IMPROVING THE IRRIGATION SERVICE TO FARMERS: A KEY ISSUE IN PARTICIPATORY IRRIGATION MANAGEMENT

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Summary

This paper argues that the notion of water delivery service and of generalized service-orientation of institutions in the irrigation sector, whether river basin agencies, reformed irrigation agencies, irrigation service providers, water users associations has become central in new concepts and definitions of participatory irrigation management and irrigation management transfer.

After a definition of the concept of irrigation service and how to evaluate it, the existing literature on the evaluation of impacts of on-going participatory irrigation management and irrigation management transfer programmes in terms of water service delivery, agricultural productivity and agricultural performance, which is one of the is one of the reasons of this evolution, is reviewed. The paper then reviews how the service orientation of irrigation water delivery is taken into account in physical woks, monitoring and evaluation systems, and tools for design and preparation of operation and maintenance plans.

The sustainability of the water users associations is seen to depend on their capacity to provide an adequate water delivery service and control and allocate water and to provide an improved service to allow the agricultural productivity to take place. In the context of Asia, diversification of rice crops is a major issue for increased income by farmers and improved agricultural and water productivity. This in turn is essential for the capacity of farmers to pay water and the water users associations to e financially viable. A more forward-looking strategy anticipating these future needs is therefore required. As a result, it is now recommended that strategies of gradual improvement of irrigation systems be adopted to support the transfer of water management responsibilities and associated rights.

The paper then reviews the implications of improved agricultural productivity and improved water productivity in terms of required quality of water service, particularly in the case of rice and diversification of rice-based farming systems.

The paper then argues that concepts of irrigation management transfer/participatory irrigation management transfer and modernization of irrigation systems operation are therefore converging. However, there are still some substantial differences: the infrastructural physical improvements which must be supported must be designed with a

view to improve equity and reliability of water delivery service and evolve towards increasing levels of flexibility. Operational and technical details become very significant. Environmental considerations need to be better into account in a perspective of integrated water resources management.

Recent visioning processes in the water sector provide a good condition for strategically panning organizational and technical changes in participatory and irrigation management. The paper therefore presents trends and evolutions towards integrated water resources management as well as concrete examples of water visions and their implications in terms of transformation of the irrigation sector. However, there is a general lack of knowledge of modern service-oriented design and operation concepts at all technical levels in the irrigation sector in the region. The paper presents modernization design and operation concepts as well as possible modernization strategies.

Intensified and on-going training programmes for both professionals in the reformed irrigation agencies, consulting firms who will provide advisory services to water users associations and to the managers of water users associations and the technical staff that they may employ for operation and maintenance of their irrigation schemes are understood as one of the conditions for sustained success of the transfer programmes.

It is therefore essential that these programmes introduce and provide knowledge on ways and means to design and operate irrigation systems cheaply for good performance and adequate service to farmers as they evolve toward more commercial forms of agriculture. An appraisal of initial conditions and performance of the systems to be transfer would allow both a better design and strategic planning of physical improvements together with a definition of the service to be provided both by the irrigation service provider to WUAs and by WUAs to their members, with indications on ways and means to achieve these service goals and improve them in the future.

It is suggested that the Rapid Appraisal Process developed and used in the evaluation of modernization programmes of IPTRID could be used for this purpose at programme appraisal stage and for individual irrigation systems. The use of internal process indicators would be useful in monitoring and evaluation systems A pilot training programme on modernization concepts and application of the Rapid Appraisal Procedure which builds on the knowledge synthesis acquired in recent years on modern design principles and participatory irrigation management shows promising results. Its application to a system in Thailand by staff of the Royal Irrigation Department is presented.

A concept for a more ambitious re-training programme based on the same concepts and tools has been developed and could be supported in the context of efforts to improve the performance of programs to transfer the management of irrigation systems to the users (Burt and Facon, 1999). The paper also concludes that a second condition for the sustained success of participatory irrigation management is the availability of financial instruments that allow farmers to invest in the upgrading of their irrigation systems.

Another condition for the sustainability of the reforms is the development of a suitable service environmental to assist farmers in increasing the productivity of agriculture.

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A. SERVICE AND PERFORMANCE INDICATORS

Retracing the introduction of the service concept in irrigation management, Charles Burt (1996) notes that although the primary function of irrigation dams, canals, and pipelines is to provide water delivery service for agricultural use, there have been few significant efforts made to measure the characteristics and success of this function. The concept of providing service in irrigation projects is relatively new. The idea of assessing performance, including some measures of service, is even more recent.

In the 1980s, discussions on irrigation project improvements emphasized management improvements almost entirely over better hardware selection and design. At that time, the concept that irrigation projects must provide service to customers was also introduced from other utilities and sectors such as electricity supply, communications and transport.

In the early 1990's, IIMI began to develop "Performance Indices" for international projects. Murray-Rust and Snellen (1993) examined 15 projects and documented significant differences between promised versus delivered flow rates at various offtakes. They also provided a narrative discussion of factors which they felt influenced the level of service. Their recommendations emphasized management improvements over hardware improvements. Plusquellec et al (1994) re-emphasized the importance of proper hardware selection and articulated the need for a approach to modernization based on the service concept. They pointed out that many management goals are impossible to achieve without the proper hardware in place.

IWMI's action research program for the years 1994-1998 (IIMI, 1994; ILRI, 1995) included some types of performance assessment. ICID has a Working Group on irrigation and drainage performance which coordinates with IIMI. The ICID Working Group (ICID, 1995) published a list and description of currently used performance indicators. The performance indicators emphasize ratios of volumes of water delivered, lost, and consumed at various times and locations. In addition, some indices were developed for concepts such as dependability of supply and regularity of water deliveries.

A task committee of the Water Resources Division of the American Society of Civil Engineers completed a significant, multi-year effort to provide a definitive document regarding Irrigation Efficiency (Burt et al., 1996).

In this document, a definition and description of the various aspects of the notion of water delivery service is given in the context of the description of the irrigation project as consisting of distribution system layers. Most water distribution systems in irrigation projects consist of networks of canal and/or pipelines. Water is supplied to downstream layers from the upstream layers. A main canal would be one layer, supplying water to secondary canals, the next downstream layer.

The definition of water delivery service at any layer in the distribution system includes:

1) specification of the water right of the beneficiary (for example, cubic meters per hectare per season for volumetric deliveries, or proportional allocation of available supplies in the case of uncertain supplies);
2) specification of the point of delivery (farm level; user association; minor outlet);
3) flexibility in rate of delivery (fixed; variable; variable between limits);
4) flexibility in duration (fixed; variable but predetermined; variable by agreement); and
5) flexibility in frequency (every day; once per week, undefined).

The service definition will also specify the responsibilities of all parties (farmers, Water User Associations (WUAs), operators of the tertiary canal, operators of the secondary canals, operators of the main canals, and project authorities) in operating and maintaining all elements of the system. A main canal provides water, with a certain level of service, to secondary canals. Each upstream layer in a hydraulic distribution system provides service to the layer immediately downstream of it. The actual levels of service at each layer must be examined to understand the constraints behind the level of service which is provided to the field.

The point of differentiation within an irrigation system is the location for which upstream water deliveries can be deliberately and effectively manipulated separately with time. Downstream of the point of differentiation, all turnouts are treated identically, without the ability to provide special treatment to any of them. The point of differentiation is not the point of ownership transfer. A water user organization may become responsible for the distribution system above, below, or at the point of differentiation. For all systems in which there is a concept of water management by the individual farmer, the point of differentiation must be at the individual field scale.

There is a wide range of levels of irrigation service, and the nature of the service may vary significantly from a highly flexible service differentiated at the farm level to an inflexible service provided on an undifferentiated basis to a large number of farmers. It is therefore important to qualify the level of service. It is important to re-emphasize that an irrigation project is a network which consists of many hydraulic delivery layers, and each layer provides service to the next lower layer, finally ending at a "point of differentiation".

The levels of service may be different at each layer. It is also important not only to identify what the existing level of service is, but also what the expectations are at each layer of operation.

Factors to define include:

1. The flexibility of water delivery. The three aspects of flexibility, <u>at any layer</u> in the system, are:
   a. Frequency. How often can water be delivered, or can a flow be changed when desired?
   b. Flow rate. What flow rate can be delivered at a point? How often can the flow rate be changed, and how much advance notice must be given? Is the flow rate controllable? Is the flow rate even known?
   c. Duration. Can the duration of an irrigation or water delivery be adjusted?
2. The equity of water delivery to all levels in the system.
3. The reliability of water deliveries.
4. The timeliness of water deliveries.

B. SERVICE AS AN OBJECTIVE OF PARTICIPATORY IRRIGATION MANAGEMENT

The failure to develop adequate operation and maintenance (O&M) mechanisms to ensure the sustainability of the irrigation schemes (mostly large, public schemes) is principally at the origin of participatory irrigation management (PIM), irrigation management transfer (IMT) or increased participation of users in the management of the schemes. An important consideration was the poor performance of government-managed systems but the principal motivation for governments was financial, i.e. to transfer the costs of O&M to the users. In this context, improvement of the irrigation service was seen as an incentive for farmers to accept paying higher irrigation service fees (Bruns, 1996).

Ruth Meinzen-Dick (1997), describes these processes as the state assuming more tasks at high level of water management while farmers take on more tasks at lower levels. IMT consists in the turnover of systems to users, rollback of government and agencies cut. In PIM, farmers' involvement complements or substitutes the role of the state agency. Central approach to design, construction and operation results in poorly adapted service which result in deteriorating systems and structures – problems of local adaptation, incentives and information cannot be managed by such an approach. The establishment and active participation of farmers in irrigation management would therefore improve the performance and sustainability in a number of ways. More efficient water delivery services and the design and construction of irrigation projects better adapted to local needs and constraints would be potential benefits.

Groenfeldt and Sun (1997), propose that under the demand management approach, users through their associations make management decisions for distributing water, maintaining systems and collective fees, while government plays a supportive role. The Water Users Association (WUA) enters into a contract with the sate agency for operating and maintaining portions of the system or the entire system. The WUA has authority and responsibility to operate the system as it desires, and to hire its own management and other technical staff. Both the manager and the staff are then accountable directly to the farmers they serve. The accent however is on accountability and not on the notion of operating as you wish, i.e. defining service level. However, implicitly, the notion of demand management which is to be achieved through at all levels entails involvement in decision on service. It is stated that when management is transferred from the supply-oriented irrigation agency to demand-oriented farmers, a solution to irrigation management problems – whether poor maintenance or poor water distribution – becomes suddenly more possible. The impact from farmers' perspective would include such "intangible" benefits as improved irrigation service.

Vermilion, 1999, indicates that the key rationale of the Andhra Pradesh Farmer Managed Irrigation System Act (APFMIS) of 1997 was existing irrigation inefficiency and inequity, low cropping intensities and yields. Thus the re-orientation of Irrigation departments as competent authorities to provide technical support to farmer organizations who would manage the systems. He states that new procedures adopted by WUAs and for water distribution are "another very important issue. Unless water distribution is improved, it is unlikely that WUAs will be able to raise the level of water charges and increase the collection rate. Unless more funds are raised locally of irrigation O&M than at present, the schemes will continue to deteriorate after minimal rehabilitation and the gap between potential and actual irrigated areas will continue to widen ".

Namika Rabi (in *Participatory Irrigation Management in the Philippines, National Irrigation Schemes*), describes the three types of contracts between Irrigators Associations (IA) and the National Irrigation Agency (NIA), maintenance, collection, system turnover. These contracts imply a progressive transfer of responsibility in system operation. However, the water delivery plan even in the case of the system turnover contract is agreed with NIA and the emphasis is always on the carrying out by the IA of minor repairs and regular maintenance. In an IDD 1996 study on evaluation of performance of IAs, for a total score of 100%, implementation of O&M is weighted 48%, while O&M performance outputs is weighted only 12%. In the maintenance contracts, IAs allocate and deliver water in timely fashion adequate amounts of water from lateral head-gates to individual farms and in the turnover contract, they also implement a jointly agreed water delivery plan for entire system. However, how they fulfill these tasks is not captured in their evaluation criteria.

While this may be quite representative of Asian PIM programmes, the notion of service has been more central to IMT/PIM programmes in other regions, notably in Latin America and Turkey. In Turkey for instance (M. Svendsen and G. Nott, 1997), the objective of the IA as stated in the standard agreement is:

- To provide high quality irrigation service to all its members
- To do this reliable and sustainably
- To contain costs
- To collect fees effectively
- To develop the capacity for self-reliant O&M

As in Mexico or Colombia, the IA receives bulk water supply from the irrigation agency as is entirely responsible for O&M in its area of jurisdiction.

C. EQUITY AND RELIABILITY AND SOME MEASURE OF WATER USE EFFICIENCY THE MAIN OBJECTIVES OF PIM IN ASIA

In large public irrigation schemes in Asia, the main problems of irrigation service delivery faced by the farmers were usually erratic delivery and inequity between the heads and tail-ends of the canals, resulting in low cropping intensities, in a poor proportion of the systems' command area being irrigated, and poor yields. The service objective of PIM programmes has therefore been chiefly to improve reliability and equity of water delivery, the main expected outcome being an increase in irrigated areas and an increase in cropping intensity.

The APFMIS Act of 1997 is a typical example. Indicators by polling to estimate the quality of irrigation service address reliability and equity only. Equity and reliability have actually very often been the only service objective.

Bruns and Helmi (1996), assessing the experience of PIM in the small irrigation systems of Indonesia, state that "accumulated experience provides a basis for reengineering irrigation O&M to create better patterns for cooperation between government and farmers in the key process of equitably delivering irrigation water".

D. ACHIEVEMENTS OF PIM/IMT IN IMPROVING QUALITY OF SERVICE AND THE INCREASING ATTENTION PAID TO SERVICE

There is still a significant knowledge gap on the impact of IMT and PIM (Vermillion, 1997) in general. However results of recent and impact evaluations synthetic efforts of literature notably by the International Network on Participatory Irrigation Management (INPIM) and IWMI allow to draw some general conclusions on the impact of PIM/IMT programmes on the quality of water delivery service. As most of these programmes have included some measure of rehabilitation or upgrading or infrastructure, or on-farm infrastructure development, it is often difficult to separate farmers involvement benefits from other changes such as rehabilitation (Vermillion, 1997, Meinzen-Dick, 1997).

Vermillion (1997), reviewing 29 impact studies, states that quality of operations and maintenance is often a stated goal of programmes, but that most of evidence is qualitative statements. Of the 29 studies, only 8 involve direct measurement of operations and 5 direct inspection of structures. They rely heavily on secondary data collected from agency offices which may not reflect the situation. However, there are indications that in general there has been an improvement in service quality, and notably in equity of distribution and reliability. Negative results in these categories are also mentioned however. Increases in irrigated area and crop intensity are mentioned in many instances.

Flexibility is not a service characteristic explicitly investigated but some results in terms of timeliness and adequacy are registered. Improvements in terms of water use efficiency are more uncertain.

