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INTERVENTION AND INNOVATION IN FARMER-MANAGED IRRIGATION SYSTEMS IN NORTHERN PAKISTAN

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ABSTRACT

In the harsh physical environment of northern Pakistan, food security long has been linked with irrigation development. Irrigation systems here are small-scale, traditionally farmer-designed, constructed and managed using indigenous technology and techniques. Government attempts in the 1970s to expand the agricultural resource base through new system construction generally were unsuccessful. In 1982, the Aga Khan Rural Support Program (AKRSP) began an innovative strategy of social organisation, mobilizing rural people into village organisations capable of undertaking development work on a permanent, locally-sustainable basis. Through community consensus, villages propose, plan, and implement a productive physical infrastructure (PPI) project with AKRSP financial and technical assistance. To date, 166 AKRSP-assisted PPI projects in Gilgit District are new or expanded farmer-managed irrigation systems, approximately doubling the region's agricultural resource base. This paper, based upon a field survey of 25 old and new irrigation systems in Gojal (Upper Hunza), identifies key components in AKRSP's irrigation intervention strategy. It describes farmer innovations in traditional irrigation management practices, and outlines processes for capitalizing further on the new irrigation investment.

Introduction

The focus of this paper is on development and change in farmer-managed irrigations systems stimulated by the intervention strategy of the Aga Khan Rural Support Programme (AKRSP) in Hunza, part of Gilgit District in Pakistan's federally-administered Northern Areas. AKRSP is a non-governmental agency which in 1982 began a programme of rural institutional and physical development, first in Gilgit District and subsequently expanded to include Baltistan District, as well as Chitral District, North West Frontier Province (Figure 1). The primary objective of AKRSP is to facilitate the development of strong, broadly based village organizations that can continue to undertake a wide-range of rural development activities on a permanent, locally-sustainable basis.

AKRSP accomplishes this objective through an unique intervention strategy that encourages each village to identify and propose a single "productive physical infrastructure" (PPI) project which will increase the incomes of most--if not all--village households, the implementation of which will be funded by a grant from AKRSP. It is the process of collectively identifying, proposing, planning (with AKRSP-provided technical assistance) and implementing the PPI which initiates and strengthens a Village Organization (VO) that subsequently can begin to manage the planning and implementation of other common development activities.[1] In short, an income-generating PPI project is an investment in social organization, in addition to its direct economic impact, and it serves as an effective entry point for subsequent development work in the village and the region.

In Gilgit District, 166 (60%) of the 280 PPI projects initiated in villages through AKRSP's intervention are irrigation projects--improvement of older systems or development of new systems--all farmer-managed.[2] They have been identified and implemented by villagers at an average cost to AKRSP of (PK)Rs 139,000 (appx. US$ 8175) per project. Although the primary objective of AKRSP clearly is to facilitate institutional development, not just intervention to expand irrigation resources, these irrigation-focused PPI projects have proven to be particularly effective "social organizers", primarily for two reasons. First, agriculture in Gilgit District depends almost entirely upon irrigation, and developing and sustaining these systems in this difficult environment requires a high degree of organization and collective management. Second, AKRSP's insistence upon sponsoring only PPIs that are supported by consensus focuses attention on those infrastructure needs wherein most village households have an interest. Irrigation systems more frequently meet this criteria than any other potential PPI. Moreover, the consensus requirement has tended to ensured that the subsequent benefits of PPI development are widespread, thereby reinforcing continuing household interest in the VO.

Figure 1

Project Area of Aga Khan Rural Support Programme
(Dhani, et. al., 1987)

Thus it could be argued that AKRSP's initial interventions to assist farmer-managed irrigation system (FMIS) development, in practice, have had two goals:

>> improved village management of a common property resource--water--which is potentially locally-sustainable through continued collective management; and,

>> increases in farmer incomes that are widespread and, preferably, equitable.

The large numbers of functioning VOs emerging through irrigation PPIs verifies their effectiveness as "social organizers", quite possibly a legacy of the pre-existing common property management systems in these villages. A recent preliminary evaluation of irrigation projects undertaken by AKRSP also indicates emerging, widespread improvements in farmer incomes resulting from these FMIS interventions (Hussein, 1986).

This paper is based upon a rapid field survey of seven villages in the upper Hunza River basin, a part of Gilgit District known as Gojal, where FMIS interventions already have been completed, and the process of managing the expansion of irrigation capacity is now well underway. The purpose of these investigations was to learn more about institutional and technical innovations, adaptations or changes in irrigation management practices in response to the rapid changes which have occurred. Many of these developments may have potential for wider dissemination and adoption, offering further opportunities to capitalize upon the initial PPI investment.

Environment: Water and Agriculture in Gilgit

The deep valleys cut by the Gilgit and Hunza Rivers and their tributaries as they drain the Karakorum Mountains are the locus of permanent settlement in Gilgit District, in villages perched precariously on river terraces or the sides of alluvial fans, often threatened by unstable talus just above. The district headquarters is the small city of Gilgit, itself situated on old river terraces formed at the juncture of the Gilgit and Hunza Rivers, located slightly more than 600 km north of Islamabad with which it is now connected by the Karakorum Highway. Gilgit also is the administrative center for the Federally-administered Northern Areas, a strategic area which borders Afghanistan, China and India. The region is an ethnic melange, its population reflecting a racial, linguistic and cultural diversity stemming variously from mountain refuge, travellers and traders passing though on the legendary Silk Route, and periodic invasion. The climate is dry continental, characterized by a great range in average temperatures, 45°C or more between January and July, and low annual rainfall at elevations where settlement is concentrated.

