

INSTITUTIONAL ASPECTS OF SUSTAINABILITY FOR IRRIGATED AGRICULTURE IN ARID AND SEMI-ARID REGIONS

Iván del Callejo¹, and Vladimir Cossío¹

ABSTRACT

Concerns, arguments, and approaches to sustainability are exposed in both scientific and technical irrigation literature which is based on the priority of food production and water preservation as a basic resource. Different approaches related to sustainable irrigated agriculture are identified beyond the technical considerations of irrigation as dealt with by very specialized scientific literature. These focus on socio-economic and institutional aspects of irrigation management. In this chapter, four main approaches are discussed: “New institutionalism” is an approach which emphasizes economic and financial issues such as cost recovery and the role of the market in water rights reallocation. A second approach, “Common pool resources management” highlights the role of local organizations and institutions with respect to collective water management, and the possibilities to design “robust institutions” considering the involvement of different stakeholders, not only (state) authorities. A third is identified as the “Empowerment approach”. In this approach, topics such as power relations, autonomy, gender relations, as well as water rights and access are considered as key elements configuring water management practices in irrigation systems. Finally, there is the “Post-institutional approach”. It outlines concepts such as “institutional bricolage”, uncertainty, and legal pluralism used as analytical elements to understand the dynamics and complexities of irrigation development. In conclusion, different levels to analyze sustainability are discussed from an institutional perspective by identifying key knowledge gaps and the need to integrate some of the elements found in the different approaches.

Key words: institutional approaches, irrigation institutions, water management, sustainable irrigation.

INTRODUCTION

Sustainability is an important topic in development intervention and discourse, especially related to the use of natural resources. Concern comes from evidence of the depletion and deterioration of resources, particularly water.

This paradigm has become mandatory for governments, donors, practitioners, and a generalized concern in international spheres during the last three decades. At the same time, it has constituted a strong argument to get funds for development programs and projects implemented by governments and non-governmental organizations (NGOs).

Within academic spheres, the topic has also been dealt with from different perspectives, some trying to specify and present explicit content, others advocating its importance without providing concrete measures, and finally other streams tend to be prescriptive by applying

in “developing countries” what is supposed to be working in the “developed world”.

It is generally agreed that sustainability is understood as “the need to ensure the preservation of natural resources involved in economic activities over time for future generations”. In this context, sustainability of irrigated agriculture is an obvious issue because it relates two key, mutually dependent and critical global concerns: food supply and water access and use.

DIFFERENT PERSPECTIVES OF SUSTAINABILITY OF IRRIGATED AGRICULTURE

More than three decades ago, the main concern in agriculture was technological problems to meet a rapidly-growing food demand. Nowadays, it can be said that technological development has allowed reaching unsuspected yield levels by improving different components of the production cycle. Everson and Gollin (2003), quoted by Zhang *et al.* (2007), attributed 21% increase in yield to the use of plant breeding technologies, 20% to the expansion of the agricultural area, and 59% to

¹Universidad Mayor de San Simón, Centro Agua, Cochabamba, Bolivia (ivan.delcallejo@centro-agua.org; vladimir.cossio@centro-agua.org).

the intensive use of agricultural inputs, of which irrigation has a big share. Main concerns related to sustainability of irrigated agriculture tend to look at it only from a technological point of view and thus related to the optimization of inputs, efficiency, and profitability (Gruhn *et al.*, 2000; Khan *et al.*, 2006; Wichelns and Oster, 2006; Haie and Keller, 2008).

Some literature about peasant or small farmer agriculture in Latin America supports the modernization approach by questioning the viability of such a production method (Kay, 1997). This issue is mainly based on neoclassic economic approaches that perceive peasant agriculture as “disconnected” from the market and outside a modernization process. Inefficiency, low profits, poor technology, very low yields, lack of specialization, and subsistence agriculture qualify this agricultural method (Bebbington, 1999).

Besides technological improvements of agricultural practices and the large areas incorporating irrigation, water application was also modernized. Sprinkler and drip irrigation are good examples of this. Although important outcomes were reached in terms of water savings, other issues are still unresolved such as energy supply, financial constraints, information, and technology access for isolated regions and small farmers.

As regards water management practices in irrigation schemes, there are also several recommendations for more efficient irrigated agriculture through water application modernization (irrigation method), and also from an institutional perspective. Water (and irrigation) reforms seeking more “efficient” arrangements at local and national levels are part of these recommendations especially in countries where the State plays a major role in irrigation management. They are based mainly on the assumption that external (private) agent participation can positively influence irrigation performance, thus becoming more “durable and efficient institutions”. Arguments for implementing such reforms are typically bureaucracy, technical deficiencies, politics, and corruption, all of which are attributed to State irrigation management settings (Bromley *et al.*, 1980; Small and Carruthers, 1991; Small and Svendsen, 1992).

On the other hand, in countries with a long tradition of collective or communal management arrangements, prescriptions have been the same, although arguments are different. Collective water management systems are supposed to unequivocally fall in a “vicious circle” of inefficiencies, lack of maintenance, and management drawbacks leading to the famous “tragedy of the commons” described by Hardin (1968) and Ostrom (1990).

During the 80s, some emerging alternative streams criticized such a production model and sought equilibrium between productive and economic goals,

and environmental goals. Hence, new concerns become evident such as soil and water conservation practices. Parallel to technological disciplines, social sciences have contributed in developing a better understanding of irrigation problems, and the relationship between agriculture, local management practices, and peasant dynamics during the last two decades.

Ethnographic studies, for instance, describe in detail the different organizational forms, cultural manifestations, and values related to water, thus trying to explain implications on water management practices and embeddedness in historical processes. Besides analyzing internal complexities in collective (communal) irrigation schemes, these studies have helped in understanding the interrelations (or disconnections) of types of local water management with state institutions, mutual policy influences, and possible biases imposed by different visions of water and development prevalent in each country or region (for the Andean region see: Gelles, 1994; Guillet, 1992; Gerbrandy and Hoogendam, 1998; Trawick, 2001). Some of these studies also give evidence that refutes the “tragedy of the commons” as stated by Hardin (1968).

This chapter focuses on institutional issues related to sustainability of irrigated agriculture and applying the different trends and approaches discussed above-mentioned on fundamental institutional components. The core of the chapter is a critical review of the main institutional approaches and a summary of key elements that need to be discussed and complemented to better understand the complexities of irrigated agriculture.

STATE OF THE ART ON INSTITUTIONAL ASPECTS OF IRRIGATION

Literature on institutional issues is diverse, particularly in relation to water resources. Geographically and historically, concerns have evolved in different directions, promoting the evolution of different conceptual approaches at the same time.