M. Svendsen, J. Trava, S. Johnson III (1997), synthesizing the experience of PIM in 5 countries, state that although few specific studies on quality of service after IMT exist, general impression is that after turnover, services have substantially improved in regard to timeliness, reliability, and equity. The main factor for the outcome is estimated to be that there is closeness and less distance of irrigation service provider. They summarize the impact of PIM project from the farmers perspective as follows:

Impact: from farmers perspective

Sense of ownership Increased transparency of process Greater accessibility to system personnel Improved maintenance Improved irrigation service Reduced conflict among users Increased agricultural productivity	Higher costs More time and effort required to manage Less disaster assistance No assured rehabilitation programme Less secure water right Decreased agricultural productivity

Recent research reports of IWMI using the comparative performance indicators developed by the Institute (Molden, D., R. Sakthivadivel, C. J. Perry, C. de Fraiture, and W. H. Kloezen. 1998) provide further information on some irrigation schemes, mostly in South America. For instance ,Levine G., Crux Galvan A., D. Garcia, C. Garcés-Restrepo, and S. Johnson (1998)conclude about the performance of two transferred modules in the Lagunera region of Mexico that:

- IMT has resulted in good management capability
- There is agreement in planning at district and module levels
- There is consistency in proportional water allocation t field levels
- Distribution is effectively in hands of canalero and/or users collaborate highly, which allows the average Field Water Supply (Actual) to have rather low values, indicating a high efficiency.
- Management is tuned to field conditions.

A recent study focusing more directly on quality of service in 16 modernized irrigation schemes (FAO, IPTRID, World Bank, Modern water control and management practices in irrigation, impact on performance, Water Report 19,1999) provides also some insights on the impact of PIM/IMT, as all modernized systems investigated were also the object of some PIM or IMT. Six of these schemes are in Asia (Majalgaon, Dantiwada and Bhakra in India, Kemubu and Muda in Malaysia, and Lam Pao in Thailand).

Svendsen and Nott (1997) note that “the purpose of any irrigation system is to provide high quality irrigation service to farmers fro growing crops. The effects of any program which modifies the organizational arrangements for providing this service must therefore be evaluated in terms of the quality of that service”. The methodology followed for this research therefore takes into account the definition and characteristics of service as defined above in A. and evaluates them through a rapid appraisal procedure (RAP) using a series of external performance indicators and internal process indicators.

Merrey (1992) distinguishes between indicators for comparing the performance of irrigated agricultural systems or external performance indicators and internal process indicators are required: the objective of the latter is to assist managers to improve water delivery service to users. Targets are set relative to objectives of system management, and performance measures tell how well the system is performing relative to these targets. If the target is not reached, then either you change the process or you change the target.

External indicators examine values such as economic output, efficiency, and relative water supply (i.e., ratios of outputs and/or inputs). Because of the tremendous differences in water availability, climate, soil fertility, topography, and crop prices, "external" performance indicators are primarily applicable to compare actual results with what was planned - to compare outputs from a project before and after modernization.

The study's hypothesis is that it is absolutely necessary to understand the internal mechanisms of irrigation projects, and to provide selective enhancement of those internal mechanisms, if irrigation project performance is to be improved. These "details" of internal mechanisms are so important that investments must be based around specific actions to improve them, rather than deciding on the framework for detail improvement only after the investment is approved. Therefore, internal indicators, which when examined as a whole, are assessed and indicate how and where irrigation investments should be targeted.

A Rapid Appraisal Process quickly (within a week) evaluates an irrigation project to assess what type of modernization is needed. External performance indicators are also quantified. These characterize the inputs and outputs of irrigation projects, including amounts of water, yield, and economics. Internal process indicators are be quantified for each irrigation project. A detailed questionnaire is developed to obtain information needed for external performance indicators and internal process indicators. A list of baseline project data (acreage, budgets, crops, climate, water availability) is requested from project authorities prior to the visit. Typical baseline data is either available or it isn't. If the data does not already exist, spending an additional 3 months on the site will not create the data. Baseline project data is needed to quantify external performance indicators. A 5 day visit is made to the project. Ideally, only 1 day is spent in the office to examine system maps and to review the baseline project data that has been prepared in advance. The majority of time is spent in the field with field engineers/operators, making observations and collecting the data needed for internal process indicators. Substantial lengths of the main canal, some secondary canals, tertiary canals, etc. are visited. Observations are made regarding the types of structures, general conditions, operator instructions, quality of flow and water level control, and other operational points. Impromptu conversations are held with farmers and operators. Short visits are made to any water user associations that may exist.

Internal indices provide ratings to hardware, management, and service throughout the whole system at all levels, an approach which has not been used in the past. The complete picture enables one to visualize where changes are needed, and what impact the changes would have at various levels. When the internal indicators are examined together and also combined with some of the external indicators, a clear image emerges about the design, operation, and management of an irrigation project.

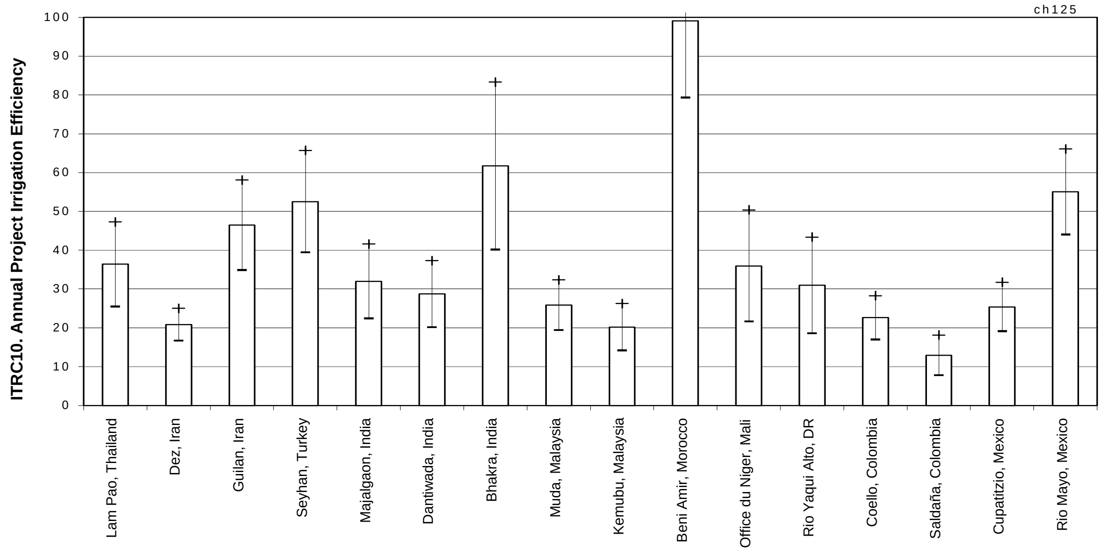
The table below provides information on one of the internal process indicators, including weighting factors of the sub-indicators. The final weighted scores of the internal process indicators were always adjusted so that the maximum (best) indicator value is 10.0, and the lowest value is 0.0. This demonstrates that quality of service is not intangible as petitioned by Groenfeldt but can indeed be measured (with data) or estimated with an objective scoring system. Note the score of dictated rotation which match crop needs" (it receives a score of 2 out of 4 there are therefore significant differences between adequacy and flexibility).

Sub-indicators for Indicator I-1 (Actual service to individual fields, based upon traditional field irrigation methods).

No.	Sub-Indicator	Ranking Criteria	Wt
I-1A	Measurement of volumes to field	4 - Excellent measurement and control devices, properly operated and recorded. 3 - Reasonable meas. & control devices, average operation. 2 - Meas. of volumes and flows - useful but poor. 1 - Meas. of flows, reasonably well. 0 - No measurement of volumes or flows.	1
I-1B	Flexibility to field	4 - Unlimited freq., rate, duration, but arranged by farmer within a few days. 3 - Fixed freq., rate, or duration, but arranged. 2 - Dictated rotation, but matches approx. crop need. 1 - Rotation, but uncertain. 0 - No rules.	2
I-1C	Reliability to field (incl. weeks avail. vs. week needed)	4 - Water always arrives with freq., rate, and duration promised. Volume is known. 3 - A few days delay occasionally, but very reliable in rate and duration. Volume is known. 2 - Volume is unknown at field, but water arrives when about as needed and in the right amounts. 1 - Volume is unknown at field. Deliveries are fairly unreliable < 50% of the time. 0 - Unreliable freq., rate, duration, more than 50% of the time; volume is unknown.	4
I-1D	Apparent equity	4 - It appears that fields throughout the project and within tertiary units all receive the same type of water. 3 - Areas of the project receive the same amounts, but within an area it is somewhat inequitable. 2 - Areas of the project receive somewhat different amounts (unintentionally), but within an area it is equitable. 1 - It appears to be somewhat inequitable both between areas and within areas. 0 - Appears to be quite inequitable (differences more than 100%) throughout project.	4

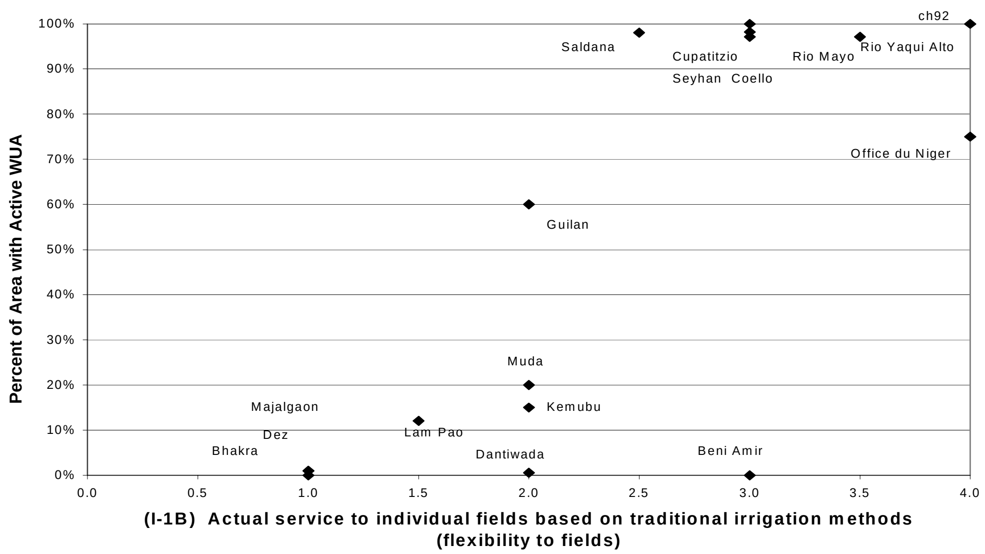
The combined weights of RELIABILITY (I-1C) and EQUITY (I-1D) represent 73% of the total score for indicator I-1. This is because traditional field irrigation techniques are not sophisticated, and obtaining reliability and equity is essential to avoid anarchy. This weighting corresponds to the prevailing situation in large irrigation systems in developing countries and particularly in Asia, as noted above.

Among the findings of the study, annual project irrigation efficiencies (one of the important external performance indicators) are typically low and not significantly different from values encountered in other irrigation schemes, as is shown in the graph below.



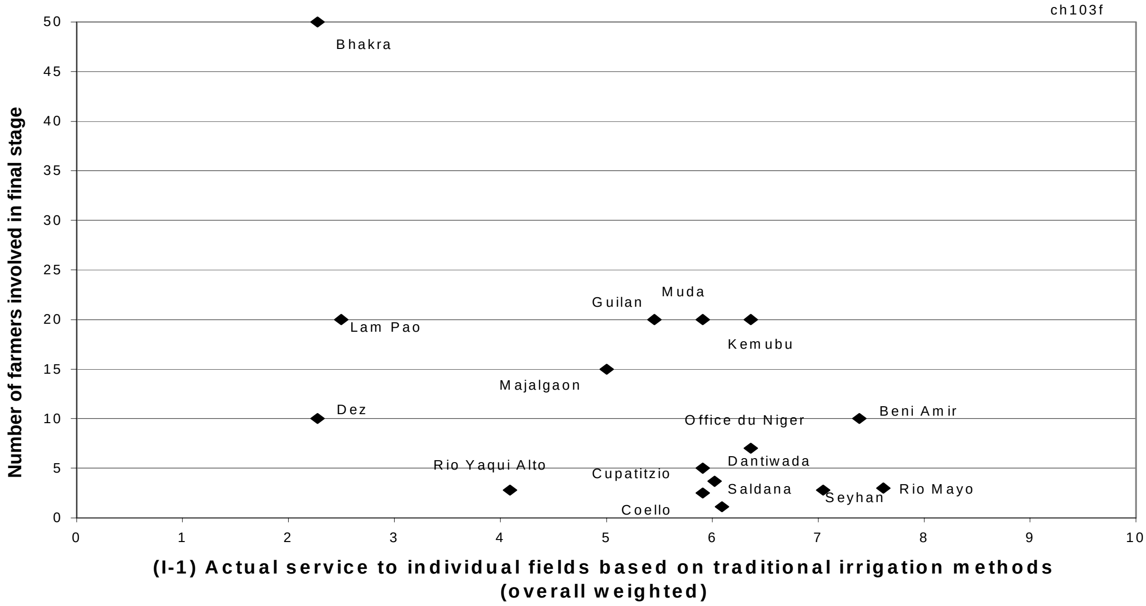
Internal process indicators have been correlated, notably concerning the WUAs on the systems. The "social" WUAs that are developed for the purpose of providing maintenance and collecting water fees were consistently found to be either weak or imaginary. The "business" WUAS that hired staff to distribute water and ran the water distribution similar to a business operation were often quite strong. This does not prove a cause/effect relationship, but could be interpreted to show that as the actual service to individual fields improves, the area with active WUAs increases.

[Actual flexibility of water delivery to fields] versus [percent of area with an active water user association].



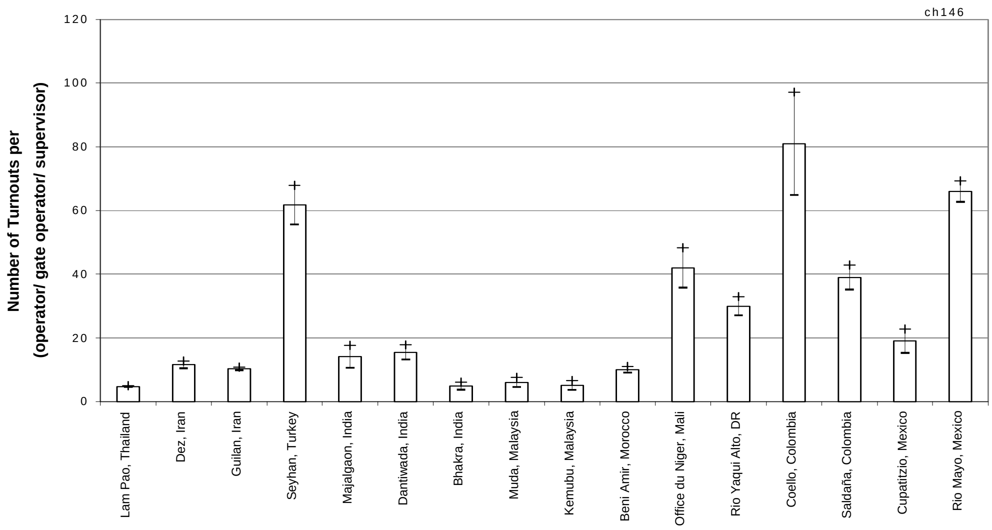
Water Delivery Service and Turnout Density. The figure below shows a trend of increased water delivery service to the fields if there is a high density of turnouts, i.e. if less farmers need to cooperate.

