CURRENT CANAL MODERNIZATION FROM AN INTERNATIONAL PERSPECTIVE

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ABSTRACT

DEFINITION OF MODERNIZATION

Irrigation project modernization is defined (FAO, 1996) as:

> *A process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reform, with the objective to improve resource utilization (labor, water, economic, environmental) and water delivery service to farmers.*

Modernization differs from rehabilitation, which simply returns a deteriorated project or structures to their original new state. Rehabilitation by itself typically only perpetuates the vicious cycle of rehabilitation, deterioration, rehabilitation, etc.

A modern irrigation design is the result of a thought process that selects the configuration and the physical components in light of a well-defined and realistic operation plan that is based on the service concept. A modern irrigation design is not defined by specific hardware components and control logic. Advanced concepts of hydraulic engineering, irrigation engineering, agronomy, and social science should be used to arrive at the most simple and workable solution (Plusquellec et al., 1994).

QUICK REVIEW OF CONDITIONS IN THE U.S.A.

Prior to discussing irrigation projects in Less Developed Countries (LDCs), it can be instructive to note key factors which exist in many irrigation projects here in the U.S. First, in the intermountain states many of the irrigation districts are far from modernized. Many have large amounts of conveyance losses, poor on-farm irrigation efficiencies, and poor budgets and maintenance programs. Some operate on very rigid rotation schedules. In other areas of the western U.S. irrigation districts have very high district-level irrigation efficiencies (as high as 80%, including impacts of both delivery and on-farm), and have very flexible water delivery schedules to farmers. But the point to make is that a consultant

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from the U.S., or any other country, might have a long experience with irrigation districts but that experience may have nothing to do with modernization.

In the U.S. we also have a considerable amount of literature and research on sophisticated canal control algorithms. However, in the field almost all control on canals is upstream control, with a few districts having extensive computer controlled upstream control. Certainly there are numerous examples of SCADA systems and downstream control, but most of the complex control is found on a few very large canals such as the California Aqueduct or the Central Arizona Project. Such large canals are inherently simpler to manage on a minute-to-minute basis than are small canals because of their excellent maintenance and communications systems and the lack of wide fluctuations in flow rate in a short time.

There is a special environment in irrigation projects in the U.S. that has a bearing upon successes and failures in the U.S. Aspects of this environment include:

- Most consultants in the U.S. must live with the results of their work. News travels fast. And most consultants in U.S. modernization (that is implemented) are private local consultants who are professional engineers, as opposed to researchers.
- U.S. projects have very stable workforces. Many irrigation district employees spend almost their whole career in the district.
- The U.S. projects benefit from water rights, and (extremely importantly) the ability to enforce water rights and rules.
- U.S. projects have excellent legislation for the formation of Water User Associations (WUAs). And most WUAs are operated as not-for-profit businesses with professional management staff that are responsible to elected Boards of Directors.
- Various agencies such as the US Bureau of Reclamation have provided long term financial and technical assistance to irrigation districts.
- There is an excellent supply infrastructure for spare parts and new equipment.
- Even in remote projects, the life of irrigation professionals is good. Schools in remote areas are sometimes better than schools in more urbanized areas. Furthermore, good housing and medical care are available, and the transportation network is excellent so that even at remote projects, one does not typically feel "isolated".
- While there is often undue influence in irrigation districts by some board members or difficult individual farmers, corruption is very rare.

STATUS OF MODERNIZATION IN LDCs

General

First, the typical environment that is listed above for U.S. irrigation projects is almost never found in LDCs. There are, of course, good living conditions in some projects in countries such as Mexico, Colombia, Malaysia, and Thailand. But the combination of good living conditions (health, education, crime) for the family of a professional in a rural setting, job stability, water laws, enforcement of laws, etc., is rare.

This means that modernization must be appropriate, and some types of modernization are more difficult to install and sustain than would be the case in the U.S. It does not mean that modernization should not occur, as has been strongly recommended in numerous articles and discussions in the international irrigation world. Every project in the world can benefit for the appropriate combination of technical, managerial, and institutional changes....which is the essence of modernization.

