

WATER DELIVERY SERVICE AS A DETERMINANT OF IRRIGATION PROJECT PERFORMANCE

LES SERVICES DES EAUX COMME DETERMINANT DES RESULTATS DU PROJET D'IRRIGATION

S.W. Styles¹, M.A. Mariño²

ABSTRACT

Performance of an irrigation system is represented by its measured levels of achievement in terms of one or several parameters that are chosen as indicators of the system's goals. The purpose of this paper is to utilize and refine a set of evaluation indicators that can be used to describe the irrigation performance for sixteen international irrigation projects in less-developed countries. The irrigation performance of many international irrigation projects in less-developed countries has been reported as poor. The cause of the poor irrigation performance has been blamed on technical, financial, managerial, social, and/or institutional causes. This study is specifically designed to evaluate whether irrigation project performance could be improved with modern irrigation design. A key feature of the new standards will be to provide irrigation project managers the information required to effectively improve the operations and service within a project. Results of this project indicate a need for a combination of both management and hardware improvements in every project visited. The primary conclusion is far-reaching and extremely significant for the future of irrigated agriculture in less-developed countries -- increased levels of water delivery service (flexibility in flow rate, duration, and frequency) is a key determinant of improved performance of the farmers within the irrigation project (increased yields). The results from this study are very clear -- modernized irrigation design can positively impact irrigation project performance.

RESUME ET CONCLUSIONS

Le but de cette recherche est d'utiliser et de déterminer une série d'évaluation indicatrice qui pourront être utilisées pour décrire la performance de l'irrigation pour seize projets internationaux dans des pays moins développés. Ce projet de recherche est spécialement créé pour évaluer si les résultats d'irrigation pourraient être améliorés avec des systèmes d'irrigation modernes.

L'agriculture internationale est au seuil d'une nouvelle révolution historique qui est connue comme la **Révolution Bleue**. Ce terme a été originalement utilisé par un Lauréat du prix Nobel Norman Borlaug (aussi connu comme père de la Révolution Verte), pour décrire des améliorations technologiques qui continueront à pousser pour des améliorations. Dans quelques parties du monde la Révolution Bleue a déjà commencé. La base de ce concept est que les directeurs de projet doivent moderniser

¹ Director, Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo, California 93407. tel: (805) 756-2434 fax: (805) 756-2433 email: sstyles@calpoly.edu.

² Professor of Hydrologic Sciences and Civil & Environmental Engineering, University of California, Davis. fax: (530) 752-5262 email: mamarino@ucdavis.edu.

leur operation autant que par l'aspect technique administrative. La difficulté est de déterminer comment mesurer le résultat pour évaluer les projets.

Le point primordial est que la plupart des directeurs d'irrigation n'ont typiquement pas beaucoup d'intérêt des mesures d'évaluation. A moins bien sur qu'il soit compensé sur ces résultats de mesure. Cette etude a comme dessein de determiner ces indicateurs qui seront bénéfiques autant pour les directeurs mais aussi pour les chercheurs et les politiciens qui sont en charge d'évaluer ces projets.

Une conséquence de ces indicateurs développés pour cette étude est qu'il fournisse aux directeurs des informations précises sur ce qui est précisément nécessaire pour améliorer leurs operations. Il faut espérer que les futurs perfectionnements de la définition et les applications des équations sur le terrain modifieront les techniques utilisé pour évaluer ces indicateurs.

L'index des services d'eaux globaux peut être utiliser comme déterminant d'un indicatif d'un projet d'irrigation économique. Ces projets qui ont une les meilleurs résultats par les services d'eaux ont eu les meilleurs rendements de récolte. Il est claire qu'il y a une corrélation entre l'amélioration de la flexibilité du projet d'irrigation et l'indicatif du résultat économique. Fournir de l'eau au fermier au moment approprié est un taux d'écoulements flexible avec une durée qui repond a la demande d'eau de la récolte montre, grâce à cette étude, que le resultat améliore les rendements.