[Actual service to individual fields based on traditional irrigation methods (weighted overall)] to the [number of farmers involved in the final stage]



In large irrigation projects, the managers tended to point out how difficult it is to manage a project with large areas of land and large numbers of fields and farmers. Such arguments seem misguided, as they were typically associated with top-down management styles which did not break the water distribution into layers, plus did not empower employees to make decisions. The number of farmers in a project is not important if one turnout only supplies 50 farmers (e.g., Bhakra). The figure below shows a more meaningful index. Seyhan, Office du Niger, Coello, Saldaña, and Rio Mayo all provided relatively good water delivery service to the field - an interesting point since their operators are responsible for many more turnouts than their counterparts in the Asia projects.

Number of project operated turnouts per operator.



Another example of internal process indicator refers to management style. In general, employee training and incentives were much higher in the projects with "business" WUAs than in the other projects. Table below provides a glimpse of employee conditions.

Data on Internal process indicator I-24 sub-indicator values

Item	Avg. Value (0 = minimum; 4 = maximum)	Coefficient of Variation
Frequency/adequacy of training of operators and managers	.57	.41
Availability of written performance rules	.34	.85
Power of employees to make decisions	1.67	.43
Ability to fire employees	.94	.85
Rewards for exemplary service	.35	.83
Salary (relative to farm laborers) of canal operators/supervisors	1.18	.52

The relatively low pay and lack of training and evaluation of operators may explain an interesting focus seen in some projects. A feature of modern design and operation is often the *minimization* of the collection of large amounts of data, which are used for **statistics**. On the other hand, modern projects tend to *increase* the availability of information needed for **operation**. It was apparent from this research project that there is tremendous confusion between these two types of data. Some irrigation projects waste tremendous amounts of employee time by *collecting* meaningless data (e.g., water levels at the head of lateral canals in non-rated canal sections), where the time would be much better spent in *controlling* water levels and flows. When dealing with the *operation* of a canal system, one must focus on **results** rather than on **process**. For example, the Lam Pao management emphasizes "process" and requires operators to diligently *record* the gate positions and water levels, when the desired "result" is a water level. Field operators are not allowed to take personal initiative to achieve the desired result - they must instead follow a process. This is typical of some top-down management styles.

Through a number of similar analyses, the research was able to provide elements to support and further document the findings of studies by IWMI and INPIM and numerous other authors on two critical aspects of PIM and IMT:

- Water user associations of some form (para-statal or private sector) provide distinct advantages in terms of quality of water delivery service, irrigation performance and cost recovery if they are properly empowered.

- Direct government contributions to O&M activities can realistically be reduced if the projects are first brought up to the point where reasonable water delivery service can be provided.

It seems that the increasing availability of studies documenting the impact of IMT and notably the lack of discernable improvement f irrigated agriculture productivity has raised the awareness on the linkages between service and performance. Also, WUAs which do not perform a significant role in decisions on service are seen as weak. User organizations needed to provide services (over large systems) are unlikely to be sustainable unless they also offer their members greater control over water. This means they must have decision-making authority for water allocation, as well as distribution (Svendsen, 1997). Problems when transfer of responsibility not accompanied with transfer of authority to follow though with management decision are noted (Meinzen-Dick, 1997). An equivalent observation is made in terms of rights (as synonymous to authority) by Groenfeldt (1997).

D. Vermillion, 1997, in “management devolution and the sustainability of irrigation: results of comprehensive versus partial strategies” sates that there are five conditions for an irrigation management devolution program if the objective is to produce sustainable improvements in the performance of irrigated agriculture:

- a sustainable water right
- an agreed irrigation service
- balance between responsibility and authority devolved
- devolution of integrated management responsibility, i.e. finances, O&M and conflict resolution
- adequate incentives and sanctions to ensure accountability

He argues that the water right should be environmentally sustainable and vested in a legally recognized WUA. This enhances farmer confidence in the service and willingness to invest in the long-term viability of the system. Second, clear and binding irrigation service agreements between government and WUAs and between WUAs and individual users create essential cross-accountability between parties and clarify expectations essential to effective management. Such agreements should also be implementable within the constraints of local management capacity and irrigation technology. He comes to that conclusion, comparing the impact of complete devolution (USA), partial devolution (Colombia) and minimal devolution (Sri Lanka) that impact in terms of productivity and performance are proportional to the degree of devolution. Interestingly, it is also proportional to the initial degree of performance in terms of water control: the fact hat farmers of the Colombia district (USA) were able to switch to pressure systems without significant changes in operations indicates a high initial degree of service (certainly improved with the gradual improvement strategy developed by USBR). Could it be that possibilities to exert this authority are related to the possibility to effectively control water and adopt diversified operational strategies (possibility to allocate water for instance)?

The Government of India has called in 1998 in the preface to the World Bank Irrigation Sector Report, for "a total revolution in irrigated agriculture … with much more focus on the improvement of performance of existing irrigated facilities and provision of a client-focused irrigation service … a paradigm shift in emphasis … toward improving the performance of existing irrigated agriculture … a second revolution in irrigated agriculture is required now" (Facon, 1999). What is interesting is the link established between, performance, service orientation and the performance of irrigated agriculture.

The need for WUAs which are recognized as service providers to their members (the farmers) is also increasingly recognized. Vermillion (1999) notes among important topics for the future of PIM in AP, India, the shift toward member-oriented WUAs, as well as the "moral equivalent of war against mal-distribution of water": long-standing mal-distribution within irrigation schemes is seen as critical for reform success. Bruns and Helmi, 1996, note that more professional models a for WUA management (such as in China, Vietnam) exist in small-scale irrigation systems in Asia (i.e. they are not confined to large schemes in Latin America) and suggest that, in Indonesia, WUA and federation leaders could act as a board, contracting for management, supervising the operator's performance and making "policy" decisions such as constructing major improvements.

Vermilion, (guide to monitoring and evaluation of irrigation management transfer, 2000) now defines irrigation management transfer as the turning over of authority and responsibility to manage irrigation systems from government agencies to water user associations . This involves two key roles:

- The authority to define what the irrigation services will be
- The authority to arrange for the provision of those services

Arranging for the provision of those services includes choosing service providers and collect whatever resources are required to implement the desired services. Key services are:

- Water delivery and maintenance
  Followed by:
- Technical consultation, design and construction
- Information

- Extension
- Credit
- Marketing etc.

After IMT, the WUA decides what services should be provided, what their objectives and target should be, what service performance standards are acceptable. In a monitoring and evaluation system, key issues about outcomes and impact include as potential immediate outcomes the quality of the water delivery service (including efficiency, reliability and equity). Possible eventual impacts are related to socio-economics and productivity. Potential areas of interest for water user are estimated to be the quality of O&M, the cost of O&M, the use of funds collected, agricultural and economic productivity (quality of service to the water user is not mentioned).

Several observations can be made on the proposed indicators of implementation, outcome and impact: physical works are not connected to service or performance goals. Impacts, which are the indirect or ultimate effects of an intervention, include certain indicators which should be identifiable as specific objectives (outcomes of the adoption of O&M procedures and physical works) cropping intensity, number of crops grown, if design and operational rules are performance-oriented. Environmental sustainability indicators are also impact indicators and purely internal (salinization, waterlogging, instead of water quality of effluents, etc.). O&M and physical works are still considered as different components. M&E is meant to provide information but also strengthen locals management capacity, enhance skills and support problem solving by WUAs. Proposed tools are:

- Walk-through and inspection of irrigation systems
- Planning maintenance or rehabilitation priorities
- Preparing O&M plan
- Supervising field staff
- Conducting technical audits

The RAP and internal process indicators could obviously be used beneficially in a M&E system.

E. PRESENT PRACTICES

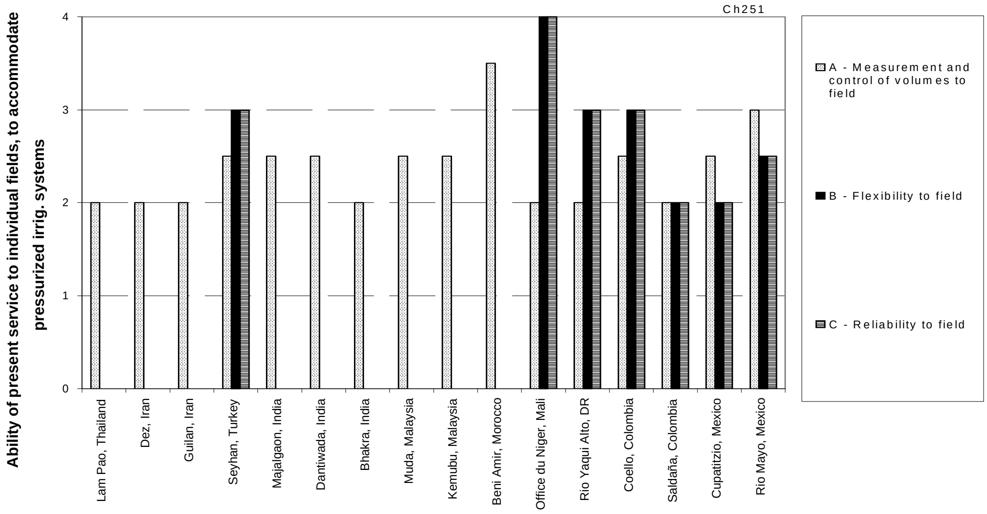
In this section we examine more in details the practices thorough which physical works are planned in PIM/IMT programmes, particularly in Asia. The underlying intention is a from of demand-led design, in the sense for instance that turnouts are located where farmers wish, and that only these works that are necessary and useful to farmers are identified. The idea is also often to foster the principle of preventive maintenance to reduce the phenomenon of differed maintenance and cyclical rehabilitation. Works identified will typically consist in repairing breaches, preventing leakages, improving the water intake structure, division boxes to facilitate water distribution, etc. (Vermilion, 2000, Bruns and Helmi, 1996, FAO training guidelines, SPIN project, 1998). The most common planning tool is the walk-through. The objective is to improve conveyance and reliability, reduce canal maintenance requirements (drop structures, etc.). In practice, a diagnosis of operation procedures is not performed and operational rules and procedures are not really discussed or linked to identified works. PRA mapping, transects, of land tenure, farming systems, ecosystems are also tools used on the field, mostly to prepare canal layout designs and identify objectives of rehabilitation/improvement.

The detailed questionnaire for conducting a "walk-through' of an irrigation scheme developed by DANIDA for the "Support to Water Resources Management" Project in Dak Lak Province, Vietnam, represents a typical social as well as technical audit. The point s to ask whether there are established operational rules, not whether they exist, and whether users have been involved in their preparation. Operation is diagnosed in the form of complaints received, responsiveness to deal with complaints or conflict resolution. Technical forms are in the free format (technical description, unspecified). Information requested on structures is number (number of turnouts, not type), whether they are functional, not how they function or how the are operated, state of disrepair.

In the report on FMIS award and training on the theme of conservation measures in irrigation systems, October 1999, Nepal (INPIM award and training series, which is designed to encourage innovation in FMIS, initiatives mentioned are maintenance of canals headworks, siltation and leakage; no questions relate to operation, scheduling, etc, i.e. to operation, with the exception of dealing with indiscipline by hiring someone and enforcing rules. Solutions listed are implementation of some works related to the potential diagnosed problems or hiring a watchman. Rules to implement conservation measures. Having one rue to implement conservation measures or one suggestion by members to improve rules allows the IA to score point. Of the team of six experts evaluation the efforts of the IA on the field, one is an engineer.

As a rule, expectations are low. It is interesting to note that this is also typically the case of the modernization project evaluated by the IPTRID research study (FAO, 1999). Most field (on-farm) irrigation methods in these irrigation projects are relatively simple, and the farmers and irrigation project staff have low expectations of the level of water delivery service needed. The initial focus on upgrading is generally on reliability and equity.

Internal process indicator I-26 sub-indicators. Ability to accommodate pressurized field irrigation systems today.

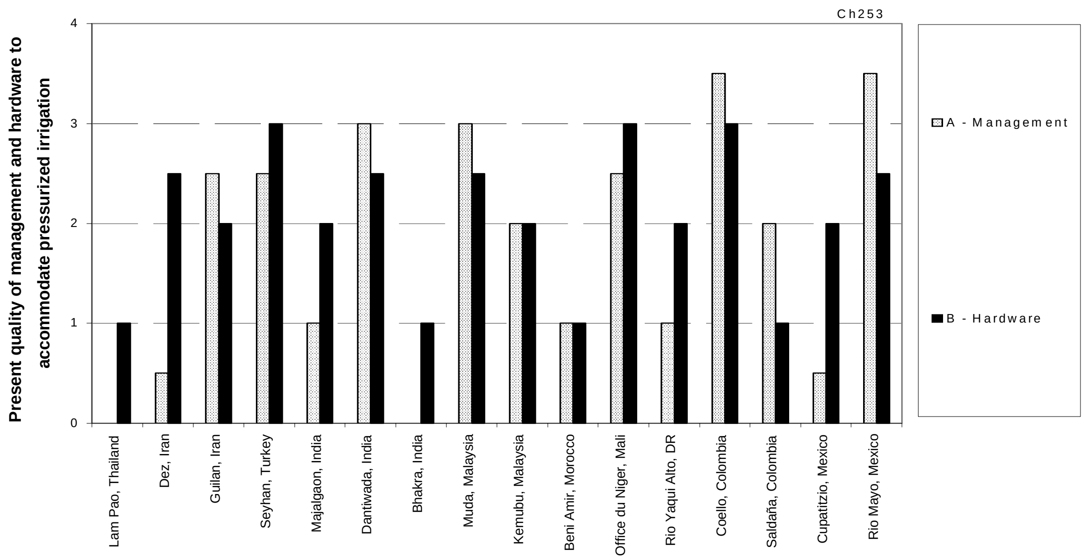


This shows that most of the projects are not even close to being able to accommodate pressurized field irrigation systems (the turned over systems in the Colombia District (USA), Vermilion, 1997, were). Most of the projects rate "0.0" on the scales of necessary flexibility and reliability needed for modern systems. These factors have a more stringent rating than for traditional irrigation methods. An interesting case is Beni Amir, which rates fairly high with traditional field irrigation methods but with its rigid distribution system design simply cannot supply the necessary flexibility for modern field irrigation systems.