Three main groups of studies can be described which are related to the recent historical processes in different countries in Africa, Asia, and Latin America. One group is represented by studies carried out in some African or Asian countries in the post-colonial period where the need to reconfigure society, especially institutions, was the main focus of (new) governments (see examples in Nemarundwe and Kozanayi, 2003; Mtisi and Nicol, 2003a; 2003b; Jayanath *et al.*, 2006). In these cases, it is possible to find very diverse literature: some advocating the need to formalize institutional arrangements, others defending local and communal settings and arguing the complexities of each socio-political context and criticizing the former context.

The second group corresponds to Latin American countries and some Asian countries which in spite of a longer period of ‘independence’ and supposed sovereignty, were (and still are) subject to neoliberal influences imposed especially by multilateral donors, namely the World Bank (WB), Inter-American Development Bank (IDB), and the International Monetary Fund (IMF). These measures were typically represented by national reforms such as the so-called “structural adjustments” restructuring State administration, decentralization, privatization, and liberalization of economies (including natural resources) to the market. These processes were closely related to institutional (re)setting, especially redefining the role of the State as regards natural resources management and control. Literature is also diverse in this group: some emphasizes descriptions (critically or not) of such “adjustment” processes (see Saleth and Dinar, 1999a who present a cross-country review), others show documental cases on the application or failure of “mainstream approaches” (see cases and analysis in Yoder, 1994; Merrey, 1996). In the case of Andean countries, a lot of literature is found in which socio-cultural practices, ethnicity, and gender issues are discussed (Cremers *et al.*, 2005; Boelens and Gelles, 2005).

The third group constitutes cases in which neoliberal measures are already taking place. In South America, the most relevant case is Chile where the Water Code has promoted liberalizing water rights and water (irrigation) administration to the market, thus promoting substantial change in irrigation management towards providing services and replacing any form of common property and communal management. Although the law considers water resources as common property, for all practical purposes, its use is treated as *de facto* private property connected to land (Saleth and Dinar, 1999b).

Neither simplifying reality, nor minimizing the efforts of academic and development practitioners, four main approaches were identified and systematized based on the review of recent literature, although it is possible to find a huge amount of literature containing specific trends, emphasis, concepts, and tools. The four approaches are: New Institutionalism (and New Institutional Economics), Common Pool Resources Management (CPRM), Empowerment, and Post-Institutionalism.

New institutionalism

New institutionalism perspectives are based on the New Institutional Economics (NIE) theory which focuses on the administration of water resources based on “market forces” that are supposed to do a better job of (water) resource allocation and regulation. New institutionalism “...primarily focuses on the creation of financial and other incentives by markets and institutions to improve

the economic efficiency of resource use” (Boelens *et al.*, 2005). Key concepts under this approach are:

Institutions. In this approach, institutions can be understood as “entities defined by a configuration of legal, policy, and organizational rules, conventions, and practices that are structurally linked and operationally embedded within a well-specified environment” (Saleth, 2004). This approach focuses on the structure of institutions, thus promoting better management through improving institutional structures. This means that institutions can be designed. However, several researchers advocate considering not only the structure of institutions but also the characteristics of the context in which institutions are embedded: socio-economic, political, cultural, and water-related environments (Saleth and Dinar, 1999b; Jayanath *et al.*, 2006). Saleth, 2004 quoting Williamson 1975; North, 1990 stated that “institutions can be decomposed by distinguishing the institutional structure (or, governance structure) from its institutional environment (or, governance framework)”. Institutional structure refers to legal frameworks, water policies, water management, related organizations, and local organizational practices. Cultural and socio-economic specificities of the countries are considered part of the institutional environment.

This approach is strongly related to policies of structural adjustment, legal reforms, privatization, and decentralization promoted at the country level. As regards irrigation, new policies and laws have been promoted as institutional measures to “increase efficiency” of water allocation and management in many developing countries (for Asia, see Molle, 2005; Bandaragoda, 2006 for example).

As part of these reforms, Irrigation Management Transfer (IMT) programs aimed at transferring the administration of large-scale irrigation schemes from state agencies to irrigation users were implemented worldwide as an important measure in the irrigation sector.

However, the application of reforms at country and irrigation scheme levels has been widely questioned, mainly in relation to the lack of consideration of local conditions and specific characteristics of local water management, and the top-down structure in which they were generally applied (Bandaragoda, 1998; 2006; Shah *et al.*, 2002; Molle, 2005).

On the other hand, the famous “tragedy of the commons” (Hardin, 1968) has been an argument to support institutional reforms under this approach. Applied to irrigation, such a “tragedy” means that a rapid deterioration of infrastructure and management tasks will occur as a consequence of private strategies followed by each irrigator (explained in terms of “social costs”) followed by a vicious circle of less incentives or refusal

to pay for services. The World Bank (1997) argues that these outcomes leave everybody worse off and thus, regulation (as part of institutions) is seen as the solution to prevent free riding. Following the new institutionalism perspective, avoidance of the “tragedy of the commons” also leads to consider water rights, cost recovery, and accountability issues.

Water rights. Under the New Institutionalism perspective, a key element is the formalization of water rights, assumed to be a condition for developing “water markets” and an “efficient regulatory framework” also resulting in “zero transaction costs” (Rosegrant and Binswanger, 1994). Water rights are seen “as the legal complement to technical infrastructure and institutions, the three of which are necessary for an effective allocation and distribution of water...” (Boelens *et al.*, 2005).

Cost recovery and accountability. To adequately manage water, irrigation agencies should, as it were, sell their services to those clients who are willing and able to pay for them, thereby recovering management costs and a part of the investment costs from users. Financial autonomy is, along with cost recovery, the most important mechanism (as identified by neoinstitutionalists) to bring about accountability (Boelens *et al.*, 2005).

Common Pool Resources Management (CPRM)

Just like new institutionalism, Common Pool Resources Management theory has a strong institutional focus, that is, on the need of adequate institutions to improve natural resources management. However, it is different because for new institutionalism, “...privatization and external control were seen as the only ways to solve this so-called ‘commons dilemma’. However, privatization and state regulation have not, in all cases, lived up to expectations, sometimes even causing or accelerating degradation of the CPR” (Steins *et al.*, 2000).

Empirical research states that: “... individuals with an interest in a CPR are not by definition locked in a position that leads to “tragedy”, but that individuals can work together in crafting rules regulating the benefits produced by a CPR. In other words, decision-making arrangements, or institutions, provide a mechanism to transcend the commons dilemma and may prevent the resource from degrading” (Steins *et al.*, 2000, quoting Wade, 1988; Ostrom, 1990; Bromley *et al.*, 1992).