Le besoin d'améliorer le materiel et l'administration a été demonté dans chaque projet visité. Dans le cas où le materiel et l'administration avait été mis en place, le système modernisé a une bien meilleur chance d'accroître la production pour un projet.

L'impact de ces conclusions devraient aider les conseillers techniques pour la réhabilitation de système d'irrigation déjà en place ou pour des projets avec de nouveau système. Les projets d'irrigations doivent être modernisés avec une strategie qui doit améliorer le debit d'eau. Ceci aidera les ingénieurs, les conseillés et les directeurs de projet a atteindre leurs objectifs pour maximiser la rentabilité et la longevité des projets.

INTRODUCTION

Agriculture is on the threshold of a historic new revolution that has been referred to as the *Blue Revolution*. This term was originally used by Nobel Laureate Norman Borlang (also known as the father of the Green Revolution) to describe the technological improvements that will continue to push forward improved yields in order to feed a hungry world. The Blue Revolution is the idea of targeting improvements in crop yields that can be made with changes in the methods of irrigation or other irrigation-related cultural practices.

In some irrigation projects, the Blue Revolution has already begun to arrive. There are basic and practical solutions that can be applied to all irrigated areas of the world, which will allow farmers to benefit from the technologies of the revolution. The basic concept is that irrigation project managers must modernize their operations with the appropriate technical and managerial components. There is one major reason that irrigation projects exist -- to serve farmers. Agriculture creates the project's wealth and the water must be provided with good service in order for the farmers to succeed. The

challenge is to determine the correct performance measures to evaluate projects so that appropriate recommendations can be implemented.

It is important to realize that while supporting agriculture, we must also:

- Safeguard the environment
- Deliver water safely
- Operate economically

With this in mind, there is a fairly straightforward approach to determine the appropriate technologies and strategies that should be implemented for a particular project. The approach used for this study was a rapid evaluation of the projects using techniques developed through the Irrigation Training and Research Center (ITRC).

The ITRC is an independent organization at California Polytechnic State University in San Luis Obispo, California. The ITRC provides technical assistance to federal water users under a contract with the U. S. Bureau of Reclamation (USBR) and to state water users in California through the Department of Water Resources (DWR). Irrigation project evaluation is one of the tasks that is typically done as part of these contracts. The first step to evaluating an irrigation project is to perform a rapid appraisal of the project.

The ITRC has successfully used variations of the Rapid Appraisal Process (RAP) approach as a diagnostic and research tool in a wide variety of situations both in the U.S. and internationally (Burt et al. 1996, Burt and Styles 1999, Burt and Styles 2000). There are many types of research projects. This particular area of research methodology falls under the "diagnostic research" category, which by its nature is often (not always) fairly quick and is recommendation-oriented. The ITRC has pioneered work on the RAP for:

- On-farm irrigation systems (On-Farm RAP)
- Distribution systems for irrigation projects (Distribution System RAP)
- External indicators for irrigation projects (External Indicator RAP)

The RAP technique has been used successfully to rapidly determine the appropriate actions that need to be taken to improve operations. The emphasis of this paper is on the use of the RAP technique for the evaluation of the distribution system of an irrigation project.

A Distribution System RAP is designed to:

- Identify specific and immediate actions that could be easily taken, with a minimum of investment, to improve operation and water management
- Quickly critique options that have been proposed for major future investment
- Suggest new ways to improve the overall irrigation distribution system

A RAP is very quick, and thus it is impossible to provide good cost estimates and detailed design drawings from such an assessment. This is a much different approach than is commonly used in research studies of irrigation projects. There is an assortment of evaluation errors that have been made both in the U.S. and internationally.

A major error associated with the evaluation of existing irrigation projects is recommending standard engineering solutions without consideration of how the hardware would work on a day-to-day or minute-to-minute basis. That is, no daily operation strategy for moving water around in the system is typically attached to the engineering recommendations. It is essential that irrigation engineering and hardware recommendations be tied to such an operation plan and strategy if the investment is to provide maximum benefits. If this is not done, it is almost inevitable that the wrong types and sizes of structures are installed, and key regulation and operation strategies are overlooked.

