COMPARATIVE PERFORMANCE ASSESSMENT OF THE ALTO RIO LERMA IRRIGATION DISTRICT, MEXICO

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Introduction

This paper describes and evaluates the application of IIMI's set of external performance indicators to the Alto Rio Lerma Irrigation District (ARLID), located in the Mexican state of Guanajuato. The paper has two objectives[2]:

- First, to test whether within one irrigation system, external indicators allow to distinguish between differences in performance across system levels, over time and between irrigation sources.

- Second, to evaluate the data collection procedure that was used for applying external indicators.

As argued by Molden in his paper for this workshop, the objective of using external indicators is to evaluate outputs and impacts of intervention in individual systems, comparison of performance of a system over time, and also to allow comparison of systems in different areas and at different system levels. This is in contrast to internal indicators, which are generally used to assess actual performance to system specific management targets relative to goals established by irrigation managers (Small and Svendsen 1990 and 1992)[3].

Rao (1993) provides an excellent summary of the literature on internal indicators, and many authors have applied one or more internal indicators at particular irrigation systems (see for instance Jurriens 1996). Beyond doubt, each of these indicators have proved to be useful as they provide important information about internal operational performance processes of the particular systems were the indicators were applied. However, as a set, the indicators mentioned above have shown some limitations to their usefulness and applicability. These limitations include:

- Most authors propose to use different indicators, or use different methodologies and tools to

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[2] The objectives of IIMI's research in ARLID went beyond the research objectives for this particular paper and included assessments of internal and external performance, impacts of an irrigation management transfer program and an evaluation of agricultural support services provided by public and private agencies. Results of these studies are discussed in forthcoming papers by Kloezen and Garces and by Kloezen, Garces and Johnson.

[3] Small and Svendsen (1990 and 1992) call this the *goal-oriented model*. This model is different from the *natural system model*, which measures performance more in terms of a system's ability to obtain inputs than in terms of either its outputs or impacts.

measure the same indicator. Although recent efforts have tried to standardize some internal indicators (Bos *et al* 1994), proposals for new internal indicators or other methodologies to measure indicators are still emerging. As a result, comparisons across systems or overtime are hardly possible[4].

- Internal indicators are based on the existence of clearly defined management goals and operational targets. However, in many irrigation systems, these goals and targets either lack or are too widely defined and inconsistent with each other (Brewer, Sakthivadivel and Raju 1997).
- As pointed out by Small and Svendsen (1990), measuring internal indicators following the goal-model approach, implies that subjectivity enters the performance evaluation both in the establishment of the goals and targets themselves, and in the way in which differing goals are weighted. System managers, policy maker, farmers and researchers might all set different goals and targets, especially in systems where goals and targets are not yet (or poorly) defined, or where goals have changed as result of dramatic changes in for instance cropping patterns, water availability or the political economic system.
- Generally, these internal indicators address how the input (water) is used, but does not provide information on to what wider hydrological, agricultural, economic, social and environmental impacts the inputs has led.
- Most of the performance assessment exercises described in literature were done in the context of intensive research programs, often in order to test new indicators that were introduced by researchers, rather than proposed by system managers. As a consequence, little is known on how system managers perceive the usefulness of these indicators for daily system operation and on how easy it is to apply these indicators for day to day monitoring purposes.
- Measurement of most internal indicators require complicated data collection procedures. Monitoring systems, if any, are normally not set up to collect these required data. As a consequence, applying the indicators requires additional staff, skills and equipment, which are generally not available within irrigation systems, or difficult to obtain.

Without pretending to be able to overcome all the limitations mentioned above, it is hoped that by developing a standardized set of external indicators, at least some of these problems will be dealt with. In the next section a description of the irrigation district is given. Then, the research methodology is presented, followed by 4 sections in which examples of the application of external indicators are given. A subsequent section provides a comparison between the external and internal indicators. The paper concludes with an evaluation of the data collection procedures used and draws some lessons on the usefulness and applicability of external indicators.

The Irrigation District

ARLID was constructed in the 1930s and has a gross command area of 112,772 hectares. It is located in the State of Guanajuato, central Mexico. The district is located in the upper reach of the 48,215 km^2 Lerma-Chapala water basin, which crosses five states and serves nine irrigation districts as well

[4] See for example Oad and Sampath (1995), who introduce an indicator to measure predictability, or Meintzen-Dick (1995), who revisits the indicator to measure timeliness.

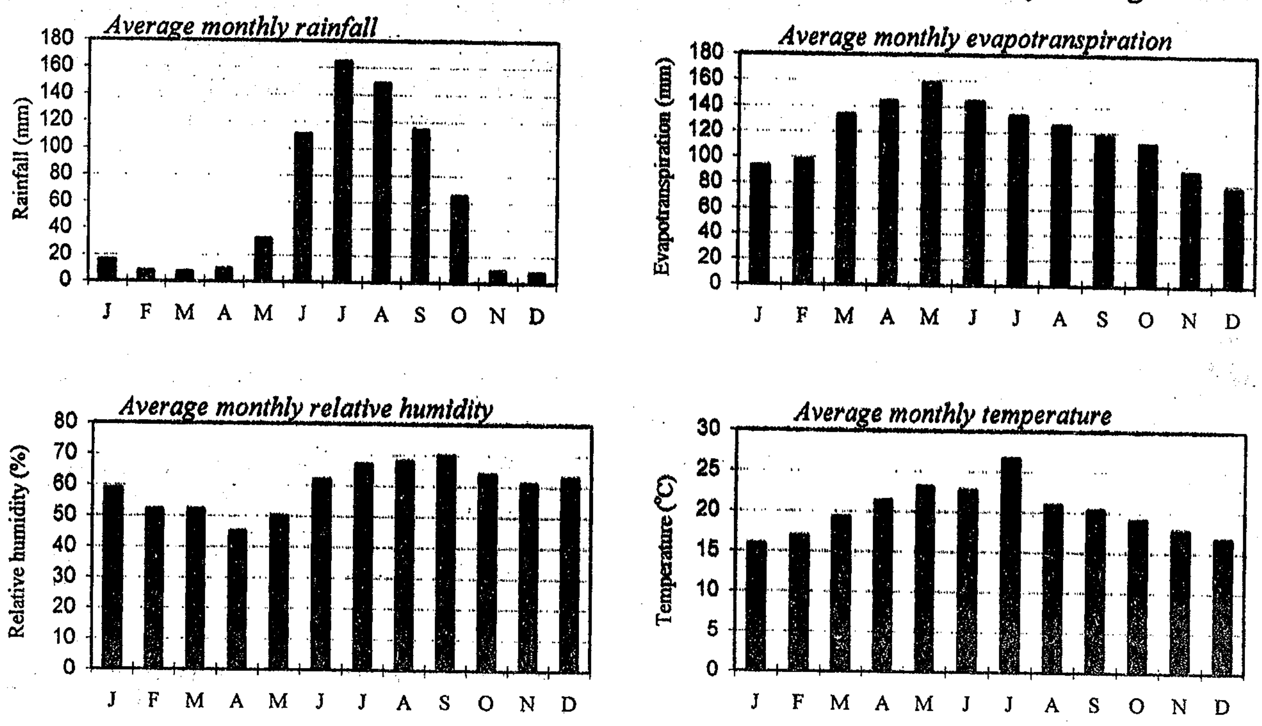
as the huge lake Chapala near Guadalajara. The total catchment run-off of this basin is approximately 4,740 million cubic meters (MCM), of which on an average 43 percent (or 2,020 MCM) is made available for the irrigation districts, 30 percent to small scale irrigation systems and the remaining to Lake Chapala, domestic and industrial uses. Of the 9 irrigation districts, ARLID is the largest, taking approximately 44 percent (or 880 MCM) of all the water stored for use within the districts (CNA 1992).