Throughout Gilgit District and elsewhere in the Northern Areas, agriculture depends upon irrigation water supplied through small, farmer-constructed gravity-fed systems. Precipitation is meager (averaging only 150 mm/year at Karimabad; 132 mm/year at Gilgit) and annual variability high throughout a region largely in the rain shadow of the greatest concentration of mountains in excess of 6000 meters found anywhere in the world. Only at higher altitudes--above 3000 meters--where more precipitation falls and is accumulated as snow do annual amounts substantially exceed 500 mm.

Water in these irrigation systems is derived primarily from snow or glacial melt; less frequently, they are fed by springs or small rivers. The most reliable water sources are perennial springs, however, they are relatively rare. More generally, glacier-fed irrigation channels show the least year-to-year variability in discharge, while those channels supplied by springs dependent upon winter-spring recharge reflect greater discharge variability. The greatest fluctuations, and thus least reliable irrigation supplies, are found in channels exclusively dependent upon snowmelt, although those supplied by small rivers are also more vulnerable to annual fluctuations in precipitation.

Reliable precipitation data are not available for villages of upper Hunza where the bulk of our research has been done. Locally available evidence, however, has shown that rainfall variations recorded at Gilgit correspond to snowfall variations in the upper catchment areas that contribute to irrigation supplies through snowmelt. Local farmers from snowmelt-dependent villages report a severe shortage of water once every 4-5 years. One researcher has estimated that this "corresponds to a Gilgit rainfall over the winter/spring--January thru May--period of 40 mm or less which can be expected in 25% of the years;" moreover, ". . . casual inspection of ibex horn trophies does show poor annual horn growth at about this frequency, reflecting poor nutrition most likely resulting from inadequately watered range" (Whiteman, 1985:13).

Although irrigation dependent upon snowmelt presents problems of considerable year-to-year variability, water derived from glacial melt often carries large quantities of suspended silt much of which is subsequently deposited in farmers' fields as a mixed blessing. During the period of seed germination and seedling growth, there is the risk that seeds will become buried too deeply to achieve a satisfactory germination rate or that seedlings will become coated with silt and normal metabolism thereby inhibited (Saunders, 1983:46). However, silt is also important in the soil-building process, especially for improving soil structure.

River-fed irrigation channels are affected by seasonal fluctuations in river flow. An intake structure constructed to divert river water for irrigation during crop planting in March may be inundated or washed out when glacial melt subsequently increases river discharge in May-June. Later in the summer, the river diversion may have to be relocated further up-stream to sustain irrigation supplies as river discharge diminishes.

Perennial spring water has several advantages over other irrigation sources: it is free of silt, it does not experience great variability, and, as noted by Whiteman (1985:15), it may be "up to 5 degrees C warmer, which has a significant advancing effect on spring growth" of crops. However, this is also the scarcest source of irrigation water in the region.

Capturing water for irrigation is only part of the task of establishing and sustaining agriculture in Hunza-Gojal. Equally, perhaps even more, arduous is the concomitant and longer process of land development. In bringing land under the cultivation of the principal crops for human and animal consumption--grains (wheat, barley), vegetables, potatoes, fruit trees (apricot, apple), fodder (alfalfa), and trees for fuel and fodder (poplar, willow, Russian olive)--soils have been drastically modified.[3]

Irrigated crops are largely confined to three landform environments and their associated soils. In the valleys of the Hunza River and its tributaries, river terraces and alluvial fans have the greatest agricultural significance. Older river terraces with their better developed and deeper soils are more important than terraces of more recent origin. On alluvial fans formed from sediments brought down by small streams and hill torrents, the lower portions are more intensively cultivated than are the upper parts because of a greater proportion of finer materials in the soils of the former. In either case, the better soils are more likely to be the locus of grain and vegetable crops as well as orchards, while the poorer, less developed soils tend to be used primarily for fodder crops and trees for fodder and fuel.

The cone-shaped scree slopes resulting from mass wasting of the surrounding barren cliffs and hills below 2100 meters are another locus of irrigated agriculture. However, because of the inherent instability of these slopes, their agricultural development presents special problems and tends to be both more recent and slower. The upper portions with a greater concentration of finer materials are cultivated first, usually with slope-stabilizing tree and fodder crops.[4]

Village Irrigation Systems in Gojal

Irrigation system development in Hunza is an old, well-established but poorly documented process, carried out over several centuries of collective effort among farmers whose livelihood has depended (and still depends) upon these ***kuhls*** or channels. Initial efforts in ***kuhl*** construction surely concentrated upon locations where water from glacial and snowmelt sources was relatively easily developed by small groups of farmers using locally available technology and resources.

Subsequently, traditional chiefs, such as the Mirs of Hunza, began to exercise their growing feudal authority to mobilize a larger population for the construction of new irrigation channels, the rehabilitation of older ones and the development of new land. Although a portion of the increased production resulting from enhanced and more reliable water supplies was extracted by a compulsory agricultural tax, the Mirs did initiate the development of irrigation and modest settlement expansion where smaller, isolated group efforts could not. Following the arrival of British-supported Dogra administration in Gilgit in 1890s, a gradual decline in feudal authority commenced with a concomitant tapering off of new irrigation system development. This trend became much more pronounced after 1947 and the independence of Pakistan, until the Mirdoms finally were formally abolished in 1974.5

Seven villages were surveyed in Gojal (Table 1). They have a total of 25 irrigation channels among them, of which 20 predate AKRSP's activities. Of these 20, at least 5 ***kuhls*** were initiated by the Mirs within the past 100 years. Those developments made possible the settlement of about one-third of the total number of households now resident in the study villages on the resulting new land thereby supplied with irrigation.