Another issue is losing sight of the economic reality of project costs. Unfortunately it is customary to make typical engineering recommendations for modernizing the distribution system of an irrigation project using concrete lining, new diversion structures, and better gates with a resulting capital cost of \$10,000/acre. The problem is that this high unit project cost will never be paid for by the agricultural operations. In addition to an unrealistic economic picture, these improvements may result in an expensive project with nice looking structures while the actual operation of the project may not be improved in terms of water delivery service that benefits farmers.

The biggest error often seen on irrigation projects is to offer the remedy of rehabilitating a project that was originally constructed and has now deteriorated to a point of almost non-operation. This is a common mistake that has been made on international projects funded by the World Bank. Rehabilitation is different than modernization. Rehabilitation typically involves returning a deteriorated project to its original condition without consideration that the deterioration may have been a symptom of a poor irrigation technical design. This can perpetuate a vicious (and expensive) cycle of rehabilitation, deterioration, rehabilitation, etc.

EXPERIENCE WITH THE WORLD BANK

The ITRC was involved with a unique study that was conceived by Herve Plusquellec (World Bank Sr. Irrig. Advisor, retired), funded by the Research Committee of the World Bank and managed by the International Program for Technology Research in Irrigation and Drainage (Plusquellec et al., 1994). The study examined 16 irrigation projects in 10 developing countries, 15 of which had been partially modernized in some aspects of hardware and/or management. These projects were selected as being representative of some of the best performing projects in developing countries. The External Indicator RAP approach was used for this study. This research project was designed to answer several questions: One was -- what is the extent of modernization in some of the best projects which can be located? The answer is -- it is just beginning. A second question was -- do modern water control and management practices in irrigation make a positive difference in performance? The answer is a resounding yes!! (Burt and Styles, 1999).

Nine of the evaluated projects were in Asia (Lam Pao, Guilan, Dez, Seyhan, Majalgaon, Dantiwada, Bhakra, Muda and Kemubu). Two projects were in Africa (Beni Amir and Office du Niger). Five of the projects were in Latin America (Cupatitzio, Rio Mayo, Coello, Rio Yaqui Alto del Norte, and Saldaña). Figure 1 shows the location of the projects.

Key findings of the study were the following:

- The partially modernized projects did not have the anarchy that has been widely documented in typical (non-modernized) irrigation projects.