Surface water for the district is provided by four earthen dams with a combined storage capacity of 2,140 MCM, serving 77,697 hectares. In addition, there are a total of 1,714 deep wells serving 35,075 hectares. The irrigation network comprises 475 km of main canals and 1,658 km of secondary and tertiary canals. Likewise, there is a network of approximately 1,031 km of drainage canals. Wheat and barley are normally grown during the dry winter season while sorghum, maize and beans are the main crops grown in the wetter summer season. Farmers with access to groundwater tend to grow more vegetables.

The State of Guanajuato has a high concentration of wells: approximately 20 percent of all the wells in Mexico are found in this State. The State has 18 different aquifers, 3 of which are exploited by the farmers of ARLID. The total area underlaid by these three aquifers is 330,600 hectares, with an average annual recharge of 500 MCM.

The climate is moderately sub-humid and with an average yearly precipitation of 730 mm and an average temperature of 19 ^{0}C. Yearly evapotranspiration is approximately 1,900 mm and relative humidity is about 60 %. The dry winter season, which receives approximately 80 mm of rainfall, starts in November and ends in April. The summer season lasts from May until November and has an average of 670 mm of rainfall (Figure 1).

Figure 1. Climatic data for the Alto Rio Lerma Irrigation District, monthly averages 1963-96.



There are roughly 24,000 water users in the irrigation district, with 55 percent classified as *ejidatarios*[5]; and 45 percent classified as small private growers[6]. The average land holding in the irrigation district is 5 hectares.

The irrigation district is divided into eleven modules, each managed by an individual WUA and ranging in size from 1,513 hectares to 18,694 hectares. Annex 1 shows the high diversity in the social (number of private growers versus *ejidatarios*) and physical (infrastructure and irrigation source) characteristics of these modules. The irrigation district and the location of its eleven modules are shown in Map 1.

Irrigation Management in ARLID

Institutional

In the late 1980s the Government of Mexico (GOM) decided to restructure and modernize its agricultural sector. One component of the strategy adopted was an irrigation management transfer (IMT) program aimed at transferring management authority of the public irrigation systems from CNA to water users associations. As a result of this program, responsibility for O&M of the irrigation systems went from being exclusively that of federal government organizations to being shared with the newly created WUAs. Officially CNA's role is now restricted to management of the nation's reservoirs, headworks and main canals. Also in 1992, hydraulic committees were formed at district level to make an annual irrigation plan and to control whether this plan is effectively implemented. These committees, where CNA, WUAs and local state officials meet, provide a venue for participatory management, negotiation and decision making.

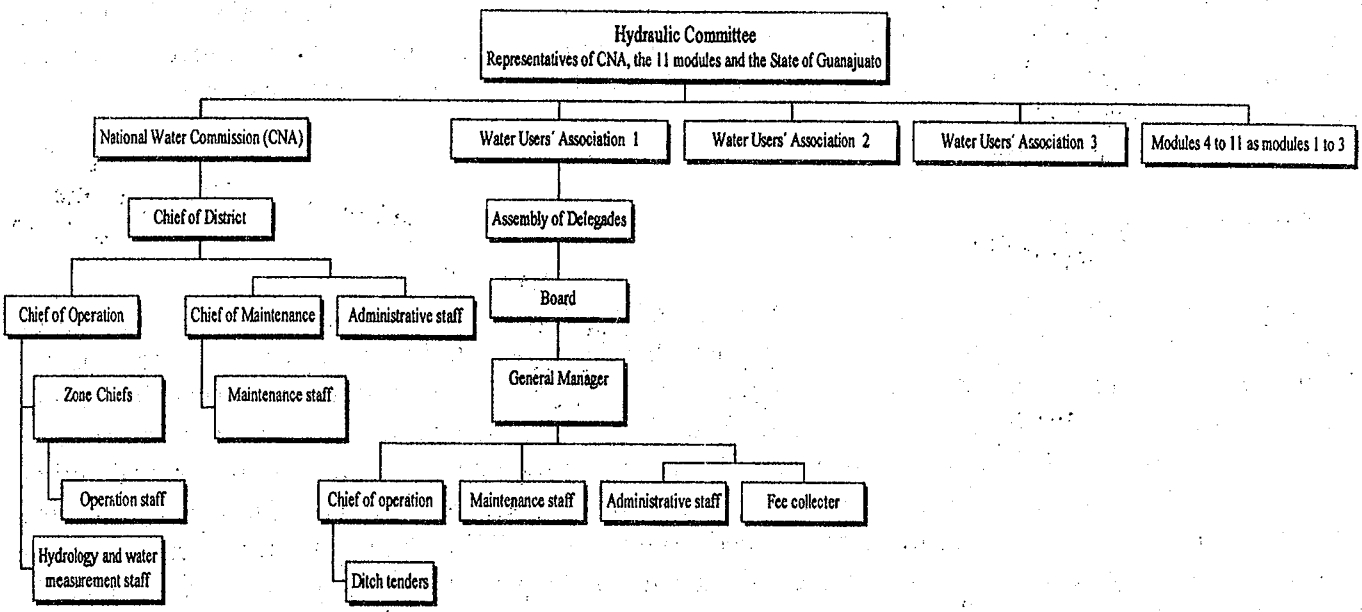
Users began sharing responsibility for management with CNA in November 1992[7]. As a result of IMT, the WUAs of the modules became responsible for O&M below the secondary canal off-takes on the main canal to the field level. WUAs have recruited professional and technical staff for operation of the irrigation system, managed by general managers appointed by the boards of the associations. The boards are elected by a free vote of the users and comprise a president, secretary and treasurer, with elected substitutes for each position. Figures 2 shows the institutional set-up of the district and the modules after transfer. The board, plus delegates from each *ejido* and two delegates per municipality representing the small growers, constitute a general assembly which generally meets each month. Prior to management transfer CNA employed 273 staff (1992), while in 1996 only 116 staff remained.

