COMMON PROPERTY MANAGEMENT OF WATER IN BOTSWANA

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INTRODUCTION

In 1974 the Botswana Ministry of Agriculture established a policy of constructing small dams to be managed by groups who before construction agreed to stock limitations and management rules. It was intended to prevent overstocking, overgrazing, and improper dam maintenance. The groups would have the right to use the dam if they abided by the conditions of the initial agreement. By 1980 the policy was considered a failure; the dams, overstocked and overgrazed; and group management, nonexistent. Much of this alleged failure was attributed to people's treating their dams as if they were open-access, free for all to abuse. This study of the use and management of these dams will show otherwise.

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BACKGROUND INFORMATION

Definitions

Excluding a few large villages, the communal areas of eastern Botswana contain approximately 20 percent of the country's land, 60 percent of its human population, at least 40 percent of its cattle, and most of its crop production. Trible land, statutorily defined as land under the allocative and adjudicative control of government land boards, comprises the majority of this area. It is commonly considered to be communally-held since it cannot be owned on a freehold basis. Communal areas include small villages, cultivated areas and cattleposts on tribal land. "Lands" denotes both cultivated fields and the general area where they are found. "Cattlepost" means both where livestock are penned and adjacent grazing areas. The major water sources include boreholes, open wells, and surface water catchments, namely dams, haffir-dams and haffirs.

Seasonal Cycles

Water management in rural areas reflects the interrelated changes in residence and activities associated with the seasonal cycles of agricultural production and rainfall. Highly variable, average annual rainfall in eastern Botswana averages between 350-500 mm. Unreliable rainfall makes crop failure probable once in four years.

Seasonal rainfall determines which sources contain water. The agricultural season generally begins with the rainy season; it in turn affects the location of people, their cattle and the nature of their water needs. Water use in a given locality varies with these changes in residence.

When the first rains fall, people move to the lands and start farming. Convenient lands water supplies are in great demand at the beginning of the cropping season, the busiest time of year for most farmers. Once harvesting is finished, the scarcity of surface water at the lands and cattleposts drives many household members back to their villages. Increased demand for water for making beer after the harvest is in also supports the residential shift back to the better watered villages.

Each village, lands, cattlepost has its own seasonal resource base and activities. Its social and economic activities may change over the course of the year. For example, after harvest a number of lands become grazing areas and villages, places for celebrations and social gatherings. These interrelated places and population shifts make the multiple locality (the village and its lands and cattleposts) the most appropriate unit of analysis for rural land and water use.

The Fallback Strategy

The seasonal water use pattern for livestock can be seen in increased reliance on groundwater sources in the dry season as surface

water use declines (Bailey, 1982:174). Shifting water sources reveal a highly adaptive household fallback strategy of water point use and management to ensure a reliable supply over time for household purposes. The sensible household has a flexible backup system of water supplies. As one water point goes dry or breaks down, the household shifts to other, sometimes less convenient, but more reliable water points.

Water Point Typologies

Rural water supplies can be characterized by four characteristics: (1) their locational frame of reference; (2) the interaction between their physical structure and the degree of seasonality of use and management; (3) the distinction between management of the water point and management of its use; and (4) the types of management.

The Locational Frame of Reference

Water management involves four locational frames of reference: the water point site; the locality; the multiple locality; and the rural water sector as a whole. For example, a borehole plays multiple roles in an area because of this locational frame of reference. At the point, the borehole is or is not used for domestic and/or livestock purposes. In the locality, it may be the village water supply free to

all. Within the multiple locality, it may serve as the drought fallback water point, the use of which is rationed during the drought. Within the sector, the borehole's operation may be hampered by the government's limited recurrent budget for all of its boreholes.

Water Point Structure and Season

Knowledge of resource availability underlies the temporal mobility and flexibility at the heart of household fallback water strategy. As seen in Table 1, this in turn is affected by whether the water point structure is fixed and whether use and management occur seasonally or year-round.

The Management Matrix

"Water management" blurs the distinction between water point management and water use management. The examples in Table 2 make this distinction and indicate how easily different types of open-access resources can be confused. To some, open access water means case 4; others would add cases 2 and 3; a few would call case 1 open access if the water were public property.