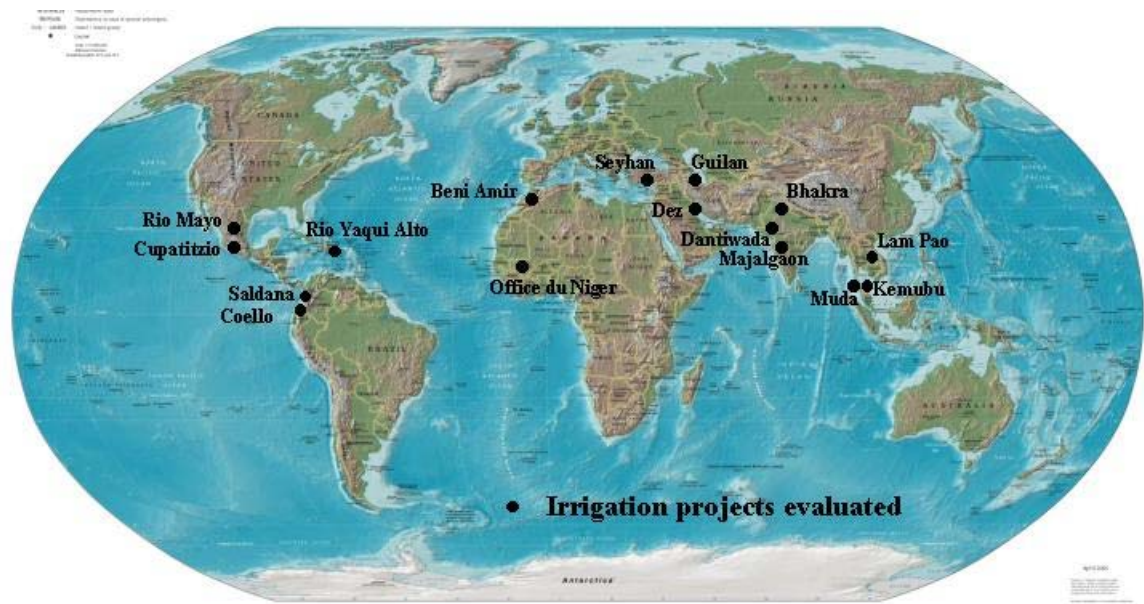


Figure 1. Location of Irrigation Projects evaluated for the World Bank (Les cites des Projets d'Irrigation évalués pour La Banque Mondiale)

- The quality of water delivery service to individual farmers is inversely related to the number of farmers who must cooperate on the final distribution of water.
- Projects with only 5 turnouts per operator (vs. 20-80 turnouts per operator for other projects) tended to provide the worst water delivery service.
- Farmers and managers appear to be satisfied with a level of water delivery service that simply eliminates anarchy and also provides "sufficient" amounts of water to farms. However, such criteria are insufficient to support modern field irrigation hardware and management.
- Modernization efforts that emphasized computer programs for predicting canal gate movements and water deliveries were generally ineffective (or worse).
- External performance indicators are best used in a before/after analysis on individual projects, rather than for comparing different projects. Figure 2 shows a sample of one of the external indicators evaluated for this study.

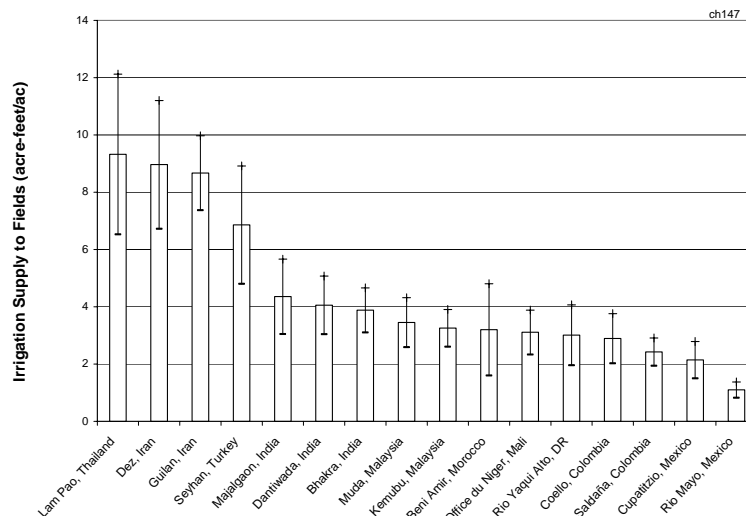


Figure 2. Annual Volume of Water Delivered to Fields, acre-feet per acre. (Volume Annuelle d'Eaux Distribuées aux Champs, par pieds par acres)

Note: There are large differences between the projects evaluated based on various factors. It is interesting to note that the top two projects for delivered water are projects documented as having low irrigation efficiencies. They are similar in that they both release large volumes of water into the project areas except one project is in a desert (Dez-Iran) and the other (Lam Pao) is in the lush tropics of northeast Thailand.

- Modernization needs were split between hardware, management, and a combination of the two. All projects needed improvements in both hardware and management.
- Overall, there is a lack of understanding of modernization strategies and how to implement them.
- Successful projects stress improved communications, focus on operational data rather than statistical data, and require a minimum of paperwork for operators.
- Simple hardware and operational changes could give immediate benefits - if people knew about them. There is a huge lack of awareness of how to design irrigation systems that provide good service.
- There is a very serious shortage of trainers and consultants who can provide focused and pragmatic training and design that properly incorporate both strategies and details of hardware and management modernization.
- While 15 of the 16 irrigation projects visited had some aspects of modernization, none of them could qualify as "modernized" irrigation projects.
- Staff who are the most eager to obtain better information and training happen to work in projects with the best performance.

