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Successfully Governing the Commons: Principles of Social Organization in an Andean Irrigation System

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Throughout the world it is unusual to find irrigation systems that work well, distributing water efficiently and with minimal conflict, especially in situations where the resource is scarce. This paper describes one such system in the Peruvian Andes, a peasant village where irrigation and water management are handled in an unusual way. It analyzes the village principles of social organization, showing that these create a situation of equity and transparency which provides people with a strong incentive to obey the rules and conserve water. By doing so, they are directly maximizing the frequency of irrigation, a benefit that is the same for everyone using a given source of water. The system is argued to be a highly effective and sustainable way of dealing with a scarce and fluctuating resource.

KEY WORDS: irrigation; water management; water policy; common-property; applied anthropology; Andes; Peru.

INTRODUCTION

There has been a surge of interest during the last two decades in the various ways that irrigation and water management are carried out around the world, especially in systems that can be described as "indigenous." The latter term has generally been used in reference to small-scale, community-based canal systems, usually encompassing no more than 1,000 hectares of land and often built by the local people themselves, in which water use is

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carried out according to custom or tradition[2] (Coward, 1977, 1979; Hunt, 1988, 1989; Mabry & Cleveland, 1996, pp. 227–229). These systems are, from the standpoint of the people who operate them, self-organized and self-governed, and today there is great interest in ones that have endured for a long period of time.

As Coward (1979) pointed out many years ago, the locally-derived rules that have fostered effective water management in specific cases are in urgent need of study, in order to rebut the theory of "the tragedy of the commons" (Hardin, 1968), which holds that people cannot work out sustainable ways to utilize common-property resources on their own. A large number of irrigation studies now exist which demonstrate that people are in fact quite capable of doing this with respect to water (e.g., Maass & Anderson, 1978; Siy, 1982; Wade, 1986, 1988, 1992; Lansing, 1991; Ostrom & Gardner, 1993; Mabry & Cleveland, 1996); yet we still have need of more of them. This is especially urgent, given the related task of devising an alternative theory which explains how—according to what kinds of rules and principles—people have managed these kinds of resources effectively throughout history (N.R.C., 1986; McCay & Acheson, 1987; Ostrom, 1990, 1992; Bromley, 1992).

It is strange that the common-property literature includes so few examples from the Peruvian Andes, heartland of one of the world's great hydraulic civilizations and a region where these kinds of local traditions might be expected to have thrived. This is not to say that a great amount of ethnographic work on irrigation has not been done there; but the many excellent studies that are available have—in most but not all cases (e.g., Treacy, 1994a,b; Gelles 1991, 1994, 1995; Paerregaard, 1994—shown Andean communities to be 'tragic,' rife with conflict over a resource that is scarce and inadequate, yet largely wasted. Moreover, the studies have revealed them to be very diverse in terms of basic organization and the rules governing water use (Mitchell & Guillet, 1994), so that few major implications for theory-building and policy-making have emerged.

Some authors have described communities that are 'centralized' or unified (Mayer & Fonseca, 1979; Fonseca, 1983; Mayer, 1985; Gelles, 1986, 1994, 1995; Valderamma & Escalante, 1986, 1988; Guillet, 1987, 1992, 1994; Treacy, 1994a,b; Bolin, 1990, 1994), according to explicit rules and procedures, while others have described ones that are "acephalous," or lacking any effective central authority (Bunker & Seligmann, 1986; Seligmann & Bunker, 1994). Still other people (Mitchell, 1973, 1976, 1994) have encountered systems that

[2]The number of studies of indigenous systems is far too large for me to cite them all here; Coward (1977, 1979), Hunt (1988, 1989), and Mabry and Cleveland (1996) provide excellent overviews. Some of these systems, such as the one described by Lansing (1991) in Bali, and a number of the ones analyzed by Hunt, are rather large in scale, but in general the term has been applied to small-scale systems.

alternate between unified and acephalous modes of organization, depending on the state of the water supply. The first type sometimes operates rather smoothly, according to customary procedures, but does not necessarily do so by any means, while the second tends to display a lot of conflict, except in cases where water is abundant (Paerregaard, 1994).

With regard to modes of distribution and watering methods, the variation is equally striking. In some villages, sectors of land and their component fields are irrigated in a fixed sequence on a single schedule, while in others this is done in a flexible, irregular or haphazard order, so that certain people, or certain crops, get water more often than others. Some communities are characterized by terraces that are relatively flat and watered from the bottom upward, others by terraces and sloped fields watered from the top downward, while most show a mixture of landscaping and watering techniques.

My own research in the region (Trawick, 1994, 1995, 1998a,b, n.d.a., n.d.b.) suggests that we can now begin to move beyond the impasse that this diverse and rather confusing picture has created, in order to make policy recommendations for resolving situations of tragedy. There is a distinctive way of managing water that exists in many communities in the Andes today, a locally-derived tradition that may once have prevailed widely and that is a highly effective means of managing a scarce and fluctuating resource. I say this based on a comparative ethnographic study of several kinds of hydraulic community in a single region, the first of its kind to be done.

The fieldwork was carried out over a period of three-and-a-half years in the Cotahuasi valley of the Department of Arequipa and in the city of Arequipa itself. Three communities were studied featuring very different modes of hydraulic organization: one unified and egalitarian (an 'indigenous' system, as defined above, which I will discuss here), a second unified and hierarchical (with the watering order determined by the relative status of landowners), and a third highly centralized (administered by a state official according to Peru's water law) and hierarchical (with the watering order determined by the relative importance of crops and the crops' specific water needs). Here I will limit myself largely to the indigenous or Andean system, and follow Coward's example (1979) by discussing its principles of social organization. These are analytical statements, derived through fieldwork with informants, which are not necessarily recognized by the irrigators themselves, though in this case most of them are. The principles make up a heritage that, according to the local people, is of Inca origin, a remarkable claim of cultural continuity which I assess elsewhere (Trawick, n.d.a. in press, n.d.b.) and will not touch upon here.

Note that my assertions about sustainability in this case are based on a lengthy period of fieldwork involving participant observation in several communities and many hours of interviews with numerous water-users and people who have served as water officials. However, the argument for efficiency must in any case rest primarily on the logic of the system as seen from the standpoint of people using it. If the goal is to share a scarcity in a sustainable way that minimizes conflict, this particular set of practices accomplishes it by giving people a strong incentive to conserve water, obey the rules and thereby avoid a tragic outcome. Indeed, the rules and principles to be discussed below are generally respected in the community because they are seen as the only arrangement that is fair, that makes sense and, above all, that allows people to irrigate as often as possible.