[5] Members of the land reform communities that were created during the Mexican revolution in the early part of the 20th century. Until the revision of Article 27 of the Constitution in 1992, *ejido* land belonged to the Mexican State.

[6] The concept "small private grower" (*pequeño propietario*) is a misnomer because in Mexico such user category could allow ownership up to a hundred hectares for an individual owner. In practice, this area becomes larger when a user divides the area among relatives.

[7] See Kloezen, Garces and Johnson (forthcoming) for a detailed discussion of the IMT program in ARLID and its impact on, amongst others, water use, O&M financing, maintenance and agricultural and economic productivity.

Figure 2. Institutional set-up of the Alto Rio Lerma Irrigation District and its eleven modules, after transfer.



Water Rights

The IMT program was accompanied by the promulgation of the new National Water Act in 1992. This Act clarifies water rights and enables trading of water. Regulations that support the Act were passed in 1994. Under the Act, each WUA within an irrigation district is granted a concession, which entitles them to a share of the water available for each season. These shares or concessions are proportional to areas with surface water rights in each module. Although concessions are granted for periods of up to 20 years, CNA retains broad discretionary power over the concessionaires right to use water and over all water transactions (sales or rental)

Under the 1992 water act, concessions may be granted to individual water users, however there appears to be a strong preference on the part of the CNA to make concessions to WUAs (Rosegrant and Schleyer 1996). The idea is that WUAs develop internal rules and regulations to equally grant subsidiary water rights to their members. Yet, in the case of ARLID none of the WUAs have established these rules and regulations. Water sales and rental arrangements among farmers was and is common practice, with or without CNA approval.

Under the new act water can be traded, for instance between two WUAs. Water sales need the approval of the CNA, as well as of the majority of the general assembly of the WUAs involved.

Financial

Prior to transfer of management responsibility, farmers paid water fees directly to CNA. However, due largely to deteriorating infrastructure and maintenance services, the proportion of fees collected fell from 85 percent in the early 1960 to only about 15 percent by the late 1980s (Palacios 1994a; Whiteford and Bernal 1996). Following transfer, fees are set and collected directly by the WUAs. Generally, farmers pay their fees prior to receiving their irrigations. In 1995 and 1996 irrigation service fees at ARLID were approximately US$7.5 per hectare per irrigation[8]. With 5 irrigations per year fees total US$37.50 per hectare, or 2.5US$ /1,000 m^3 with an approximate total irrigation depth of 1,500 mm. By 1997, these fees have increased to US$13.5 per hectare per irrigation.

As a result of IMT, a negotiated proportion of the fees collected by the WUAs is paid to CNA for provision of O&M services at the headworks and in the main canals. Percentage paid to CNA range from 11 percent to 28 percent of the fees collected, depending on the complexity and level of service CNA provides to each module. The annual water fee paid by farmers and established by the WUA must be approved by CNA.

Water allocation and distribution rules

Allocation. Water allocation rules at ARLID are based on three principles. First, at the beginning of each agricultural year (November) CNA determines the water availability in the reservoirs serving the district. Each module is concessioned a percentage of the available volume in the reservoirs. These concessions are in proportion to areas with surface water rights in each module, and are irrespective of the actual area irrigated or the crops grown. Based on these concessions and the water availability at the start of the agricultural year, the hydraulic committee makes a annual plan of how much volume will be allocated to each module. These planned volumes can differ slightly from the concessioned percentage as every year these volumes are adjusted for under or over usage of water by the module in the previous year.

Second, normally the full command area of each module can be irrigated. However, in times of water scarcity the total area to be irrigated is determined in negotiation between CNA and the modules in the hydraulic committee. This can vary from module to module and is basically determined by physical characteristics of the module, experiences with past cropping patterns and farmers preferences.

Third, the hydraulic committee also decides on the number of irrigations that can be delivered to each module, the start and the end of each irrigation period, and whether irrigation will be provided during both winter and summer seasons. Generally, this decision counts for all modules. CNA is reluctant to open the dams to deliver water to only a few modules as this would mean considerable conveyance losses in the main system

Distribution. Water distribution rules are based on four principles. First, a farmer cannot receive more irrigations than the maximum number of irrigations allocated to the module. Exceptions are made for farmers who grow crops that require more frequent irrigations, like beans, but only if this extra irrigation falls within an irrigation period determined by the third allocation rule mentioned above. Second, each farmer can grow any crop he wants to grow. Third, farmers cannot request water for more than the area registered in his or her name. In case the hydraulic committee decides

[8] The average exchange rate for the years 1995-97 was US$1.00 = N$7.50.

that less than the full command of the module can be irrigated, the module decides on the maximum area that can be irrigated by a farmer. Forth, the maximum volume of water a farmer can receive is determined by the module, based on a theoretical or planned water depth per irrigation. Generally, the module does not distinguish between water requirements of different crops, but uses a flat depth across its farmers, irrespective of the crop he or she grows.

Scheduling. Based on the total number of irrigations requested for farmers and the planned water depth, the module calculates the weekly total volume requested for by farmers. The weekly requests are communicated to CNA for scheduling deliveries to the modules. Daily CNA and module staff check at the module intake whether requested volumes are actually delivered. Water distribution between the secondary canals or laterals within a module is based on the same arranged scheduling. For each canal the total volume requested is calculated and gates are set accordingly. Unlike what is common practice at the head of the module, volumes that enter the secondary canals are not measured, but are estimated by ditchtender based on their experiences.

Operational targets and monitoring

Explicit management targets do not exist for ARLID, but interviews with system managers and two years of observations of daily management practices reveal that CNA and the modules are concerned about meeting the following six targets:

- Modules get the seasonal volume of water they have been assigned to at the start of the agricultural year.
- Modules and farmers do not irrigate an area that exceeds the planned area.
- Modules receive the weekly scheduled volume of water they have requested for at the start of each week.
- Farmers get the number of irrigations they are entitled to and have requested and paid for.
- Farmers get sufficient water to irrigate the area they are entitled to to irrigate.
- O&M costs should be fully recovered from the farmers.