The following figure shows the present qualities of management and hardware in terms of their ability to accommodate the pressurized field irrigation systems tomorrow. A high rating such as the 3.5 Management rating for Rio Mayo indicates that the present management procedures are quite good for this objective. The Hardware rating of 2.5 for Rio Mayo indicates that there is still considerable room for improvement on the Hardware aspect. However, the Hardware rating of 2.5 for Rio Mayo is high enough to indicate that the Hardware changes would be relatively easy to accomplish (compared to lower scores). The emphasis on modernization for this project would be Hardware, with some attention given to the Management. Lam Pao and Bhakra both have very low scores, indicating that both Hardware and Management need tremendous improvement if those projects are to support modern field irrigation methods and field irrigation scheduling. In both cases, investment in only one aspect would not achieve the desired affect.

Furthermore, few people had a vision for the future - although today's modernization programs should be able to service tomorrow's needs. Because modernization programs are necessarily done in stages, we must be careful that initial efforts do not hinder future requirements. For example, if one is interested in supporting modern field irrigation systems, the turnouts must have the ability to provide a wide variety of measured flow rates. Drip and sprinkler systems do not need exactly "30 LPS", whereas traditional surface irrigation systems may function satisfactorily with such a flow rate. Therefore, baffle modular distributors are an inappropriate choice for flow rate measurement and control because they are only capable of providing incremental flow rates, and cannot be adjusted for installation or design errors. As an additional note - observations in Office du Niger, Cupatitzio, Rio Mayo, and other projects showed that these particular structures are very sensitive to problems with improper installation (installed too high, too low, or with submerged discharge conditions) and that even today operators need intermediate flow rates.

Internal process indicator I-27 sub-indicators. Present quality of management and hardware in terms of accommodating pressurized field irrigation systems tomorrow.



F. PRODUCTIVITY AND AGRICULTURAL PERFORMANCE

D. Vermillion, 1997, Svendsen et al. in their reviews of PIM impact studies, note that impacts are typically not noticeable in terms of agricultural performance. In Sri Lanka, there has been no detectable change in irrigated area, crop patterns, cropping intensity or yields, PIM has neither improved nor interfered with agricultural productivity.

However, significant results in this area are seen as critical for success of PIM reforms. Bruns and Helmi, 1996, note for Indonesia that diversifying agriculture is necessary. They argue that "diversification makes irrigation management more complex. Irrigation systems designed for rice usually have enough capacity to deliver water for crops, but may need to be operated differently. Greater reliability may be required, through improved main system operation or through more flexibility for farmers to locally distribute water according to their needs."

WUAs as business enterprises are increasingly seen as a potential solution in the region, perhaps as a reflection of Latin American experience, and the question whether they might deliver other services to farmers is important in the debate on PIM reform. Namika Rabi, (from participatory irrigation management to irrigation management transfer: the process and progress in Sri Lanka,1998) documents the formation of pilot farmer companies in two systems. This represents a paradigm shift, from PIM as joint management to the formation of the farmer company: agri-business development and irrigation management turnover, in open-market economy, with irrigation more than a sub-sector of agriculture, but seen in tandem with trade, commerce and industry. Water seen as a commodity and not more tied to land and and is transferable. The farmer company institutional mechanism for commercialization of farm operations. Distributory canal organizations will continue to function fro water management and O&M. Resources allocated by government for O&M will be advanced to the company which will have four divisions: irrigation, primary production, commercial, finance and administration. The irrigation division will be responsible after transfer of management of the system and provide water rights based on land entitlement.

"PIM in Sri Lanka has failed to have results in terms of O&M, water management or productivity, so to implement participation systematically, organizations need a critical mass of mutually reinforcing practices, a participative system with an eye on the product and market. It is therefore necessary to shift the focus of PIM to agriculture as an enterprise resulting in a phased turnover of the irrigation system in totality". New suggested management strategies are significant (conjunctive use, etc.). He finally suggests that this pilot experience may be a laboratory for larger Asian countries.

G. GRADUAL IMPROVEMENT STRATEGIES

D. Vermillion et al. (An assessment of the small-scale irrigation management turnover program in Indonesia, 2000) assess that PIM in Indonesia has led to modest efforts by farmers to improve management efficiencies and responsiveness. Water distribution tended to improve or remain positive after turnover. Significant future expenditures loomed in the future unless observed under-investment in O&M is halted. There are no significant changes in agricultural performance or economic returns per unit of land or water. It is suggested that, on the one side, water reform should be deeper, with regional Indonesian services reformed towards support service, with regulatory and river basin focus, with financing coming increasingly from payments for delivered services by farmers. It is also recommended to replace periodic rehabilitation with on-going infrastructure improvements jointly financed by government and the farmers, with the objective to improve performance and ensure financial viability and physical sustainability of irrigation. Bruns et Helmi had noted earlier the need for farmer financing for irrigation development, with farmers needing some technical guidance, but they would be quite capable of financing irrigation improvements themselves, if suitable mechanisms existed with a view of improving their systems to adapt them to diversification.

M. Svendsen, J. Trava, S. Johnson III (1997) note among the major second generation problems for associations:

- Insecure water rights
- Financial shortfalls
- Rehabilitation
- Lack of financial and administrative management expertise

"Lack of rights inhibit investment in new system facilities or rehabilitation and encourage short-term thinking. Underlying difficulties in generating sufficient Irrigation Service Fee revenue to sustain system operation, in many cases, is the low productivity of irrigated agriculture in system command areas. "Low productivity can result from a large number of factors, but is often associated with small farm size (not in Asia), a subsistence orientation, production of low value crops such as grains, inappropriate agricultural policies, a poor natural resource base, and inadequate agricultural services". It is necessary to address these issues or provide assistance through other agencies for production increase, or to subsidize the association.

For farmers, the second generation problem is to increase farm productivity to pay higher irrigation fees and to take advantage of possible improvement in irrigation service quality:

- production credit
- extension service
- new technologies
- markets and market information
- access to inputs
- post-harvest services

They note that all irrigation systems required periodic rehabilitation and modernization. If IAs defer rehabilitation, they will also not upgrade the systems, and suggest that for rehabilitation, a sharing of costs is appropriate:

Required support services would be:

- Assessment of system facilities
- Credit
- Design and construction assistance

The assessment can be done jointly by agency and IA or contracted out:

- Annual maintenance planning
- Selective improvement
- Planning whole-system rehabilitation

Assistance in selection and supervision of consultants and contractors can be made at level of federation of IAs to each IA.

In Asia, where the older public schemes reach the age of 30-40 years in most countries, the issue of rehabilitation, which is related to those of operation and maintenance and modernization, is becoming increasingly important. While for some countries (such as Lao PDR, Myanmar, Philippines, Viet Nam and parts of India) the extension of irrigated land still represents an important part of irrigation programmes, in most countries rehabilitation programmes are taking on increasing importance (FAO, 1999). The content and orientation of rehabilitation in a context of PIM/IMT will therefore be critical.

H. RICE

In most of Asia, rice is not only the staple food, but also constitutes the major economic activity and a key source of employment and income for the rural population. Water is the single most important component of sustainable rice production, especially in the traditional rice-growing areas of the region. Reduced investments in irrigation infrastructure, increased competition for water and large water withdrawals from underground water lower the sustainability of rice production. However, despite the constraints of water scarcity, rice production must rise dramatically over the next generation to meet the food needs of Asia's poor. By year 2025, rice production in Asia must increase by 67 percent from the 1995 production level in order to meet the increased demand for this cereal which is the staple for more than one-half of world's population (Hossain 1995). Producing more rice with less water is therefore a formidable challenge for the food, economic, social and water security of the region (Facon, 1999/0. About 80-90 percent of all fresh water resources used are for agricultural purposes and more than 80 percent of this water is used in irrigating rice (Bhuyan, 1996). In other words, the efficiency of water use in irrigated rice production systems must be significantly increased. The existing strong interdependence between water use in the crop production subsystem and the operation of the irrigation facilities for water service elicits the need for pursuing a comprehensive agenda for improving the performance of rice irrigation systems.

Since no major net addition to currently irrigated rice areas is expected in the coming decades and major breakthroughs in raising yields of rainfed rice systems are unlikely to be available during this period, most of this additional rice will have to be produced in irrigated areas. In rice irrigation systems, rice monoculture is overwhelmingly the dominant practice. Diversification of the crop production system in these areas is desirable for several reasons. First, diversification will open opportunities for increasing farmers' income from their limited land resources. This is particularly important at the present time when profits from rice culture are very low and declining. Second, it is increasingly evident that, as productivity of the land under rice monoculture under wetland conditions is declining over time, a diversified agriculture will be more sustainable in the long-run. Third, with increasing scarcity of water, irrigated agriculture will have to aim at maximizing return to water rather than return to land. Present rice culture system requires more water than most other food crops, both in terms of quantity of food and calorie produced. Therefore, a major scope exists for increasing returns from water by growing diversified crops, especially in areas of water shortage (Bhuyan, 1996). To enable farmers to diversify their cropping pattern, they must be provided with facilities to exercize crop choice options, which is presently lacking in most rice irrigation systems.

The task of upgrading or modernizing an irrigation system for rice cropping in the wet season and for diversified cropping in the dry season is complex. It requires that any permanent structural or physical upgrading to be done for rice must also conform to the requirements of the diversified crops to be grown in the dry season. It is therefore logical to assume that the upgrading of common denominator factors, i.e. factors that are relevant for both seasons, could be upgraded permanently and these should be handled by the main irrigation system. Examples of these would include upgrading of water control, drainage, reliable schedule of water delivery, etc. at the main system. The on-farm, crop-specific factors could be handled seasonally by the farmers themselves as individuals or as groups. Examples of this type of upgrade would include the same items, as above, but at the farm level (Bhuyan, 1996). Provision of flexibility will become an additional requirement.

Reliable water supply is critically important for diversified cropping as farmers have to invest much more for these crops compared to rice. *A*reas that are far from the irrigation source generally suffer more water shortage in the dry season compared to near-by areas. Means of augmenting water supply in these areas, if they are suitable for diversified cropping, have to be found. Shallow groundwater development through the private sector is often the most reliable and affordable water source for this purpose. Groundwater has the advantage of being available on demand at the farm and able to avoid major water distribution problems.

Suitable methods of water application to the crop (e.g., basin, furrow or basin-cum-furrow), methods of controlling seepage from canals or neighboring rice areas (e.g., dikes, interceptor channel, dike-cum-interceptor channel), or means of drainage enhancement (e.g., collector gravity drain, pumping, collector-cum-pumping) will be required. Diversified cropping requirements must be thoroughly considered in pursuing the modernization process, with the objective of raising farmers' incomes through provision of flexibility and option to choose crops in the dry season (Bhuyan).

As far as rice water management itself, whether one aims at raising water productivity or water use efficiency, it is now widely accepted that:

- a river basin perspective should be adopted with much more attention being paid to defining the boundaries of intervention (farm, system, basin). Substantial progress has been made in defining concepts and methodologies (water accounting, modeling, etc.) but available data, which are already woefully inadequate to assess the merit of interventions at the farm or system level, water abstraction and even cultivated and irrigated areas, are even more lacking for the adoption of integrated river basin approaches.
- More attention must be paid to water quality issues and particularly the release of pollutants (fertilizers and other agro-chemicals) and salt concentration.

Nevertheless, practices which minimize irrigation inflow are of a direct interest to farmers who see their water supply rationed and have to pay an increasing share of its cost, for managers and developers who also face rationing because of degradation of water resources, dam siltation, transfer to other sectors, etc. and have an interest in minimizing pumping costs, and operation and maintenance as well as development costs, and indeed for water resources managers who need to plan future irrigation developments with minimum environmental impact from withdrawals or reservoirs. In addition, many major rice growing areas are located in coastal plains. Furthermore, water saving practices, which require greater water control, typically are associated with or part of packages to improve agronomic practices and the efficiency of use of other inputs, and therefore play an important role in total factor productivity.

They therefore contribute to increasing not only water use or irrigation efficiency but also to improving or sustaining water productivity. Indeed, water management methods which improve water use efficiency have been developed with a view to maintain crop yields and actually, when implemented properly, lead to yield increases (in the range of 15-20% in China for intermittent flooding and other methods). It follows that, although it is correct and necessary to use rigorous concepts for efficiency and performance at system and basin levels, and to determine under various conditions the optimum combination of improved technologies and water management practices that can meet water demand with least water consumed and managing return flows to ensure system and basin level efficiency, in practice it is difficult to find water management techniques proposed for adoption at the farm level which do not simultaneously raise irrigation efficiency and water productivity (Facon, 1999).

The range of possible strategies and their effect on various components of irrigation inflow requirements can be summarized in the following table:

Practices	T	E	S&P	SRO	RCL
Developing improved varieties	x				
Improving agronomic management	x				
Changing schedules to reduce evaporation		x			
Reducing water for land preparation		x	x	X	
Changing rice planting practices		x	x	X	
Reducing crop growth water		x	x	X	
Making more effective use of rainfall			x	X	
Water distribution strategies		x	x	X	
Water recycling and conjunctive use					x

These various practices and strategies are presented and discussed in details in SWIM Paper 5 (Guerra, Bhuiyan, Tuong, Barker, 1998) as well as in Barker, Dawe, Tuong, Bhuiyan and Guerra, 1998.

The acceptance by farmers of the above strategies and practices will of course depend on economic factors. Furthermore, they depend on improved water control and management of water at the system level, as well as adequate irrigation (in particular a reticulated irrigation distribution system) and drainage facilities. Their availability in China has allowed farmers to adopt water savings techniques described above. However, typically, at that level, conveyance, field canal and distribution efficiencies are particularly sensitive to the quality of management, communication and technical control. When water supply within the system is unreliable, farmers try to store more water than is needed. In many large irrigation systems, few control structures at any level and poor drainage structures and poor drainage networks contribute to a waste of water (Klemm, 1997).

Being confronted with this rather large number of problems, it is not surprising that farmers are reluctant to shift to more demanding water management techniques than flooding. However, considering the growing water scarcity and pressure on the irrigated sub-sector within the water sector and on agriculture by other sectors of society and overall economic development policies described in previous sections, there is not much choice and farmers must be provided both with a conducive environment and a proper production tool, i.e. better performing irrigation services (Klemm, 1997, Facon, 1999).

Improvements in the operation and maintenance of rice irrigation schemes through rehabilitation of the deteriorated systems, improvement of irrigation infrastructure for surface irrigation, irrigation management transfer, modernization, combining to various degrees institutional, organizational and technical changes, have been attempted in the region with mitigated degrees of success. Studies undertaken by the World Bank in recent years have evaluated the impact of irrigation projects.

Jones (1995) evaluated the design of rice project in the humid tropics and concluded, from the strong degree of resistance of farmers to new design standards and the level of anarchy and chaos observed on the schemes, that the more reticulated systems, capable of supporting on-demand water delivery, were not appropriate under these climates.

A more recent study (OED, 1996, Rice, 1997) assessed the agro-economic impacts of investments in gravity-fed irrigation schemes in the paddy lands of Southeast Asia, to determine whether and how the quality of operation and maintenance (O&M) services influences the sustainability of those impacts.