The implications of this for both theory and policy are profound, but it is important to note that the principles are not unique to this one case. Some of them, such as proportionality, will be recognized by anyone familiar with the irrigation literature, from the work of Glick (1970), Hunt and Hunt (1976), Coward (1979), Ostrom (1990, 1992) and others, but some have not been discussed before. The local tradition that they define, however, is found not only in this village but apparently also in two others in the same valley (Trawick, n.d.a. in press), and it clearly exists in several villages in an adjacent valley within the same region, and in numerous others throughout the highlands today (Treacy, 1994 a,b; see Guillet, 1994, p. 184). Thus it is relatively widespread in the Andes.

AN OVERVIEW OF THE COMMUNITY AND THE IRRIGATION SYSTEM

The canal system belongs to the community of Huaynacotas, located in the province of La Union of the Department of Arequipa, in Peru's southern highlands. This is a village of Quechua-speaking peasants[3] (population roughly 1,080 in 1980), one of only a few in the valley that were never actually settled by the Spanish. This is to say that the landlords who became dominant almost everywhere else in the valley never succeeded in acquiring any land there and actually residing. This elite hispanic population (also referred to as *mistis* or *españoles*) is notorious within the Arequipa region for having maintained their dominance of local communities through the end of the twentieth century, a preeminent position based in part on the rather strict practice of class endogamy. Although remote, Huaynacotas is not a pristine community, but rather one that managed to contract its boundaries at an early point in time after losing all of its low-altitude, valley-bottom lands to these local elites. The villagers thereby managed to prevent further loss of

[3]Most people are bilingual, being fully fluent in Spanish, but Quechua is their first language and the primary one in which they address each other.

land and water to the landlords and their haciendas, or private agricultural estates. In this way they were able to maintain a significant kind of autonomy, having full control over the circumstances of water use.

The village is stratified, being made up of groups of large and small landowners, and it has other features that are common in the region, especially the prevailing scarcity of water and the uses to which the resource is put. However, compared to other Andean villages, the degree of internal differentiation is quite limited: roughly 20% of the households (the large-holders) have between two and three hectares of irrigated land, 40% have between one and two hectares (the middle proprietors), and approximately 40% have one hectare or less (the smallholders).

The hydraulic system (see Fig. 1) is a dual one with two major water sources, both alpine springs, which is the typical situation in the valley and the Andes as a whole. These flows are stored at night in two tanks and distributed during the daytime through two separate networks of canals. The duality is thus hydrographically based, but it is not reflected in any kind of dual social organization, although this probably did exist in the community at one time.

The canal network as a whole spans elevations from 3,100 to 4,100 meters and encompasses roughly 410 hectares, territory that is divided into named sectors and consists of two different kinds of land. Approximately 73% is irrigated intensively and used to produce maize and other staples, and other important crops. These include alfalfa, a cultivated pasture that was introduced to the region long ago by the landlords who live elsewhere in the valley, although that is grown on only a very minor scale. The other type of land is primarily rain-fed and, here as elsewhere in the region, it was formerly used to grow potatoes and other tuber crops (Guillet, 1981; Orlove & Godoy, 1986). These sectors, called *t'ikras*, lie at high altitude and receive much more rainfall, but here some of the sectors are irrigated for planting and then watered again thereafter if the need arises. All of them now lie abandoned, however, because of a recurrent drought that began in the late 1970s and has only recently begun to show signs of ending. Thus irrigation is now confined to the maize-growing zone.

The order in which the sectors are watered is indicated by the numbers shown in Fig. 1 and in Table I. The sequence is determined by micro-climatic variation (due to topography and exposure to the sun and wind) making some sectors colder than others, which extends the germination time for maize plants. Consequently, those sectors have to be given a head start to protect them from frosts that come at the end of the year. This explains why the sequence is not strictly determined by altitude, proceeding steadily from the upper sectors to the lower, as one would otherwise expect (Mitchell, 1976). Field preparation and planting start the cycle, which is then repeated

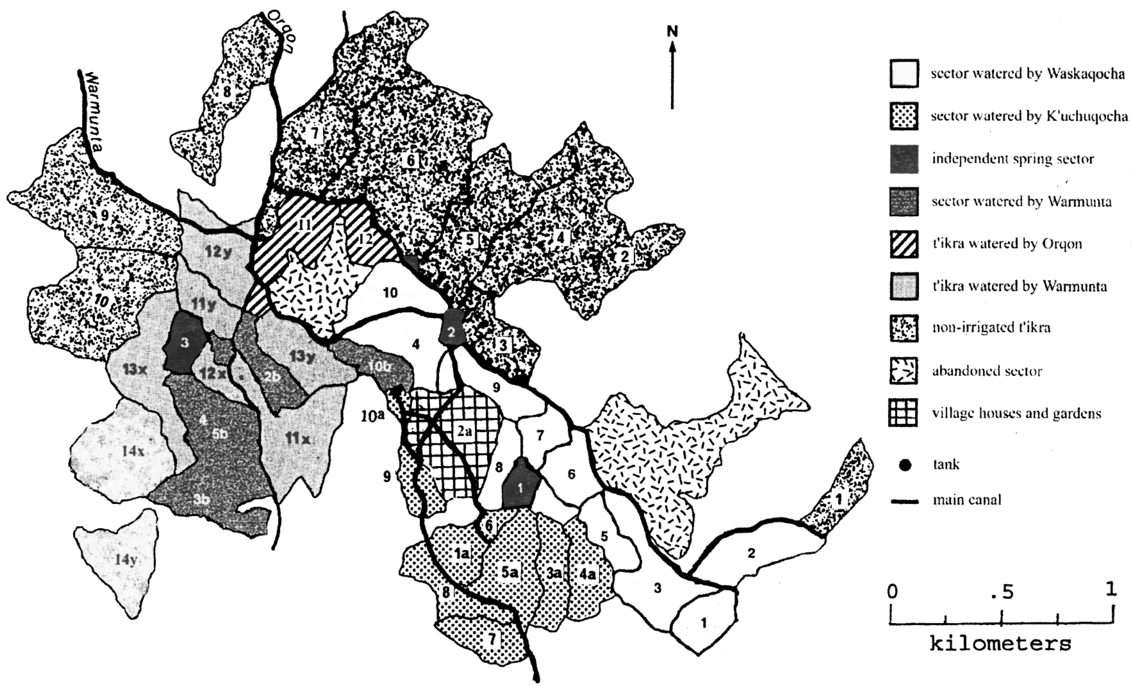

Fig. 1. Irrigation and land-use system of Huaynacotas.