CNA and the modules use several techniques to monitor whether these targets are met. Monitoring is done at three system levels.

At the field level, ditchtenders report daily to the module how many farmers have received water, for how much area and for which crop. At the end of each day ditchtenders meet at the module office to check whether their reports correspond with the weekly schedule. An estimate of the volumes delivered to each farmer is also reported. Weekly these reports are aggregated for the entire module and are sent to the CNA district office.

At the module level, daily measurements are taken at the head of the main canal, as well as at a small number of other hydrological control points. Daily reports mention both planned or scheduled and actual volumes. In theory, these volumes are checked by CNA and the module. Reports should carry signatures of both. A weekly report that totals daily volumes is sent to the CNA district office.

At the district level, CNA aggregates the reported volumes, irrigated areas and crops and produces monthly reports which are presented and discussed in the hydraulic committee meeting. Finally, as farmers have to pay their water prior to each irrigation they receive, modules are able to keep good track on the total amount of fees paid by farmers. At the end of each season, the modules report their total fee collection to CNA. As the seasonal plan defines the total area to be irrigated as well as the number of irrigations to be delivered, it is easy to calculate the total planned fee collection (planned irrigated area * # of irrigations * fee) and to monitor whether actual collection follows planned collection.

Although the described activities should be sufficient to monitor daily, weekly, monthly and seasonal performance relative to the 6 targets mentioned above, a few practices limit this. First, the ditchtenders' reports form the basis for most of the data reported to both the modules and the CNA district office. As will be demonstrated below, their estimates are often very inaccurate and unreliable. Second, monitoring of daily and weekly water distribution is based on aggregated field reports, rather than on real measurements at the canal level (except for the head of the main canal). Even so, all modules use computers, aggregation of field level data takes a lot of time. As a consequence, the production of weekly reports takes more than a week, production of monthly reports sometimes several months, and seasonal reports are normally not published before the start of the next season. As a result, these reports hardly serve as tools to take immediate management decisions when needed.

Data Collection Methodology

Performance indicators were applied for winter and summer cropping seasons from 1982 to 1997 to the district as a whole and to the 11 irrigation sub-units (or modules).

IIMI's study of ARLID was started in October 1995, with the establishment of a project offices in Cortazar and Salvatierra modules. Data collected include primary sources in the two modules and secondary sources with respect to the files kept by the respective WUA and CNA at regional, state and central levels.

The study combines data from a number of different sources, at different system levels. Time series data for the cropping seasons 1982-97 stem from records kept by CNA at irrigation district, regional and central level, as well as from the 11 WUAs at the module level. These data included cropping patterns, crop yields, farm gate prices, climate data from seven selected stations within and near the district, monthly and seasonal canal flows at different system levels, dam storage and releases, cost and volumes of maintenance work done, irrigation fees collected and planned and actual O&M budgets. Where possible, daily or weekly records were used and aggregated by IIMI, rather than using seasonal or annual summary reports published by the agency and the modules.

CNA as well as most WUAs use computers to enter, monitor and process their data. IIMI always had full and unconditionally access to these as well as other files, which provided excellent transparency of the data used for this study. Several tools were applied to check the quality of the data. Aggregation of module level data provided a cross-check for data collected at the district level. Secondary data was further cross-checked by data collected from other sources like rural development banks. Although not presented in this paper, primary hydrologic data collected for an ongoing performance study (Kloezen and Garces, forthcoming) provided a tool to cross-check the quality of officially reported canal flows at different hydrologic control points in the system during a period of four irrigation seasons.

The FAO CROPWAT and its complement CLIMWAT software packages were used to calculate crop water requirements (FAO 1996). The program is based on the calculation of a reference evapotranspiration (ETo) through the modified Penman-Montieth equation and provides three methods for the calculation of effective rainfall. Data on humidity, windspeed and hours of sunshine were taken from two nearby stations given in CLIMWAT. Rainfall and maximum and minimum temperature data were collected from 5 stations within or near the district and the two selected modules.

Outputs per unit of land and water were calculated following the standardized procedure described in Molden (1997). This procedure converts cropping patterns that comprise multiple crops into 'equivalent' yields and Standardized Gross Value of Production. The equivalent crops used is this study are wheat for the winter season and sorghum for the summer season.

To make comparisons across countries and time possible, IIMI converts local units and currencies to international standard units and constant US dollar prices. Especially the latter proved to be a difficult task for the evaluation of the Mexican IMT program. By December 1994 Mexico faced an economic crisis, which was followed by a devaluation of the peso against the dollar (from 3.5 pesos per dollar in July 1994 to an average of 7.5 pesos per dollar during the period 1995-97), as well as an inflation rate of approximately 50% in 1995. The start of the crisis fell exactly in the middle of the 4 post-transfer years. In this paper, as far as possible, all prices are converted into constant July 1994 dollars for the time series.

This paper present results that are mainly based on the collection of these secondary data for the use of external indicators. However, in order to evaluate this data collection procedure, comparison with primary field data collection procedures is useful. The following primary data were collected

- Daily field observations of water management related practices by leaders of WUAs, CNA staff, ditchtenders and farmers during a period of two years (Kloezen and Garces forthcoming).

- Measurements of water flows in selected canals, laterals and fields during four irrigation seasons; volumes pumped and energy consumption of selected wells (*ibid.*).

- A household survey in order to establish the cost of production and the cost of water to farmers, during a period of one year (*ibid.*)

- Users' perceptions of the impact of the IMT program were captured by both semi-structured open-ended interviews and a farm survey. For the farmer survey the system was divided into four zones which aggregated modules with similar physical, hydraulic, agronomic and socio-economic conditions. A total of 125 randomly selected farmers within the four zones were interviewed through a carefully designed and pre-tested questionnaire (Kloezen, Garces and Johnson forthcoming).

- Open and informal interviews with key informants, as well as attendance at CNA, module and hydraulic committee meetings and workshops during a period of two years helped to better interpret secondary data and the impact of the IMT program on the position of farmers and irrigation staff (*ibid.*).

The data collection procedures described above are evaluated later in this paper, after the discussion of the result.

