Executive Summary

This study was funded by the Research Committee of the World Bank and managed by the International Program for Technology Research in Irrigation and Drainage (IPTRID) and the Agricultural and Rural Development Department. The International Water Management Institute (IWMI) participated in developing the initial research proposal and several site visits. The principal authors were contractors of IPTRID, and are from the Irrigation Training and Research Center (ITRC) at California Polytechnic State University in San Luis Obispo, California.

The research built upon previous work presented in the World Bank Technical Paper No. 246 (Plusquellec et. al., 1994). That publication, Modern Water Control in Irrigation, provided a conceptual framework for the concepts, issues, and applications of irrigation modernization efforts. It lacked the detailed field baseline information and correlations that this report now provides.

Background.

The world population is expanding rapidly, with corresponding increased pressures on the food supply and the environment. Competition for water is becoming critical, and environmental degradation related to water usage is serious. Nevertheless, most recent Staff Appraisal Reports of Bank financed irrigation projects almost never refer to the degree of water delivery service that is provided by irrigation projects. Reports focus on the external inputs and outputs and rarely discuss the internal workings of irrigation projects. Yet, we know that typical irrigation efficiencies are in the 25-35% range, most projects fail to collect fees from farmers sufficient to cover Operation and Maintenance costs, and there is a potential for higher crop yields. There is a clear and critical need to redirect some policies with irrigation project investments.

The basic questions addressed by this 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? [Note: The answer is a definite “yes”].
4. What universal lessons can be learned and applied?

Procedure

Investigators 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.

Key indicators were graphed and discussed in the report. It was never anticipated that the data would lend itself to detailed statistical analysis because there was no ability to vary one factor while keeping all other factors constant. Nevertheless, some pairs of data with high ($r>0.7$) Pearson Correlation Coefficients provided some interesting discussions.

Findings.

The report has dozens of important observations and conclusions that are important for engineers, managers, and lending agencies alike. It provides numerous details about proper and improper design and operation of physical features such turnouts, check structures, and canals. Similar details are provided about water user organizations,

employee motivation, establishing priorities, investment, etc. Only a few of the details will be listed here.

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.
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.
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.
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).
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 were completely modernized.
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.
4. Project irrigation efficiencies are generally quite low (in the 20-30% range).
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 which 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.

Summary

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.