Table I. Planting and Watering Order

K'uchuqocha Tank (Warmunta spring)		Waskaqocha Tank (Orqon spring)
1a Oqo	1b Lluqlla	1 Lluqlla
2a Huertas (gardens)	2b Ch'akiqucha	2 Killalli
3a Montanqa	3b Sirqe	3 Campanario
4a Qurma	4b Qushmi	4 Trapiche
5a Akcha	5b Qirone	5 Ch'ilkapuqyu
6 Waykicha		6 Waynapata
7 Uchuwaru		7 Istu Grande
8 Pisqanturka		8 Tamana
9 Sinya		9 Ch'iqya
10a Qochasiki	10b Qochapata	10 Yumari
		11 Quntanya
		12 Istu Chico
Independent spring sectors		**T'ikras watered by Orqon (alternate in fallow)**
1 Uklli		
2 Q'irune		1x Huaynapata
3 Qushmi Chico		1y Qaraqara
T'ikras watered by Warmunta (alternate in fallow)		**T'ikras without water (2 year fallow, two sectors not shown in diagram)**
11x Latawichu		1 Suntu Suntu
11y Uchuqu		2 Cruzpata
12x Hueco		3 Chunkayumi
12y Pawsarima		4 Qaraqara
13x Ch'akiqucha		5 Munyapata
13y Qallwani		6 Ch'ichi
14x Kabana		7 Chuchulla
14y Qusmi		8 Qiruni
		9 Waqanya
		10 Cabracancha

Paired units (a & b) are watered simultaneously, others in sequence as numbered.

until irrigation ceases after the rains begin. Note that sectors having the same number with the added designations *a* and *b* are watered simultaneously, using the outflow of a reservoir and the daytime flow of the main canal above that same tank, respectively. Otherwise, the two flows are combined to irrigate the same sector.

The scarcity of water here is acute, even under 'normal' conditions, and this constrains the sequence and timing of distribution. As in most highland communities, the flow in each half of the system is small enough that landowners must generally take turns in using it, rather than irrigating simultaneously, making irrigation a serial rather than a parallel process—an arrangement widely known as the *turno*. The cycle of turns is slow and takes two to three months to complete, even during a good year. During the maize planting in September and the later crop plantings thereafter (e.g., beans, barley, etc.), the watering frequency gradually declines, and this continues until the rains begin and the dry season ends in late December, at which time irrigation normally ceases. This means that staple crops are watered at most twice during that entire time.

The ecological function of irrigation, here as elsewhere in the highlands, is to extend the growing season and give the crops a head start so that they can begin to grow before the rains begin (Mitchell, 1976). If the rains fail, however, watering must continue throughout the wet season, as the supplies continue to dwindle, in order to replace the precipitation that does not come, though this can only be done to a limited extent. The effect is merely one of damage mitigation. Given the extreme scarcity of the resource, the social regulation of irrigation serves to distribute the inadequate supply equitably, efficiently, and with minimal conflict. In so doing, the people make the best of a bad situation.

The arrangement of landholdings promotes this outcome in a certain way. One finds here the highly fragmented pattern, known as *minifundia*, which is characteristic of Latin America and typical of peasant villages in many parts of the world. Regardless of how much land people own, they tend to have several small plots scattered in different sectors at various elevations, usually located at various points along the canals. They also tend to have land in both halves of the system. The pattern is so highly fragmented, in fact, that one cannot speak here of a population composed of "head-enders" and "tail-enders" (see Ostrom, 1990; Ostrom & Gardner, 1993), since most people seem to be both. This kind of arrangement is significant, as Leach (1961) and Coward (1979) noted long ago, because the system can be contracted during droughts by taking land out of production, in such a way that the impact is evenly felt and does not fall disproportionately on any village member.

THE RULES OF WATER MANAGEMENT

The canal system is independently operated by the village members through a system of rotating, allocated authority in which customary procedures are exclusively followed. This is done by two water officials, elected in community assemblies, called *campos*, who oversee each half of the system. During each distribution cycle, the campos divide the flow of each main canal approximately in half, into two standard and roughly equivalent portions called *rakis*, in the act of diverting it into the secondary canals.[4] They

[4]The task is actually more complicated than this. It involves managing both the canal flow from the spring, which is continuous, and the daily out-flow of the tank, which can either be used separately or combined. The details are presented elsewhere, and there is no need to repeat them here (Trawick, 1994 b: 145–149, n.d.a.).

then allow the water to flow down to the fields, where each share is dispersed and utilized by a landowning family or household. This happens in both halves of the canal system at the same time, according to procedures that are essentially equivalent. Without exception, everyone I interviewed on the subject agreed that these are the rules, and I was able to confirm this repeatedly through participant observation.

Rules of Distribution

Certain procedures ensure that all parcels of land served by a given source, and all households, receive water with the same frequency, though one that varies with seasonal and long-term fluctuations in the supply. First, the land sectors that make up the village territory are given water consecutively in a fixed sequence based on altitude and microclimatic variation, as previously explained, which determines the planting order by affecting crop maturation times (see Fig. 1). During each cycle of the system, watering passes through all the sectors currently in production, reaching every parcel before beginning again. Thus every household gets its full share during each cycle of the system.

Secondly, the plots within each sector are likewise given water in a rigid contiguous order, starting at the bottom of the sector and moving systematically upward, in such a way that the time at which they are serviced depends only on their location, rather than on who owns them or the crops in which they are planted. Alfalfa, for example, is grown here in tiny plots, but, unlike the situation that one finds in most other local villages, here it is watered in the same way (see below) and on the same schedule as any other crop.[5] All are watered together in a fixed sequence on a single schedule.