Considering the particularities of common pool resources, this approach has widely discussed the institutional settings necessary for their management. Thus, one of the sound characteristics of this approach is the promotion of collective management considering stakeholder involvement and not just the democratically

elected authorities, based on theories of communicative rationality encouraging the formation of watershed and other kinds of stakeholder platforms (Steins *et al.*, 2000). However, the main critics of this approach are related to assumed “rational decision-making processes” which disguise the consideration of power relations between stakeholders (Cleaver, 2000; Edmunds and Wollenberg, 2001; Mtisi and Nicol, 2003b).

Most irrigation systems show essential characteristics of a common property regime. Many cases in the literature, mainly in Asia and the Andean region, stress the good performance, high accountability, and sustainability characteristics of irrigation schemes managed by autonomous community-based irrigation organizations (Yoder, 1994; Boelens, 1998; Gerbrandy and Hoogendam, 1998), and showing them as a good alternative to private property and state management approaches (Blomquist and Ostrom, 1985; Bon, 2000). The eight design principles for sustainable farmer-managed irrigation systems (FMIS), as stated by Ostrom (1990), highlight the potential of this type of management.

This institutional and design approach has been questioned by arguing that it might not be applicable in some cases (Steins *et al.*, 2000) considering the complex and particular characteristics of collective action (Cleaver, 2000).

Empowerment

Opposing the “New institutionalism approach”, a strong line of thought and literature have emerged, as a vindicatory claim against injustices, inequities, biases, etc., that are evidently present in any form of natural resources management and access. This stream is known as the “empowerment approach” and is based on the following concepts and considerations:

Institutions. Institutions, basically seen as rules and norms, are considered as dynamic processes in which different stakeholders meet, confront, and negotiate to include their ideas and interests in the organizational, technical, and normative design of a system (Gelles, 1998; Boelens, 2000). Processes of peasant strengthening, resistance, and appropriation, as well as the eventual construction of more equitable social relations occur within this same reality and are necessarily led by the vulnerable or less-privileged sectors (Boelens and Doornbos, 2001). Seen from the empowerment perspective, participation in irrigation design is a key political process to be considered in any intervention or reconfiguration of irrigation institutions (Boelens 1998; Mollinga, 1998).

People often aim to increase their control over water, system management (e.g., access to decision-making), agricultural production process (e.g., controlling inputs

and outputs), or user group activities, and behavior in general (e.g., controlling their votes, labor, etc.).

So, stakeholders may be part of the same water user groups, but this perspective also highlights the explicit and implicit interests of “outside” parties that intervene in the irrigation design process. Empowered participation means that the socio-political struggle of certain groups (e.g., marginalized, oppressed) is supported. Change may be catalyzed, but cannot be carried out by supporting institutions or professionals. Basically, empowering participation must come “from within” since it is a process of self-mobilization and creation of autonomy. Increasing local capacity for negotiation and claim-making power are important objectives, and the perspective generally extends beyond the irrigation system level (Boelens, 1998).

Power relation. The objective of empowerment involves important challenges for organizations working on development cooperation. In the first place, prior to a project design, it is necessary to analyze the socio-economic relations and other dynamics that generate vulnerability and lack of power, which allows interpreting people’s aspirations in a wider context and perspective. As a result, interventions will sometimes have to emphasize material objectives and sometimes reclaiming rights. In the second place, the philosophy of empowerment forces cooperation agencies not only to listen and consider the perceptions and objectives of persons with whom they work, but giving up being a protagonist, limiting themselves to be mere facilitators. Empowerment is not an asset that can be granted, but a dynamic process in which people are the protagonists through their individual and collective efforts (Murguialday *et al.*, 2005).

The setting or adaptation of water uses and rights imply hard confrontations between individual users or collective sectors and are not grounded on harmonic negotiations. Less powerful groups also have conflicts among themselves, and furthermore, often suffer the consequences of “water rights re-ordering” in a wider context, especially with other sectors with stronger stakeholders (Boelens *et al.*, 2001).

Collaborative platforms and discussion forums must include the interests expressed and outlined by “usual formal negotiators”, but also those of less visible, less suitable, and less organized groups. Inclusion of the interest and perspectives of these sectors implies the need to formulate and defend a non-partisan vision and accompany them in a specific and concrete way in “the negotiation forums” (Boelens *et al.*, 2001).

Empowerment may be a strategy favoring an increase in the power of marginalized groups that can gain access to the use and control of material and symbolic

resources, participate in, and influence social change. This also includes a process through which persons will be conscious of their own rights, capabilities, interests, and their relationship with the interests of other persons, with the aim of participating in decision-making from a more solid position (Murguialday *et al.*, 2005). Friedman (1992) pointed out that empowerment is related to the access and control of three types of power: a) social, understood as the access to the productive wealth base; b) political, or access of individuals to the decision-making process, especially in relation to issues that affect their own future, and c) psychological, understood in the sense of individual potential and capability.

Rowlands (1997) indicated three dimensions of empowerment: a) personal, development of self esteem, self confidence, and individual capacity; b) near relationships, capacity to negotiate and have influence on the nature of relations and decisions, and c) collective, participation in political structures and collective action based on cooperation.

As observed above, empowerment fundamentally has an individual and a collective dimension. The individual dimension implies a process through which the excluded parties raise their levels of confidence, self esteem, and capabilities to meet their own needs. The collective dimension is based on the fact that vulnerable persons have a greater capacity to claim and defend their rights when they join with common objectives (Murguialday *et al.*, 2005).

Water rights and access. Water rights are generally referred to as water access, infrastructure use, and participation in system management decision-making. Users create water rights through their involvement in the construction and participation in the maintenance and rehabilitation of the system.

“Right” is defined as a political and dynamic construct reflecting different economic, cultural, and institutional objectives, as well as the power relationships of the social groups involved. These “internal” and “external” stakeholders dispute and negotiate the rules of the political forum that constitute the development of the peasant irrigation system. In this dynamics, current rights are not determined, but rather nurtured by tradition and practice.

Boelens and Doornbos (2001) indicated that there is a relationship between water rights and power. Power can define and determine rights whereas rights can reaffirm and legitimize power.

Accompanying organizations face an important challenge with reference to supporting the legitimization of peasant irrigation rights. These rights are a group of contemporary norms that are permanently modified and it is not desirable, even impossible, to try to institutionalize

the explicit contents of these rights in national legislation where they can lose their innovative and proactive capability. Rights only make sense in the specific context in which they have been created.

The relationship between water and power causes a dilemma. It can promote the organization of a group in the search for a common asset (water), or generate conflicts among stakeholders (Boelens and Hoogendam, 2001).