Since the late 1970s there have been numerous studies of irrigation projects, focusing on a wide variety of technical, managerial, and institutional concerns. For about 10 years now the "institutional reform" advocates have dominated the scene, and their studies and conclusions reflect their biases. Numerous reform advocates have endorsed a statement made by a former president of the International Commission of Irrigation and Drainage (ICID) in a keynote address in 1992: “Irrigation schemes in many parts of the world are known to be performing well below their full potential...[There is now] wide recognition that deficiencies in management and related institutional problems, rather than technology of irrigation, were the chief constraints of poor performance of irrigation systems.”

I strongly disagree with the statement above, and I believe that the definition of modernization clearly expresses the opinion that actions should not be limited to institutional reforms. Such statements are common in part because traditional civil engineers have botched so many irrigation project designs and modernization efforts. Furthermore, many engineers have taken the equally erroneous approach that hardware alone will solve all irrigation ills. As a result, we now have worldwide programs which are promoting the development of water user associations (WUAs) that ignore the inter-relationship between technical and institutional worlds. WUAs have little or no hope of being sustainable and effective if the water delivery to those WUAs is unreliable, inequitable, and inflexible -- and the reliability, equity, and flexibility issues are beyond anything the WUA can influence. Thirty years ago I learned that it is foolish to train and motivate soldiers unless you can guarantee a supply of ammunition and supplies

to sustain them. I believe the same argument can be made about training WUAs and the dependability of water supplies.

Specifics

So what is the actual status of projects in LDCs? The answer depends upon the specific country and project. Unfortunately, there is an almost total lack of comprehensive studies that utilize a fairly uniform methodology to assess the status of projects. World Bank performance assessments focus on external indicators such as crop yields. Other assessments focus on other external indicators such as water efficiencies of various types. Efficiency studies are rarely comparable; even if different reports used the same efficiency formula (a rarity) they rarely used the same methodology for evaluating the values that go into the formula.

As a positive step to better understand the status of irrigation projects, a study was recently completed by Burt and Styles (1998) which looked specifically at LDC irrigation projects which purportedly had some aspects of modernization. That study is being published by FAO in Rome and is available on the web at http://www.itrc.org/reports/contents/html.

The basic questions addressed by the research were:
1. What levels of water delivery service are presently provided by irrigation projects having some aspects of modernization?
2. What hardware and software features impact those levels of service?
3. Do modern water control and management practices in irrigation make a positive difference in performance?
4. What universal lessons can be learned and applied?

We visited 16 irrigation projects in 10 developing countries, 15 of which have been partially modernized in some aspects of hardware and/or management. The projects were selected to represent a variety of climates, soils, design concepts, and water supply conditions. It was difficult to find a good selection of irrigation projects that had significant modernization components. The lack of any completely modernized irrigation projects highlighted the need for this study.

Three tools were utilized to systematically collect data and to characterize each irrigation project. The tools were:
1. A Rapid Appraisal Process (RAP). The use of a RAP is a relatively new concept and this project developed a customized RAP. The RAP contrasts with traditional research techniques that collect data over a year of more. The RAP requires a well-trained evaluator, and in this project utilized a questionnaire with over 700 questions that were answered based on observations, interview results, and readily available data. The RAP required about a one-week visit of the project, and incorporated some background data

provided in advance by the irrigation project staff. When combined with the next two tools, the RAP proved very successful. It is highly recommended as a technique to evaluate the operation and design of an irrigation project with the intent of providing recommendations for improvement.