Between 1983 and 1987, the AKRSP-initiated Village Organisations in Soust, Gircha, Jamalabad, Morkhon, Ghalapan, Khaiber and Passu (see Figure 2 [Dhani, *et. al.*, 1987:25]) have added more than 500 ha to their existing agricultural lands, approximately doubling the previously irrigable area. The seven irrigation (PPI) projects completed in these villages--5 new ***kuhls*** and 2 improved ***kuhls***--will have benefitted at least 288 households once the time-consuming process of land development is completed.

Channel Construction

Successful irrigation channel construction in Hunza now requires the fine-tuned balance between local wisdom--knowledge derived from generations of past experience--and contemporary engineering technology. Alone, neither source of knowledge and skills is any longer sufficient to guarantee success, and the failure to utilize both frequently leads to the frustration of poorly performing or failed systems, typically after an expenditure of substantial and scarce resources.

Table 1

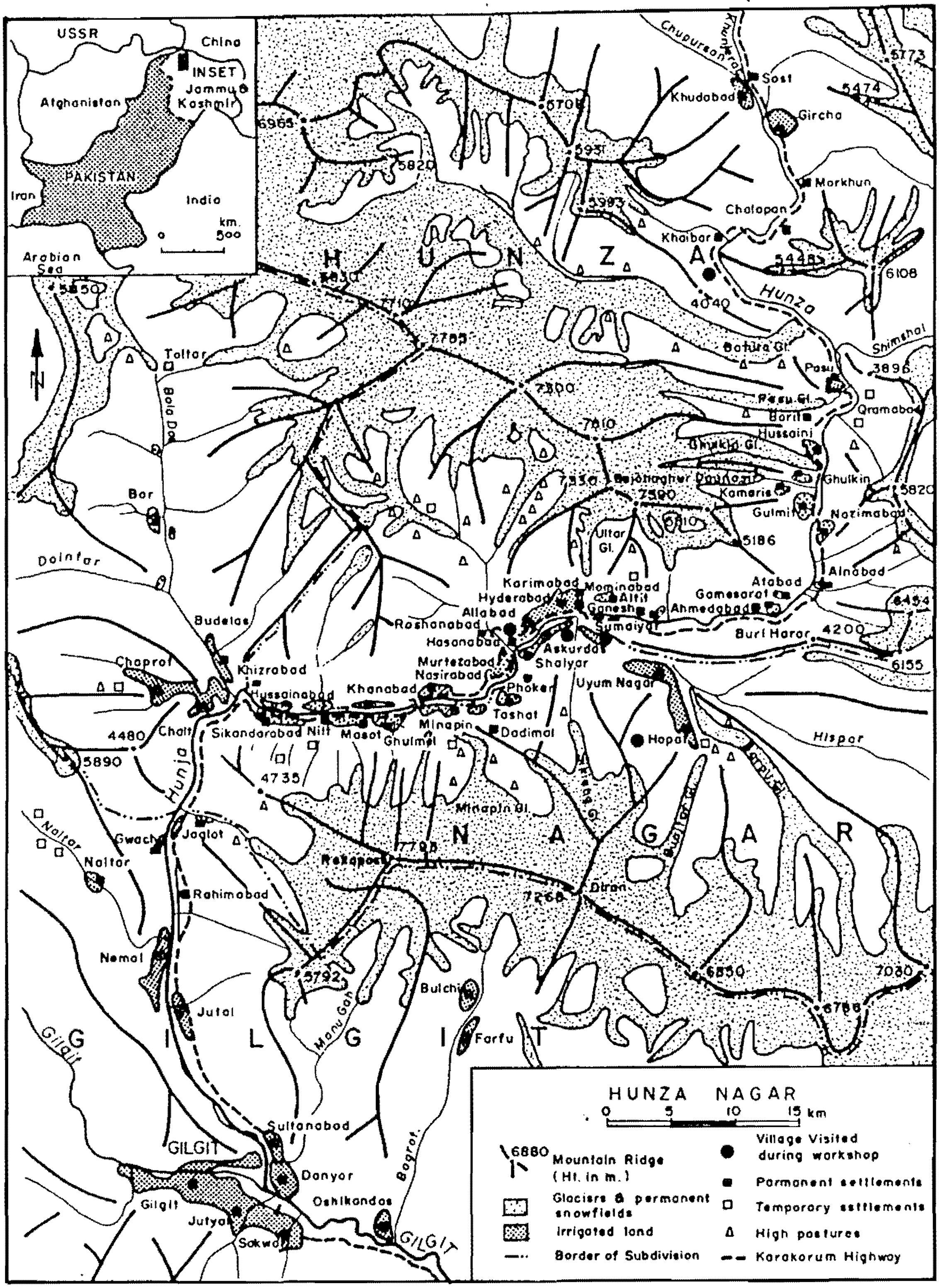
Survey Villages, Irrigation Channels and Water Sources