Gender and disadvantaged groups. Murguialday *et al.* (2005) stated that in the diverse pro-women policy approaches, the strategy named “gender and development” has been the one which has more widely incorporated the concept of empowerment. It is understood as a process of change through which women have increased their access to power, and consequently transforming unequal gender relations (gender, gender training, culture and development, gender equality, gender interests and needs, gender and health, frameworks for gender analysis, gender policies, and gender roles) as women acquire and exercise their rights to satisfy their practical and strategic interests. From this perspective, empowerment of women and other disadvantaged groups implies:

a) Consciousness about their subordination and raising self confidence (“own power”).

b) Autonomous organization to decide about their lives and the progress they wish to achieve (“power with”).

c) Mobilization to identify their interests and transforming relations, structures, and institutions that limit and perpetuate subordination (“power to”).

This way of understanding empowerment of women does not identify power in terms of dominating others, but as raising self esteem, skills, education, information, women’s rights, and definitely as the control of the fundamental resources aiming to influence developmental processes:

a) Material resources: physical, human, or financial (water, land, machinery, work, and money).

b) Intellectual resources: knowledge, information, and ideas.

c) Ideological resources: facilities to generate, propagate, sustain, and institutionalize beliefs, values, attitudes, and behaviors.

Longwe and Clarke (1994) elaborated an analytical framework called Framework of Equality and Empowerment of Women which established five levels of equality among women and men, and their achievement reflects the level of development and empowerment of women in any area of economic and social life. These five levels are referred to as material well-being, access to productive factors, gender consciousness, participation in decision-making, and control over resources and benefits.

The authors outlined that there is a mutually reinforcing, dynamic, and synergetic relationship between these five levels of equality. That is to say, power acquired by women in accessing resources is motivation for major gender consciousness; this consciousness giving the necessary impetus for greater participation in decision-making, promoting greater control over resources and benefits, meaning that women have, together with men, the power to influence their destiny as well as the destiny of their societies. Following this framework, the five levels of equality should be present in a development project if it is to contribute in overcoming gender inequality.

Autonomy. Empowerment has a narrow relationship with the approach of human development and with several other related dimensions: community participation, collective decision-making, good governance, etc. Keller and Mbewe stated in Moser (1991) that development would be an empowerment process: “the process by which people are able to organize to increase their own autonomy, to make worthwhile their independent right to make decisions and to control the resources that will help them to question and eliminate their own subordination”.

Murguialday *et al.* (2005) stated that for development agencies, the United Nations, the World Bank, or some statesmen, the term empowerment means an increase in individual capacity to be more autonomous and more self-sufficient, to depend less on the State’s provision of services or employment, as well as having a more venturesome spirit to create microenterprises and climb the social scale. It also implies improving access, as much to markets as to political structures, with the purpose of participating in economic and political decision-making. In short, it assumes a kind of participative process, but doesn’t question existing structures.

Post-institutional approach

Many attempts have been made to strengthen institutional arrangements for irrigation management. The most popular studies followed the so-called “Design principles” as suggested by Ostrom (1990; 1992). (See cases in Africa and Asia in Nemarundwe and Kozanayi, 2002). Some criticism has emerged regarding applying the common property resources management approach and its design principles. In fact, it is possible to affirm that failures in applying these principles motivated the emergence of the so-called “post-institutional approach”.

Cleaver and Franks (2005) stated that the literature tends to “emphasize the formalization of institutional arrangements, the codification of rules and regulations, the specification of clear authority structures, and the strict exercise of sanctions against ‘free riders’”.

Three principal streams of criticism are devised by the same authors as regards the conventional “design principles” promoted by the Common Property Resources Management Approach:

a) **Narrow functionalism.** The trend to consider and separate people as a function of the institution and resource to be managed (irrigators, fishermen, etc.), and the outcomes produced in terms of more effective resource management, leading to a very partial understanding of their motivations for collective action, and also simplistic assumptions about relationships between rules and decision-making structures within institutions.

b) **Simplistic evolutionism.** Institutional theory assumes an almost linear path which institutions can (or should) follow, going from a weak to a strong operation (Ostrom, 2000). “The fallacy is to equate institutional viability with fixed and formal structures and to present a static view of evolution” (Rocheleau, 2001, quoted by Cleaver and Franks, 2005).

c) **Understanding social complexity.** Neither communities nor resources consistently exist within clear boundaries (Berry, 1994). Natural resources are not simply commodities, but are invested with social and symbolic meaning to people (Mosse, 1997; Cleaver, 2000) whose decisions about them can differ from external perceptions of efficiency and optimization.

Object of study. A post-institutional approach focuses on the dynamics of social behavior and the way in which institutions are constantly shaped and re-adapted by collective action. Institutional formation is thus re-conceptualized “as a socially embedded process rather than a deliberate and transparent managerial activity...” (Cleaver and Franks, 2005). Such a view obliges having different levels of analysis, starting from household or group-institutional arrangements to the irrigation system, or municipal and catchment arrangements. Key concepts embedded in this approach are:

Institutional “bricolage”. The post-institutional approach looks at institutions neither as static nor as “robust” structures within which human behavior is supposed to be defined. On the contrary, institutions are conceived as a “bricolage” of different rules, social and power relations shaped by continuous collective action resulting in a diversity of arrangements at different levels. Institutional bricolage is defined as a process of “patching together of institutional arrangements from the cultural resources available to people in response to changing conditions, based on the logic of dynamic adaptation (Chase-Smith *et al.* (2001) quoted by Cleaver and Franks, 2005). Furthermore, “Social institutions are not things,

they are what people do, and institutions by their nature are not necessarily robust, solid, and enduring, but must be continually reproduced or re-enacted to exist”. Therefore, key issues are: historical factors, power relations, and world views (cultural repertoires).

Legal pluralism. In the basic framework describing institutions, the law is conceived as a core issue because of its supposed mandatory, regulatory, and safeguarding character as regards social relations and interrelations between people, natural resources, and the State.

However, there are different perspectives to analyze the law. Under new emerging approaches, including the post-institutional approach, the law is conceived, not as absolute and prescriptive as it usually is, but as a “social resource”, ... “given the different interests, options, constraints, dilemmas, and choices, and as a part of strategies that people develop to reach their goals” (Spiertz, 2000, quoted by Boelens *et al.*, 2005). Under the legal pluralism approach, the law is not recognized as an exclusive prerogative of the State. On the contrary, it recognizes how social practices shape local and national norms by conforming a pool of co-existing normative frameworks. The concept of “human agency” is useful to understand the law as social resources and ... “the social significance of law should start from human experience and behavior” (Boelens *et al.*, 2005).

Uncertainty. The post-institutional approach suggests the issue of uncertainty should be considered more seriously. Mehta *et al.* (1999) suggested four types of uncertainty relevant to people’s use of natural resources: a) Ecological uncertainty: due to variability and (un)predictability of natural processes; b) Livelihood uncertainties: related to the unpredictable nature of ecological, economic, and social processes affecting local livelihoods; c) Knowledge uncertainties: related to the partial and incomplete nature of different kinds of knowledge; and d) Social and political uncertainties.