2. External performance indicators. These indicators characterize the *inputs and outputs* of irrigation projects, including water, yield, and economics. Existing IWMI indicators were evaluated, and new indicators were developed to help standardize irrigation project performance. Important contributions of this research in this area were:
   a. Confidence intervals were provided for the various external performance indicator values. Previously published reports do not adequately recognize the uncertainties, which always exist in data.
   b. Recommendations were made for the improvement of various external performance indicators, thereby minimizing inconsistencies and errors.
   c. It was concluded that external performance indicators are useful for comparing conditions before and after changes within a project. In general, they cannot be used to compare one project against another to determine whether an investment in one project is or was worthwhile.

3. Internal process indicators. Thirty-one primary indicators were developed and quantified for each irrigation project, as well as 3-4 sub-indicators for each primary indicator. These indicators characterize the *internal workings* and type of *water delivery service* provided by an irrigation project. They provide a new evaluation tool; when implemented worldwide they will serve as a valuable training and diagnostic tool for modifying the internal hardware and operation of irrigation projects.

Table 1. Projects of the Burt and Styles (1998) study

Project Name	Country	Closest Major City with (Region or State)
Lam Pao	Thailand	Kalasin (Khon Kaen)
Dez	Iran	Dezful (Khuzestan)
Guilan	Iran	Rasht (Guilan)
Seyhan	Turkey	Adana
Majalgaon	India	Parli (Aurangabad)
Dantiwada	India	Deesa (Ahmedabad, Gujarat)
Bhakra	India	Chandigahr (Haryana)
Muda	Malaysia	Alor Setar
Kemubu	Malaysia	Kota Bharu
Beni Amir, Tadla	Morocco	Beni Mellal
Office du Niger	Mali	Segou
Rio Yaqui Alto	Dominican Republic	Santiago
Coello	Colombia	Espinal (Tolima)
Saldaña	Colombia	Saldaña (Tolima)
Cupatitzio	Mexico	Apatzingan (Michoacan)
Rio Mayo	Mexico	Navojoa (Sonora)

Positive Findings: A number of findings were very positive, including:

1. Hardware modernization can drastically improve the ease of system operation and the degree of water delivery service provided, which influences whether a strong water user association can exist. Conversely, without some key design features (such as sufficient density of turnouts) to provide good water delivery service, it is unlikely that water user associations can be sustainable.

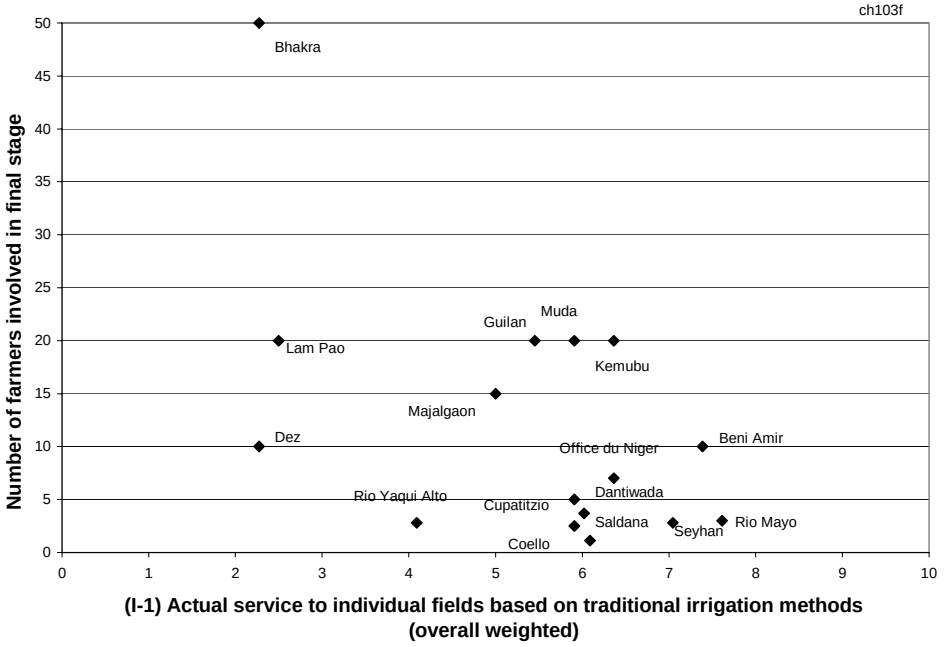

Figure 1. Relationship Between Number of Farmers Who Must Cooperate and Final Water Delivery Service.