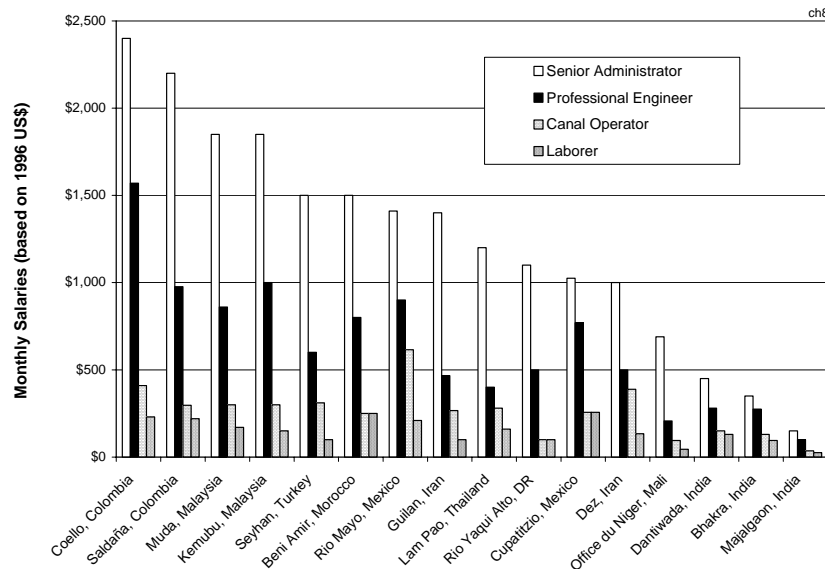


Figure 3. Monthly salaries, \$US (Salaires Mensuels, \$US)

Note: There are significant differences between the salaries of common agricultural laborers and the canal operators. In Iran (Dez and Guilan), the canal operator played a very strong role in resolving local disputes. It is also interesting to note the difference in pay between the administrators and the lower level employees. All of the top five projects based on salary had flexible levels of water service.

- Programs aimed at improving irrigation scheduling for field irrigation are doomed to failure unless the water delivery service is well controlled, reliable, and flexible -- which means most such programs are currently doomed to failure.
- Modernization is a slow and expensive process.

A significant finding of this research was a positive correlation of two new variables generated for this study. The correlation was found between the overall water delivery service and the potential production indicator (Styles 2001). This has essentially provided the difficult-to-obtain evidence of a relationship between the concept of modernizing for improved flexibility and obtaining an economic benefit (see Figure 4).

The overall water delivery service index can be used as a determinant of an economic irrigation project performance indicator. Those projects that had the highest rankings of water delivery service also had the highest relative crop yields. It is clear there is a correlation between improving the flexibility of an irrigation project and an economic performance indicator. Delivering irrigation water to the farmers in a timely manner, at a flexible flow rate, and with a duration that reflects actual crop water requirements is shown in this research to result in improved yields.