Table 1 A Typology of Water Point Structure, Use and Management

Water Use and Management	Water Point Structure: Fixed	Water Point Structure: Unfixed
Seasonal	Many dams	Emphemeral puddles
Permanent	Some wells and boreholes	Sandriver (wadi) pits redug in different sites of the same riverbed

Table 2 A Typology of Water Use and Management

The Water Point	**Water Use: Managed**	**Water Use: Unmanaged**
Managed	**1. Managing operation of some dams and boreholes**	**2. Unherded cattle breaking through a dam's bush fence**
Unmanaged	**3. Cattle herded into open-access dam or river for drinking**	**4. Cattle freely watering from puddles and pits**

Management Type

Classifying a water point by management type is complicated. A group-operated, government-owned borehole may be managed as if it were a private borehole, i.e. a single person or family dominates. A privately-owned well may be used by residents of a locality as if it were a communally-held open-access facility. It is not uncommon to find a water point with a different owner and manager or being used in a way not originally intended by either.

Thus, it is useful to classify water point management in three ways: (1) by owner, (2) by manager, and (3) by the kind of access locality members actually have to the water point. Owners and managers can be separated into four categories: (1) private individuals or families; (2) small non-kin groups; (3) government authorities; and (4) communities. Access to a water point is defined by whether its use is open or restricted in practice.

In general, community owned and managed natural water sources are open access. But there is noone one-to-one association between private ownership, private management, and restricted access. A group-managed water source can be managed as a restricted access water source.

THE CASE STUDY: AN APPLICATION OF THE OAKERSON FRAMEWORK

Physical and Technical Attributes of Small Dams

Small dams, with steep walls and deep excavation pits, appear to have structural aspects affecting the jointness, exclusiveness, and indivisibility of their water supply. But, as seen in Table 1, water point structure cannot be isolated from factors making its access and operation variable over time and place. While the structural features of water point technology are fixed, their effects are almost all variable.

The constraining effects of water point technology depend on location, when the water is available, how is it made available, and

how the source is managed. The availability, quantity and quality of labor used to draw water bear profoundly on the bundle of physical constraints associated with the use and management of a particular dam. The same dam, with the same amount of water, presents a fundamentally different set of physical constraints to users a month before and after harvest.

Decision-Making Arrangements: The Theory

Here the rules people were to follow for the Ministry of Agriculture small dams are considered according to our locational frame of reference. At the dam, group behavior was to be guided by the Terms of Agreement the group signed with the government as the condition for takeover of the dam. Within the locality and multiple locality, a major rule used by land boards required at least 8 kilometers between livestock watering points to minimize the potential for overgrazing between them. The water sector was affected by traditional norms defining and regulating common property land and water resources. Finally, the formulation and implementation of the dam policy were conditioned by broader institutional and national concerns.

At the Dam: The Terms of Agreement

Under the dam policy, the dams were to be primarily for stock watering in the lands and cattleposts; they were not intended to provide domestic (human drinking) water to villages. A dam group was to consist of approximately 15 members, averaging fewer than 20 adult cattle each, with no single person allowed to water more than 50 head. Each group, consisting of farmers who wanted the dam and were "willing to control their grazing," was to be formed prior to dam construction and to sign standard "Terms of Agreement" as a precondition to handover. The major conditions in the agreement were: (1) Group members would maintain and repair the dam. (2) Each member would pay an annual fee per adult animal to provide revenue for dam maintenance and repair. (3) No more than the equivalent of 400 adult cattle would water at the dam.

It is unclear if the Terms of Agreement were a binding legal document, although they included a clause enabling local government authorities to take "appropriate action" if conditions were not fulfilled.

Within the Locality and Multiple Locality: The Eight Kilometer Rule

Whether any official government document ever stipulated an 8 kilometer spacing between livestock watering points is unclear. Yet, both inside and outside government, the widespread impression is that

land boards should follow such a rule as an unofficial policy. The presumption has been that this rule was appropriate for spacing permanent livestock watering points for between 300 and 500 head of cattle. The rule applied to the spacing of small dams built under the 1974 policy.

Within the Sector: Differing Norms and Institutional Concerns

Traditional common property norms and Ministry of Agriculture institutional objectives often contrast sharply in Botswana. The expatriate planners of the 1974 dam policy appear to have been unaware that many users perceive dams—especially those built by government—as common property facilities (Schapera, 1943). The government believed water scarcity justified a flat-rate water charge to discourage overutilization of the dam. This ran counter to the traditional norm that all who needed to could use surface water, particularly when it was scarce. Officials argued that water prices were necessary to impress water scarcity upon dam users, failing to recognize water was scarce only seasonally and that traditionally the Batswana had managed scarce common property resources without resorting to explicit prices.