2. Anarchy was largely absent in the projects with modernization aspects. This contrasts with traditional irrigation projects.
3. Water user associations which were managed and operated in a business style, which had sufficient enabling legislation and law enforcement support, and which were physically capable (because of good physical infrastructure) of providing good water delivery service, were collecting close to 100% of their O&M fees. These were predominately located in Latin America.

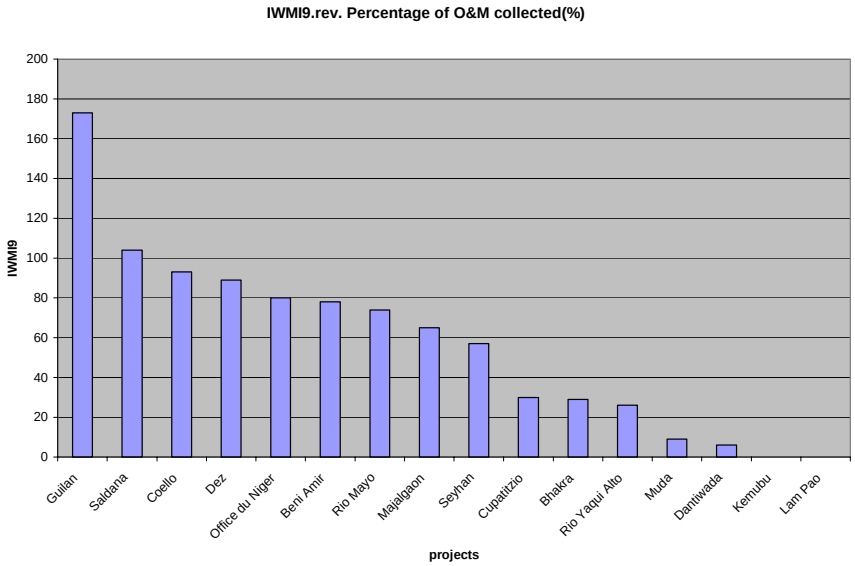

Figure 2. Percentage of Operation and Maintenance Expenses Collected from Water Users.

4. Several projects have very motivated lower-level staff having good communications and mobility. These field staff spent the majority of the time in the field working on operations (as opposed to collecting statistical data or working in the office), and could resolve conflicts rapidly (within a few hours). Farmers in these projects were largely satisfied with the level of service provided.

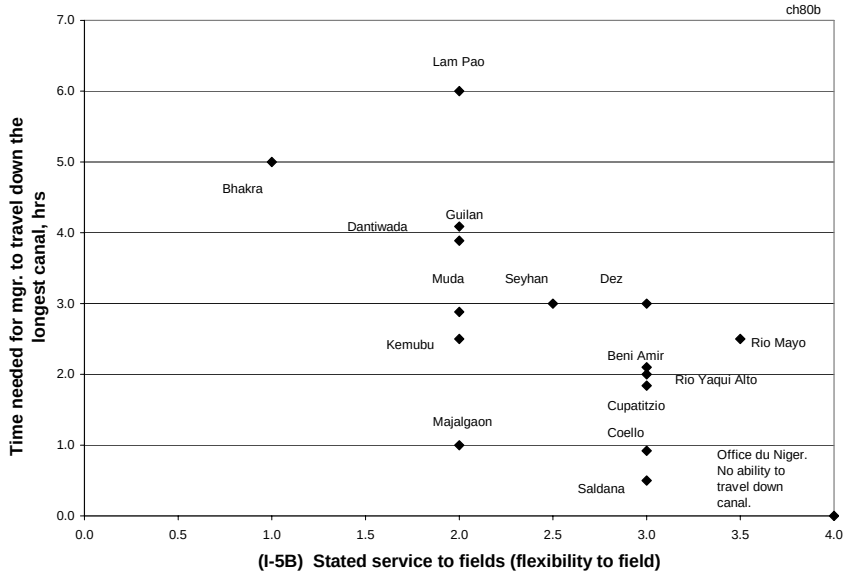

Figure 3. Flexibility in Water Delivery Service as Related to Travel Time by Operators.