Thirdly, as previously mentioned, a standard method of adjusting to drought ensures that the impact of periodic shortages is absorbed equally by all households, so that the uniform frequency of irrigation is preserved. After a year of poor rains, as the water flows subside during the planting season, the sectorally-fallowed lands lying at the upper end of the system are taken out of production and dropped from the sequence, in order to prevent a further decline. This was done in response to the ongoing drought about twenty years ago, and the sectors have remained abandoned ever since. Since everyone had land in these sectors, most people were affected by the

[5] As I have shown elsewhere (Trawick, 1994, 1995, n.d.a., n.d.b.), alfalfa is an extremely thirsty plant that has had a huge impact on irrigation in the Andes, greatly contributing to histories of tragedy in the commons. The changes widely associated with its cultivation are: the destruction of terracing and the re-creation of sloped landscapes, the consequent development of a new and very wasteful watering technique, the loss of proportionality among water shares, and, most important of all, the privatization of communal water by estate owners.

contraction, which took place in both halves of the system at the same time. And everyone benefited equally, since the effect was to prevent the watering cycle from stretching out to more than 100 days, which would have seriously jeopardized the maize harvest.

The result is that, even though the springs that supply this community are the most vulnerable ones in the entire province to droughts, which have reached alarming frequency during the last twenty years, conflict over water is far less prevalent in Huaynacotas than in other local villages, most of which have far less equitable arrangements (Trawick, 1994, n.d.a, n.d.b.). I can say this with confidence because my study included the two other communities. In both cases, inequity, water theft, favoritism by water officials, and other sources of conflict occur often, are a regular focus of conversation and a cause for constant concern. That is simply not true in Huaynacotas, as the village members readily point out. They recognize their way of doing things to be distinct and unusual, in this and other respects.

Rules of Utilization

The entire landscape here is terraced, consisting of level surfaces that are deliberately designed—and carefully maintained—to promote the absorption and retention of water. These make it possible for the actual watering to be carried out by means of a uniform technique, one which helps to ensure that the duration of irrigation, and the amount of water consumed by people in each allotment, are strictly proportional to the extent of each property. Though some adjustments are made for variations in soil type, this basic symmetry is maintained by the fact that standard water containment features called *atus*—earthen structures of uniform height (see Fig. 2)—are used by everyone. Because liquid is pooled on the surface to the same depth in each case, the regulation of irrigation time, and of water consumption, are inherent features of the technology.

No departures from this arrangement—such as the destruction of terracing and the irrigation of slopes, practices that are common in most other local villages—are allowed by the water distributors. Duplication of irrigation, for example, returning to fill or top-off the structures again after they have had time to drain somewhat, is normally prohibited and considered a form of water theft. The only contexts in which it is allowed are in the sectors known to have sandy soils that retain water poorly; there it is allowed as a way of compensating for this fact. These customary procedures, and all the ones described above, are not just techniques but also rules according to which irrigation and water use must take place.

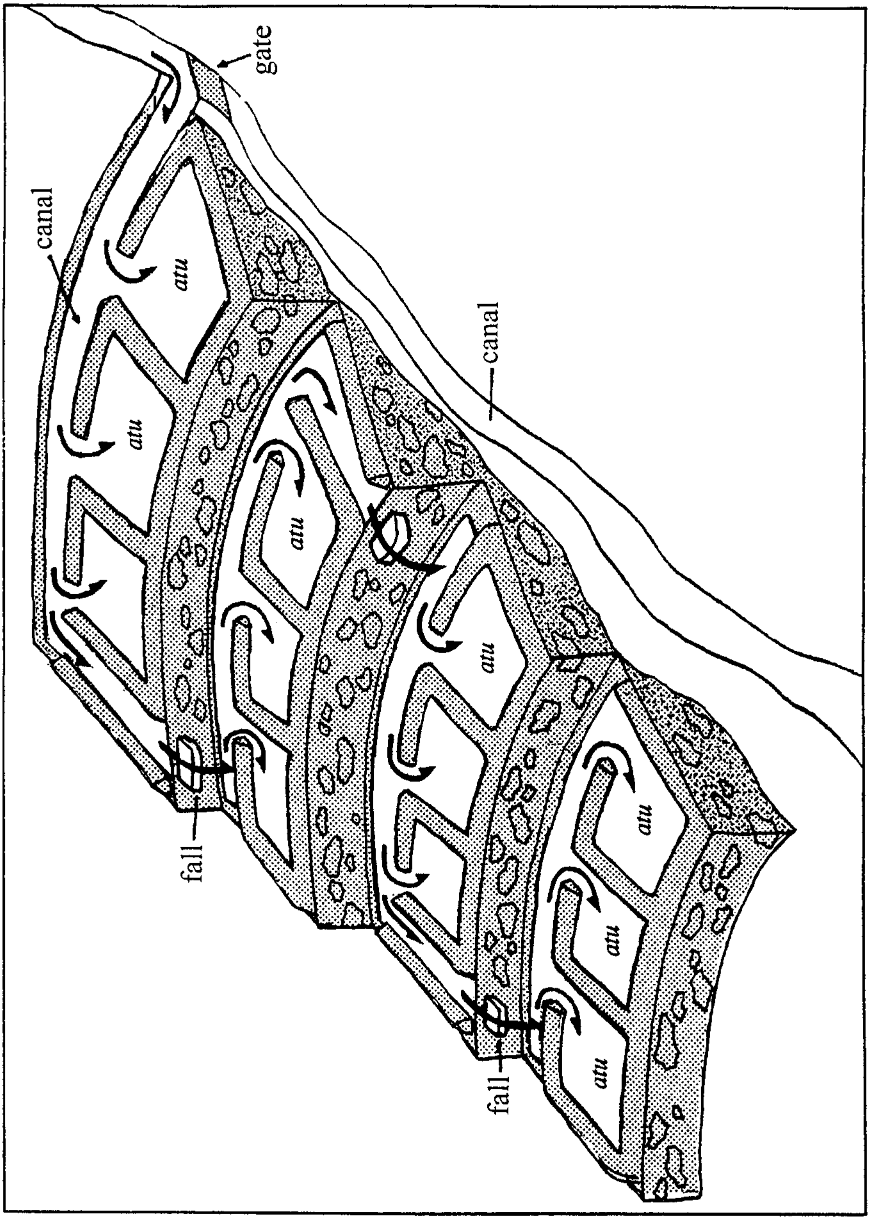

Fig. 2. A typical terrace irrigation unit.