Second, since at least the 1960s drought, many government authorities have considered forage the first limiting factor in tribal area livestock production in tribal areas. In this view, livestock deaths including drought deaths, were caused by lack of grazing due to excessive overstocking around permanent water supplies. So

conditioning government water point development on user stock limitations appealed to many officials. The small dam policy was justified as a lever for obtaining better grazing control, both through constructing new dams in a more dispersed fashion and through stock control measures. But surveys suggest that rural households see grazing land as a seasonally renewable resource, not as a limiting factor and attribute overgrazing to poor rainfall rather than to overstocking.

There is also a subtle difference in perceptions about the lack of man-made watering points restricting access to new grazing areas. Some Ministry of Agriculture staff believe that the development of livestock watering points in a new grazing area increases that area's effective carrying capacity. But the availability of "frontier" grazing and water sources has probably worked against their more efficient use in the older established areas and undermined the stated government intention of treating water and grazing as scarce resources, because Botswana stockholders believe it is cheaper to get forage and water in new areas than to manage them more effectively in old areas.

Finally, small dam policy reflected three strong Ministry of Agriculture institutional biases at the national level.

Anti-Overstocking Bias Sensitive to charges that earlier large dams had encouraged overgrazing and overstocking, officials tried to control stocking rates at the 1974 dams through stock restrictions in the Terms of Agreement and by designing smaller dams with lower watering capacity.

Sandveld (Desert) Bias Extending livestock water supplies into the sandveld areas has been a major government objective since at least the 1950s. The view of isolated desert boreholes operating far from alternative water sources led some government staff to the erroneous assumption that reliable livestock watering sources were similarly spaced everywhere and that therefore existing points would be managed.

Reliability Bias The small dams were intended to be managed year-round, with the assumption that water supply reliability is the most single important factor in rural water demand.

Decision-Making Arrangements: The Practice

The decision-making arrangements described above were realized in practice in substantially different ways than were originally intended.

Patterns of Interaction at the Dam

Terms of Agreement Information was collected on 24 of the estimated 99 small dams constructed under the policy between 1974 and 1980. Of these, 21 had some sort of group management in the form of maintenance, regulation, and/or revenue-collection activities.

Maintenance Functions Dams require no technically complicated maintenance unless they collapse or silt up, reasonably infrequent events in Botswana. Maintenance is largely preventive and its absence is not immediately apparent. About half of the groups did some maintenance. No dam group did all stipulated maintenance. Most maintained the fence enclosing the dam wall and reservoir, less to lengthen dam life than because regulation of use depended on them.

Regulatory Functions All groups tried to regulate the use of their dams. As the alternative sources began drying up, they began restricting access to the dams. The regulations did not always follow government forms (no dam group set stock limits), but they did lead to water management. Four kinds of regulation were common.

Limiting Numbers of Users Managers generally turned away outsiders, even those willing to pay fees, rather than nonpaying members of the group or of the same locality.

Restricting Types of Use Some dams were limited to domestic purposes only, either permanently or seasonally as other sources went dry. The success of such limitations depended on the availability of alternative and fallback water points.

Controlling the Manner of Use Limiting direct cattle access into the reservoir was generally found at dams used for domestic purposes.

Ironically, this regulation desired by the government occurred mainly in conjunction with a use for which the dams were not primarily intended.

Regulating the Time of Use Some dams are closed completely at certain seasons. In some cases dams were used as back up points for other water points subject to breakdowns, such as boreholes. Other dams were part of the sequential system of fallback points.

Revenue-Generating Activities As dams have few, if any, operating costs, dam users perceived less need for fees than users of water points such as boreholes with obvious and compelling operating and maintenance costs. Nine groups said they charged fees; none used the recommended flat-rate fee for livestock. Revenue was generated in response to specific needs, often as a contribution, e.g., paying a caretaker for the dam. Few dam groups seemed inhibited by want of funds from taking essential action.

The next section examines why groups did what they did. Since much of their behavior is explained by operating norms and perceptions within the water sector as a whole, discussion of the use of the eight kilometer rule is deferred until later.