Livelihoods. The fourth main concept in the post-institutional approach is livelihoods. It is necessary to state the different views that exist in the literature about livelihoods. Some of them, related to common property resources theories, conceptualize livelihoods as “a means of living”, which straightaway makes it more than merely synonymous with income, “...a livelihood comprises the assets (natural, physical, human, financial, and social capital), the activities, and the access to these, mediated by institutions and social relations that together determine the living gained by the individual or household” (Ellis, 2000).

In addition, Scoones (1998) discusses the concept of sustainable livelihood, referred to as when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets while not undermining the natural resource base.

On the other hand, Cleaver (2000) and Mehta *et al.* (1999) discussed the idea of livelihood in a different way, criticizing the views of Ellis (2000), Scoones (1998), and others because of their functionalist view towards formalized prospects of institutional arrangements and designs. On the contrary, both authors proposed a different concept of livelihoods, beyond the economic conception of assets, but "...as a conjunction of activities and actions shaped by the prevailing cultural milieu"; "...livelihoods are not simply technically and economically rational sets of survival strategies in varying contexts, but are "...clearly linked to ideas about a way of life, to practices in relation to resources, to other people, and to aspirations that are heavily loaded with symbolic meaning" (Mehta *et al.*, 1999).

GAPS IN THE ANALYSIS OF INSTITUTIONAL IMPLICATIONS AT VARIOUS LEVELS IN IRRIGATED AGRICULTURE

The literature review on institutional issues has shown that topics are mostly covered in scientific and non-scientific literature. Some of the literature tends to be prescriptive (for instance, designing and evaluating institutional arrangements); another portion is more in the field of narrative literature to share (un)experiences about specific water management themes, and another (approaches) tends to develop some criticism around mainstream approaches, advocating broader and more flexible approaches, but with difficulties to propose concrete instruments or actions.

Table 1 is an attempt to summarize a group of subjects or concepts that are dealt with in the different levels of

analysis on irrigated agriculture from the previously identified approaches. Following this summary, a discussion of the main gaps in institutional aspects and emerging questions is presented, helping in the analysis of sustainability of irrigated agriculture.

Table 1 helps to identify main gaps at different levels as dealt with by the different approaches. These gaps can be summarized as follows:

- Analysis of the different levels identified supports the statement that most irrigation literature is mainly concerned with physical and technical aspects, especially at a plot level (studies on water efficiency and productivity), as well as the irrigation system level (studies on irrigation management performance). The other two levels, production unit and watershed, are mainly discussed in a theoretical way.
- At the production unit level, it is possible to identify three main approaches: i) Based on farm management economics, it is concerned with aspects such as profits, income maximization, cost-benefit analysis, shadow prices, efficiency, and other concepts from neoclassical economics; ii) A second approach deals with peasant agriculture, especially in developing countries. It is based on perspectives of "peasant economics" and mainly concerned with the social relations of production, reciprocity, complementarity, commoditization and non-commoditization patterns, production, and use values, etc.; and iii) A third approach is "peasant and livelihood strategies". It recognizes the multiple activities in which rural people are involved in and from which they earn their livelihoods.
- From the previous discussion, it is also possible to conclude that because of the main focus of the different approaches at the plot and system levels, there is a gap in the analysis of the relationship between agricultural and irrigation practices at the production unit (farm) level and water management arrangements at the system

Table 1. Levels of analysis and gaps of different approaches.

Plot	New institutionalism	Common pool resources	Empowerment	Post-institutionalism
Production unit				Livelihoods Uncertainty
Irrigation system	Irrigation management transfer Property rights Accountability	Principles for institutional design	User participation, control	Uncertainty Legal pluralism Bricolage
Watershed		Watershed management Watershed platforms		Environmental uncertainty
Sub-national and national	Policies and laws	Policies and laws		Uncertainty Legal pluralism

level. This means that neither the role of irrigation as a key factor of agricultural development is clearly analyzed nor are the conditions and requirements generated by agricultural practices towards irrigation system management (performance). These kinds of relationships can only be analyzed by conceiving irrigation not only as a purely technical activity, but recognizing it as a complex socio-technical process.

- The plot level seems to be irrelevant for institutional analyses since it is the place where most of the physical implications of agricultural practices are evident, and consequently, are treated in physical terms: efficiency, environmental effects, soil conservation and degradation, etc.
- Although an integrated approach to water management is encouraged by mainstream discourse (including policy makers), the difficulties of such integration are evident in practice. On the contrary, most irrigation literature on institutional aspects (e.g., the one under new institutional approaches) concentrates on (irrigation) sector overviews and very little on inter-sector relationships despite the need to focus on local, sub-national, or national levels and their interactions.
- Though common pool resources theory analyzes different dimensions related to irrigation, there is still a gap in the analysis of irrigation systems (and other use sectors and management) from a watershed perspective. There is a big discussion about the watershed as a planning unit and the need to integrate multiple uses and users within it. However, this approach is mainly developed in a theoretical way, and there are few or no current experiences in this field.
- The empowerment approach generally uses multi-level focus and analysis, but experiences and actions following this approach are still mainly concentrated at the irrigation system level from a sector perspective (irrigation sector) and concerned more with water access and participation issues.
- Post-institutional approaches seem to treat the issue from a wider perspective, but focused above all on criticizing mainstream approaches (New Institutionalism and Common pool resources theory), offering interesting emerging views and new interconnected concepts, though in some cases inadequately developed.

CONCLUSIONS

Common elements to analyze institutional aspects of irrigation. Although it might seem obvious, it is necessary to remark that institutional analysis under different approaches coincides with the general elements

used: institutional structure and administration, local arrangements and practices, norms and legal framework, and policies. Although, with some specific features, a common element is also the way in which institutions are conceived, not only as a state or formal structure, but mainly as rules that govern people's interactions.

On the contrary, the differences among the approaches are the specific elements that are used to analyze institutional dynamics and their practical implications: some consider the structure and the need to formalize rules under state law and administration as being more important, and others recognize the role of collective action as the driving force that shapes institutional functioning.

The multi-level dimension of water and irrigation institutions. Institutions are not necessarily fixed structures, on the contrary, they play a dynamic role, have influence and are manifested at different levels: country level, intermediate level (departmental and provincial), and local level (municipality, community). It is important to clarify that these levels are not always related to formal state organizations. Although there is a trend to attribute formality to upper-level institutions and "informality" to local institutions, this separation is not obvious.

This means that some institutions, at whatever level, may be legally recognized and vested with some tasks in relation to water, and others that might not be legally recognized are involved in water issues based on so-called "uses and customs" (consuetudinary arrangements).