External Performance: One Year, One District

The basic idea behind external indicators is that they provide a tool to compare irrigation performance of a specific district to other irrigation systems world wide and to other years. Yet, it would be interesting to see what kind of information on irrigation management performance and its agricultural output can be obtained by only looking at external performance in one year.

Data for the 1995-96 were used for this purpose and are presented in Table 1. Production values are already given in 'equivalent' yields in order to follow the standardized procedure. Corresponding farm gate and world market prices of base crops are given to calculate the agricultural-based indicators. The indicators are explained in the paper that Molden prepared for this workshop.

The 1995-96 agricultural years was average in terms of rainfall and water availability. In November 1995, the start of the 1995-96 agricultural year, the gross storage in the four reservoirs supplying the district was 1,118 MCM, of which approximately 742 MCM was assigned to irrigation. This gross storage is the sixth lowest level in a series of 14 years reported in Kloezen, Garces and Johnson (forthcoming), while the volume assigned to irrigation is about 140 MCM less than the annual average of 880 MCM available for the district. The hydraulic committee decided that this volume was sufficient for a total of five irrigations: four for irrigation of winter wheat, and a single irrigation for summer sorghum. As is shown in Table 1, the actual total supply for both season was 807 MCM, of which 773 MCM was released from the dams and the remainder from public wells. This means that dam release was five percent higher than planned by the hydraulic committee.

Table 2 summarizes the external indicators for the irrigation district, which are discussed below.

Relative Water Supply (RWS). The indicator is the ratio of total water supply to the total demand at field level, and can be used both as a measurement of adequacy (Levine 1982) and seasonal timeliness (Meintzen-Dick 1995). According to IIMI's definition, the total crop demand at field level includes consumptive use, non-beneficial ET, losses to drains and net flow to groundwater. Given the lack of reliable data and the complexity of the surface-groundwater interface, non-beneficial ET, losses to drains and flows to groundwater could not be measured, but are estimated to be 5 percent of total demand.

Table 2 shows that the RWS values are high, generally above 2.0 at the level of the intakes to the modules. Previous worldwide experience with the RWS indicator would suggest that the district did not face a constraining water availability situation during the observed year and that water distribution is not tightly related to crop water demand (Levine 1982, Murray-Rust 1983 and Garces 1983). Water supply has adequately met the crop water requirements.

Table 1. Basic data set used to calculate external indicators of the Alto Rio Lerma Irrigation District, agricultural year 1995-96.

	Winter 1995	Summer 1996
Gross Command Area (ha)		
Surface irrigation	77,697	77,697
Public wells	7,421	7,421
Surface irrigation plus public wells	85,118	85,118
Private wells	27,654	27,654
Cropping Intensity (%)		
Surface and public wells	70	60
Private wells	75	90
Main Crop (% of total cropped)		
Surface and public wells	Wheat (92%)	Sorghum (81%)
Private Wells	Wheat (62%)	Sorghum (82%)
Equivalent Production (ton/ha)		
Surface and public wells	6.7	9.8
Private Wells	8.9	9.6
Gross Irrigation Supply (x 1,000 m^3)		
Surface and public wells	667,440	139,236
Private wells	191,370	111,002
Rainfall (mm)		
Total	54	683
Effective	44	510
Evaporation (mm)	929	1,098
CROPWAT Water Requirement (mm)		
Surface and public wells	500	497
Private Wells	467	507
Sales Prices (US$ /ton)		
Farm Gate Price	247 (wheat)	120 (sorghum)
World Market Price	262 (wheat)	105 (sorghum)

Relative Irrigation Supply (RIS). This indicator is the ratio of irrigation supply over irrigation demand (total demand less effective rainfall). Effective rainfall is assumed to be 80 percent of total rainfall. This 80 percent method is one of the three methods suggested by CROPWAT, and is supposed to be suitable for areas with relatively low storms. Storms in ARLID never exceed 20 mm/day. By definition, effective rainfall can never exceed the crop water requirements. In cases where effective rainfall equals crop water requirements, the RIS value is zero.

The winter season value of 2.5 suggests abundant irrigation supply relative to the irrigation requirement. For the rainy summer season the value of zero means that effective rainfall equaled crop water requirement or was higher, which means that no irrigation would have to be supplied.

Table 2. External indicators for the Alto Rio Lerma Irrigation District, 1995-96.

Indicator	Unit	Winter 1995-96	Summer 1996	Entire Year
Relative Water Supply	(ratio)	2.4	1.9	
Relative Irrigation Supply	(ratio)	2.5	0.0	
Water Delivery Capacity	(ratio)	4.6	5.6	
GVO / unit of land cropped	US$ / ha	1,752	1,028	2,780
GVO / unit of command	US$ / ha	1,228	612	1,840
GVO / unit irrigation supply	US$ / m^3	0.16	0.37	
GVO / unit water consumed	US$ / m^3	0.35	0.21	
Gross return on investment	%			23
Financial Self-sufficiency				
Actual collection over O&M cost	%			109
Actual over Planned collection	%			123
Loss to waterlogging and siltation	%			negligible
Fall of static water table	meter/year			2 to 5

Water Delivery Capacity (WDC): This non-dimensional indicator addresses the question of whether the system has been designed and constructed in such a way as to be able to meet the peak water demand in a particular period. The high values for the system as a whole can be explained because it is the river itself that carries the discharges supplied by the dams to the various main canals. Hence, in order to obtain the WDC it is better to look at each of the main canals. Two examples are given here. The Coria main canal that serves in Cortazar, Irapuato and Abasolo modules has RWS values of 1.1 and 1.3 for the winter and summer seasons, respectively. WDC values for Gugorrones main canal in Salvatierra module are 2.2 and 2.6, respectively. These examples show that the modules have sufficient capacity at their intakes and therefore allow for the high RWS values presented above.

Yields. Table 1 shows that the average winter wheat equivalent production in ARLID was 6.7 ton/ha The equivalent sorghum production of summer sorghum is 9.8 ton/ha. These equivalent production values for wheat and sorghum are high compared to actual production levels for these crops: between 5.5 ton/ha and 7.0 ton/ha for wheat, and between 7.0 ton/ha and 8.5 ton/ha for sorghum. The higher equivalent values is explained by the fact that farmers also grow beans and vegetables, which produce high wheat and sorghum equivalents. Both normal and equivalent yield levels are high compared to other irrigation district in Mexico (Palacios-Vélez 1994b) and nearby small scale irrigation systems in the State of Guanajuato (Dayton-Johnson 1997).