Table II. Basic Principles of Irrigation in Huayncotas

1. Autonomy: The community has and controls its own flows of water
2. Contiguity: Water is distributed to fields in a fixed contiguous order based only on their location along successive canals
3. Uniformity:
   Among water rights: Everyone receives water with the same frequency
   In technique: Everyone irrigates in the same way
4. Proportionality (equity):
   Among rights: No one can use more water than the amount to which the extent of their land entitles them, nor can they legally get it more often than everyone else
   Among duties: People's contributions to maintenance must be proportional to the amount of irrigated land that they have
5. Transparency: Everyone knows the rules, and has the ability to confirm, with their own eyes, whether or not those rules are generally being obeyed, to detect and denounce any violations that occur
6. Regularity. Things are always done in the same way under conditions of scarcity; no exceptions are allowed, and any expansion of irrigation is normally prohibited
7. Graduated sanctions: Sanctions for rule violations are imposed by the community, and graded according to the gravity of the offense

THE BASIC PRINCIPLES OF ORGANIZATION

The principles that govern irrigation in the village are derived analytically from the rules previously discussed, and other conditions, and are summarized above (Table II). Some have been encountered in other places and discussed in other studies: autonomy[6] (Bolin 1994), for example, is of course basic to self-governed systems, which we now know exist in many parts of the world (Ostrom, 1990; Ostrom & Gardner, 1993). In this particular case, the control of water is unified or centrally-directed (see Hunt, 1988), but the system is not directly articulated with any outside agency and is, at the present time, fully autonomous. Although the State theoretically owns all of Peru's irrigation water according to existing law, the government irrigation bureaucracy has never had any presence in Huaynacotas, as in many other places, probably the majority of highland communities.

Because the village is so remote, the local state water administrator never visited the village during his tenure in the valley, and, according to

[6]This formerly was only a relative autonomy. Two neighboring communities, which have haciendas and occupy lands that formerly belonged to Huaynacotas, formerly used the same two water sources and had exclusive rights to use them on certain days of the week, two in one half of the system and one in the other, according to a customary arrangements with the estate owners that clearly went back quite far in time. On those days the water simply bypassed the village, and distributors from the other communities oversaw the irrigation process. Autonomy in that case referred merely to local control over the rules and procedures that govern water use. However, a new canal was recently built to provide those other communities with water from the Cotahuasi river, so that the sharing arrangement is no longer in effect, and Huaynacotas is now fully autonomous in water use.

the local people, the bureaucracy has never influenced the way things are done here in any way. Outside of major political and economic centers like the provincial capitals, the State has often had little influence on irrigation in Peru, although it has widely tried to intervene in places like the nearby Colca valley (Gelles, 1994; Guillet, 1992, 1994). This has left local people free to observe their own customs. As Ostrom (1990, 1992) and others have noted, people are much more likely to respect rules when it is they who set them.

Another basic principle, proportionality among both rights and duties, has been discussed by Glick (1970); Hunt and Hunt (1976); Coward (1979, p. 31) Ostrom (1990, p. 92, 1992, p. 69), Guillet 1992, pp. 204–5), Treacy (1994b) and others, and it is found in a large number of well-functioning irrigation systems (Ostrom, 1990; Ostrom & Gardner, 1993). However, it should be pointed out that, without another principle that has not been explicitly recognized, uniformity, especially in the watering frequency, no such proportionality among people's rights can exist. One can see that clearly in this case, where uniformity is a major preoccupation and a primary concern. Indeed, it is the individual water-user's active role in preserving this principle and thereby defending his or her own right—the right to one proportional share of water for their land during each distribution cycle—that allows the system to function effectively, by affirming the egalitarian principle upon which life in this community has long been based. To my knowledge, the latter concept has not been defined precisely in any previous study, probably because it is a feature that has been widely undermined by recent historical events.

People's rights—de facto claimant rights,[7] in the terminology of Schlager and Ostrom (1992), otherwise known as 'communal' rights—are qualitatively equal, in that everyone is subject to the same rules and procedures, which they know well. Indeed, everyone in the village knows not only how to irrigate a terrace but also how to operate the entire system, since the male heads-of-household do this in rotation, also sponsoring and directing the yearly Water Festival, *Yarqa Aspiy*, the ritual cleaning of the irrigation canals. Ostrom (1987) has stressed the importance of this kind of arrangement, which ensures that knowledge of the rules is evenly distributed throughout the community, rather than being concentrated in the hands of the water distributor.

Even more importantly, water rights here are quantitatively proportional to each other, varying only with the extent of a person's land. In

[7] In this system, users participate in setting, or continually ratifying, collective-choice rules of management, but they cannot alienate their rights, which are tied to the land, nor can any landowner in the community be excluded. These have more commonly been called communal rights (see Schlager & Ostrom, 1992:253), but they are not recognized by law, since, as of 1969, the Peruvian state, which has no presence here, has been the legal owner of all the country's irrigation water.

practical terms, this means that no one is allowed to deprive other people of water by using more than the amount to which the extent of their land entitles them, or, as commonly happens in other places, by getting it more often than everyone else. According to my experience in this valley and elsewhere, including the better-known Colca Valley (Mitchell & Guillet, 1994), such proportionality is crucial, amounting to a basic moral principle that clearly defines everyone's rights. And where it does not exist, as in most other communities in the Cotahuasi valley, this is a major source of conflict and a primary reason for the ongoing decline of communal and civic life. Indeed, it is this history of social decline in the other communities, the decline of proportionality, that I was able to trace in my research (see Trawick, 1994, 1995, n.d.a. in press, n.d.b.).

In any case, note that in this village, some families have more land and use more water than others, just as in any other stratified community, but that a fundamental symmetry prevails, not only in the size and frequency of household allotments, but also in the corresponding duties that people must fulfill in order to preserve their rights. Because large landowners have more land and use more water, their contributions to the Water Festival, and generally to the upkeep of tanks and canals, are required to be greater, in terms of labor and other inputs, than those of the smallholder majority. This is the other side of proportionality, as Coward (1979), Ostrom (1990, 1992), and Guillet (1992, pp. 204–206) have noted, in studies acknowledging its central importance elsewhere in Peru and in various other parts of the world.

Largely because of this arrangement, the infrastructure is well maintained, in contrast to what one sees in the villages of the lower valley, and in many other communities throughout the highlands, where no such proportionality of rights and duties exists. The breakdown of these communal work traditions has been widely noted in the Andes for many years (Erasmus, 1965; Hendriks, 1986), but in my opinion the main reasons for it, a lack of proportionality among rights and duties, and the resentment and conflict that arise among people because of this (especially smallholders), have never been understood. In a comparative analysis of several Andean communities, Guillet (1994, pp. 204–206) has come to essentially the same conclusion.