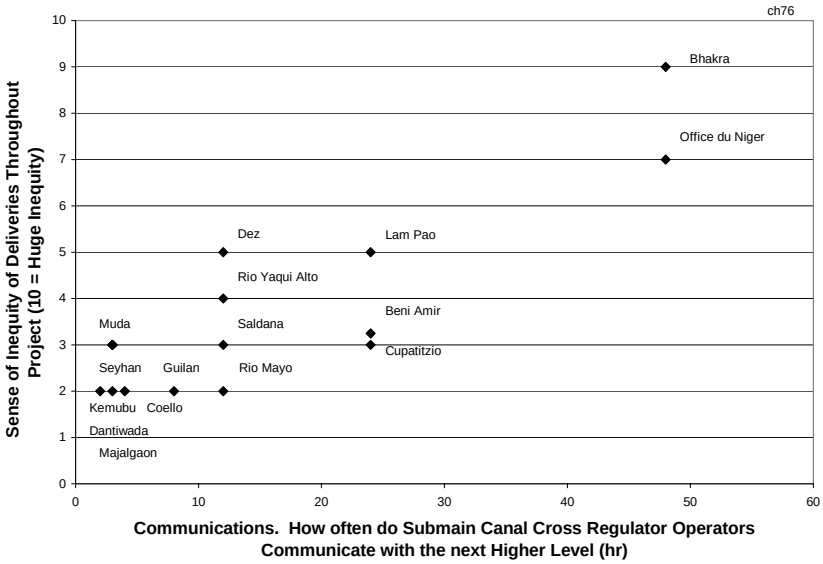

Figure 4. Relationship Between Sense of Inequity of Water Delivery, and the Frequency of Communication of Water Operators.

5. Very large projects such as Dantiwada (India) can be operated reasonably well once the managers understand the concept of dividing a project into manageable layers where each hydraulic layer is responsible for providing a specified level of service to the downstream layer (e.g., a secondary canal services the tertiary canals).

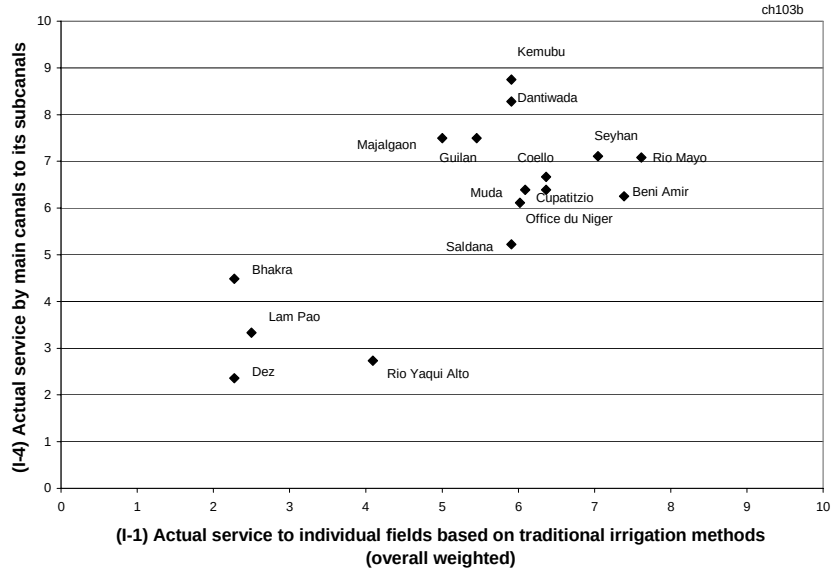

Figure 5. Actual Service By the Main Canal to Submain Canals, Versus Water Delivery Service to Fields.