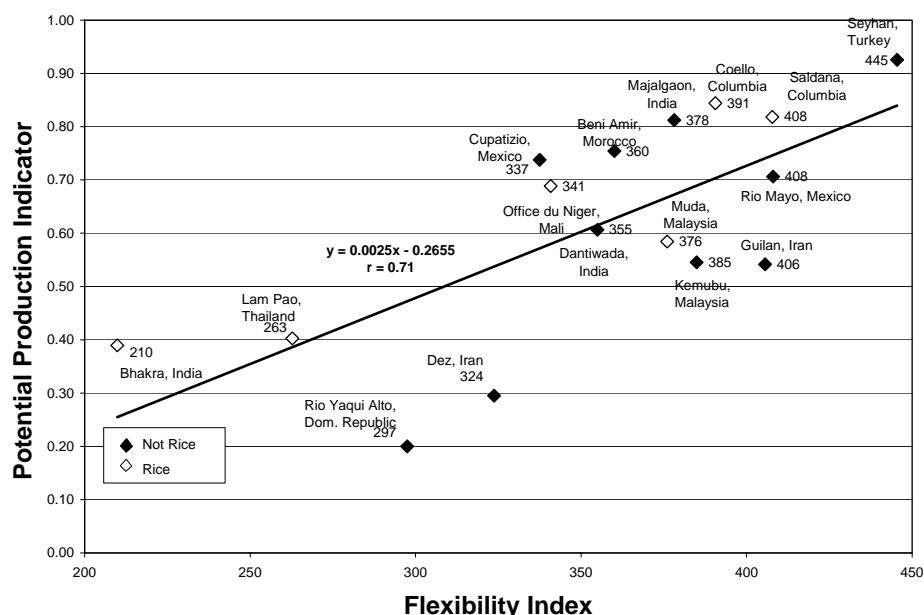


Figure 4. Correlation between Water Delivery Service Index and Potential Production Indicator (Correlation entre l'Index des Services d'Eaux et l'Indice de la Production Potentielle)

The impact of these conclusions should help planners in preparing for both rehabilitation of existing irrigation projects and the design of new irrigation projects. Irrigation projects must be modernized with a strategy of providing improved water delivery service. This will help planners/engineers/managers meet the goal of maximizing profitability and sustainability of projects.

IRRIGATION PROJECT IMPROVEMENTS

There appears to be two basic approaches to the design of irrigation projects. There is the historical approach that considered the farmer as simply one of the variables. The farmer's needs were not part of the formula in determining how the water should be delivered to the fields. In some cases, this approach can provide a significant increase in production and wealth to a region as compared to the "without irrigation" option. However, there are always drastic levels in production improvement that could be made in these systems. Figure 5 represents the historical approach to irrigation system design. While some projects may have farmers who will be generally content with the existing operations, Figure 6 emphasizes the improved potential productivity with a modernized approach to design.

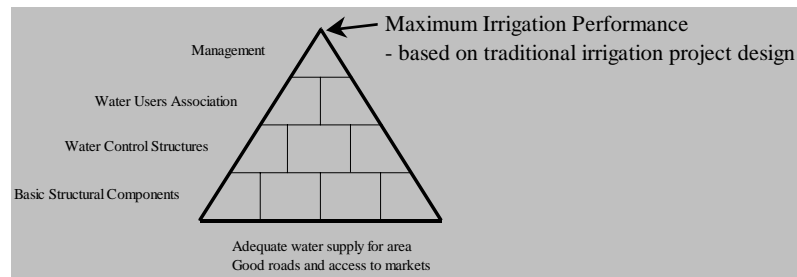


Figure 5. Historical Irrigation Project Pyramid (Pyramide Historique de l'Irrigation)