At four of the six sites, the areas supplied by the irrigation systems were significantly less than planned. Cropping intensities were also substantially lower than expected at three sites and falling at a fourth. Only one scheme had attained both its area and intensity targets. Paddy yields varied widely—between schemes and in comparison with expectations—but a weighted average for the wet and dry seasons at all the schemes was about 3.3 tons, or 85 percent of appraisal projections. However, farmers had not diversified out of paddy. Indeed, the concentration on paddy had increased. Output was between 32 and 73 percent of appraisal estimates for five schemes. The returns had also been driven down by the decline of the international price of rice.

Overall, agency and irrigator performance appeared to be substantially better than expected. Farmers cooperated to achieve at least basic O&M objectives regardless of the level of maturity of the formal organization. There was no substantial negative constraints on irrigated production attributable to poor performance in O&M. Those O&M operations that are essential to keep sufficient supplies of water flowing to the great majority of the fields were adequately carried out. The study also noted the dismantling of complex technological control systems installed in the 1980s in favor of fixed structures that have no adjustments and structures that adjust automatically to changes in water levels; the rejection by farmers of both rotations and gates. Rotations do occur, but they tend to break down under conditions of shortage, which is when they are most needed.

The main finding was that given that they offered poor economics and low incomes, these paddy irrigation schemes faced an uncertain future. Small-holder irrigated paddy could no longer provide the basis for a growing, or even stable, household economy, driving younger family members off the farms while older members who stayed behind concentrated on basic subsistence crops, social capital would erode and O&M standards were likely to suffer. As economies expanded, irrigated paddy would not be able to compete with the incomes to be had from other employment opportunities. Improved O&M performance would not rescue them. The study made these recommendations:

- Sharpen the response to O&M failures by disaggregating O&M; identifying the poorly performing components; and dealing with disincentives specific to each, such as the tertiary gates that farmers below consider unfriendly.
- Simplify the infrastructure and operations technology by converting to fixed and automatic controls that need less human intervention and by supporting authorities who plan with the farmers to abandon equitable rotations by rationing water during emergencies.
- Promote the transfer of management to farmers and their WUGs judiciously by recognizing that organizing user groups pays off, but also accepting that immature WUGs cannot handle some management responsibilities.
- Improve household earnings by diversifying cropping systems and supporting research, extension, and marketing services keyed to specialty crops and integrated, high-value farming.

The findings and conclusions of these two studies, combined with the results of the evaluation of modernization projects conducted by IPTRID, seem to be rather pessimistic and contradictory. However, put together, they tend to indicate that present project designs or operations are not capable of supporting both economically and technically the intensified, diversified and more water efficient and productive rice production systems which will be required in the future. They also seem to indicate that purely software solutions or mere improvement of operation and maintenance do not deliver the expected results in terms of improvements in performance and yields. They also reveal that many modernization or improvement efforts have been inappropriate, poorly adapted to local circumstances and the specific character of rice-based production systems, and incomplete or fragmentary (Facon, 1999). Conjunctive is practiced within "modern" irrigation schemes (see Annex1 also): it may provide a solution but is not available in all places.

I. PIM/IMT AND MODERNIZATION

Facon (1996) summarizes as follows the present trends as they affect irrigation in Asia and possible responses:

ISSUE	**RESPONSE**	***MEASURES***
Population growth & national food security	→ Increase and secure food production	• *Augmenting irrigated land and/or cropping intensity* • *Reclaiming land* • *Maintaining soil fertility* • *Upkeeping irrigation system* • *Reducing yield gap* • *Improving crop husbandry* • *Agricultural support services* • *Develop conducive environment to agricultural investment* • *Increasing profitability of agriculture*
Water resource constraint	→ Protection of water resource → Water resource management (quantity and quality) → Further develop surface water resources → Develop conjunctive use → Develop alternative water resources → Optimize rainfall use → Improve water use efficiency by irrigation → Develop appropriate cropping patterns	
Irrigation system performance • **Economic** • **Financial** • **Water use efficiency** • **Reliability** • **Flexibility** • **Equity** • **Cropping intensity** • **Environmental**	→ Optimize water use throughout the year	
	→ Match supply with crop water requirements	
	→ Reduce transportation and conveyance losses	• *Rehabilitation of infrastructure* • *Upgrading infrastructure* • *Improving design* • *Improving operation* • *Improving maintenance* • *Improving flexibility and responsiveness*
	→ Conjunctive use → Intermediate storage → Upgrade existing institutions → Institutional reform → Water pricing	
	→ Improved on-farm water management	• *Upgrading infrastructure* • *Improving scheduling*
Degradation of irrigation infrastructure	→ Rehabilitation programmes → Rehabilitation/modernization programmes	
	→ Improving financial base for O&M	• *Increasing water charges* • *Transferring costs to users* • *Transferring O&M to users* • *Improving pattern of public expenditure* • *Improving income from farming*
	→ Reducing O&M costs	• *Increasing efficiency of O&M* • *Improving designs* • *Increasing accountability of agency*

Modernization of an irrigation system could be defined as the act of *upgrading or improving the system capacity to enable it to respond appropriately to the water service demands of the current times, keeping in perspective future needs* ***(Bhuyan, 1996).***

The definition of modernization arrived at the FAO Expert Consultation on Modernization of Irrigation Schemes (Bangkok, 1996) is the following:

> 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, economics, environmental) and water delivery service to farms

Modernization of irrigation schemes is understood by FAO as a process of change from supply oriented to service oriented irrigation. The process involves institutional, organizational and technological changes. Modernization in that sense is a response to current social and economic trends which also affect the irrigation subsector with, in particular, a shift from protective to productive irrigation. It implies changes at all operational levels of irrigation schemes from water supply and conveyance to the farm level. Although improvements in canal operation will generally be a critical first step in the modernization process, it will be of utmost importance to always keep in mind that the objective is to improve irrigation services to farmers. It is they who have to take the final decisions on the modernization programmes and improvements should not stop at the canal level (Wolter and Burt, 1996, Facon, 1997).

From the sections above, it is apparent that there is a gradual convergence between the concept of modernization as defined above and thinking in PIM/IMT, particularly as studies on outcomes and impacts become increasingly available, with the following common elements:

- the centrality of service
- the ultimate goal of irrigated agriculture productivity
- on-going improvement process

There are still however substantial differences:

- the lack of attention to technical details
- the lack of attention to operational rules and practical details of irrigation management
- physical works and rehabilitation conceived as a separate component of O&M
- environmental considerations in an integrated water resources management perspective are not fully taken into account

Th modernization concept promoted by FAO understands that the devil is in the details, integrates a vision of future operations in immediate interventions and uses a modern performance-oriented design process that incorporates environmental objectives and requirements of integrated water resources management. The contractual approach to bulk supply provision or irrigation service provision may require changes in hardware and operational rules at the interface between the management levels.

An illustration of these differences may be found in Bruns, 1997 (Participatory irrigation management for agricultural water control in Vietnam: challenges and opportunities). While the necessity of reengineering irrigation, i.e. taking as fresh look at key processes and how they can best be carried out ("Irrigation can be analyzed by focusing on the key process of delivering irrigation water") and of considering both hardware ad software elements are emphasized as irrigation becomes more commercial, software is only considered as the institutional element and inadequate infrastructure consists in the lack of tertiary canals (neglecting control structures) and the proposed design method for improvement with participation is just a walk-through.

On the question of what design standards are appropriate, he notes that flow measurement and graduated water allocation are not felt to be necessary or practical. They will be come essential as farming business strategies become individualized and water has to be controlled more finely either for charging or agricultural purposes. In contrast, the objective of People's Republic of China as concerns rice irrigation is real-time irrigation scheduling so that farmers can adopt the water savings techniques developed in that country, that require individual control of the water depth in each plot (i.e. individual turnouts and drainage) to practice the various forms of intermittent flooding or non-flooded rice water management strategies (IPTRID mission report to People's Republic of China, 2000).

However, Brewer, Sathkivadivel and Raju (in Water Distribution Rules and Water Distribution Performance: A Case Study in the Tambraparani Irrigation System, IWMI 12) conclude that if the water distribution rules define a pattern of water distribution that does not match technically feasible and desired goals of the water users, then the users will subvert these rules. This will lead to poor water delivery performance and increases in the cost of irrigation to users. Inconsistency in the water distribution rules creates difficulties in system operations that are likely to lead to inefficient and inequitable water distribution performance. Especially inconsistency of rules between various levels: reservoir, main canal, channels is detrimental. Rules in channels cannot be followed if there is unpredictability of delivery by main canal.

Making water delivery match goals is important: in the case of the Tampraparani system in India, banana and betel would be affected by rules designed to serve rice, which is much less profitable. The need for change in response to changing environment, changing agriculture, diversification, etc. requires adapting water distribution rules to changing demands. The users must accept the limitations on uses imposed by water availability and the features of the system.

These considerations call for a greater attention, in the transfer process, to an analysis of operational rules at all levels in the system and particularly to a proper articulation of operational rules at the interface between the future irrigation service providers and water user associations, to the necessity of improving operations in the upper levels of management if water users associations are to be in a position to develop applicable rules and procedures, and to the necessity of incorporating at all levels production objectives of the farmers.

J. PIM/IMT AND INTEGRATED WATER RESOURCES MANAGEMENT

Participatory irrigation management lies squarely within an integrated water resources management perspective and the policy and institutional changes that this new perspective demands (Meinzen-Dick, 1997, Groenfeldt, 1997). The growing understanding of the centrality of water rights and water allocation issues reinforces this integration. Clearer water rights and farmer participation in basin water resources management to facilitate more equitable, more efficient processes to improve water use efficiency and reallocate water among users (Bruns and Helmi, 1996) become an important issue. The question of the restructuring and reorientation of the existing irrigation agencies towards assuming responsibilities in implementing water resources management further strengthen these linkages (see box, see also FAO Irrigation and Drainage Paper 58, Guidelines for transfer of management of irrigation systems, 1999)**.**

Integrated water resources management is a continuing process that needs to be integrated into economic development processes (FAO-ESCAP, 2000). In this context, it is necessary to have a long-term vision of integrated water resources management and f the transformations that will be required in each sector. For this purpose, the validity of strategic planning approaches to identify actions that need to be taken by each actor in each sector by redefining missions, goals, objectives, strategies and priority plans for

Possible new roles for irrigation agencies

- river basin planning
- water resources allocation & monitoring
- development of new policies and regulations
- environmental monitoring and enforcement
- groundwater monitoring and control
- project planning, design and construction
- technology transfer to IA
- advisory services to associations
- monitoring of association performance
- arbitrating disputes

from M. Svendsen, J. Trava, S. Johnson III PIM: benefits and second-generation problems, 1997 immediate action has been tested by FAO and ESCAP in four countries in the region: Malaysia, Philippines, Thailand, Vietnam (FAO-ESCAO, 2000). This exercize was coordinated with the global, regional and national visioning processes animated by the World Water Council and Global Water Partnership in preparation of and as a follow-up to the Second World Water Forum (the Hague, March 2000). This international initiate was taken with the objective of averting the looming water crisis and foster immediate concerted action. This water crisis is illustrated by the prospective work of IWMI, FAO, IFPRI and other institutions (see box below, see also FAO, Agriculture, Land and Water, Changing Linkages, 1999).

At the occasion of national round tables organized this year, these four countries have reconfirmed their national water visions.

Malaysia

In support of Vision 2020 (towards achieving developed nation status), Malaysia will conserve and manage its water resources to ensure adequate and safe water for all (including the environment).

Philippines

By the year 2025, water resources in the Philippines are being used efficiently, allocated equitably and managed sustainably with provisions for water-related disasters

Thailand

By the year 2025, Thailand will have sufficient water of good quality for all users through an efficient management, organizational and legal system that would ensure equitable and sustainable utilization of its water resources with due consideration on the quality of life and the participation of all stakeholders.

Viet Nam

The Vietnamese Water Vision is the integrated and sustainable use of water resources, the effective prevention and mitigation of harms caused by water for a better future on water, life and the environment.

In World Water Demand and Supply, 1990 to 2025: Scenarios and Issues (IWMI Research Report 19, Seckler, Amarasinghe, Molden, de Silva and Barker, 1998), IWMI projects growth in water demand with two scenarios for the irrigation sector,. In the first scenario, the 1990 level of irrigation efficient remains constant through 2025. In the second scenario, higher efficiencies are attained (70% except for rice-growing countries where 60% is projected, or a doubling of present efficiency, whichever is lower). For the region as a whole, in the first scenario, total water withdrawal from all sectors would increase by 62% as against 18% in the second scenario, or a total saving of 691KM3 per year. Still additional withdrawals of 315KM3 per year over the present withdrawal of 1555KM3 per year would be required and, globally at the regional level, potential water savings deriving from increases in irrigation efficiency could not compensate for the growth in food and other demands, additional water resources would need to be developed and there could be no net transfer of water resources from irrigation to the other sectors.

Under the second scenario, approximately 1 billion people (Pakistan, Afghanistan, parts of China and India) would live in regions of absolute water scarcity. The other groups would have sufficient resources to meet future water demand and can be categorized by economic water scarcity, as many of them would have to embark on massive water development programs. Countries such as Nepal, Cambodia, Myanmar, Malaysia would need to increase water development by between 25% and 100%: they would need to invest massively in both water development and improvement of their national irrigation system in order to avoid water becoming an overriding constraint in socio-economic development and to meet food security objectives, but they have a varied capacity to do so. They represent a total population of close to 500 million people and their capacity to make the necessary investments is very diverse.

Countries such as the Philippines, Vietnam, Bangladesh would have only modest requirements for additional water resources development while countries such as South Korea, North Korea, Japan, Thailand and Sri Lanka would have zero or negative needs for water development. So, many countries in the region would be able to meet total societal water demand for their socio-economic development at the cost of relatively limited further water development (and therefore limited environmental impact) and/or with their available water resources, provided that they embark on significant and far-reaching improvement programs of water use efficiency in the irrigation sector. The potential benefits or problems averted would be greater for those countries with limited investment capacity such as Vietnam or Bangladesh, which otherwise would need to almost double their developed water supplies.

But approximately one billion persons or about a quarter of the region’s population would live in countries or regions of absolute water scarcity with severe consequences for their rural (and urban) population and substantial impact on the agricultural sector, for which Governments would need to prepare the populations and assist them in finding employment and income generating activities in other economic sectors, and develop other sectors to be able to meet their food import bills in order to achieve food security. This situation may be mitigated to a certain extent by inter-basin transfers within China or India. As many of the regions concerned are major production areas for vital cereal food productions, it is foreseen by many experts that the need for these regions to import cereals could have severe consequences for the poor segments of the population in other countries, by raising their prices on the international markets. A major factor of poverty eradication in the past has been the reduction of food commodity prices thanks to the (irrigated) green revolution. In theory, a shift in global production patterns for crops with a high virtual water content from water-scarce regions to well water-endowed regions and countries could ensure the satisfaction of demand, but whether this will happen is far from certain. What seems to be certain is that nearly all countries in the region will need to invest considerable efforts and resources in a mixture of improved demand management of the water sector and interventions on the supply side. In addition to the required economic investments on the supply side, considerable investments entailed by an irrigation water management improvement program or the institutional and social capacity of the countries in implementing the necessary reforms in the water sector as a whole or in the irrigation sub-sector to achieve the very considerable improvements in water use efficiency postulated in the second scenario would be required. These raising costs will be borne increasingly by the water users though a combination of pricing and cost recovery.