The different levels in which institutions are present at the same time constitute "resources" (institutional) that people or water user organizations use to guarantee or protect their access to water. These characteristics also allow people to cope with different kinds of uncertainties found in agricultural activities. As stated by post-institutional analysis, people may use different institutional frameworks, whether formal, informal, or a combination of both. This situation can be identified in the region despite the different configurations of institutional arrangements in different countries. On the one hand, there is a greater presence of the State, regulatory and administrative structures, as in Chile. On the other hand, there are stronger local arrangements and less presence of the State (Bolivian case). There are other cases in between such as Brazil that represent more decentralized institutional settings with a greater participation of local entities in watershed committees. In this context, legal pluralism and "institutional bricolage" are important elements when water institutions need to be analyzed regardless of the institutional setting of any one country.

Flexibility. Notwithstanding the institutional setting, it is possible to affirm that the presence of informal arrangements is evident in any one country, though meaning different things for different people in terms of their water access. On the other hand, although institutions at all levels can have organizational attributes of structure, rules, norms, and policies, they always function in a flexible way.

Power relations, class and gender issues, or inter-sector relationships influence the application of norms, making them negotiable given the specific context existing at that moment.

Flexibility is thus one of the main characteristics of local irrigation organizations and local institutional arrangements. To some extent, local organizations have the capacity to change their way of acting in accordance with the necessities of the farmers at that moment, or to immediately respond to hazards. It is more difficult to find this kind of flexibility in state organizations though in practice they may also be flexible.

Uncertainty. An important characteristic of agricultural activities, demand from (local) institutions not only focuses on risk assessment but considers uncertainty. Although post-institutional approaches discuss uncertainty as an important element in understanding water management and institutional dynamics, it is not yet clear how to deal with the different dimensions of uncertainty as an institutional element.

During the last few years, water availability has decreased, fact attributed to the change in rainfall regime or climatic change. At the same time, urbanization and industrial expansion exert more pressure over water resources in two ways, increasing demand and water pollution. On the other hand, agricultural inputs are subject to global and other local variations. It is the same for agricultural products with seasonal or sometimes random variations. All of these factors represent riskier conditions and uncertain situations that make agricultural production insecure.

Given these conditions, flexibility in institutional arrangements and the possibility of relying on different institutions at different moments (forum shopping) can be an advantage for coping with uncertainty. In concrete aspects of irrigation, this means the possibility of water distribution patterns, readaptation of irrigation schedules, and even renegotiation among water organizations within a river basin.

A thorough analysis of the farming unit can help to distinguish between agricultural activities related to other activities in which families (production unit or family farm enterprise) are involved. A main issue here is related to the prioritization of activities (e.g., agriculture as the main or

secondary activity) by considering the type of established production and the external and internal factors that have pushed or influenced farmers to adopt a certain production strategy and its implications on irrigation practices. From an institutional point of view, some issues to be treated would be the interdependence of agricultural and productive activities with irrigation practices, whereas another important issue is the competition between agriculture and other sectors, the type of interaction, and the rules established for that purpose.

Final remark. Analysis of irrigation systems by considering the watershed as the planning unit, or at least as a reference, can help to discuss irrigation systems in relation to the environment (e.g., water withdrawal, water pollution, and soil degradation) on the one hand, and irrigation systems in relation to other uses on the other hand, given increasing water demand due to population growth and its effects on the environment. Issues of planning, coordination between sectors, negotiation and power (mis)balances, water allocation mechanism, and use priority setting can be some topics to discuss in relation to institutions. To understand the complexities in the irrigation sector from an institutional perspective can be helpful in considering new challenges towards more integrated water resources management.

RESUMEN

Aspectos institucionales para la sustentabilidad de la agricultura de riego en regiones áridas y semi-áridas. En la literatura científica y técnica sobre riego se han planteado diferentes preocupaciones, argumentos y enfoques que contribuyan a su sostenibilidad, basados en la prioridad dada a la producción de alimentos y a la preservación del agua como un recurso básico. Más allá de consideraciones técnicas sobre el riego, tal como son abordadas por literatura científica especializada, se han identificado diferentes enfoques relacionados a la sostenibilidad de la agricultura bajo riego. Estos enfoques se concentran principalmente en aspectos institucionales y socioeconómicos de la gestión del riego. En este capítulo se discuten cuatro enfoques: El “nuevo institucionalismo”, que enfatiza temas económicos y financieros como la recuperación de costos o el rol del mercado en la reasignación de derechos de agua. Un segundo enfoque es el denominado “Gestión de recursos comunes”, que resalta el rol de organizaciones e instituciones locales en la gestión colectiva y en las posibilidades de diseñar instituciones “robustas” si se considera el involucramiento de diferentes grupos de interés y no únicamente autoridades (estatales). Un tercer enfoque se identifica como “Enfoque de empoderamiento”. Otros

tópicos como relaciones de poder, autonomía, relaciones de género, acceso y derechos al agua, son considerados como elementos clave en la configuración de las prácticas de gestión del agua en sistemas de riego. Finalmente, un cuarto enfoque es llamado “Enfoque pos-institucional”. Dentro de éste, conceptos como “bricolaje institucional”, incertidumbre, pluralismo legal, son usados como elementos analíticos para entender la dinámica y complejidades en que se desarrolla el riego. Como conclusión, se discuten los diferentes niveles en que la sostenibilidad puede ser analizada desde una perspectiva institucional, identificando vacíos de conocimiento y la necesidad de integrar algunos de los elementos encontrados en los diferentes enfoques descritos.

Palabras clave: enfoques institucionales, instituciones de riego, gestión del agua, riego sostenible.