The principle of contiguity is vital for several reasons. In addition to providing a uniform frequency of irrigation—a basic right of all community members—the contiguous pattern limits waste of the resource due to evaporation and filtration (a serious problem nearly everywhere in the highlands) by minimizing the total surface area of canals in use at any point in time. As in most villages, the canals here are unlined and allow a great amount of water loss. Consequently, it is best to concentrate irrigation in one small area, rather than jumping erratically around, as happens in other local communities under other kinds of arrangements. The reason was explained to me by the water distributors, who pointed out that the water loss decreases dramatically once a canal surface and the soil beneath it have become saturated or waterlogged. By taking advantage of this and watering the entire surrounding area before moving on, the amount of loss is minimized (see Treacy [1994a, p. 224] for another case where this fact is explicitly recognized).

Even more importantly, the contiguous pattern makes irrigation a public affair. Since everyone knows the rules that govern distribution, and thus the exact order in which they are supposed to receive water, and because the owners of adjoining parcels tend to irrigate on the same day, people are normally putting their fields in order, or simply waiting and watching, while their neighbors finish their turns. This means that monitoring, an essential function in any irrigation system, is pervasive and routine, spread out among users throughout the system, rather than a special task put entirely in the hands of the water distributor. The vigilance helps the distributors in ensuring that traditional procedures are followed, and it has the vital effect of providing controls upon theft, favoritism on the part of water officials, and other forms of corruption.

Such assistance is crucial because, in the steep and convoluted terrain of the Andes, it is ultimately beyond the capacity of any distributor, even the most physically fit individual, to divert the water from the main canals, guard against theft higher upslope, and monitor the circumstances and duration of water use in the fields, all at the same time. Typically, the vertical landscape is physically overwhelming and simply precludes this, as I have seen many times, in several communities, while accompanying distributors on their rounds.

The rules and the work involved, together, thus create a situation of transparency, another principle that is vital to the functioning of the system. People can see what is going on and, since they always know roughly where the water should be, and how fast the cycle should be advancing in a given area, they tend to know an infraction of the rules or other problem when they see one. They are quite confident of their ability to protect their own rights, and this has everything to do with their strong tendency to obey the rules and respect tradition.

The simplicity and efficiency of this arrangement are reflected in the fact that no daily or even weekly meetings are needed (often called *reginas*) so that the Campos can tell people when the water will be theirs to use, as is the tradition in the other communities where I did my research. Instead, they simply pass the word informally in the evening from house to house, telling landowners that the water is about to enter their particular canal or section thereof. Everyone knows the watering order and the way things are supposed to proceed—even roughly how long it should take to irrigate their area at different times of the year.

Infractions and other causes of conflict are rare in Huaynacotas, but, due to the extreme scarcity of the resource, they do occur. This will happen to some extent in any irrigation system, no matter what the rules, and of course there is always the possibility that the rules will not be enforced, especially when the penalties are harsh, as is the case here. However, in such a transparent system this kind of corruption cannot happen repeatedly without being discovered by the other water users. When infractions are detected the penalty is severe, but graded according to the gravity of the offense; it varies from the loss of one allotment during a given cycle to the loss of one's water rights on a given field for the remainder of the year. This is another design principle—graduated sanctions—that has been widely encountered and much discussed in the literature, particularly in Ostrom's work (1990, p. 90, 1992, p. 71), and it is part of the tradition here.

There is one local landowner who was formerly notorious for breaking the rules and taking water out of turn. The man would confront the distributor if he objected, threatening him in an effort to force him to accept someone else getting bumped down in the watering order. The head of a relatively wealthy family having a fair amount of power within the community, this individual and his sons often used such strong-arm tactics to prevent any penalties from being imposed. The abuses reportedly continued for several years, but ultimately led to various forms of social ostracism by the other community members, who were quite aware of what was going on. Partly as a result, the family was ultimately forced to leave, selling their land and moving to the city. The example shows that such defiance or "free-riding" is always possible, and no system of rules and sanctions can ever fully prevent it. The important points in this case are that the community knew about it, and that it led to ostracism and various kinds of informal sanctions, rather than to the spread of such cheating behavior within the community. Water distributors insist that theft is rare, and that this is the only persistent case that has occurred in recent memory.

Unfortunately, there are no kinds of quantitative data that are capable of demonstrating that this is indeed a highly effective arrangement for sharing a scarce resource (but see Mabry and Cleveland [1996] for an argument for the superior efficiency and sustainability of 'indigenous' systems over industrial ones). Water flow measurements cannot do this, and crop production figures would have to be gathered over a long period of time. Ultimately, however, the assertion can only rest on the basic design principles and the manner in which they work together, on the functional logic of the system. Data on the frequency of theft and the imposition of sanctions, which might be one way of illustrating it, are unavailable because no such records are kept. But, again, village members seem to agree emphatically that such incidents are rare.[8]

However, the Andean literature does provide some supporting data, coming from other communities where this type of system is utilized. Treacy (1994a, pp. 221–224) provides the best example, the community of Corporaque in the Colca valley, where the system is part of a dual or moiety organization that traditionally had two modes of operation: a contiguous one exactly like that of Huaynacotas (referred to as *mita*), used when the resource is scarce, and a more erratic and flexible one (known as *saya*), used when it is relatively abundant. While arguing that the mita is by far the more efficient of the two (also arguing that it must have been the original Inca system), Treacy pointed out that, while using it, a total of 291 people were able to irrigate in a single month during the dry year of 1981–82. In contrast, only 205 were able to irrigate under the other regimen in the same month during the following year, a time of water abundance. That, of course, is an impressive difference, in one of the few places in the Andes where two kinds of system are in place and where a fully controlled comparison is therefore possible.

Gelles (1994) examines a different version of the saya system in his study of another village in the Colca valley. In that case, implementation of the mita (or *de canto*) system, due to pressure by officials of the Ministry of Agriculture, resulted in a water savings of six days, greatly shortening the distribution cycle. Interestingly, the change was nevertheless resisted by the local people, mainly because the Ministry allowed certain powerful landowners within the community to use those six days of water in order to expand the system onto formerly unirrigated lands. That went against the principle of regularity and thus fully negated the benefit for the other village members—a higher frequency of irrigation—thereby contradicting the logic of this kind of system.