Considering the national vision and specific considerations of food security, agricultural and rural development, the countries have defined sectoral visions that encapsulated integrated water resources management goals and developed priority action plans. Significantly, irrigation management transfer and participatory irrigation management were high on the agenda in each country. By applying strategic planning approaches to the irrigation sector, Vietnam and the Philippines found that mere rehabilitation of irrigation infrastructure would not be sufficient to achieve the vision and that the pilot introduction of modern water control and management concepts was identified among the main priority actions. Modernization of irrigation systems is already an integral part of Malaysia's water resources management strategies and is one of the measures being studied at present in Thailand.

As an illustration of the national processes at work in the region, the water resources policies of Thailand, which were endorsed by the National Water Resources Committee in its 20 July 2000 meeting and subsequently by the Government on 25 July 2000) include the following components:

1. Accelerate the promulgation of the Draft Water Act to be the framework for national water management by reviewing the draft and implement all necessary steps to have the act effective, including reviewing existing laws and regulations.
2. Create water management organizations both at national and river basin levels with supportive laws. The national organization is responsible for formulating national policies, monitoring and coordinating activities to fulfill the set policies. The river basin organizations are responsible for preparing participatory water management plans.
3. Emphasize suitable and equitable water allocation for all water use sectors to fulfill basic water requirements in agriculture and domestic. This is done by establishing efficient and sustainable individual river basin water use priorities under clear water allocation criteria, incorporating beneficiaries' cost sharing based on ability to pay and level of services.
4. Identify clear directions for raw water provision and development compatible with the river basins' potentials and demands, and having suitable quality while conserving the natural resources and maintaining the environment.
5. Provide and develop raw water sources for farmers extensively and equitably to response to water demand in sustainable agriculture and domestic, similar to deliveries of other government basic infrastructure services.
6. Include in educational curriculum at all levels water related topics so as to create awareness for water value, understanding the importance of efficient water utilization, necessity and responsibility in maintaining natural and man made water sources.
7. Provide sufficient and sustainable financial support for water related research, public relation, information collection and technology transfer to the public.
8. Promote and support participation, including clear identification of its format, of non-government and government organizations in efficient water management. The water management includes water utilization, water source conservation and monitoring of water quality.

9. Accelerate preparation of plans for flood and drought protections, including damage control and rehabilitation efficiently and equitably with proper utilization of land and other natural resources.

Apart from important achievements in the development of national water policies mentioned above, the ongoing water resources strengthening programme is expected to achieve other important results from the implementation of the following components:

(1) **Pilot project for trial of organizing river basin committee in sub basins of Chao Phraya** which includes the Upper Ping, Lower Ping, and Pasak River basins.

(2) **Study on Establishment of Chao Phraya Basin Organization**: to take into also recommendation for improving of water sector capacity.

(3) **Study on Right Based Allocation of Water:** to address some aspects of concept in the management of the Chao Phraya River basin e.g. implementation strategies and a pilot program for this approach.

(4) **River Basin Management:** to formulate river basin management system in 3 areas: the Ping River in the North, the Mun River in the Northeast and the Klong Thatapao in the South, including review of available information and data for water resources management and watershed protection.

(5) **Thailand Integrated Water Resources Management System** which aims at the promoting research work and activities on water resources management.

(6) **Modernization of Irrigation System**: study on conjunctive use of surface and groundwater, study on cost recovery in irrigation projects, and promoting people's irrigation management; privatization of irrigation, modernization of irrigation infrastructure to support and enable the institutional changes and water allocation system.

It was pointed out during the implementation of ongoing projects on water resources management that the Ninth National Plan would focus mainly on (1) balanced development, (2) quality of development, and (3) strengthening the national development foundation. In this connection, incorporation of water resources policies in the Ninth National Plan would aim to achieve strategic results at the end of the Plan on (1) conservation and rehabilitation of water resources, and (2) establishment of management plans for sustainable utilization of water resources and best efficiency and effectiveness. These would involve (1) establishment of mechanisms for effective management of water resources at the national, basin and local levels, (2) completion of the management plan which includes crisis management plan, (3) social code and water law for assessment and public participation, (4) institutional reform, and (5) capacity building. In tandem with the strategic incorporation of water resources management issues in the Ninth National Plan, efforts are being made to vigorously implement the programme on decentralization of water resources management as stipulated in the New Constitution. The Constitution requires decentralization in three areas: (1) public participation in the development process, (2) decentralization of authority and (3) local participation in natural resources management.

The example of Thailand illustrates concretely several important issues to be considered while one analyses organizational changes for participatory irrigation management:

- arrangements will need to take into account water rights and allocations in a river basin perspective;
- modernization of irrigation systems can be understood as the combination of water management strategies and related institutional and technical solutions;
- an integrated water resources management perspective, even in the long term, requires changes now.

Historically, modifications to irrigation projects did not give thorough consideration to environmental consequences. Scarce water and concern for environmental impacts increase the need for improved on-farm irrigation management (Burt, 1996).

Low irrigation efficiencies have been documented in various projects, and improved irrigation efficiencies are often listed as a major source of "new" water. However, it is now evident that return flows from an "inefficient" project are often the supply for downstream projects, in the form of surface flows or groundwater recharge. Therefore, typical project irrigation efficiencies in the 20-30% range by themselves give no indication of the amount of conservable water within a hydrological basin unless that project is at the tail end of the basin (Clemmens et. al., 1995). Conservation (i.e., less spill, deep percolation, and seepage) within one project may deprive a downstream project of part of its accustomed water supply. Effective modernization programs will have to adopt a more sophisticated approach to examining water consumption and conservation. Most "new" water for existing basins and projects will only appear if there is improved irrigation water manageability by farmers. The potential sophistication of on-farm water management is highly dependent upon the level of water delivery service provided to individual fields, which in turn depends upon the conveyance manageability[1] within the complete water distribution system (Plusquellec, 1988). The methods that yield "new" water will include:

1. Improved Water Use Efficiency (WUE), where WUE is defined as

   $$WUE = \frac{\text{Crop Yield}}{\text{Irrigation Water Consumed}}$$

   Improved WUE can come from:
   - Improved use of rainfall,
   - Improved timing of irrigations to match critical stages of crop growth,
   - Improved investment in fertilizers, pesticides, and cultural practices,
   - Reduced water logging.
2. Improvements in the quality of surface return flows.

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[1]Conveyance manageability. The ease with which the water supply can be manipulated to respond to changing upstream and downstream conditions. It includes the relative difficulty of moving water through canals, and the ability to change flow rates, maintain safe water levels, and store water within the distribution system of main, secondary, tertiary, etc. canals and pipelines.

3. Reduction of deep percolation from farmer fields, and the associated reduction of nitrate leaching.
4. Reduction of on-field deep percolation destined for a salt sink.

The critical importance of maintaining minimum flow rates and water qualities in natural drains and rivers is increasingly being understood. In the U.S.A. and Europe, for example, many of the recent irrigation system modernization efforts have stemmed from the need to reduce in-stream damage to endangered species of fish. In Malaysia, modernization strategies also incorporate similar environmental objectives for rivers. The quantities and timing of river diversions, and qualities and quantities of irrigation return flows, have a tremendous impact on the environment. As an example, for rice production in California, new legislation requires that farmers hold water inside rice paddies (called "lockup") for a minimum of 28 days after herbicides are applied. Surface drainage is not allowed during this period. This has put new pressures on the irrigation projects to provide only the amount of water which is needed, even though the weather can change rapidly.

Increasingly the issues will have to be explicitly dealt with by irrigation systems and farmers in the region. This s already the case in some of the most economically developed countries, and will be a future requirement in other countries which must be anticipated now.

K. MODERNIZATION CONCEPTS AND STRATEGIES[2]

Appropriate modernization is a process which incorporates new design procedures and new equipment with a vision of future operations. Modern design is the result of a thought process. Configuration and the physical components are selected in the light of a well defined and appropriate operational plan. Advanced concepts of hydraulic engineering, irrigation engineering, agronomy and social science should be used to arrive at the most simple and workable solution. A modern irrigation design is not primarily defined by specific hardware components and physical configurations, but will have all or some of the following characteristics:

- The overriding principle of modern irrigation is that irrigation is a service to farmers which should be as convenient and efficient as possible. Farmers ultimately have to generate the benefits which keep the system functioning.
- Modern irrigation schemes can be imagined to consist of several sub-systems or levels with clearly defined interfaces, where water is measured and controlled.
- Each level is financially autonomous and hydraulically as independent as possible. Transactions at each level are transparent for the next lower or upper level.
- Each level is technically able to provide reliable and timely water delivery to the next lower level. At each level there are the proper types, numbers and configurations of

[2] The following section is drawn from Wolter and Burt, 1996 and Facon, 1997

gates, turnouts, measurement devices, communication systems and other means to control flow rates and/or water levels as desired.
- Each level is responsive to the needs of its clients. Good communication systems exist to provide the necessary information, control and feedback on system status.
- Each level of delivery has confidence, based on enforceable rights, in the reliability, timeliness, and equity of water which will be supplied from the next higher level. Effective mechanism for conflict resolution are in place.
- The hydraulic design of the water delivery system is created with a well-defined operational plan in mind. The operational plan is established with a clear understanding of the needs of the end users.
- The hydraulic design is robust, in the sense that it will function well in spite of changing channel dimensions, siltation, and communications breakdowns. Automatic devices are used where appropriate to stabilize water levels in unsteady flow conditions.
- Motivated and trained operators are present at all levels of the system. They are not necessarily the farmers themselves but preferably hired professionals. Instructions for individual operators are well understood and are easy to implement.
- Maintenance is the obligation of each level. Maintenance plans are defined during design and are adequately funded and implemented.
- There is a clear recognition of the importance and requirements of agriculture and of the existing farming systems. Engineers do not dictate terms of water delivery; rather agricultural and social requirements are understood at all levels and in all stages of the design and operation process.

Operational levels, objectives of irrigation scheme operation, and required changes

In large irrigation schemes there are typically four or five levels of irrigation operation to consider:

- On-farm irrigation.
- Distribution systems of about 500 to 2000 ha, which are frequently controlled by water-user organizations (WUA) and consist of:
- a. A minor canal supplying water to several large turnouts
- b. Final distribution systems downstream of the minor outlets, supplying 20 to 40 individual plots.
- Primary canals (major or branch canals) which deliver water to the minors and are usually operated by the irrigation department (ID).
- Dams and the watershed, controlled by the National Water Authority.

The purpose of each of the operational service levels (dam, major, minor, chak) in the water delivery system must be to provide the appropriate degree of service to the next lower level. In turn, each lower receiving level (farm, WUA, ID, dam) will compensate the next upper level for the services received, thus creating an autonomous system. The operational objectives may differ from one level to another. There should be a consensus that the primary objective of scheme operation is to enable farmers to improve the quality and quantity of crop yields, while ensuring or improving economical and environmental sustainability.

Consensus is also required on the following:

1. The service concept should be adopted throughout the system. This will require improved flow measurement, water level control, communications, etc. throughout all levels of the water delivery network down to the individual turnout.
2. A general consensus should be reached that a major cause of the low performance of irrigation projects is low level of irrigation service received by the farmers and the resulting low application efficiencies on individual fields. Therefore, the benefits of a modernization program will only be realized if there is an improvement at farm level in reliability, equity, and flexibility of water delivery. The question is not whether improved reliability, equity, and flexibility is desirable - the question is how exactly can it be obtained.
3. The question of how much flexibility should be provided to each farm should be decided by the members of water user associations themselves. The water user associations must decide what level of service should be extended down to the individual field level in their particular cases. However, they must also face the financial consequences of their decision.

Because the purpose of an irrigation project is to enhance on-farm production and profitability, any analysis of the operation of an irrigation project must begin with the farm level. Future agricultural development and on-farm irrigation technology will require profound changes in the present operation of all service levels. Operations which are under the control of the water user associations will also require improvements and funds must be allocated for those needs. The concept of service in the larger canals must include the vision of the eventual, future use of water on the individual farms.

Present operation vs. future operation at the different operational levels

Present Operation	Future Operation	Action Needed
Service Level between the Minor and Primary Canals		
Minor canals: Typically only one change of flow- rate at the head of the canal every 1-7 days.	Multiple changes of flow-rate per day at the head of each secondary canal.	This means that simple rehabilitation such as replacement of broken gates is insufficient; the future operation will be completely different.
Primary canals: Typically only one change of flow rate at the head of the canal every 3-7 days.	Multiple changes of flow rate per day.	It will require a better understanding of the operational relationship of structures in primary and secondary canals.
Silt and aquatic weed growth reduces flow capacity.	Reduced blockage of flow.	Basic maintenance and rehabilitation, with improved equipment and access to canals.
Service Level between the Farm and Minor Canal		
Rotation schedule	Arranged schedule	Improved communications
Inequitable water delivery to farm-turnouts. Tail-ender do not get equitable supplies	Equitable water delivery	Improved final distribution system
Water distribution system (open ditches) difficult to access and maintain. Seepage losses.	Simplified maintenance and operation. Reduced seepage losses.	Lining of canals or pipelines or installation of pipelines.
Water delivery only possible to one farm at a time.	Water deliveries to more than one farm at a time or at least with more flexibility.	New design criteria for flexible service. Different methods of conveying and measuring water. Fewer farms served by a single turnout.
Insufficient capacity for flexible deliveries.	Larger capacities, so that multiple farms can be serviced simultaneously.	Different types of water delivery control and conveyance between the canal turnout and the farm. If possible interim storage reservoirs.
Lag time between water delivered at the canal turnout and water reaching the field.	Reduced lag time.	Piped distribution, or Fewer farms served by a canal turnout.
Flow rates are only measured at the canal turnout.	Multiple deliveries downstream of the turnout. Flow is controlled and measured at each farm during simultaneous deliveries.	New delivery control and conveyance systems. Development of portable, totalizing flow measurement devices for canals and pipelines.
Frequent spills. If a farmer shuts off water to his plot, water must be switched to another one	Farmers may be able irrigate independently.	Remote monitoring, automation, piped distribution. Options upon location and economics.
On-Farm Level		
Poorly designed and maintained traditional surface irrigation systems (basin) in many areas, lack of proper land grading.	Well designed and maintained on-farm irrigation systems. Mix of modern level basin, furrow, sprinkler, and drip. Irrigation sys-tem designs to meet individual field crop, soil, topography, economic, and labour requirements.	Capability to supply each farm below a chak outlet at request with a constant flow rate. Private companies are able to design new on-farm irrigation systems.
Irrigation frequency and rate are scheduled by tradition or on instruction from ID (warabandi, Shejpali)	Irrigation frequency, rate and duration customized to match more closely irrigation technology, soil, weather, crop, and labour schedules.	More flexible and reliable water deliveries. On-farm storage for drip and sprinkler systems. Water deliveries available on an arranged basis. Improved communication between farmers and water suppliers.
Insufficient awareness of correct agronomic practices and irrigation inputs.	Improved awareness of necessary inputs and agricultural practices.	Education about on-farm irrigation, agronomic inputs, soil/water/plant relationships.
Annual water consumption per plot is unknown to farmer, or not understood in terms of volume.	Water allocations will be done on a volumetric basis, with annual or seasonal limitations.	Ability to measure flow rate and volumes delivered to individual plots. WUA and farmer will both need to keep records.
Water losses are only understood in terms of surface runoff. The magnitude of deep perco-	Water losses will be understood to include both surface and deep percolation losses.	Improved rules for water distribution. Improved record keeping.

lation losses is not understood.		Improved law enforcement procedures.