Command Area	Channel	Source
SOUST [60 hslds]		
Soust (old)	1. Aziz Baig's	
	2. Main	Soust Nullah
Nazimabad (old)	3. Upper	Glacier + Snowmelt
	4. Main	
Soust (new)	5. New	
GIRCHA [27 hslds]		Sarteez Nullah
Sarteez (old)	6. Sarteez	Snowmelt + Spring
Lower Gircha (imp)	7. Main	Spring
MORKHON [45 hslds]		
Morkhon (old)	8-10. Three Left Bank	Morkhon Nullah
Morkhon (new)	11. High Left Bank	Glacier, Snowmelt
Morkhon (old)	12-13. Two Right Bank	+ Spring &
		Flow from
JAMALABAD [24 hslds]		7 Small
Jamalabad (imp)	14. Main	Nullahs
GHALAPAN [10 hslds]		
Morkhon (old)	Left Bank	
Ghalapan (old)	15. Jurjurkhon Nullah	Snowmelt
Ghalapan (new)	16. Vundergar Nullah	Snowmelt (more)
KHAIBER [55 hslds]		Khaiber Nullah
Khaiber (old)	17. Lower	Spring
	18. Upper	Glacier + Snowmelt
Imamabad (old)	19. Main	Glacier + Snowmelt
	20. Small	Snowmelt + Spring (less)
Khaiber (new)	21. New	Hunza River
PASSU [67 hslds]		
Passu (old)	22. Main	Passu Glacier
	23. Nobod	Glacier + Snowmelt
	24. Yashvandan	
Passu (new)	25. Batura Glacier	Glacier + Snowmelt

Note: The above inventory does not include many other small channels used to irrigate the pasture lands of these villages.

Figure 2

HUNZA, GILGIT DISTRICT
(H. J. Kreutzmann, 1986)



The traditional method for determining the slope of the channel, still followed in a few villages, is the use of water as a level. Starting from the source, water flows along as the channel is dug on a carefully estimated, but unsurveyed line; the objective (and hope!), of course, is to emerge with the desired command. This approach "works" so long as the scheme is physically possible, and village elders are commonly consulted for advice on past glacial movements, avalanche and mud flow paths, and stream flows from glacial and snowmelt or springs. However, if an impassable outcrop is encountered, or the velocity of water flow drops so low that command is lost--conditions usually discovered only after kilometers of channel have been constructed--the project must be redesigned or abandoned (Hudson, 1983:4).[6] Passu villagers report seven failed earlier attempts at channel construction using such techniques to tap the melt of Batura Glacier.

By itself, modern engineering science too often has scarcely produced better results. In an environment where local physical conditions vary greatly within short distances, or from one season to another, engineering surveys and irrigation designs that fail to engage the detailed local knowledge of villagers have a high probability of resulting in expensive failures. The high proportion of failures among irrigation channels in Gilgit designed and constructed by the Northern Areas Public Works Department since 1974 without the consultation or participation of local people mutely testify to this observation.[7]

A major element in AKRSP's intervention strategy of assistance to farmer-managed irrigation systems is combining local knowledge with modern engineering skills in the planning, design, and construction of new *kuhls*. AKRSP engineers jointly survey the selected site for a new system accompanied by several knowledgeable farmers selected by the village as a whole; frequently, this will involve several field visits.[8] During channel construction, which is carried out by VO members with AKRSP technical support, there is frequent consultation between farmers and AKRSP engineers to solve unanticipated problems. This approach has resulted in the successful implementation of several irrigation development projects in Gilgit previously thought too difficult to undertake, two of which have been carried out in the surveyed villages of Passu and Soust.[9]

Water Distribution

The practice of ***warabandi***--irrigation turns taken according to an established roster--is a familiar, well known technique to equitably allocate water and ensure irrigation turns in Hunza-Gojal, as it is throughout most villages in Gilgit District. In virtually all villages studied, ***warabandi*** is followed during periods of water scarcity in the irrigation system, notably the period between March and May. Where water scarcity is not a problem (e.g. the older systems in Passu), or when the period of water scarcity is over, water distribution reverts to a comparatively informal system of irrigation turns as and when needed.

Under the *warabandi* system within a ***kuhl*** command, each household takes its irrigation turn from available supplies on a specific day, for an equal period, and at a specified time.[10] Between farmers whose turns fall within close proximity of one another, there often is some informal trading or exchange of water. Generally, food crops have first priority in water use, followed in order by fodder crops such as alfalfa, and finally by trees. Hence, where night irrigation is practiced, it is usually for trees, with food and fodder crops being irrigated during the daylight hours.[11] Amongst food crops, vegetables typically take priority over food grains, even to the point where an operating *warabandi* can be interrupted out of turn should a farmer plead the necessity of water for a vegetable plot.[12] The ***warabandi*** remains as perhaps the most durable, least readily changeable of traditional irrigation system management practices in Hunza-Gojal.

Channel Maintenance

Maintenance of irrigation systems reflects their common property origins and a continuing collective management basis. The general principle followed in the maintenance of the common portion of the irrigation channel continues to be, as it traditionally has been, an annual contribution from all farmers served, either in the form of labor, produce or, now, cash. Typically the general annual maintenance is carried out in spring, before the onset of the first irrigation for the crop year, and when water flows are low or non-existent. Channels carrying heavier silt loads may require a 1 or 2 day mid-season desilting in which all farmers also participate. Non-common lateral channels or field channels are an individual farmer's responsibility.

During the irrigation season, some villages employ a *chowkidar* or watchman to patrol the common portion of the channel to close leaks, repair small breaches, and to adjust the channel intake and keep it clear of debris.[13] Where *chowkidars* are not employed, farmers take regular turns patrolling and maintaining the common channel, usually done by those whose turn it is to irrigate. In either case, should a major breach or other emergency occur, all farmers served by the channel will assist in its repair.