There are other basic principles of the Huaynacotas system, such as well-defined boundaries, which are found in other well-functioning irrigation systems (Ostrom, 1990, p. 90, 1992, p. 71), and which I will not discuss here. Instead I want to focus on principles that create a strong incentive, for the community members, to comply with the rules—on the positive consequences of cooperating, rather than on negative sanctions that coerce people

[8]Perhaps the most feasible kind of theft would be stealing water at night above a reservoir, while the tank is being filled. Several factors seem to discourage this, however. First of all, people in the village generally do not like to irrigate at night because of the cold and the risk of illness. Secondly, the distributor can easily track this down, and in fact he spends a lot of his time and energy determining whether or not it has occurred. This is because he is able to concentrate most of his attention in the upper part of the canal system, since he has the assistance of neighboring users in overseeing water use in the fields. That is the main benefit of this kind of arrangement (see below).

into it, or back into it when they misbehave. Clearly, both kinds of incentives must be present in any effective system, but it is the positive one that in this case is especially strong. I have said that I think this is a highly effective way of managing and utilizing a scarce resource. What, then, is so unusual about the tradition from the perspective of the water user?

THE INCENTIVE TO CONSERVE

All of the principles play their part in creating a transparent and equitable system, and all contribute to its effectiveness. They include regularity (see list above), whose importance is indicated by the case described above. As I learned through my work in the other valley communities, exceptions to the rules and special provisions that modify the way things are done only promote mistrust by introducing a degree of opacity, and they open the door wide for favoritism and abuse. The rules must be consistent at all times, in all places, for everyone involved, as they are in Huaynacotas. In the rugged terrain of the Andes, the motive for conservation and cooperation can only be found in the link between the efficiency of water use—in terms of avoiding waste and respecting the rules—and the duration of the irrigation cycle. And that link is only direct and obvious, to the farmer, under these conditions. Allowing irrigation to expand, of course, would break that link by allowing certain people to benefit directly and disproportionately from the cooperation of others.

Although each of the principles is crucial, the most pivotal one in terms of the incentive to cooperate is the uniformity of the watering frequency, this basic commonality among people's rights. When everyone irrigates their land on a single schedule, and when any sudden expansion is prohibited,[9] the water saved by individuals through conservation and self-restraint causes the distribution cycle to run faster. Thus, by limiting watering to a fixed period of time and obeying the rules, people are able to irrigate more often, as often as possible from the long-term point of view. And, conversely, in a situation of uniformity, "free-riders"—people who ignore the rules and steal water in order to give their crops an extra dose (60 days between turns is, after all, a very long time) or who irrigate excessively—interfere with the efforts of others to shorten the cycle and instead cause it to slow down. Consequently, the arrangement generates strong social pressures against this kind of behavior.

[9]Expansion is, technically speaking, allowed on any unused land lying within the confines of the canal system. However, no such land exists, since every available space has been terraced and is in production. Some expansion is now occurring in the abandoned t'ikras, but that requires the permission of the community.

Such behavior is readily discovered under the conditions I have described, and its negative effects for everyone in the community are obvious. Contrary to what Hardin (1968) argues in his theory of tragedy, that harm becomes tangible and easily perceptible once the cheating spreads beyond a certain point. And it affects everyone in the community, even the perpetrators, in the same way and to the same extent. Hardin, of course, argues that the advantages of such cheating behavior fall directly on the perpetrator, the free-rider, whereas the disadvantages or costs of such behavior are shared with and absorbed by everyone else in the community. For the offending individual, this is thought to mean that only a tiny fraction of the harm done is even perceived, let alone directly felt, so that people tend to act in spite of it and treat it as a trivial thing.

Water, however, is a unique resource: dynamic and capable of quickly manifesting the consequences of such behavior, at least under certain conditions. It presents a special case wherein the "commons dilemma" can potentially be avoided. What happens under the circumstances I have described is that the cheating soon results in another day, or even more, being added to the watering cycle. This means that, from the standpoint of the individual user, the damage done by any contemplated cheating is not signified by some abstract **1/n**, as in Hardin's model, where n equals the number of irrigators in the whole community. Instead, the damage that would be done in this case can be represented by **1/s**, a fraction of a day's total shares of water: the tangible delay, in terms of shares and hours, that the cheating would cause in the irrigation cycle. For example, where a three-hour share of water is taken out-of-turn, in a day consisting of three such shares, the harm done by the cheating would be 1/3 of a day. It is true that, if only one person in the entire community does this, the delay will be 'diluted' by everyone else, so that the net effect will ultimately be nil. But that is not how it works in this kind of system; the decision must be made on the basis of a far smaller set of people: the group of users along a given canal and those within the surrounding sector of land, the one where watering is legitimately supposed to be taking place.

Under the conditions I have described, it is obvious that, if only two other people do the same thing, another day will have to be added to the watering cycle, yielding a total damage or cost of 1. In a situation where water is far from adequate for crops, as in Huaynacotas, this will ultimately be harmful to everyone, even the free-riders themselves. Only two other people have to infringe in order to cause the water to delay an entire day in leaving a given canal. And, under this kind of arrangement—where there are no exceptions, no separate cycles for certain crops or special allotments for certain individuals—people know rather precisely how long this should take, at different times of the year. If one then widens this perspective slightly to include the other canals in the surrounding sector of land, whose cycles are also known, as well as the other landowners, it becomes clear how quickly the effect can magnify and become a serious threat. And the threat is obvious to everyone because the link between individual behavior and the irrigation frequency is as direct as it can possibly be.

The feedback on such cheating behavior is therefore immediate and quite perceptible, indeed quantitative: the number of days that the watering cycle takes for a given area of land. This creates a powerful incentive—a positive one—to cooperate and be vigilant, since by doing so people are minimizing that number and maximizing the frequency of irrigation. By conforming to the rules and respecting tradition, people are optimizing, and any failure to do so has tangible consequences for everyone.