GVO per unit of land cropped (US$/ton). The winter season value is close to US$1,800. The corresponding summer season value is much lower as a result of depressed world market prices of the main crop: US$262/ton for winter wheat against US$105/ton for summer sorghum.

The annual GVO is approximately US$2,800 per hectare cropped. Here, a problem with this external indicators expresses itself. One need to have a reference to be able to interpret the value. In comparison to 15 other systems studied by IIMI (Molden, Sakthivadivel and Perry forthcoming), the output per unit of cropped land of ARLID are among the highest.

GVO per unit of command area (US$/ton). The annual cropping intensity of 130% explains why the total annual GVO of US$1,840 per hectare is lower than the value obtained from the previous indicator. .

GVO per unit of irrigation supply (US$/m³). The winter season value of US$0.16/m³ is slightly higher than those reported for the Coello (US$0.12/m³) and Saldaña (US$0.11/m³) systems in Colombia, which are also arranged scheduled systems but under different climatic and economic conditions (Vermillion and Garces 1996). Comparison with other systems reveals that -irrespective of the relatively high RWS values found- the ARLID output per unit of irrigation supplied values are in the range from medium to higher values (Molden 1997).

Although the market price for the main summer crop is much lower than for the winter season crop (Table 1), the values of output per unit of surface irrigation supplied are nonetheless higher since much less irrigation is needed due to the higher rainfall.

GVO per unit of water consumed (US$/m³). In general, for the winter season, these values are higher than in the previous indicator because it excludes system losses and considers only that resource that was actually evapotranspirated by the crop, the non-beneficial ET, losses to sinks and thus is no longer available to be used elsewhere.

Gross return on investment. The construction cost of a water distribution system of the same characteristics of the ARLID can be obtained from current construction work by CNA. This cost is estimated at US$8,000 per hectare (CNA 1996). Utilizing the annual GVO per unit of command for the entire year on the district, the gross return on investment is 23 percent. This value compares favorably with those reported by Vermillion and Garces (1996) for Coello and Saldaña and RUT (Alvarez 1997) in central Colombia, but are much lower than the values obtained in Samaca (Mora Peña 1997).

Financial self-sufficiency. This indicator can be expressed in both actual fee collection over actual O&M expenses and actual fee collection over planned fee collection. Planned fee collection is obtained from the product of the fee per hectare, times the number of irrigations entitled to, times the area to be cropped. From Table 2 it is apparent that the level of self-sufficiency is above 100% for this particular year. This suggests that expenses are kept under control and that there is good planning in establishing fee levels required to operate the system smoothly.

Environmental impacts. No significant evidence was found pertaining to negative environmental effects as a consequence of either water logging or salinity conditions.

Groundwater table fluctuations have been monitored and point towards a worrisome situation. In 1995, and following a trend over the last five years, static water tables are falling at an average annual rate of 2 to 5 meters, reaching an average depth of more than 100 meters. The high concentration of wells in the State of Guanajuato has resulted in an alarming annual over-exploitation of groundwater of 829 MCM for the entire State and 117 MCM for the three aquifers that serve the irrigation district. These volumes correspond to an over-exploitation of the aquifers by factors of 1.4 and 1.2 for the State and the district respectively.

Summarizing this section, the values in Table 2 suggests that ARLID is a system without any constraints in water availability and water delivery capacity. The high RWS and RIS may point to the need of further research on how exactly the water is used and what happens to excess water. The system produces high outputs, both per unit of land and unit of water. Furthermore, farmers adequately cover O&M costs. The alarming level of fall in the static water table definitely asks for further studies on how the aquifer is management.

Comparison of Performance Across Modules

As is demonstrated in the previous section, the application of external indicators for one district for one year provides a snap shot of the type and quality of performance. This is particularly the case if performance can be compared to other systems or if reference values are available for each of the indicators. This section of the paper shows that application of external indicators to sub-units allows to distinguish important differences in performance within the system. Although, the indicators do not explain these differences, they help to signal out irrigation management gaps within the system. Three examples are used to support this argument.

The first example shows the difference in RWS values for the winter irrigation season across the 11 modules. Figure 3 shows RWS for three successive winter seasons, plus the average of these values. A number of observations can be made from this graph.

First, there is a clear difference between the modules. The three year average of the 11 modules is 2.6. Yet, as can be observed from the graph, especially Acambaro and Salvatierra modules have much higher averages (3.5 and 4.6, respectively), whereas Valle has only 1.7. The rest of the modules have values that range from 1.9 to 2.9. The high value of Acambaro can be explained by the fact that this module is located right under the Solis dam and hence has easy access to water. Furthermore, owing to its climate conditions, it needs less irrigations and therefor can use its concession to apply higher water depths per irrigation. As explained in detail by Kloezen, Ramirez and Melgarejo (1996) and Kloezen and Garces (forthcoming), the extremely high values in Salvatierra are explained by the fact that this module has a high percentage of crops with lower water requirements, like beans and vegetables. Yet, the module plans and schedules its irrigation deliveries as if all farmers grew wheat. Also, the module suffers from severe disrepair of its infrastructure as it uses some of the most ancient irrigation canals in the Latin American continent.

Second, with exception of two head-end modules of Acambaro and Salvatierra, there does not seem to be a clear head to tail bias of water allocation between the modules. This suggests that the district management seems to succeed in allocating irrigation following the proportional concession of each module.

Third, seven of the 11 modules succeeded in reducing its RWS values in the three successive years demonstrated in Figure 3. As will be discussed below, this reflects the effort of most modules to reduce its water use after the responsibility of irrigation management had been transferred to them in 1992.

Figure 3. RWS values for the modules of the Alto Rio Lerma Irrigation District, winter seasons 1994 to 1997.