Patterns of Water Sector Interaction: Dam Operating in Perspective

Why People Followed Some Government Management Procedures Dams served a useful purpose. But, contrary to the Ministry perception, dam users valued convenient and cheap water supplies, not just reliable ones. Since investments of time and money in the transport of water could be applied elsewhere, it was worthwhile to protect and preserve a nearby supply. Fences were maintained because people saw their effectiveness as management tools. Similarly when the water in a dam came under stress within a fallback system, its use was regulated. The rest of the year the dry dam was of little interest to its users.

Why People Did Not Follow Other Government Management Procedures Two sets of broad factors, technical and social organizational, seemed to have encouraged groups to depart from the Terms of Agreement.

Technical Factors. The Small Capacity of the Dams Dams were intended to provide water through the dry season given adequate rainfall. But even given sufficient rain, many small dams cannot provide water then because of improper siting or the pressure of an excessive number of stock. If a dam is perceived by its users as likely to go dry, it makes sense to "mine" the water while it is there, especially if there are other water points to fall back to.

The small capacity was the result of a Ministry of Agriculture decision to opt for smaller dams to prevent overstocking. But by

choosing smaller dams, the Ministry reduced their reliability for year-round livestock watering, and thus an incentive for permanent management.

Dams As Low Maintenance Facilities Many people favor dams precisely because maintenance requirements are perceived to be low, and the need to pay fees minimal.

The Role of Dams in the Fallback System During the rainy season when water is plentiful and often during the late dry season when many people have returned to the villages, dam management does not pay. Management makes sense only when the dam is used as a fallback point or needs repair. If fees are collected, it is typically at this time. Management occurs under stress at the time when dam water is critical.

Dams as Multiple-Purpose Water Points If livestock access to dam water is restricted, users are more likely to use it for domestic purposes. Twenty of the 24 dams surveyed were used for drinking water. Management of dams providing both domestic and livestock water often differed from those used for livestock only. For example, users looked upon domestic water charges with even less favor than livestock watering fees since domestic water was supplied free of charge in most villages.

Social Organizational Factors. Shortage of Labor Dam use was affected by a perceived shortage of agricultural labor, especially for

cattle-herding. Herders would much rather open a gate and allow cattle to water freely than to pump water into a trough. Labor-intensive dam maintenance activities may not be done for lack of labor. Indeed the very lack of fences and deep reservoirs may have increased the value of some smaller dams to labor-short stockholders who only used them to water livestock. This, however, ensured these dams would not be managed as required by government.

Local-Level Perceptions Affecting Dam Use Government dams are generally considered to be government property, the local feeling sometimes being that government should take care of them as it does its other property. The policy of group formation prior to construction that was meant to foster a sense of local ownership did not always succeed. Because of the traditional norm of open access to many surface water sources, a small dam was commonly perceived as belonging either to government or to the people of the locality in which it had been sited; rarely was it seen by residents as belonging exclusively to a small group of people in that area, even if they had been registered by the government.

Dam Groups As A Government Creation Dam groups had little or no basis of local legitimacy. The official members were not particularly deserving of a dam. They were simply in the right place at the right time. From the government viewpoint, the group had been given the right of exclusive use of the dam and the responsibility to manage it properly. But other residents of a locality were often not prepared to

recognize this "right." The communal land on which the dam was built "belonged" to all residents, including the neighbors of group members. The dam itself was constructed by the government at no cost to the group. The water was rain water. This distinguishes the dam groups from individuals whose private right to wells or dams comes from the labor or capital invested in their development. Dam groups cannot draw on traditional norms to support their claims. Moreover, as long as there is mutual assistance among neighbors, dam group members hesitate to turn away people who might help them in other circumstances.

The Declining State of Self-Help The absence of community sanctions against those who did not support the management of a dam might have reflected the low priority that all self-help activities received in an area. Failure to contribute to dam management may have occurred in the context of an increasing lack of trust and cooperation in some localities.

Insiders Versus Outsiders Rural Batswana consider their major water and land difficulties in the communal areas to lie less in developing or managing the resources directly than in managing the conflict caused by differential access to and control over these resources. People complain about their neighbors being uncooperative in assisting in the operation of a water point. Others complain about marauding "outsiders" who come in and use locality resources without permission. At all levels there is conflict over the use and management of tribal land and water resources in many parts of eastern

Botswana, where determining who is an insider and who are outsiders to a locality and its land and water is fast becoming the central feature of this conflict.