LITERATURE CITED

- Bandaragoda, D.J. 1998. Need for institutional impact assessment in planning irrigation system modernization. 25 p. Research Report 21. International Water Management Institute (IWMI), Colombo, Sri Lanka.
- Bandaragoda, D.J. 2006. Institutional adaptation for integrated water resources management: An effective strategy for managing Asian river basins. 44 p. Working paper 107. International Water Management Institute (IWMI), Colombo, Sri Lanka.
- Bebbington, A. 1999. Capitals and capabilities: A framework for analyzing peasant viability, rural livelihoods and poverty. *World Development* 27:2021-2044.
- Berry, S. 1994. Resource access and management as historical processes: conceptual and methodological issues. p. 25-45. *In* Lund, C. and H. Marcussen (eds.) Access, control and management of natural resources in Sub-Saharan Africa. Methodological considerations. Occasional Paper 13. International Development Studies, Roskilde University, Roskilde, Denmark.
- Blomquist, W., and E. Ostrom. 1985. Institutional capacity and the resolution of a commons dilemma. *Policy Studies Rev.* 5:383-393.
- Boelens, R. 1998. Gestión colectiva y construcción social de sistemas de riego campesino. Una introducción conceptual. *In* Boelens, R., and G. Davila (eds.) Buscando la equidad. Concepciones de justicia y equidad en el riego campesino. Van Gorcum, Assen, The Netherlands.
- Boelens, R. 2000. Collective water management and the construction of normative frameworks in irrigation systems. An analysis of some basic working rules, water rights and distribution principles in peasant irrigation. *Territoires en Mutation* 7:51-74.
- Boelens, R., and B. Doornbos. 2001. Derechos del agua y el empoderamiento en medio de marcos normativos conflictivos en Ceceles, Ecuador. *In* Boelens, R., and P. Hoogendam (eds.) Derechos del agua y acción colectiva. Instituto de Estudios Peruanos (IEP), Lima, Perú.
- Boelens, R., A. Dourojeanni, A. Duran, and P. Hoogendam. 2001. La gestión del agua en las cuencas andinas y el fortalecimiento de las organizaciones de usuarios. *In* Boelens, R., and P. Hoogendam (eds.) Derechos del agua y acción colectiva. Instituto de Estudios Peruanos (IEP), Lima, Perú.
- Boelens, R., and P. Gelles. 2005. Cultural politics, communal resistance and identity in Andean irrigation development. *Bull. Latin Am. Res.* 24:311-327.
- Boelens, R., and P. Hoogendam. 2001. Derechos de agua y fortalecimiento organizativo. *In* Boelens, R., and P. Hoogendam (eds.) Derechos del agua y acción colectiva. Instituto de Estudios Peruanos (IEP), Lima, Perú.
- Boelens, R., M. Zwarteveen, and D. Roth. 2005. Legal complexity in the analysis of water rights and water resources management. p. 1-20. *In* Roth D., R. Boelens, and M. Zwarteveen (eds.) Liquid relations: contested water rights and legal complexity. Rutgers University Press, New Brunswick, New Jersey and London.
- Bon, E. 2000. Common pool resources and communal control: Two case studies in Himachal Pradesh, India. *In* 8th IASCP Conference, Bloomington, Indiana, USA.
- Bromley, D.W., D. Feeny, M.A. McKean, P. Peters, J.L. Gilles, R.J. Oakerson, *et al.* 1992. Making the commons work: Theory, practice and policy. ICS Press, San Francisco, California, USA.
- Bromley, D., D. Taylor, and D. Parker. 1980. Water reform and economic development: Institutional aspects of water management in developing countries. *Econ. Dev. Cult. Change* 28:365-387.
- Chase-Smith, R., D. Pinedo, P.M. Summers, and A. Almeyda. 2001. Tropical rhythms and collective action: community based fisheries management in the face of Amazonian unpredictability. *IDS Bull.* 32:36-46.
- Cleaver, F. 2000. Moral ecological rationality, institutions and the management of common property resources. *Dev. Change* 31:361-383.
- Cleaver, F., and T. Franks. 2005. How institutions elude design: River basin management and sustainable livelihoods. BCID Research Paper N°. 12. 21 p. University of Bradford, Bradford, UK.

- Cremers, L., M. Oijevaar, and R. Boelens. 2005. Institutional reform in the Andean irrigation sector: Enabling policies for strengthening local rights and water management. *Nat. Resour. Forum* 29:37-50.
- Douglas, M. 1985. Risk acceptability according to the social sciences. *Social Research Perspectives: Occasional Reports on Current Topics* N° 11. Russell Sage Foundation, New York, USA.
- Edmunds, D., and E. Wollenberg. 2001. A strategic approach to multi-stakeholder negotiations. *Dev. Change* 32:231-253.
- Ellis, F. 2000. Livelihoods, diversification and agrarian change. p. 3-27. *Rural livelihoods and diversity in development countries*. Oxford University Press, New York, USA.
- Friedman, J. 1992. Empowerment. The politics of alternative development. Blackwell, Malden, Massachusetts, USA.
- Gelles, P. 1994. Channels of power, fields of contention: The politics of irrigation and land recovery in an Andean peasant community. p. 233-274. *In* Mitchell, W., and D. Guillet (eds.) *Irrigation at high altitudes: The social organization of water control systems in the Andes*. Society for Latin American Anthropology Publication Series. Vol. 12. American Anthropological Association, Washington, DC, USA.
- Gelles, P. 1998. Lógicas culturales que compiten: modelos estatales e indígenas en conflicto. *In* Buscando la equidad. *In* Boelens, R., and G. Dávila (eds.) *Buscando la equidad. Concepciones de justicia y equidad en el riego campesino*. Van Gorcum, Assen, The Netherlands.
- Gerbrandy, G., y P. Hoogendam. 1998. Aguas y acequias. Los derechos al agua y la gestión campesina de riego en los Andes Bolivianos. 397 p. Programa de Enseñanza e Investigación en Riego Andino y de los Valles (PEIRAV), Cochabamba, Bolivia. Gerben Gerbrandy/Paul Hoogendam-Plural Editores, La Paz, Bolivia.
- Gruhn, P., F. Goletti, and M. Yudelman. 2000. Integrated nutrient management, soil fertility, and sustainable agriculture: Current issues and future challenges. *Food, Agriculture, and the Environment Discussion Paper* 32. International Food Policy Research Institute (IFPRI), Washington DC, USA.
- Guillet, D. 1992. Covering ground. Communal water management and the State in the Peruvian highlands. The University of Michigan Press, Ann Arbor, Michigan, USA.
- Haie, N., and A. Keller. 2008. Effective efficiency as a tool for sustainable water resources management. *J. Am. Water Resour. As. (JAWRA)* 44:961-968.
- Hardin, G. 1968. The tragedy of the commons. *Science* 162:1243-1248.
- Jayanath, A., L. Crase, and P. Pagan. 2006. A preliminary assessment of water institutions in India: An institutional design perspective. *Rev. Policy Res.* 23:927-953.
- Kay, C. 1997. Globalization, peasant agriculture and reconversion. *Bull. Latin Am. Res.* 16:11-24.
- Khan, S., R. Tariq, C. Yuanlai, and J. Blackwell. 2006. Can irrigation be sustainable? *Agric. Water Manage.* 80:87-99.
- Longwe, S.H., y Y. Clarke. 1994. El marco conceptual de igualdad y empoderamiento de las mujeres. *In* León, M. (comp.) 1997. *Poder y empoderamiento de las mujeres*. Tercer Mundo Editores, Santa Fe de Bogotá, Colombia.
- Mehta, L., M. Leach, P. Newell, I. Scoones, K. Sivaramakrishnan, and S. Way. 1999. Exploring understandings of institutions and uncertainty: New directions in natural resource management. *IDS Discussion Paper* 372. 48 p. Institute of Development Studies (IDS), University of Sussex, Brighton, UK.
- Merrey, D. 1996. Institutional design principles for accountability in large irrigation systems. *Research Report* 8. International Irrigation Management Institute (IIMI), Colombo, Sri Lanka.
- Molle, F. 2005. Irrigation and water policies in the Mekong region. Current discourses and practices. *Research Report* 95. International Water Management Institute (IWMI), Colombo, Sri Lanka.
- Mollinga, P. 1998. Equity and accountability. Water distribution in a South Indian canal. *In* Boelens, R., and G. Davila (eds.) *Searching for equity. Conceptions of justice and equity in peasant irrigation*. Van Gorcum, Assen, The Netherlands.
- Moser, C. 1991. La planificación de género en el Tercer Mundo: Enfrentando las necesidades prácticas y estratégicas de género. p. 55-124. *In* Guzman, V. *et al.* (comp.) *Una nueva lectura: Género en el Desarrollo*. Flora Tristán-Red Entre Mujeres, Lima, Perú.
- Mosse, D. 1997. The symbolic making of a common property resource: History, ecology, and locality in a tank-irrigated landscape in South India. *Dev. Change* 28:467-504.
- Mtisi, S., and A. Nicol. 2003a. Caught in the act: New stakeholders, decentralization and water management processes in Zimbabwe. *In* Sustainable Livelihoods in Southern Africa Program. Institutions, Governance and Policy Processes. *Research Paper* 14.