The basis for the presence or absence of a *chowkidar* to perform channel maintenance during the irrigation season in the survey villages is somewhat ambiguous; there are several possible reasons for the practice, including channel length, whether or not night irrigation is done, and the nature of the silt load in the channel. An examination of these variables in Table 2 suggests that channel length is the most common variable in the use of *chowkidars*. This is as might be expected for channel length reflects not only the quantitative nature of the maintenance requirement, but the cost of walking to the head to regulate the discharge at various times during

Table 2

Variables in the Presence or Absence of Chowkidar for Irrigation Channel Maintenance

Irrigation Command	Chowkidar Present ?	Lengthy Channel ?	Irrigation at Night ?	Significant Silt Load ?
Soust (old)	YES	NO	NO	YES
Nazimabad	YES	YES	YES	YES
Soust (new)	PLANNED	YES	NO	YES
Sarteez	NO	NO	YES	NO
Lower Gircha	NO	NO	?	NO
Morkhon (old)	NO	NO	NO	NO
Morkhon (new)	NO	YES	NO	NO
Jamalabad	YES	YES	YES	NO
Ghalapan (old)	NO	NO	NO	NO
Ghalapan (new)	PLANNED	YES	**	NO
Khaiber (old)	YES*	YES	NO	NO
Imamabad	YES	YES	NO	NO
Khaiber (new)	YES	YES	NO	NO
Passu (old)	NO	NO	NO	YES
Passu (new)	NO	YES	NO	YES

Notes:

* Formerly village hired; now employed by PWD because of hydro-electric project.

** Channel recently completed and new land development not yet underway.

Night irrigation generally is for trees and fodder crops.

the day as well: when the melting rate increases the discharge at the source (early afternoon) or when the water demand is minimal (after sunset), the weir at the head of the *kuhl* must be modified. For new channels, the previous existence or absence of a *chowkidar* in the village also appears to be significant. Other conditions seem to be somewhat less important.

Other System Infrastructure

The irrigation systems in two villages, Soust and Passu, also have infrastructure to reduce the heavy loads of silt carried by the glacial-origin water. Sedimentation tanks or stilling basins have been constructed at the head of each channel system; the tanks on the Soust *kuhl* are meant to trap rock debris carried in the glacial melt as well. During the irrigation season, the sedimentation tanks occasionally must be desilted, a task carried out collectively by the irrigation community. Several farmers in Soust also have dug shallow stilling basins close to their fields. Here the silt removed from these basins is mixed with animal manures and then spread on the fields to improve soil fertility and structure.

Two older farmer-managed systems--Soust and Nazimabad--have overnight storage tanks that permit the augmentation of channel flows during day-time irrigation. This infrastructure is not as wide-spread as might be anticipated, most probably because of the difficulty encountered in inexpensively constructing tanks of sufficient size for irrigation water that will not leak (Hudson, 1983:7). The commonly practiced alternative to overnight storage during periods of water scarcity, of course, is night irrigation.

Innovation, Adaptation and Experimentation in FMIS

After a generation or more of comparative quiescence, AKRSP's intervention activities have initiated a period of rapid change in farmer-managed irrigation systems in Gilgit. Based upon the evidence from Hunza-Gojal systems, the response has been both institutional innovation and substantial farmer-initiated experimentation with modifying existing irrigation management practices or techniques. There is evidence as well of the continued vitality of proven approaches to solving problems in FMIS, of farmers adjusting new systems to better fit environmental conditions. In the following discussion, we briefly describe several examples that substantiate these observations.

Institutional Innovation in System Design

From an agency intervention and technical assistance perspective, especially in Pakistan, possibly the most significant innovation in relation to assisting FMIS has emerged from AKRSP's conscious adoption of and commitment to using a strongly participatory rural development strategy. This is the development and use of by AKRSP of design criteria for irrigation channels based upon the study and measurement of bed slope conditions in several older farmer-managed systems in Gilgit.[14] Empirically-based parameters were established and are used as basic design criteria for new systems.[15] The stimulus for this change, at least in part, was the visible evidence of the high failure rate of previous government intervention efforts to construct new irrigation systems in the Northern Areas. There, engineers had used "textbook" standards that were widely applied in--and more appropriate to--environments outside this region. The general farmer satisfaction with and apparent absence of failure in AKRSP-assisted systems is strong evidence that careful study of existing FMIS and skillful adaptations of farmers' previous irrigation experience are sound complements to modern engineering skills in successfully developing new systems.

Village Irrigation Specialists

The *chowkidar*, is a traditional and familiar village specialist, over the years building up a highly detailed, intimate knowledge of the irrigation system in which he works. He is accountable to the farmers; they pay him willingly because he provides them economies of specialization for an essential service, but they also are likely to quickly replace him with another should he fail in his duties. In three of the seven survey villages--Soust, Morkhon and Passu--water from lengthy new channels is being supplied to land that is not immediately adjacent to an already developed command area. Somewhat unexpectedly, none of these villages has a *chowkidar* for their new channels; on the new Soust ***kuhl***, farmers say they plan to employ a *chowkidar*, "eventually". Neither Morkhon or Passu have *chowkidars* for their older systems and their absence on the new ***kuhls*** may be related to this fact, although we are not confident of this based on information available to us. However, on the new channel in another village, Khaiber, an unusual adaptation of the *chowkidar* system has emerged in conjunction with another innovation, the VO's decision to collectively develop the command area for the first five years without assigning individual ownership rights.