Patterns of Interaction Within the Locality and Multiple Locality: The Eight Kilometer Spacing Rule

The small dams at the survey sites were often closer than eight kilometers to other permanent water sources, and in four sites dams were less than eight kilometers from each other, indications of the many exceptions made to the eight kilometer rule.

Technical Ambiguities in the Rule The rule was intended to prevent exceeding the carrying capacity of the rangeland through the spacing of permanent water points with capacities up to 500 adult cattle. There are a number of technical problems with its underlying assumptions.

Carrying Capacity A key problem is using a 450-500 kg animal as the standard of carrying capacity. Because of local production strategies, cattle in these areas often weigh considerably less.

Grazing Around the Water Point Since existing livestock watering points in the east are often nearer than eight kilometers to each other, grazing does not always improve with distance from a water point.

Watering Up to 500 Head Stocking rates are difficult to assess since they usually vary by season. Comparing two watering points with numerically equivalent stocking rates at different seasons of the year would require normalizing stocking rates and estimating equivalencies for seasonally variable forage conditions.

8 km Spacing This rule implicitly requires an animal to trek 8 kilometers or more a day although this is inadvisable for certain types of animals at certain times of the year. Hydrological and topological conditions also affect the practicality of standard spacings.

The Political Mandate for the Eight Kilometer Rule Despite these technical difficulties, it is precisely the technical aura of the rule which is politically appealing to land boards. The Tribal Land Act gave land boards statutory authority over land and water allocation and adjudication, but left them with the task of establishing the legitimacy of their exercise of that authority. The rule represents a resource (Comaroff, 1978), which can be manipulated to assert a land board's claim over regulating the use of a site. Apparent rule breaking by allowing a closer spacing is often done within the context of appealing to other "rules" which the land board claims it can also apply to govern land and water use (Cf. Roe and Fortmann, 1982:132-133).

Outcomes

Equity

The government's program of building and operating village boreholes for drinking water has clearly helped both rich and poor users (Fortmann, 1981:57; Roe and Fortmann, 1981). But, since its dam building policy was intended primarily for stock watering, a side effect might have been the exclusion of the poor who have no livestock.

Using a Guttman scale of relative wealth, Fortmann found no statistically significance difference between the richer and poorer households in their domestic use of dams and haffir-dams (Ibid.). All households using the small dams, whether for livestock or domestic purposes, benefited from the generally free water.

Data on use of government-provided livestock watering points (including a few boreholes) show that the very poorest cattle holders used such sources to a greater extent than other wealth classes. (Small sample sizes argue for caution in interpretation.) Collapsing wealth classes into two categories showed, however, that, while some poorer cattle holding households had access to government-provided sources, a greater proportion of the richer cattle holding households used them. Since this comparison is based on cases of use,[2] it is

[2]"Cases of use" is the sum of all water points used by all households in the Survey. If one household used two water points and a second household used three water points, there are five cases of use represented by those two households even if they are using some of the same water points. This does not measure volume of water used or frequency of use.

not known how many head each wealth category watered at such sources or how crucial they were for each class. Still, the larger percentage of richer cattle holders using these sources indicates that they benefited more from them for cattle watering purposes. While the dams were not intended for domestic use, it is probably the case that this use not only led to much of the observed management at the dams, but also made the overall effect of the dam policy more equitable.

Efficiency

To determine if small dams had encouraged overstocking and overgrazing, dry season and wet season counts of livestock numbers (converted into standard livestock units) were taken at 39 regularly monitored water points at 12 sites; and a dry and wet season range condition was scored at 46 points, with 34 water points common to both surveys. Nonparametric statistical tests of significance were used to measure differences between physical and management types.

Few significant differences between the range scores of different physical types were found. Small dams were not noticeably better or worse than other water point types. In contrast, group-owned and managed water points did have significantly better dry season range conditions than did privately-operated sources. Type of access accounted for the greatest statistical difference. Restricted access water sources had clearly better range conditions than did open access sources, particularly in the wet season. (These results are more fully described in Roe, 1985).