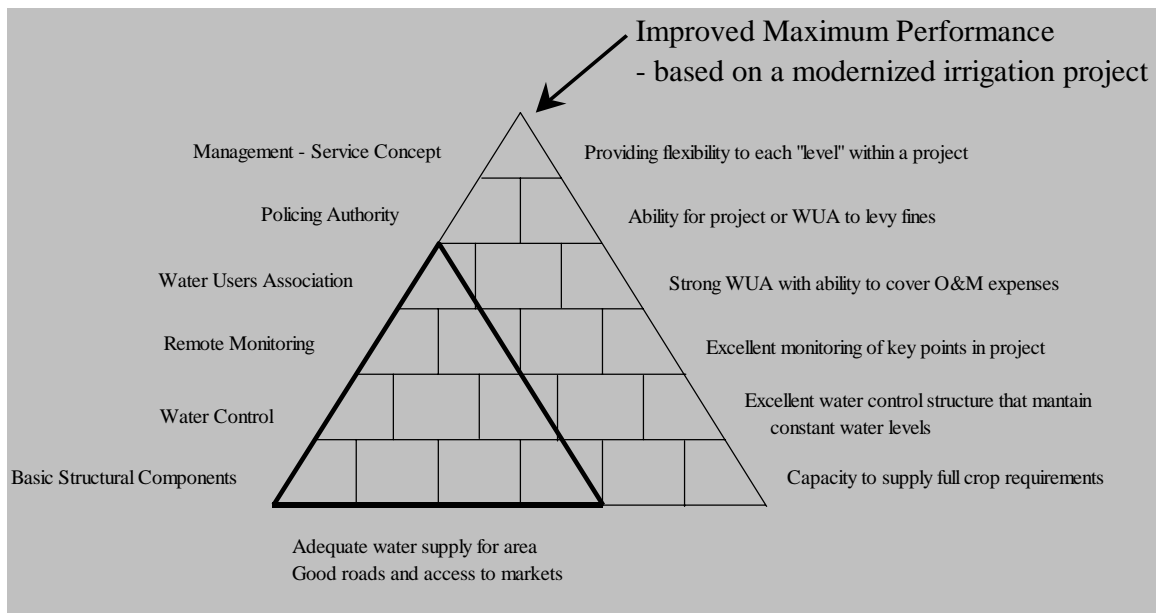


Figure 6. Modernized Irrigation Project Pyramid (Pyramide de l'Irrigation Moderne)

RECOMMENDED STRATEGY FOR MODERNIZATION

Modernization is defined as follows (FAO 1996):

Irrigation modernization is a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes with the objective to improve resource utilization (labor, water, budget, environment) and water delivery service to farms.

The following rules for modernization are a general list of the steps to take based on experience from irrigation projects in the western U.S. and internationally (Styles 2001). For more detailed information for the design and evaluation of modernized irrigation projects, the reader is referred to Burt and Styles (1999) and Plusquellec et al. (1994).

Top 10 List Of Rules for Modernization

Rule #10 for Modernization

Always think of how your actions will improve water delivery service to the farmer.

Increasing the water delivery service will improve the ability for the farmer to increase yields.

Rule #9 for Modernization

Modernization is a PROCESS, not a single item or action.

It appears that many modernization projects are under-funded with respect to expected outcomes. Experience in many countries, including the U.S., has shown that irrigation project improvement is both a long term and a costly procedure.

Rule #8 for Modernization

Each project is different.

Most projects can benefit from combinations of both hardware and operational changes. It is rare that simply recommending a hardware change such as concrete lining will result in any significant changes to the service for the farmer.

Rule #7 for Modernization

Concrete lining and computer programs are not modernization - in and of themselves.

Unfortunately, it is a common misconception that the first step and highest priority in a modernization plan is to add concrete lining. Another misconception is that an irrigation project can be operated using a computer model to dictate flow rates throughout the system.

Rule #6 for Modernization

Centralized computer automation is almost never warranted.

However, distributed control, with local automation and centralized monitoring/alarming is very good.

Rule #5 for Modernization

Must Understand Basic Engineering Principles:

- *Understand hydraulics*
- *Understand performance options*
- *Get out in the field and evaluate things.*

There is insufficient attention by all parties to the importance of the technical details of how water moves and is controlled throughout an irrigation project, both from an operational and a hardware standpoint (these are linked). This must be changed. Irrigation project proposals, at the onset, must clearly define:

- The desired service that will be provided at all levels within the system. This will require more than a few sentences in a report. Performance-based design requires that substantial thought and resources be dedicated to this matter.
- The operational procedures that will be used to provide this desired level of service.
- The hardware and irrigation project game plan (*strategy*) that is needed to implement the proper operation

Rule #4 for Modernization

It is essential to have a good strategy for how water should move throughout the district under unsteady flow.

Someone must be able to visualize how everything interacts in order to come up with an appropriate strategy. There is an insufficient pool of qualified technical experts who can make proper design and modernization decisions (especially on the strategy and information synthesis levels), as well as who can implement those decisions.

Rule #3 for Modernization

The devil is in the details.

Although experts may be aware of tools available to implement the decisions, it is still possible to poorly execute a plan. For example, using a new water level control structure as a flow measurement device.

Rule #2 for Modernization

Use sophisticated design, understanding, and modern management principles to develop designs and operation plans that are simple as possible.

Rule #1 for Modernization

Keep it simple, silly (Kiss).

Complex rules and operational strategies can easily doom a project for failure.