The incentive to comply is thus remarkably strong, especially when one takes the pervasive monitoring and the threat of sanctions into account. And the tragedy of the commons, far from being inevitable, is actually rather difficult to bring about. Such a situation, which might be likened to 'comedy' in the classical sense, i.e., "the drama of humans as social rather than private beings, a drama of social actions having a frankly corrective [and mutually beneficial] purpose" (Smith, 1984, cited in McCay & Acheson, 1987, p. 15), is created by the scarcity of the resource, which in this community is especially grave, and the arrangements that people have worked out for dealing with a situation that is far from ideal. That is the 'dilemma' that the people of Huaynacotas face, but it is not one they have brought upon themselves.

CONCLUSION

I have discussed these principles, not just to show that they exist in this community, but to encourage other researchers to look for them in other places. I know that they are widespread; it is easy to confirm from the available literature that this same set of principles, and even highly similar practices, have been worked out in similar situations in many other parts of the world (Maass & Anderson, 1978; Coward, 1979; Siy, 1980; Ostrom, 1990; Ostrom & Gardner, 1993). They exist, I think, wherever we find irrigation systems that work well and where people have dealt with scarcity successfully for a long time. I am confident that, once people begin to look at the data more closely from the perspective of the water user, they will be recognized and their implications for theory-building and policy-making will become clear.

This is not to say that Huaynacotas and other communities like it are perfect, some kind of hydraulic and social utopia, for they are not. Again, water is occasionally stolen, given by the distributors illegally, or otherwise taken out-of-turn, infractions that always generate conflict because the frequency of irrigation is so low. But this kind of system is, I think, as close to perfect as we are ever likely to get. By way of conclusion, let me mention some alternative ways of managing the resource, and explain very briefly why they do not, and cannot, work as well.

An approach that seems to be common in many parts of the world, despite a prevailing shortage, is to allocate water according to some kind of hierarchy. This can be a social one, with shares given to households rather than to fields in an order that is ranked, based on the status and prestige of the landowners. Or it can be agronomic, based on the relative importance of crops and their respective water needs. Plants—and fields—are sometimes given water preferentially, even separately in different cycles, according to what those needs are thought to be during the various stages of plant growth. Both kinds of hierarchy are common in the Andes, and both are found in the Cotahausi Valley; indeed, they characterize the other two communities where I did my research.[10]

Unfortunately, both of these systems foster scarcity and a greater degree of conflict, since both create perverse incentives that encourage people to waste and otherwise abuse the resource. This occurs for two reasons. First of all, the watering order becomes somewhat flexible in both cases, typically changing from one cycle to the next (see Treacy, 1994a, pp. 220–224). Under the social kind of hierarchy where landowners have to formally ask for their allotments (in meetings) each time the cycle comes around, they frequently request that time conflicts and other inconveniences be accommodated, something that distributors are inclined to do, since they alone determine the exact order under this arrangement. Secondly, the order is more dispersed in both cases—spread out along a given canal, within a given sector of land, or even within a wider area, rather than being concentrated in one small area at a time. This pattern greatly increases the total surface area of canals in use at any given moment, and, for reasons already explained, it

[10]The first type of hierarchy probably has prehispanic roots, like the more equitable and efficient tradition found in Huaynacotas, an issue that I cannot deal with here but do elsewhere (Trawick, 1994, n.d.a, n.d.b.). It seems to have become instituted widely during the colonial period, a time of sustained population collapse. This caused water to become abundant for the first time in centuries, eliminating the need for conservation, a situation that persisted for a very long time. The second type has often been imposed by the State in the rural areas directly under its authority, those where the bureaucracy actually has a presence in irrigation. This general model, sometimes called irrigation-by-crop, was the one used in drafting the provisions of Peru's current water law that deal with drought emergencies, and it often results in the implementation of a special cycle for food crops only called the *auxilio*. This measure, like the General Water Law itself, is based on the assumption that there is enough water available to satisfy fully the 'needs' of the most important crops, a situation that rarely exists in the Andes. As my comparative study of these different systems shows (Trawick, n.d.a), the far better solution during a shortage is to share the scarcity equitably and fairly.

increases the amount of water lost through filtration, thereby exacerbating the scarcity (again, see Treacy [1994a, p. 224] for a precise measurement of the effect). Just as importantly, such flexible and dispersed arrangements necessarily have the effect of making the system less transparent, or more opaque, to the water user.

When the watering order is dispersed and subject to change from one cycle to the next, irrigation ceases to be a public activity, an act carried out by neighbors in full view of one another. The opportunity to observe each other irrigate does not come routinely, so that monitoring becomes problematic, now falling largely on the water distributor. Furthermore, since the distribution order is flexible and somewhat complicated, the rules are no longer as clear. People don't necessarily know where the water should be at a given moment, nor do they always know an infraction when they see one. Under these conditions, theft and favoritism can occur much more easily because the controls on them are not strong. The same is true of waste, the most serious problem and one that has tragic consequences for all.

It might seem that theft, at least, is easily discovered even under these conditions. After all, it is obvious from the condition of the soil in a field if that particular parcel has just been watered. However, in rugged and steep terrain, people have to go to a lot of trouble in order to track the water down, something that the distributor may be unwilling to do, as I have seen for myself. Unless he has the assistance of neighboring users in overseeing water use in the fields, under a transparent and contiguous arrangement, he may simply be unable to guard against theft because his responsibilities exceed his physical capacity and the time he has available to cover so much ground. Consequently, the task is often left up to the person whose water has been stolen, who may not be willing to do it either, but opt instead to wait, allowing him/herself to be bumped down in the watering order.

A hierarchical system is much more easily corruptible at all levels, as I saw in the other communities where I did my research. The link between one's own behavior and the frequency of irrigation is not as direct and obvious, and people are aware of this, of their inability to see clearly what is going on and to protect their own rights. For the water user, this kind of arrangement creates a feeling of vulnerability and mistrust, on the one hand, and a desire for a way out of their predicament, on the other—key ingredients for a tragic outcome. And the greater the scarcity, the greater the likelihood it will happen.

What is a person to do in this kind of situation, but behave badly and join in the struggle over a scarce resource? Where is the motivation to conserve water and obey the rules? Hardin, of course, felt that people have a natural tendency to act this way, selfishly and without regard for the consequences for others. I strongly disagree, and point out that everything depends on the specific resource involved and the institutional arrangements that have been worked out for utilizing it. Water is special, unlike any other resource and absolutely essential for life. Fluid and dynamic, it connects people with each other in a unique way. And, under certain simple conditions, it can create a kind of clarity that allows them to see, and even to pursue, the common good.

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