This evidence strongly suggests that group-operated small dams were in fact less intensely grazed than were open access sources. Many of the private water sources were open access or operated for longer periods of time than the group dams, which often were restricted access and were not in operation throughout the year. In fact, since use of these dams typically occurred within a fallback system, livestock watering numbers rarely exceeded the limitation of the Terms of Agreement. Only 12 percent of the recorded daily counts at the 15 government small dams monitored were over 400 livestock units, and most of these counts were recorded at one dam. Contrary to the Ministry view, these dams were probably no more intensively grazed than other water sources.

In a sense, though, the Ministry was correct. There was overgrazing around the dams. But there was overgrazing (often relatively worse) around most every other water point. Statistical tests should not detract from the fact that the absolute values of the range scores were often less than half of what the Ministry thought appropriate for the area.

Such evidence simplifies measuring the costs of overgrazing induced by dam development, since it suggests that at the margin, the addition of one dam in an overgrazed area will only slightly worsen range condition. The conservation loss due to increased degradation probably is small compared to the dam's capital and operating costs and potential benefits.

While a new dam may have little impact on the conservation efficiency where grazing has already exceeded maximum sustainable

yield, overgrazing does affect the economic efficiency of livestock feeding off that grazing. Outside the experiment station, it is next to impossible to measure the marginal productivity of water for livestock production controlling for all the factors. Nonetheless, the figures in Table 3 suggest that the more water points per unit of land area, the more overstocking, associated overgrazing, and liveweight losses incurred.

The recorded weights are less than expected for a 450 kg beast (around 240 kg), illustrating some of the loss incurred by the poor grazing as well as the production strategy which emphasizes numbers. Still, variability in range condition and stocking rates tied to water point density probably does have an economic cost in terms of cattle condition.

TABLE 3 Dry Season Carcass Weight and Indicators of Range Pressure

Village	1979 Dry Season Carcass Wgt/Kg	1979 % HHs Grass Probl.	1979 Range Score (Dry)	Stocking Rages (Ha./LSU)	Water Point Density/km^2
1	207.8 (178.3)	41.2%	19.2	8.8	0.03
2	179.7 (150.8)	53.3%	9.9	5.4	0.06
3	163.3 (106.6)	94.4%	14.6	3.3	0.17

Notes:

Column 2: Carcass weight figures in parentheses include condemnations. Data are from three livestock marketing cooperatives selling cattle in September/October 1979.
Column 3: Percent who had trouble only with grazing (Bailey, 1982:116).
Column 4: Figures are 1979 dry season lower layer species scores. The higher the value, the better the range (Fortmann and Roe, 1981:91).
Column 5: LSU are standard livestock units equivalent to 450 kg. (Bailey, 1982:107). In reality an adult animal is smaller.
Column 6: Basedon the area and numbers of water points mapped for each village water use area using Bailey's estimates for available grazing area (Fortmann and Roe, 1981:158-160). Water point types were standardized for the percentage of total livestock months spent at each type by the households sampled (Bailey, 1982:136-137).

A rough estimate indicates that the building of a new dam in an area will, on average, lead to a 1 percent decrease in carcass weight for each LSU, which if aggregated over the life of the dam and converted into livestock units, would represent a loss of about 3 LSU over 15 years, at about 5 cents per cubic meter of water in the average dam. Even if this figure were doubled, it is a relatively small increment to the total cost of water. Bailey (1980:passim) estimated at a 12 percent interest rate and assuming a service life of 15 years, the annualized unit cost of a cubic meter of water from a government dam was around $2.20/m^3, a figure probably on the low side since dam water is less available than originally intended. At a 2 percent interest rate the cost would be around $1.20/m^3 in 1979/80 prices. His computations for boreholes and open wells show that, on cost effectiveness grounds, small dams are comparatively cheaper.

In a number of mixed lands and cattleposts the dams have become a major part of the fallback water point strategy. They allow households to arrive early and leave the lands later, which can lead to increased crop production. They provide a more convenient source of both domestic and livestock water for a number of households when convenience and reliability are at a premium. As such, a cubic meter of water probably has at least between $1.25 and $2.25 associated with it for those communities which find it a strategic water source. Indeed the intensity of some dam management is the best indication that willingness to "pay" exists for such sources.

CONCLUSION

We have presented a bare bones analysis of communal water use and management in Botswana. It has been shown that villagers manage water in a systematic and rational fashion, although not necessarily in the way the government thinks is right and proper. It has also been shown that the factors affecting water management differ according to the level of social and spatial organization. Hence a complete analysis of any water use and management system will require careful data collection at a number of levels.

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