6. It is possible to have relatively simple operation yet provide very flexible water delivery service to the farmer – if the hydraulic design is appropriate. An example is areas of Office du Niger, where farmers receive water almost "on demand".
7. In 11 of the 16 projects, the stated (by project managers) levels of water delivery service throughout the project were similar to the actual levels of water delivery. In these 11 projects, the staff was typically eager to learn how to improve their operations and design.
8. In almost every project that was visited, there were a number of very simple operation or design changes which could be made that could have a significant beneficial impact on the level of water delivery service.
9. Most of the design and operation solutions to improving water delivery service, even those requiring substantial time and capital investment, are relatively simple in nature. This does not mean that institutional problems are simple to correct, but it does mean that a significant percentage of the constraints for successful irrigation projects can be removed with relatively simple solutions that are well within our grasp. Most people just are not aware of these solutions or how to select them and put them together for a total plan.
10. There is excellent and realistic potential for improvement of water management and crop yields.

Negative Findings: A number of findings were negative, including:

1. Very little modernization has been accomplished in irrigation projects. It was challenging to find good examples of modernization to visit, and the selected projects typically only had a few components of modernization. None of the projects had been subjected to anything resembling a comprehensive modernization program.
2. There is a very low level of awareness by project personnel and consultants about the details of designing irrigation systems so that they are easy to operate and so that they can provide good water delivery service. This means that most attempts at "modernization" are inappropriate and doomed to failure. It also means that we cannot expect newly funded irrigation projects to achieve great performance unless something is done to address this lack of knowledge.
3. Although farmers were generally satisfied with the level of water delivery service they receive, they are basing this opinion on prior experiences with extremely poor water delivery service and very simplistic needs of crude, traditional field irrigation methods. The present level of water delivery service in almost all of the projects is incapable of supporting modern field irrigation management and methods. This means that if one is interested in promoting rapid expansion of sprinkler and drip irrigation methods, one should concentrate on areas with well water supplies. Of course, there are

almost always some limited areas in irrigation projects (typically next to large canals) which can receive water with a high degree of flexibility.

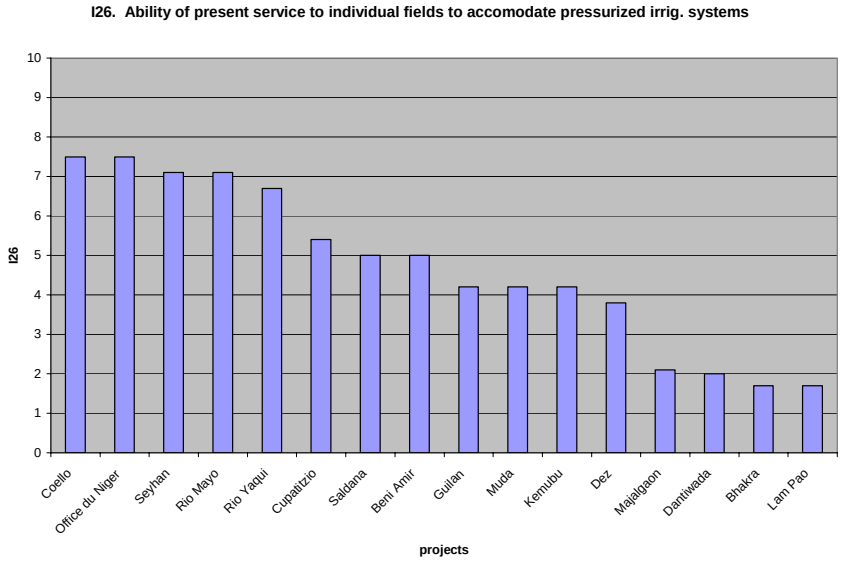

Figure 6. Ability of the Present Water Delivery Service to Accommodate Pressurized (Drip and Sprinkler) Irrigation Methods (Max. Poss. Score = 10).