SUMMARY AND CONCLUSIONS

The purpose of this research was to utilize and refine a set of evaluation indicators that can be used to describe the irrigation performance for sixteen international irrigation projects in less-developed countries. The was specifically designed to evaluate whether irrigation project performance could be improved with modern irrigation design.

International agriculture is on the threshold of a historic new revolution that has been referred to as the **Blue Revolution**. In some parts of the world, the Blue Revolution has already begun to arrive. The basic concept is that irrigation project managers must modernize their operations with the appropriate technical and managerial components. The challenge is to determine the appropriate performance measures to evaluate projects.

A key issue is that most irrigation project managers do not typically have much of a real interest in irrigation performance measures. That is, unless the manager is compensated based on the performance measure. This study was designed to determine indicators that would not only be useful for the manager but also to researchers and policy makers who are charged with evaluating projects.

A key outcome of the performance indicators developed for this study is that they provide project managers precise information on what is required to improve the operations of their projects in a practical and straightforward manner. It is expected that future refinements of the definitions will modify the techniques used to evaluate these indicators.

The overall water delivery service index can be used as a determinant of an economic irrigation project performance indicator. Those projects that had the highest rankings of water delivery service also had the highest relative crop yields. It is clear there is a correlation between improving the flexibility of an irrigation project and an economic performance indicator. Delivering irrigation water to the farmers in a timely manner, at a flexible flow rate, and with a duration that reflects actual crop water requirements is shown in this research to result in improved yields.

The need for a combination of both management and hardware improvements was identified in every project visited. With some of these hardware and management

options implemented, the modernized system has a greater potential to improve production for a project.

The impact of these conclusions should help planners for both rehabilitation of existing irrigation projects and for designs of new irrigation projects. Irrigation projects must be modernized with a performance-based strategy of providing improved water delivery service that benefits farmers. This will help planners/engineers/managers meet the goal of maximizing profitability and sustainability of sponsored projects.

REFERENCES

Borlang, N.E. and C. Dowsell. 2000. Global Food Security: Harnessing Science in the 21st Century. Gene Technology Forum, Kasetsart University, Thailand. March 2000.

Burt, C.M., H. Plusquellec, and H.W. Wolter. 1994. Modern Water Control in Irrigation: Concepts, Issues, and Applications. World Bank Technical Paper Number 246. Irrigation and Drainage Series.

Burt, C.M., S.W. Styles, and R.E. Walker. 1995. Irrigation System Evaluation Manual- A Comprehensive, Documented Software Package for Evaluation of Agricultural Irrigation Systems. ITRC, California Polytechnic State University, San Luis Obispo, CA.

Burt, C.M., K. O'Connor, S.W. Styles, M. Lehmkuhl, C. Tienken, and R.E. Walker. 1996. Status and Needs Assessment: Survey of Irrigation Districts. ITRC, California Polytechnic State University, San Luis Obispo, CA.

Burt, C.M. and S.W. Styles. 1999. Modern Water Control and Management Practices in Irrigation: Impact on Performance. FAO Water Report, No. 19. Food and Agricultural Organization of the UN, Rome, Italy.

Burt, C.M., D. Cordova, and A. Mutziger. 2000. Benchmarking of Flexibility Needs: Survey of Irrigation Districts, USBR Mid-Pacific Region. Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo, CA.

Burt, C.M. and S.W. Styles. 2000. Irrigation District Service in the Western United States. ASCE J. Irrig. and Drain. Engrg. Div., 126(5). 279-282.

Food and Agricultural Organization (FAO). 1996. Expert Consultation on Modernization of Irrigation Schemes: Past Experiences and Future Options. Bangkok, Thailand 26-29 November 1996. Food and Agricultural Organization of the UN, Rome, Italy. Document WP.4.

Styles, S.W. 2001. Irrigation District Modernization. California Irrigation Institute 39th Annual Meeting. January 2001. ITRC, California Polytechnic State University, San Luis Obispo, CA. Powerpoint Presentation.

Styles, S.W. 2001. Water Delivery Service as a Determinant of Irrigation Project Performance. Doctor of Engineering Dissertation. University of California, Davis, CA.