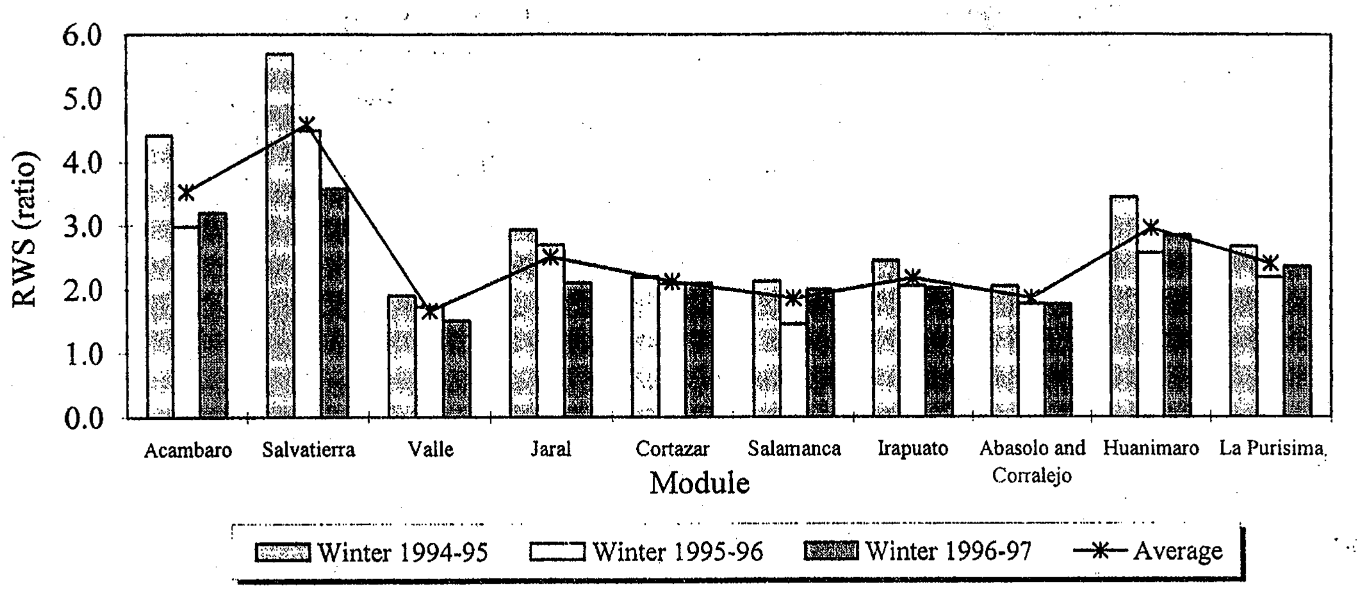
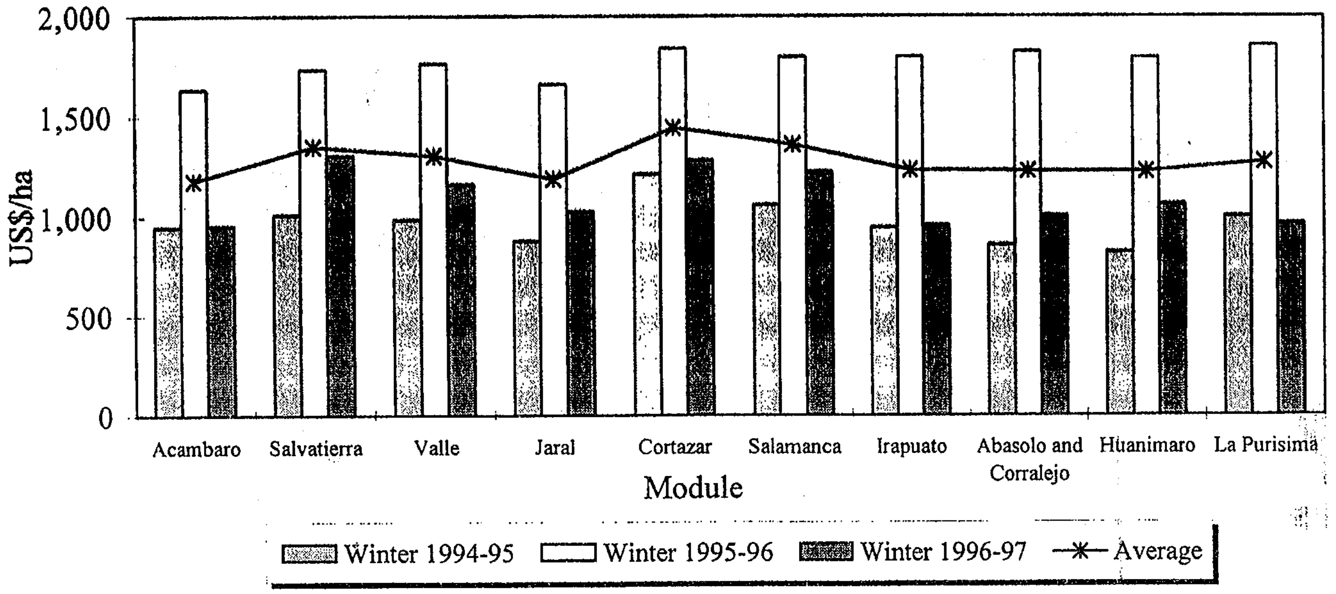


Figure 4 shows the second example of how external indicators can be used to distinguish between differences in performance across modules.

Figure 4. Standardized gross value of production (GVO) per hectare for the modules of the Alto Rio Lerma Irrigation District, winter seasons 1994 to 1997 (adjusted for World Market Price).