A full understanding of the above principles is needed by all participants in the modernization process. The wholehearted support of the present operators is important to success of any modernization program, and they must be in a position to participate in the decision-making process: consensus building and training will therefore be a critical component of the modernization process. All training should be conducted in the context of the broader purpose of modernization - to improve on-farm production and profitability, and to protect or enhance the environment. The changing functions of ID personnel require a larger knowledge basis. A top priority is that the key personnel and individual professionals be familiar with the recent advances in on-farm irrigation. Training topics should therefore include not only water delivery modernization options and canal maintenance, but also improved on-farm irrigation methods. Modern irrigation is knowledge-based and therefore long-term training needs will have to be planned and organized for principal groups involved: the engineers, designers, and technicians within ID and the water user associations; managers within ID and the water user associations; consultants who will provide design assistance; persons from the banking and financial industries; university and extension personnel; and farmers. Specialized training materials and sessions should be available for officers and the technical staff of the water user associations. Since these people hold the purse strings to future investments, and since their decisions have such a tremendous impact on the final outcome of policy decisions, it is important that they have an understanding of some basic principles of hydraulics and water control, as well as knowledge of some maintenance options.

New design manuals will be required. Many field engineers in Asian countries are using design manuals which are based on outdated design concepts which treat irrigation water control as a steady flow problem. The real need in modernization is something different - it is to solve the problems unsteady flow conditions in canals and pipelines. The field engineers need new design guidelines because they may not have the background, confidence, or authority to deviate from existing official practices.

Time is of essence under the modernization program. A rapid assessment must be made of the technology needs and present level of performance of each individual project prior to allocation of funds for specific actions. This assessment should not only address symptoms (traditionally performance assessment focus on water use and distribution efficiency and conditions such as high water tables, high salinity, and crop yields) but also focus on the level of service by questionnaire-based or rapid appraisal-type field investigations.

Larger schemes should be broken down (partitioned) into sub-units (main canals, secondary and tertiary canals) corresponding to operational levels and operators, for the assessment of the needs for physical improvements. The responsibility for such an assessment should rest with the authority in charge for the particular works. The canals under control of a water user association should be assessed by members of that association, with technical assistance from the ID. Major points to consider would be: all-weather access to critical sites; maintenance equipment; communications network; improved control on the main canals; automated secondary canal headings; new turnout designs and long crested weirs.

Planning groups should be created at each level. Their first action would be to participate in the local assessments and review the results of the rapid assessment of the current operations and symptoms. They would then try to achieve consensus on the vision for the future operations. Special training in important technical aspects of modernization would be useful. The proposed planning procedure implies that the formation of effective water user organizations (WUAs) and definition of water rights are pre-requisites for physical improvements. After these first steps, local planning groups should:

1. Develop technical and management options for modernization (including time and cost estimates).
2. Request input from the review panel regarding additional options/modifications to the original ideas.
3. Present a list of technical recommendations, justifications, costs, and implications to the WUAs.
4. Modify the recommendations based upon the desires of the WUAs, and present these new recommendations to the WUAs as many times as required.
5. Request input from the regional or national review panel.
6. Receive new approval from WUAs.
7. Conduct a complete economic feasibility study.
8. Receive final approval from WUAs.
9. Implement the program.

The results of the first stage of a modernization program to this stage would have resulted in the installation of a limited number of better gate types at critical locations (with sufficient capacity to accommodate future requirements), accounting for flows and volumes with proper measurement and control structures, improved communication, and an increased number of canal turnouts. Assuming that maintenance is reasonably good, the operation at this stage should now provide: equitable deliveries to the minors, except in some areas with insufficient canal capacities which is a problems of the original design; good control of flow rates at farm turnouts; reasonably flexible deliveries, with the capability to provide deliveries to individual farms with 2-3 days advance notice; some tail-ender problems in the form of spill at the ends of all secondary and tertiary canals.

The water delivery infrastructure would not be perfect but should be quite reliable and equitable and reasonably flexible. Once these steps have been taken, noticeable improvements in project water management should be observed. Additional benefit would occur when improvements are made downstream of the minor outlet. Those improvements could be sustained because the water delivery infrastructure is robust and very functional.

Once the basic water delivery infrastructure has been improved, the objectives of improving agricultural production and profitability would probably have to address the following remaining problems (listed in order of importance for the majority of areas):

1. Poor on-farm irrigation technologies and management. The on-farm irrigation efficiencies may be in the range of only 50%. However, on-farm irrigation efficien-

cy can only be improved when the infrastructure is in place to enable farmers to adopt more efficient technologies and management. Prior to this stage of modernization, unreliable or inflexible water deliveries would have discouraged farmers from investing in better on-farm irrigation systems.

2. Inadequate technological agronomic inputs (fertilizer, seed varieties, appropriate pesticide applications).
3. Physical bottlenecks in the water delivery system which prevent adequate water deliveries in some areas.
4. Inflexibility in deliveries and lack of control at individual farm turnouts.
5. On-farm and project drainage problems.
6. Some inflexibility in water deliveries to the minors and some tail-ender spills.

While of course national circumstances, technical and operational aspects would vary greatly across countries, FAO believes that the concepts of modern irrigation and proposals for modernization processes and plans of action, which are in fact inspired by the experience of Mexico, have a wider validity.

However progress in the field is slow. There are four major hurdles for the implementation of proper modernization processes. First, the lack of understanding. Second, transparency and accountability must be improved through modern management principles and tools. Modernization requires irrigation management transfer. The institutional side of the modernization process looks at the institutional reforms and the conditions of turn over of management responsibility from irrigation agencies to farmer associations. Third, the powerful and prestigious irrigation bureaucracy in many countries must be reformed from top-down management of water scarcity to a service oriented mode of operation. This involves foremost a change in attitude. Fourth, additional funding for the upgrading of the new water control and communication devices is required.

Progress in Asia is even slower and at present limited to a few experimental schemes. The availability of a tool to diagnose quickly the performance of irrigation schemes and to identify cost effective ways of modernization such as the RAP methodology developed for the IPTRID evaluation study provides the opportunity to more quickly disseminate modernization concepts. With an RAP such as will be introduced, a good irrigation engineer should be able to quickly assess the suitability of the existing hardware and operational rules in a project, and to develop a plan for modernization needs. The RAP has a special focus on *how to solve the problems* through modernization. Internal indicators, which when examined as a whole, can be assessed and indicate how and where irrigation investments should be targeted. They indicators provide a rational basis for developing a program of rehabilitation and modernization that will enhance the operation, management, and outputs of an irrigation project.

The application of the RAP to the modern schemes that were evaluated has allowed the identification of a number of key findings that can be instrumental in successfully design future modernization strategies (see box and following paragraphs below).

Modern Water Control and Management Practices in Irrigation:
Impact on Performance

Key findings

1. The partially modernized projects did not have the chaos and anarchy that has been widely documented in typical (non-modernized) irrigation projects. Projects with the greatest chaos (i.e., differences between actual and stated service) tended to provide the worst water delivery service.
2. Several projects have been modernized to the point that the water conveyance operations and hardware were able to support functional water user associations, and in turn those water user associations were collecting sufficient water fees to pay for all or most of the O&M expenses.
3. 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.
4. Modernization efforts which emphasized computer programs for predicting canal gate movements and water deliveries were generally ineffective (or worse).
5. All projects needed improvements in both hardware and management.
6. Overall, there is a lack of understanding of modernization strategies and how to implement them.
7. Successful projects stress improved communications, focus on operational data rather than statistical data, and require a minimum of paperwork for operators.
8. Simple hardware and operational changes could give immediate benefits - if people just knew about them. There is a huge lack of awareness of how to design irrigation systems that provide good service.
9. There is a very serious shortage of trainers and consultants who can provide focused and pragmatic training and design which properly incorporates both strategies and details of hardware and management modernization.
10. Programs for improved 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 doomed to failure.

Hardware vs. Software. The argument of hardware vs. operation (software) needs has a simple answer - all projects have both needs. The particular emphasis in each project will be different. Certain hardware options such as a high density of turnouts, effective water control structures, regulating reservoirs, project-level recirculation systems, and remote monitoring can tremendously simplify the operation of moving water around.

*Modernization Strategies***.** In general, project personnel and designers are thinking of "components" when they discuss modernization. The components should only be chosen after good water control and operational strategies are selected. In general, there is insufficient understanding of how to simplify water control operations and how that will impact social factors such as anarchy and efficiency of employees.

Furthermore, few people have a vision for the future - although today's modernization programs should be able to service tomorrow's needs. Because modernization programs are necessarily done in stages, we must be careful that initial efforts do not hinder future requirements.

Immediate Results. Simple and relatively inexpensive hardware and operational changes could give some immediate benefits to most projects. The RAP supported by training aims at identifying such changes and benefits. Examples of simple potential improvements applicable to rice irrigation and drainage projects are: re-orienting employees from statistical data collection to operations; focusing on results rather than process; using weir flow on cross regulators rather than only orifice flow; modification of turnout operations for improved flow control and measurement, including some physical modifications to the turnouts; installation of recirculation systems within the project to easily collect and reuse spill; improved voice communication and mobility of operators; remote monitoring of spill points, and subsequent adjustment of the headworks for the pertinent canal, which can be done manually with radios or even over a reliable telephone network; more frequent adjustment of flow rates at the source of a project, based on meaningful data from throughout the project

Recommended Strategies for Modernization: First, there is insufficient attention by all parties to the importance of the technical details of how water moves and is controlled throughout a 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 requirement needs 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 which 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.

Approach to training: Training cannot simply be a textbook exercise or a list of facts. One must focus on pragmatic aspects, such as how to apply various hydraulic principles. Trainees must also understand service-oriented irrigation project design and management, rather than just knowing simple hydraulics.

For the first time in Asia, in March 2000, a training programme with these characteristics has been organized by FAO with the support of the World Bank Research Committee for staff of the Royal Irrigation Department and consultants involved in the preparation of the irrigation modernization component of the Natural Resources Management Programme which Government of Thailand is currently preparing[3] (Facon, 2000). The application of the Rapid Appraisal Process and modernization concepts has enabled the participants to prepare a Priority Action Plan for the Makhamtao-Uthong Canal in Region VII of the lower Chao Phraya river basin, which s presented in Appendix 1.

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[3] Participants from Malaysia and Viet Nam also participated in the training programme

L. CONCLUSION

The notion of water delivery service and of generalized service-orientation of institutions in the irrigation sector, whether river basin agencies, reformed irrigation agencies, irrigation service providers, water users associations has become central in new concepts and definitions of participatory irrigation management and irrigation management transfer.

The evaluation of impacts of on-going participatory irrigation management and irrigation management transfer programmes in terms of agricultural productivity and agricultural performance is one of the reasons of this evolution.

The sustainability of the water users associations is seen to depend on their capacity to provide an adequate water delivery service and control and allocate water and to provide an improved service to allow the agricultural productivity to take place. In the context of Asia, diversification of rice crops is a major issue for increased income by farmers and improved agricultural and water productivity. This in turn is essential for the capacity of farmers to pay water and the water users associations to e financially viable. A more forward-looking strategy anticipating these future needs is therefore required.

As a result, it is now recommended that strategies of gradual improvement of irrigation systems be adopted to support the transfer of water management responsibilities and associated rights.

Concepts of irrigation management transfer/participatory irrigation management transfer and modernization are therefore converging. However, there are still some substantial differences: the infrastructural physical improvements which must be supported must be designed with a view to improve equity and reliability of water delivery service and evolve towards increasing levels of flexibility. Operational and technical details become very significant. Environmental considerations need to be better into account in a perspective of integrated water resources management.

Recent visioning processes in the water sector provide a good condition for strategically panning organizational and technical changes in participatory and irrigation management

However, there is a general lack of knowledge of modern service-oriented design and operation concepts at all technical levels in the irrigation sector in the region.

Intensified and on-going training programmes for both professionals in the reformed irrigation agencies, consulting firms who will provide advisory services to water users associations and to the managers of water users associations and the technical staff that they may employ for operation and maintenance of their irrigation schemes are understood as one of the conditions for sustained success of the transfer programmes.

It is therefore essential that these programmes introduce and provide knowledge on ways and means to design and operate irrigation systems cheaply for good performance and adequate service to farmers as they evolve toward more commercial forms of agriculture.

An appraisal of initial conditions and performance of the systems to be transfer would allow both a better design and strategic planning of physical improvements together with a definition of the service to be provided both by the irrigation service provider to WUAs and by WUAs to their members, with indications on ways and means to achieve these service goals and improve them in the future.

It is suggested that the Rapid Appraisal Process developed and used in the evaluation of modernization programmes of IPTRID could be used for this purpose at programme appraisal stage and for individual irrigation systems.

A pilot training programme on modernization concepts and application of the Rapid Appraisal Procedure which builds on the knowledge synthesis acquired in recent years on modern design principles and participatory irrigation management shows promising results. A concept for a more ambitious re-training programme based on the same concepts and tools has been developed and could be supported in the context of efforts to improve the performance of programs to transfer the management of irrigation systems to the users (Burt and Facon, 1999).

A second condition for the sustained success of participatory irrigation management is the availability of financial instruments that allow farmers to invest in the upgrading of their irrigation systems.

Another condition for the sustainability of the reforms is the development of a suitable service environmental to assist farmers in increasing the productivity of agriculture.

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Appendix 1

Performance Evaluation of Makhamthao-Uthong Project with a Rapid Appraisal Procedure

Introduction

Confronted with the need to drastically improve water resources management in the face of growing water scarcity and increasing population in order to continue on the path of socio-economic development, a number of countries of the region have embarked on far-reaching programmes to develop more effective institutional arrangements at the basin, sub-basin and local levels, with stakeholders and a changed role for government, and establish a fair and effective system for allocating rights for the use of water. In particular, the performance of irrigated agriculture needs to be drastically improved if water demand for feeding the population and satisfying the needs of other sectors is to be met. Modernizing water delivery and irrigation infrastructure to enable and support the institutional change objectives and future water allocation is a priority and substantial investments are being planned for this purpose.

