. 43-83.
- GELLES, Paul (1990) *Channels of power, fields of contention: The politics and ideology of irrigation in an Andean peasant community*. Ph.D. Dissertation. Department of Anthropology. Harvard University.
- GLICK, Thomas (1970) *Irrigation and society in medieval Valencia*. Cambridge: Harvard University Press.
- GUILLET, David (1992) *Governing Ground: Communal Water Management and the State in Highland Perú*. University of Michigan Press.
- LEACH, Edmund (1961) *Pul Eliya: A village in Ceylon*. Cambridge: Cambridge University Press.
- MAAS, Arthur and ANDERSON, James (1978) *...And the Desert Shall Rejoice*. Cambridge, MA: MIT Press.
- MANGAS NAVAS, José M. (1981) *El régimen comunal agrario de los concejos de Castilla*. Madrid: Servicio de Publicaciones Agrarias.
- MOLINERO HERNANDO, Fernando (1986) «Tipología de los regadíos de Castilla y León». In: F. Sánchez López: *Los Regadíos de Castilla y León en el Marco de la CEE*. Salamanca.
- ORÉ, Teresa (1989) *Riego y organización: Evolución histórica y experiencias actuales en el Perú*. Lima: Tecnología Intermedia n.d. La Achirana. Ms.
- OSTROM, Elinor (1990) *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.
- RODRÍGUEZ LÓPEZ, Pedro (1907) *Episcopólogo austuricense*. 4 vols. Astorga: Imprenta de Pórfiro López.
- RUBIO RECIO, J.M. (1955) *La ribera del Órbigo*. Ph.D. tesis. Madrid: Facultad de Filosofía y Letras.
- TEIJÓN LASO, Evelio (1948) «Notas de geografía física sobre el valle de Órbigo». *Estudios Geológicos*, 9:3-50.
- (1949) «Introducción al estudio geográfico-humano de la región natural del valle del río Órbigo (León)». *Boletín de la Real Sociedad Geográfica*, 85: 231-309, 452507.
- TREACY, John (1989) *The fields of Coporaque: Agricultural terracing and water management in the Colca Valley, Arequipa, Perú*. Ph.D. dissertation. University of Wisconsin, Department of Geography.
- VALDERRAMA, Ricardo F. y ESCALANTE GUTIÉRREZ, C. (1988) *Del tata mallku a la mama pacha. Riego, sociedad y ritos en los Andes peruanos*. Lima: Desco.