The land commanded by the new Khaiber ***kuhl*** is located 2 to 3 kilometers from the village. The Khaiber Village Organization decided to maintain the new commanded area in collective ownership, at least through the expected duration of its initial development. For the past two years, fruit trees as well as tree species for fodder and fuel have been planted, increased amounts of alfalfa grown, and a small nursery-vegetable plot managed by Khaiber women developed. Because ownership of the new land remains collective, there are no specific individual responsibilities for irrigation, and this condition required the Khaiber VO to devise a new approach to managing the irrigation of the new land. Two possible solutions were immediately obvious: either small groups of farmers could carry out irrigation on a rotational basis, or *chowkidars* could be hired and their traditional patrolling and maintenance duties modified. Khaiber chose the latter. Three men have been hired for the 4 month agricultural season, at a monthly salary approximating the local wage labor rate, to carry out daily irrigation activities in the newly commanded area. In addition these "specialist" *chowkidars* continue to perform the other tasks traditionally associated with them.

Flexibility in Water Allocation

We have previously noted that ***warabandi*** is one of the most durable institutions in farmer-managed irrigation systems in Gilgit. A familiar, known technique arrived at collectively to equitably allocate water and ensure irrigation turns, ***warabandis*** vary in complexity from system to system. They also demonstrate considerable flexibility. Both aspects are reflected in the ***warabandi*** adopted for the new channel in Soust. Here, within the same period of the channel's operation, a different water allocation procedure is followed for the smaller terraced fields of fruit trees and intercropped fodder on steep slopes, than is made for the larger, more level fields below planted to annual grains, though both are being irrigated simultaneously.

The allocation of water for the command area of the new Soust ***kuhl*** also involved a significant reallocation of the water rights of the two older systems in Soust and Nazimabad. Previously, the two existing systems received water on alternate days during periods of water scarcity. Now, when water is scarce, each command area gets its turn every third day, an unusual reallocation of water from already developed land to new land.

Adjusting New Systems

With the substantial increase in irrigable area brought about by the construction of new ***kuhls***, considerable attention has been focused upon an apparent slow rate of new land development by farmers, at least slower than had been expected by outside observers. This situation is best illustrated by the case of the new system in Passu commanding at least 273 ha, an area sufficient to increase the average landholding five-fold, but less than 10% developed 3 years after channel construction. However, farmers know that no matter how well designed and constructed, a new irrigation system can not be made that immediately fits its environment perfectly; commonly a period of adjustment is necessary. Farmers in the new Passu system are engaged in that process: they have relocated the intake to compensate for glacial retreat and to improve the bed slope condition in the upper reach of the channel, they have completed the cement and stone lining of 100 meters of channel where substantial leakage was impacting upon the Karakoram Highway, and finally, they are stabilizing or "hardening" the channel.

The latter activity is a process encountered elsewhere in new systems in Hunza-Gojal. Each year as silt from the glacial melt water fills soil interstices along a longer reach of the bottom and sides of the main channel, discharge at the system head is gradually increased. "Hardening" the channel in this way reduces the likelihood of major breaches occurring that would be difficult and costly to repair.[16] Passu farmers estimate that it will be another 4 or 5 years before they can confidently operate the new system at full supply levels. Clearly, the process of bringing new land under irrigated agriculture can not proceed ahead of adequate water supplies.

Field-level Experimentation and Change

In general, most of the land thus far developed commanded by the new *kuhls* has been planted to trees and alfalfa. (An exception is Soust where considerable developed area on a comparatively level old river terrace also has been planted to food grains.) This condition largely reflects both landform (scree, steep slopes) and soil characteristics (poor structure, low fertility). Nevertheless, village plantations of fuel trees and fodder crops or orchards on the scale now underway is a new phenomenon in Hunza-Gojal, and considerable farmer innovation and experimentation in field level water management is already evident.

In Morkhon and Jamalabad, farmers have adopted a new method to irrigate the alfalfa and trees planted on the scree slopes in the new *kuhl* command. Instead of constructing the familiar (but expensive) stone-walled terraces and using basin irrigation techniques, trees and alfalfa have been planted on shallow reverse slope terraces, and farmers have constructed field ditches along the contour to deliver irrigation water. One knowledgeable farmer observed that this innovation in plantation irrigation was merely an extension of furrow irrigation techniques already used for such crops as potatoes in non-steep sloping fields.

On several steeply sloping fields in the new Soust command, this technique has been modified again for individual holdings, with field irrigation ditches constructed as a series of linked "S"s down slope and small drop structures constructed from stone and polyethylene to carry water from one level to the next lower to reduce soil erosion. On the new Soust channel, too, several field inlets traditionally fabricated from readily available stone have been replaced by wooden gates or lengths of iron pipe set into the channel embankment. When asked why more farmers hadn't begun using these techniques, the taciturn response of an experienced Soust irrigator was that "people are different."

FMIS Development: Continuing the Momentum

How can the processes of innovation, adaptation and change in farmer-managed irrigation systems in Gilgit, now substantially underway, be further facilitated? Are there additional opportunities to further capitalize on the new irrigation infrastructure created in Gilgit and elsewhere in the Northern Areas? What is the significance of a rising opportunity cost of labor resulting from tourism, transport and other new economic activities for farmer-managed systems? Questions such as these pose a substantial challenge to AKRSP as it is pressed to simultaneously address "downstream" or "second generation" irrigation management issues emerging from FMIS development already or largely completed (World Bank, 1987) while continuing to expand its rural development program to more villages, particularly in Baltistan and Chitral.