- Mtisi, S., and A. Nicol. 2003b. Water Points and Water Policies: Decentralization and community management in Sangwe communal area, Zimbabwe. *In Sustainable Livelihoods in Southern Africa Program. Institutions, Governance and Policy Processes. Research Paper 15.*
- Murguialday, C., C. Pérez de Armiño, and M. Eizaquirre. 2005. Empoderamiento . *Diccionario de acción humanitaria y cooperación al desarrollo.* Available at <http://dicc.hegoa.efaber.net/listar/mostrar/86> (accessed August 2009).
- Nemarundwe, N., and W. Kozanayi. 2002. Institutional arrangements for water resource use: A case study from Southern Zimbabwe. *J. S. Afr. Stud.* 29:193-206.
- Nemarundwe, N., and W. Kozanayi. 2003. Institutional arrangements for water resource use: A case study from Southern Zimbabwe. *J. S. Afr. Stud.* 29:193-206.
- North, D.C. 1990. *Institutions, institutional change, and economic performance.* Cambridge University Press, Cambridge, UK.
- Ostrom, E. 1990. Reflections on the commons and a framework for analysis of self-organizing and self-governing CPRs. p. 1-28, 182-221. *In Governing the commons: The evolution of institutions for collective action.* Cambridge University Press, Cambridge, UK.
- Ostrom, E. 1992. *Diseño de instituciones para sistemas de riego auto-gestionarios.* p. 45-71. *Institute for Contemporary Studies, San Francisco, California, USA.*
- Ostrom, E. 2000. Collective action and the evolution of social norms. *J. Econ. Perspect.* 14:137-158.
- Rosegrant, M.W., and H.P. Binswanger. 1994. Markets in tradable water rights: Potential for efficiency gains in developing country water resource allocation. *World Dev.* 22:1613-1625.
- Rowlands, J. 1997. *Questioning empowerment. Working with women in Honduras.* Oxfam, Oxford, UK.
- Saleth, R. 2004. *Strategic analysis of water institutions in India. Application of a new research paradigm. Research Report 79.* International Water Management Institute (IWMI), Colombo, Sri Lanka.
- Saleth, R., and A. Dinar. 1999a. *Evaluating water institutions and water sector performance.* World Bank Technical Paper N° 447. 93 p. World Bank, Washington DC, USA.
- Saleth, R., and A. Dinar. 1999b. *Water challenge and institutional response (A cross-country perspective).* World Bank Policy Working Paper 2045 (January 1999). Available at <http://ssrn.com/abstract=569189> (accessed January 1999).
- Scoones, I. 1998. *Sustainable rural livelihoods. A framework for analysis.* *In IDS Working Paper 72.* 22 p. Institute of Development Studies (IDS), University of Sussex, Brighton, UK.
- Shah, T., B. van Koppen, D. Merrey, M. de Lange, and M. Samad. 2002. *Institutional alternatives in African smallholder irrigation: Lessons from international experience with irrigation management transfer. Research Report 60.* 33 p. International Water Management Institute (IWMI), Colombo, Sri Lanka.
- Small, L.E., and I. Carruthers. 1991. *Farmer-financed irrigation: the economics of reform.* 225 p. Cambridge University Press, Cambridge, UK.
- Small, L.E., and M. Svendsen. 1992. *A framework for assessing irrigation performance. Working Paper on Irrigation Performance N° 1.* International Food and Policy Research Institute (IFPRI), Washington, DC, USA.
- Spiertz, H.L.J. 2000. *Water rights and legal pluralism: Some basics of a legal anthropological approach.* p. 245-268. *In* Bruns, B.R., and R.S. Meizen-Dick (eds.) *Negotiating water rights.* Intermediate Technology Publications, London, UK.
- Steins, A., N. Röling, and V.M. Edwards. 2000. *Re-designing the principles: an interactive perspective to CPR theory.* 8th Conference of the International Association for the Study of Common Property, Bloomington, Indiana, USA. 1-4 June 2000. Indiana University, Bloomington, Indiana, USA.
- Trawick, P. 2001. *Successfully governing the commons: Principles of social organization in an Andean irrigation system.* *Hum. Ecol.* 29:1-25.
- Wade, R. 1988. *Village republics: Economic conditions for collective action in South India.* Cambridge University Press, Cambridge, UK.
- Wichelns, D., and J. Oster. 2006. *Sustainable irrigation is necessary and achievable, but direct costs and environmental impacts can be substantial.* *Agricultural water management* 86:114-127.
- Williamson, O.E. 1975. *Markets and hierarchies, analysis and antitrust implications: A study in the economics of internal organization.* Free Press, New York, USA.
- World Bank. 1997. *Toolkits for private participation in water and sanitation.* World Bank, Washington DC, USA.
- Yoder, R. 1994. *Locally managed irrigation systems: Essential tasks and implications for assistance, management transfer, and turnover programs.* IIMI Monograph N° 3. International Irrigation Management Institute (IIMI), Colombo, Sri Lanka.
- Zhang, W., G. Liu, and C. Bai. 2007. *A forecast analysis on global production of staple crops.* 10 p. Available at <http://www.stats.gov.cn/english/icas/papers/PO20071114315023592169.pdf> (accessed October 2009).