4. Project irrigation efficiencies are generally quite low, as seen in Figure 7.

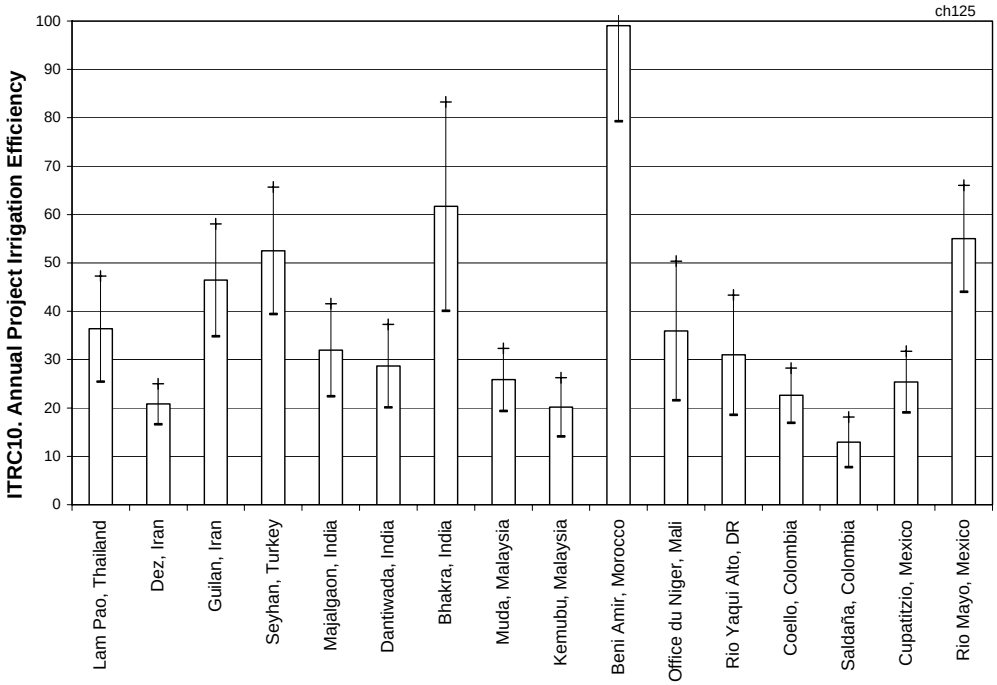

Figure 7. Project Annual Irrigation Efficiency.

5. Many consultants and engineers are using computers incorrectly. In the process, they are wasting limited time and financial resources, and are giving "modernization" a poor reputation.
6. The projects with the poorest water delivery service and the greatest mismatch between stated and actual service are those with upper management who think they are doing a great job. These managers also seem to lack a strong thirst for outside knowledge.
7. It is common for people to misunderstand modernization as consisting of simple actions such as lining canals, establishing water user organizations, and experimenting with computer programs, rather than as a whole new integrated thought/design/operation process which targets good water delivery service and good water management throughout a project. For example, water user organizations that do not receive a manageable water supply are likely to be ineffective.

Key Observations: Many observations do not qualify as either "negative" or "positive". Some of the more important observations of this nature were:

1. Modernization cannot be done with only hardware or management changes. Modernization needs were split between hardware, management, and a combination of the two. In this case, "management" includes institutional factors.
2. Overall, there is a lack of understanding of modernization strategies, even if there is a good understanding of individual modernization actions (e.g., how to install a specific type of gate).
3. The "devil is in the details." Irrigation project design and management are very complex, and each project has different constraints. Designers and institutional reformers must have a very comprehensive understanding of options in order to make the proper choices for modernization. Irrigation project planning is much more complex than road or port planning, for example. Excellent and substantial training programs are needed immediately to develop a large cadre of experts who understand the details and how they fit into a total modernization program.
4. There is absolutely no point in discussing modern irrigation scheduling, soil moisture measurement devices, and water measurement with farmers who receive water on a rotation basis (such as the rigid warabundi schedule), or if the farmer does not have the ability to modify the duration of the water delivery. The reason is simple; the farmer has no control over the topics being discussed. In other words, unless the field water is available on a "demand" or true "arranged" schedule, these principles do not apply.
5. In order to have *both* a good field-level water delivery service (equity, flexibility, and reliability) *and* a high project level irrigation efficiency (i.e., minimal spills and good on-farm irrigation efficiency), a project must have been modernized in *both* operation and design. It is sometimes possible to obtain good field-level water delivery service *or* a high project-level irrigation efficiency without a complete and appropriate modernization program. For