Typically, the irrigation systems to be modernized support rice cultivation as the main crop during the dry season and also during the dry season, although crop diversification is generally observed. It is hoped that upgrading the irrigation and drainage systems will result in water savings, improved water productivity, the possibility for farmers to diversify crops during the dry season. At the same time, the results of recent evaluations by financial institutions such as the World Bank of investments in paddy irrigation in the humid tropics (low economic return and low farmer incomes) are such that these institutions are cautious in supporting future investments. However, substantially increasing water productivity and rice yields and diversification require improved water control to the fields.

It is therefore essential for the sustainability of paddy rice cultivation in those systems that proposed upgrading result in actual improvements in water control and overall system performance at the least possible cost, while supporting institutional reform, but also to assess whether the proposed improvements will actually result in water savings to be made available to other sectors. The results of the appraisal of the performance of the Makhamtao-Uthong irrigation project using a Rapid Appraisal Procedure and a Priority Action Plan for its modernization, the possibility of achieving water savings through the modernization of the system, discussions on the validity of this tool and modern water control concepts for paddy irrigation projects.

The Makhamtao-Uthong project performance appraisal: context

Thailand has invested in the past large amounts of capitals for the development of new water resources. There is now however very little scope for further expansion of water supplies. Increased competition from industrial and urban consumption, explosive growth of rice cultivation during the dry season over the last three decades raise a new challenge for the government of that country.

At the request of the Royal Irrigation Department of Thailand (RID), FAO has recently organized a training workshop on irrigation project modernization, in March 2000, with support from the World Bank Research Committee. This workshop was organized in the context of the preparation of the irrigation management modernization component of the Natural Resources Management Project which Government of Thailand will submit to the World Bank for funding. Twenty-two staff and consultants were trained in modern irrigation and management concepts and developed a priority modernization plan which will be used for the detailed preparation of the modernization component. The two-week workshop included a three day course to present modern concepts in water control and management, a Rapid Appraisal Procedure (RAP) using a field questionnaire to compute internal and external performance indicators, a five-day field visit to assess the Makhamtao-Uthong project, a sub-project of the Chao Phya project, and three day to evaluate the results of the field evaluation and formulate proposals for the modernization of management of that project. During the last day, the trainees developed their own conclusions and recommendations and presented them to RID Management and consultants in charge of preparation of the World Bank proposed project.

The training programme used extensively the tools and findings of a major and unique study funded by the World Bank Research Committee and implemented by IPTRID on the evaluation of the impact on performance of the introduction of modern water control and management concepts on 16 irrigation modernization projects including 6 rice irrigation schemes. This study has been published by FAO as *Water Paper Series 19*.

The Makhamtao-Uthong canal system

The Royal Irrigation Department (RID) of Thailand selected the Makhamthao-Uthong (MU) canal system in the Chao Phya basin for the field exercise included in the schedule of the training workshop. The Lower Chao Phya Project, a nearly one million ha project, is served by 5 main canals diverting the Chao Phya water from Chainat diversion dam. The Lower Chao Phya Project is divided in 26 Operation and Maintenance Areas. The boundaries of O&M areas were defined for limiting the distances from area headquarters but are not based on hydraulic considerations. Each canal system is under the responsibility of several O&M areas. Each area is responsible for sections of several main canals. Consequently it is very difficult to get the basic data to calculate the external performance indicators of individual canal system. The Project is under the management of RID Region VII on the Right Bank and Region VIII on the left bank. The Northern part of the Lower Chao Phya project is a typical conventional gravity gated system. The Southern part, south of Ayutthaya, is a typical delta irrigation system where the navigation channels play the role of irrigation, drainage, flood and pollution control canals. Each dry season, the RID Office of Hydrology and Water Management allocates the volumes available from the two main storage reservoirs of the river basin for municipal and industrial supply, irrigation, navigation and pollution control and determines the areas of the Lower Chao Phya which would be irrigated. RID records indicate that areas irrigated during the dry season exceeded planned areas by about 20 to 35 % during the years 1995 to 1998 (Table 1). In 1999, under the pressure of farmers' complaints, RID increased the volumes of water released from Bhumipol and Sirikit dams by about 15 to 20 % while water was available till the reservoirs were nearly drained. Exceptional rains in spring 1999 saved the dry season paddy crop.

Table 1: Planned and Actual volumes of water released from Bhumipol and Sirikit reservoirs (MCM) for dry season and planned and actual paddy areas (ha)

Year	**1995**	**1996**	**1997**	**1998**	**1999**
Water availability in both dams	12733	14582	12107	6200	3879
Domestic water supply	1100	1800	1650	1600	650
Dry season crop: Phitsanulok	300	800	500	500	150
Dry season crop: Chao Phya	3000	4150	3700	2900	1900
Navigation	300	400	300	300	0
Water supply Bangkok	700	750	750	750	650
Salinity control	600	600	500	450	350
Total planned (MCM)	6000	8500	7400	6500	3600
Total actual (MCM)	7216	9643	8556	6656	2575
Area planned (ha)	448,000	560,00	528,00	432,00	304,00
Area actual (ha)	512,000	669,00	649,60	606,00	538,00
Actual volume (m3/ha)	7366	8839	7954	7870	6743

Use of groundwater for irrigation has exploded during the last 5 years. It is reported that 28,000 tubewells are now in use in region VII. The MU canal is the most western system on the Right Bank of the river. The MU canal system consists of a 104 km long canal with a design capacity of 35 m3/s and twenty-four lateral canals serving about 44,500 ha on the left bank. Only the last 15 km of the main canal are concrete-lined. Lands on the Right Bank of the main canal are also irrigated by illegal pumping from the main canal and by drainage inlets. However no systematic monitoring of the illegally irrigated areas and volumes diverted have been made. The guess-estimates vary from to 2,800 to 8,000 ha. The MU canal system was designed for supplemental irrigation during the wet season (0.78 to 0.82 l/s/ha).

Responsibility for the management of the MU system is shared between three O&M area projects: Poniathep, Thabothe and Don Chedi. Don Chedi is only responsible for the last 47 km of the main canal and lateral canals serving 23,700 ha. A seasonal delivery schedule is prepared in advance by RID Office of Hydrology and Water Management. The MU main canal diverts water from a branch of the Chao Phya river about 15 km upstream of Chainat diversion dam. The design of the intake affects the delivery of water to the MU project area. The intake was designed for delivering the design capacity flow when the water level is at (or about) normal full level. A pumping station was constructed in 1998 to supply water when the level drops below that level. Upstream weekly variations of water level in Chainat reservoir, of about half meter, are due to the reduced power generation at Bhumipol and Sirikit plants and the reduced water released during weekends. The MU main canal is operated on rotational basis during the dry season: Water is delivered for 10 days to the lateral canals upstream of km 57 and for 12 days to the downstream lateral canals. A second 6-day upstream /downstream rotation was established between the lateral canals of Don Chedi. Finally water is delivered on rotation basis to the farm outlets.

The main canal is equipped with 6 gated cross-regulators, none of them with a weir section. All the gates are manually operated. The operation concept is based on delivering target flow downstream of each cross-regulator, particularly at the interface between O&M areas. The offtakes of lateral canals are either equipped of single gates or constant orifice gates (one of the gates frequently being not installed). All the field operators of cross regulators and lateral offtakes are supposed to and apply strictly the instructions given to them by the Operation chief of their O&M area. None of them is expected to take any initiative in adjusting the gates. A considerable volume of information is transmitted from the field to higher level for statistical purposes. Flows in the main canal are calculated by the orifice formula with a low degree of confidence; and flows diverted to the lateral canals are determined by "experience". All the farmers interviewed during the field visit reported having an individual pumping equipment used to pump from any possible source of water: Main or lateral canals if gravity supply is insufficient, main and tertiary drains, borrow pits along the main canal, and groundwater. Farmers interviewed are hardly aware of RID plans to match the irrigated areas in the Chao Phya basin with the water available in storage dams. All of them admit that they take risk, maximize pumping and eventually would request RID to increase water releases through political channels.

Rice is the main crop during dry and wet season. Average annual cropping intensity is about 170-180 %. Sugarcane is cultivated in Don Chedi area and fishponds are also important. Average farm size is about 2.5 ha with a maximum of 15 ha. Average yields during the last five years in Don Chedi area were about 4.05 and 4.80 tons/ha. The volumes of water delivered at the head of Don Chedi area during the dry season 1996-98 range from 7900 to 8700 m3/ha. The Don Chedi O&M project has 155 employees of which 12 officers. (Administration section: 11; engineering section: 7; mechanical section:8; operation: 100+ of which water masters: 2; zonemen: 12; gate tenders: 38; canal tenders: 37). This staffing is rather high (150 ha per O&M staff). No water charges are collected from the farmers. However farmers spend between 10 to 35 US$/ha in pumping costs per dry season. The annual budget of Don Chedi area is about US$ 27.5/ha for O&M (excluding improvement works), of which about 66 % is for staff salaries (US$ 18.2/ha).

External Performance Indicators

Some external indicators required for giving a score to some internal sub-indicators have been estimated. The values of indicators of outputs/unit areas of the MU Project are in a good average, given the high cropping intensity and crop yields. Water indicators (relative water supply and relative irrigation supply) are certainly on the high side compared with other projects. The canal system is just able to pass the peak evapotranspiration requirements for a 100 % cropping intensity (cropping intensity is about 75% for the authorized irrigable area, but additional irrigated area on the right bank pushes the "legal" cropping intensity close to 100 %.). The volumes delivered to Don Chedi area (8,500 m3/ha) for the dry season are far below the volumes reported in other performance studies and even in feasibility studies. Obviously the main reason is the high level of recovery of drainage water within and on the boundaries of the project, combined with the use of groundwater.

Internal Indicators

The average values of internal indicators scored by the trainees for the project were (1 to 10):

I -1	Actual service to individual fields, based on traditional on-farm irrigation methods	4.1
I- 2	Actual Service to avg. point of Effective Differentiation based on Traditional On-Farm Methods	2.6
I -4	Actual Service by main canal to its subcanals	3.7
I- 5	STATED service to fields.	3.4
I- 6	STATED service to avg. point of EFFECTIVE differentiation.	4.1
I- 8	Stated Service by main canals	6.9
I- 9	Evidence of Lack of Anarchy in Canal System u/s of ownership change	4.8
I- 10	Cross-Regulator Hardware (Main Canal)	2.3
I -11	Capacities (Main Canal)	5.7
I- 12	Turnouts (from Main Canals)	5.1
I- 13	Regulating Reservoirs	0
I- 14	Communications (Main Canal)	4.7
I -15	General Conditions (Main Canal)	7
I -16	Operation (Main Canal)	0.5
I -28	Number of Turnouts/(operator, gate oper., supervisor)	0.5
I -29	Feedback Information	0.5
I -30	Computers for billing/record management	2
I -31	Computers for Canal Control	0
I-32	Effectiveness of water supply releases from reservoir	3
I-33	Effectiveness of main system operation	5
I-34	How closely are instructions followed?	10

The analysis of the internal indicators and sub-indicators reveals that:

- the main canal provides a very poor and inequitable service to the secondary canals and sub-projects
- the reason lies not in poor maintenance nor in the cross-regulators but how they are operated
- secondaries provide a very poor service to the points of effective differentiation (irrigation blocks
- poor performance at the farm level is compensated by pumping and conjunctive use
- there is a water supply problem which cannot be solved overnight (linked to water level at the Chao Phraya dam on the Chao Phraya River)
- as instructions are followed, the solution lies in changing the instructions to gate operators. Some minor adaptation of cross-regulators would provide much more flexible and equitable distribution
- communications and procedures can be drastically improved
- staff density is very high and can be reduced
- there is no reliable measurement at any level

In addition:

- A transfer of the canal as it is presently operated would create problems of inequity between secondaries and sub-projects which cannot be solved by institutional measures alone.

- Rules established by WUAs equivalent to present rules would be subverted by farmers as they are at present, for the same reasons.
- Shallow water tables are not available everywhere.
- Some areas are not dominated by the canals.
- Establishment of WUAs at the level of secondaries would allow to control the problem of illegal turnouts and implement a different operation strategy negotiated with the main canal ISP. Upstream and downstream areas have different cropping patterns which could be accommodated by a different service.
- Problems of inequity between upstream and downstream require a re-centralization of operational responsibilities for water dispatching in the main canal.

Priority Action Plan

The recommendations presented by the trainees during the closing session derived from the assessment of the external and internal indicators included:

priority	Cost (Million Baht)	Action
1	0	Change instructions: water level control and empower operator to make adjustments
2	0	Establish a single operation unit for the main canal
3	5	Flow measurement at the head of the canal and each project
4	1.2	Flow measurement at the head of each secondary (flumes)
5	5	Long-crested weirs at cross regulators
6	0	Better transfer of data on turnouts
6	0.1	Walkie talkies for zonemen and gate operators
6	0.4/year	Improved mobility/transport
7	6	Motorize cross-regulator gates
8	0	Control or eliminate illegal turnouts

Longer-term measures identified were:
- Management of water recirculation within the project
- Management of conjunctive use
- Development of tertiary network
- Improve water supply to the main canal

Conclusions

The MU project is performing well in terms of productivity and water use despite the low capacity delivery of the canal system. Farmers have invested in individual farm pumps which have allowed secondary water sources to be tapped, the development of conjunctive use, increased reliability in water supply and to some extend in crop diversification and fishponds. The importance of individual pumping is overwhelming but has an economic impact on farmers' income. An evaluation limited to external indicators of the Makhamthao-Uthong system would have concluded that the project compares well with the best performing rice projects of the IPTRID study. Obvious recommendations would have been to establish water user associations and a system of water charges. The internal indicators provided the basis for a rational program of improvement which will enhance the operation, management and outputs of the project.

Benefits expected from a modernization program are expected to be a reduction in pumping costs and a reduction in O&M staff. Given the present efficiency of the project and of the Lower Chao Phya Project it is doubtful that a modernization program could generate some water savings. However the improved reliability associated with a better discipline in water allocation should have a positive impact on crop productivity.

Proposed changes would enable a transfer of water management to users in good conditions of equity between different areas with the possibility to implement rules at the level of the secondaries, and to apply and enforce a water allocation and water charging system.

Most of the actions identified are of the software type and require training only. The physical upgradings identified are minimal are cost less than the upgrading budgets currently spent on the system.

The RAP procedure, which has been defined in the course of the IPTRID study, is rapid and comprehensive enough to give good indications of the critical internal links of an irrigation system. The complete picture provided by external and internal indicators enables one to visualize where changes are needed.

More generally, this training workshop has confirmed the efficacy of the modernization concept and tools such as the RAP for rapidly designing suitable irrigation modernization strategies. It is suggested that conducting a similar training programme for national officers and consulting firms including a RAP of selected representative schemes at early stages of project appraisal could lead to improvements in project scoping, design and strategy. Subsequently, during the implementation of an irrigation modernization programme, carrying out a Rapid appraisal of each scheme to be modernized by trained local staff and consultants could lead to similar improvements. Indeed, re-training of staff at all levels should be considered an essential component of an irrigation modernization programme.