Generally, AKRSP has approached the problem of introducing innovations--technical and institutional--or inducing changes in common property through a coordinated and experimental two stage sequence. First, it seeks to determine whether or not the VO or another village-level organization is interested in and capable of adopting and managing the proposed innovation. Secondly, through on-site experimentation, it attempts to ascertain whether or not further refinement and adaptation is necessary, or if the innovation is ready for widespread adoption and use. AKRSP will fund, through "seed" grants to the first few villages that meet the first criteria, the adoption of an innovation that passes the second stage. However, when managerial and financial resources are limited and the range of potential opportunities is increasing such an experimental approach is both too costly and time-consuming.

In the following discussion, we illustrate how an alternative analytic approach may be used to more quickly screen and narrow the growing range of options. It permits a more rapid assessment of the potential of innovations and changes, now occurring in the collectively owned irrigation systems in Gilgit, for wider dissemination and adoption. We then suggest a supporting monitoring process that would systematically provide the kind of information necessary for AKRSP to make such an assessment of new opportunities, as well as to rapidly identify other emerging FMIS management issues and problems that will require solutions.

An Approach to Innovation and Opportunity Assessment

Large silt loads and seepage control present two important and persistent maintenance challenges to FMIS in Gilgit. Silt removal is a regular, collectively-shared maintenance activity in many channels. Silt traps and stilling basins can be an effective technology for reducing the total amount of labor devoted to channel desilting. The field survey identified only two systems in Hunza-Gojal that use this method. Both systems tap glacial water sources that carry significant silt loads, and in one of them, several shallower stilling basins also have been constructed by farmers. Other systems that tap glacial melt water do not use this infrastructure, thus the question emerges: does this desilting infrastructure constitute an innovation with potential for more widespread application? But the criticial question in assessing this potential is: what is the economic payoff to farmers of an alternative for more efficient desiltation of their channel?

The apparent major benefit to farmers of a reduced silt load is the lower labor cost of cleaning and maintaining the channel.[17] If, for example, the improved desiltation infrastructure at Soust reduces the labor required for cleaning the ***kuhl*** from 2 person-days per household to 0.5 person-days, then the annual value of this saving, for 60 households, at Rs 30 per person-day, is Rs 2,700. At discount rates (to perpetuity) of 12.5% - 15% per annum, this saving has a capitalized value between Rs 18,000 - Rs 21,600. The relevant question now becomes: can innovative infrastructure for desiltation be designed with lifetime costs less than Rs 18,000 - Rs 21,600? A systematically executed rapid appraisal survey could provide the information necessary to answer this question. It is probable, however, that improvements in desilting infrastructure in FMIS would have to be available at a low cost in order to justify such an investment by the farmers.

Silt also is a key element in the traditional maintenance method of controlling seepage from ***kuhls***. In FMIS where water supply is ample at all times at all locations, or where micaceous silt is abundant, the control of seepage is likely to be an unimportant maintenance objective. However, where neither condition prevails, farmers traditionally have had to transport from some other location quantities of suitable fine-grained material to seal their channel. Hudson (1983:5) identified several potential alternatives to this traditional method of controlling seepage.

If we assume that the traditional method is as efficient in controlling seepage as a new one, then the upper bound on the cost of this possible innovation can be derived from the savings on the transportation and labor required for the traditional procedure. If an innovation for controlling seepage is more efficient than the traditional method in conserving water, then the returns to increased water supply also must be evaluated. Clearly the returns would be large in systems with a season-long shortage relative to those in systems where water is scarce only for part of the crop year. Using factors for yield response to water at different growth stages of each crop (Doorenbos and Kassam, 1979), the value of incremental production can be readily estimated. Then the capitalized value of annual incremental production adds to an upper bound on the cost of an innovation that also improves irrigation supplies.

Monitoring FMIS for Innovation and Change Assessment

Effective use of an analytic procedure which assesses the potential returns of innovations in FMIS, as has just been illustrated, requires a larger, more accurate and rapidly acquired information base than is now readily available to AKRSP through its occasional case studies or wider-ranging field surveys, often carried out with different objectives. The need is similar for it to be able to assess how well the actual benefit stream flowing from increased irrigation supplies, changing irrigation practices and developing land use patterns in new or improved FMIS matches that which was expected, or to spot irrigation management problems confronting VOs in an environment of continued rapid economic and social change. Finally, there needs to be a procedure whereby the findings--conclusions, recommendations or solutions that emerge from the analysis of such data--can be efficiently fed back to the users, VOs and farmers.

We suggest that a process to systematically monitor the changing FMIS environment of the Northern Areas is likely to meet these requirements. That so large a proportion of PPIs assisted by AKRSP are for a new or improved FMIS would seem to justify a modest investment of institutional resources in such an effort. The monitoring program should be limited to a reasonable sample of villages and VOs that reflect the range of different hydrologic and agro-climatic environments of the region. It should be institutionally-reinforcing and efficient--tapping the new institutional infrastructure of VOs and use appropriate rapid appraisal techniques (e.g. Yoder and Martin, 1985)--and parsimony in data acquisition should be a guiding principle. The technology for rapid data analysis and synthesis--micro-computers and software--is already available.

Logically AKRSP's Social Organizers (SOs) would be a key component of this program. Their knowledge of and participation in the rural institutional environment can both guide and supplement the monitoring process. In their facilitator role, SOs provide the link whereby the results of findings can be made quickly available back to the appropriate VOs.

In conclusion, we have shown that there has been significant innovation and change accompanying the intervention of AKRSP in farmer-managed irrigation systems in Gilgit. Traditional institutions have demonstrated both resilience and flexibility in adapting to an environment of rapid social and economic change. The challenge that now confronts both AKRSP and the new Village Organizations is how best to facilitate the sustained performance of these new and expanded systems as new economic opportunities emerge through the growing integration of the Northern Areas into the national economy.