example, Beni Amir in Tadla, Morocco (which has some modernization *components* but has not undergone comprehensive modernization) has a high efficiency but suffers from inflexible water delivery service. Parts of Office du Niger in Mali provide water to farmers almost "on demand" because of modernization of certain parts of the project, yet the overall project has not been modernized with a recirculation system which would be required to have a high project irrigation efficiency.

Study Summary: The following points summarize the Burt and Styles (1998) report:

1. The visited irrigation projects with even a partial modernization program and motivated personnel have almost eliminated anarchy and are often well on the way to being self-sufficient from an O&M standpoint.
2. There are very few true modernization programs in irrigation projects, and generally they only have a few modernization components.
3. Even the partially modernized irrigation projects that were visited are incapable of supporting modern field irrigation systems and management that are available today and which will certainly be needed in the 21st century.
4. There is an immediate need for a major and pragmatic training in the concepts and details of modernization.
5. Irrigation project modernization requires a long-term commitment to training, O&M expenditures, and fine-tuning.
6. Most policy and institutional reforms cannot be fully implemented without the right physical environment. Application of volumetric water charges and quotas, implementation of water rights and active water markets, and demand management are reform tools which require confidence from the users in the water delivery service, and proper water control to provide that service.

FUTURE EFFORTS

There is no doubt that some types of institutional problems tend to be greater in LDCs than in the U.S. However, this should definitely not hold back good modernization efforts that include essential engineering and management improvements. I suggest 3 key areas in back-to-the-basics approach.

1. First, engineers need to make informed decisions. It was apparent in the Burt and Styles (1998) study that both the consultants and in-house engineers need better, pragmatic training. Training programs should be given the same weight as construction projects in terms of commitment of funds and personnel.
2. Second, it was apparent that very simple engineering solutions could provide major benefits in terms of water delivery service. Somehow these are often overlooked and many LDC projects seem to have been treated as research projects. For example, simple recirculation systems, when combined with

better communications and transportation, can provide simplicity of operation, excellent water delivery service, and high project-level efficiencies with simple upstream control on many canals. Furthermore, the associated structures and control logic are extremely robust.

3. Third, we need to be more realistic regarding the time and costs that are required to implement modernization programs. If we delude ourselves into thinking that miraculous things will happen in a 5 year program, we will not build in sufficient depth of key elements such as training, in-country participation, de-bugging, maintenance programs, etc.

Some countries such as Turkey and Mexico have taken the modernization programs seriously. They are rapidly developing programs which address the institutional, managerial, and hardware challenges. They also appear to understand that rapid development of even a few aspects can really mean "within 10-15 years", rather than "within 5 years".

SUMMARY

Comprehensive modernization is rare in LDC irrigation projects. It is difficult to find even a reasonable number of projects that have components of modernization. However, it is apparent from a number of projects that a realistic approach to modernization produces tangible results. It is also apparent that we need more training and the application of excellent engineering skills to develop simple and robust solutions.

I am very optimistic about the potential for irrigation modernization. First, we have no choice but to modernize. The world's environment and food security are linked to irrigation design and management. Second, I have seen motivated and realistic engineers and managers making substantial progress in widely divergent areas of the world. Third, many of the solutions are simple enough that I am confident that they will be widely applied once they are better understood.

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