ENDNOTES

1. In implementing its rural development programme, AKRSP proceeds through a well-defined operational process consisting of three "dialogues" with village residents. The First Dialogue between AKRSP management and villagers invites the latter to identify a project of common interest. The Second Dialogue, following project identification and often proceeding over a longer time span, is focuses upon the joint determination of the technical feasibility and project design. The Third Dialogue results in project approval once agreement in reached between AKRSP and the village on the terms of partnership for implementing the project. Throughout the process, AKRSP draws upon a staff of experienced professionals--engineers, Social Organizers, research scientists and managers. Project monitoring and evaluation also are embedded in the AKRSP approach, the results of which have been published in a regular series of progress reports and annual reviews since 1983. See Khan and Husain (1983:1-23) for a detailed description and discussion of AKRSP's strategy of rural development, and AKRSP (1984:18-21) for a complete copy of the standards terms of partnership between AKRSP and a VO.

2. Irrigation systems comprise a similar percentage of PPI projects assisted by AKRSP in Chitral and Baltistan Districts as well.

3. See Mian (1985:10-11) for a description of the numerous steps in the land development process.

4. Non-cultivation seasonal agricultural activities also occur at higher elevations, but they do not involve irrigation. On the more widely scattered residual soils resulting from locally favorable moisture and temperature conditions associated with altitude changes, generally between 2100 and 3300 meters, soils have developed from physical, chemical and biological processes acting upon parent material. These locations support forest trees and grasses and serve as summer pastures for the animals of villages in the lower valleys.

5. See Kreutzmann (1988: 246-50) for an historical overview of the origins and development of irrigation systems in Hunza.

6. Hudson, 1983, p. 4

7. Only one of the twenty schemes undertaken by the Northern Areas PWD, at an average cost of Rs 1.85 million, is reported as still functioning (M. Hussein, 1986: p. 3). Interestingly, the Chinese and Pakistani engineers who executed the construction of the recently completed Karakoram Highway recognized the value of

such location-specific knowledge. They frequently sought advice and information from village elders during the right-of-way survey process.

8. This survey process is referred to as the <u>Second Dialogue</u>.

9. Overall, of the 166 irrigation assistance projects initiated through AKRSP's intervention strategy, only one channel thus far has proven to be a complete failure. The high frequency of success in ***khul*** development in the context of a recent history of disappointments has been a major factor in the effectiveness of AKRSP's efforts in village organisation.

10. For example, the ***warabandi*** for the command area of the old Soust ***kuhl***, 24 households are divided into two equal groups. One group irrigates between 0600 and 1200; the other from Noon to 1800. On Nazimabad ***kuhl***, a 4 day rotation is followed with 9 households irrigating during each 24 hour period; two groups of 4 or 5 farmers each irrigate cereal and vegetable crops daily, one in the morning and the other in the afternoon. The orchards and fodder/fuel trees of each group are irrigated at night. Irrigation turns are longer here because landholdings are somewhat larger on Nazimabad ***kuhl*** and soils newer and relatively less well formed; moreover, the ***warabandi*** is in force the entire season. All 60 Soust and Nazimabad households have land in two locations in the command of the new Soust ***kuhl*** which is allocated water on alternate days. On each day, 30 households in one location get their irrigation turn, one-half in the morning and the other half in the afternoon. Thus in 4 days, all holdings can be irrigated.

11. Exceptions to this general rule have been observed. Potato fields (in Passu) and alfalfa (in Nazimabad and Soust) also are irrigated at night, usually because water scarcity means basic food crops are given priority and because like trees, neither potatoes nor fodder require careful attention in irrigation once they are well established. Locally, night irrigation is known as *shuper* ("night stay" in Wakhi) and is done by diminishing the flow of water allowed to enter the field to a trickle.

12. Hussain Wali Khan, *personal communication*, November, 1987. Interestingly, vegetable plots traditionally are the focus of cultivation and irrigation activity by women, who otherwise have not shared in the common property management of water for irrigation in Hunza-Gojal.

13. *Chowkidars* are employed by the entire water user community on a channel, with each household making an equal contribution to his salary, usually on a seasonal basis. Payment is commonly in kind, a combination of food grains (wheat) and fodder. At current market prices, the value of these payments ranges between

about Rs 900 to Rs 1400 per season.

14. The intention here is not to slight the significance of Village Organizations as perhaps the key rural development innovation emerging from AKRSP's activities in the Northern Areas; rather, we wish to confine our discussion to developments in the farmer-managed irrigation sector.

15. AKRSP's Senior Programme Engineer, Hussain Wali Khan, is credited with initiating this change. Having previously worked in the Northern Areas PWD, he was particularly familiar with the failure of design standards adopted by that organization to effectively accommodate field conditions.

16. Another factor in the "hardening" process is the time it takes for saplings of willow and poplar planted along channel embankments to establish reinforcing root systems.

17. There also may be other modest benefits to farmers from a reduction of silt in irrigation water, e.g. an increase in crop yield if less silt enters the field during the germination stage of plant growth. Other, locally significant benefits--and costs--would need clarification, e.g. the value of silt in controlling seepage, an important consideration in new channels, or the cost of additional labor to haul silt from the traps to the fields. However, to illustrate the suggested analytical approach, we have sought to simplify our discussion here by focusing upon the most readily identified benefit.

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