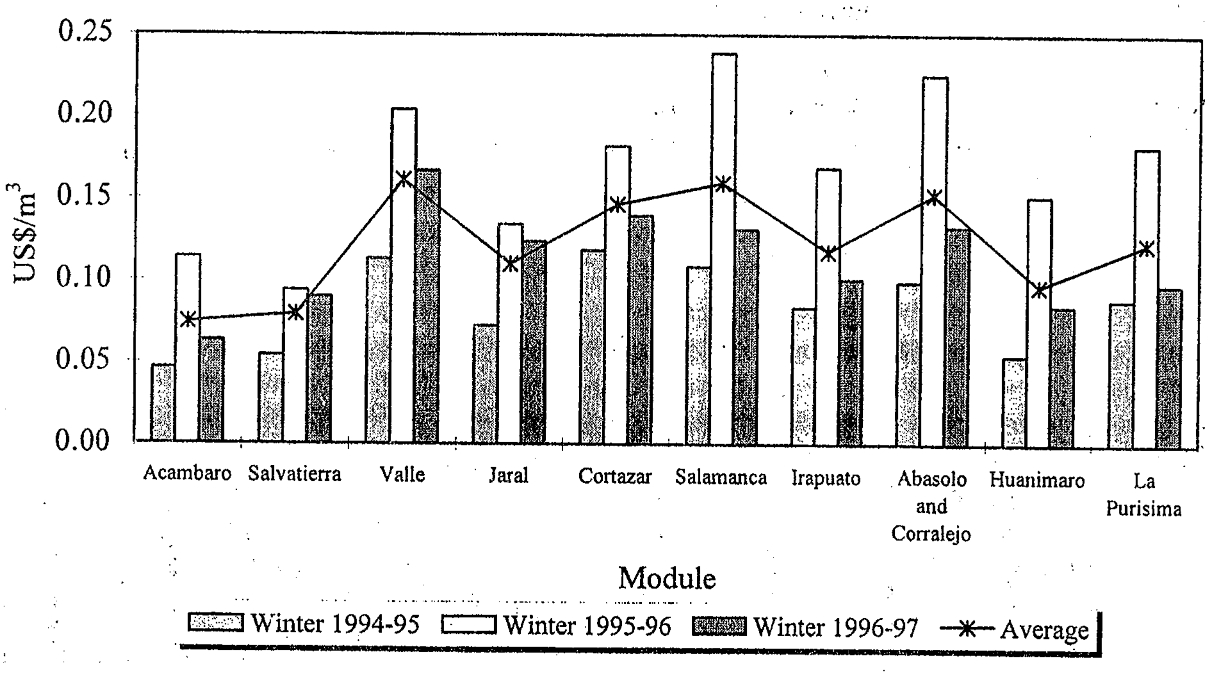


Although, 'normal' wheat yields ranged from 5.5 to 7.0 ton/ha in the three years reported in Figure 4, equivalent yields ranged from 5.2 ton/ha in Huanimaro (1994-95) to 7.6 ton/ha in Salvatierra (1996-97). This high equivalent yield in Salvatierra is explained by the fact that during the 1996-97 winter season 21% or the irrigated area was cropped with beans. Yet, Figure 4 shows surprisingly little difference in standardized GVO/ha. The average value is US$ 1,279 per hectare, while the standard deviation is only US$81/ha (or 6.3 %). This suggests that the modules are able to guarantee productivity, irrespective of their level of water availability. There is no correlation between the RWS values and the productivity of the modules. The correlation coefficients between these values are -0.13, -0.50 and -0.11 for 1994-95, 1995-96 and 1996-97 respectively[9].

A second important observation from Figure 4 is the high difference in values between three years that are reported. The average values for these years are US$973/ha, US$1,769/ha and US$1,095/ha. These difference are entirely attributed to the change in world market price for wheat in those years: US$159/ton, US$262/ton and US$ 173/ton, respectively.

Finally, Figure 5 shows the output per unit of irrigation water supplied. It could be regarded as a combination of both previous graphs and summarizes the conclusion of this section. The graph shows the high range in values, with no clear bias to the location of the module. The average value is US$0.12/m^3, while the standard deviation of the average values is US$0.03/m^3 (or 25%). Comparision of the three graphs suggests that farmers in ARLID pursue yield per unit of land as an objective, rather than optimizing their output per unit of water.

Figure 5. Standardized gross value of production (GVO) per m^3 for the modules of the Alto Rio Lerma Irrigation District, winter seasons 1994 to 1997 (adjusted for World Market Price).

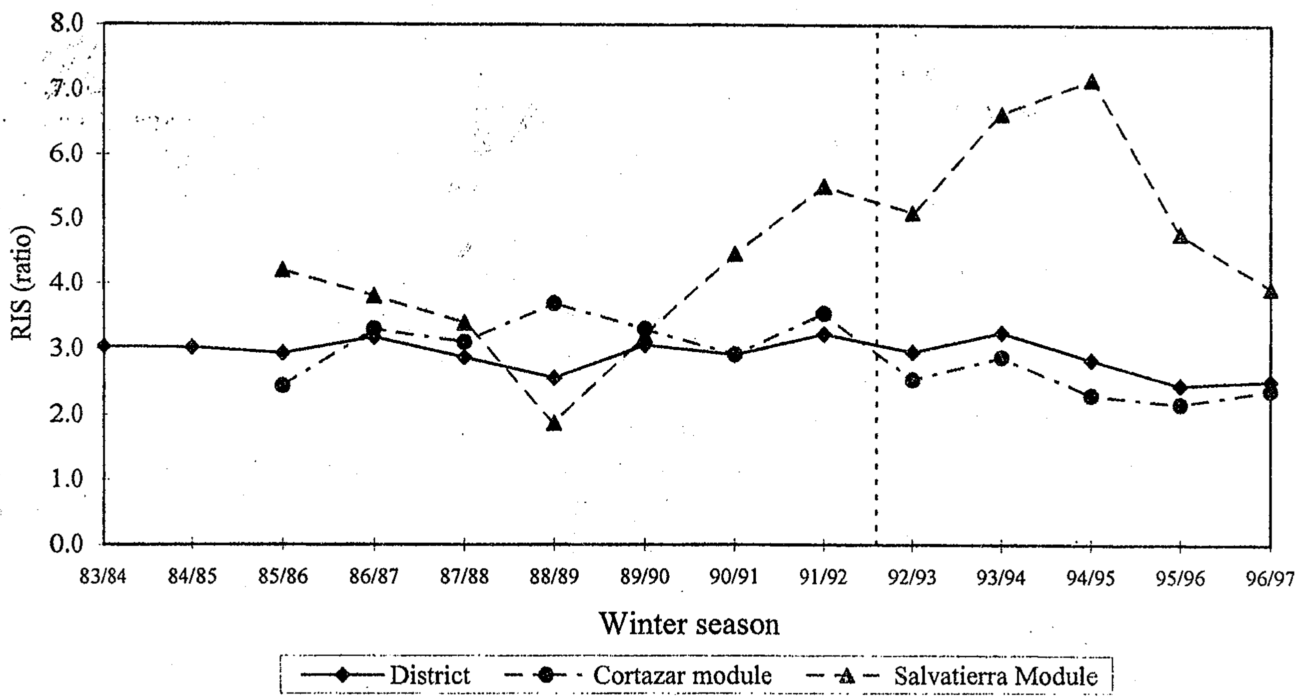


[9] Also Garces (1983) demonstrates in his thesis that, especially for RWS values higher than 1.5, there is no correlation between RWS and productivity.

Comparison of Performance over Time

IIMI´s first mandate to do research in ARLID was to assess the impact of the IMT program on irrigation management, O&M financing, cost of water to farmers as well as to evaluate agricultural and economic effects of this program. The set of external indicators proved to be an excellent way to start comparing the quality of performance over time. For this purpose 1983 to 1997 time series were used, which comprise 10 pre-transfer and 5 post-transfer years. It was hypothesized that these time series would help to indicate major changes in performance as a result of an management intervention program like IMT. These time series were applied at the district level, as well as for two selected modules: Cortazar and Salvatierra. During the course of the study the need to add other and more detailed external and internal indicators emerged, particular in the fields of reservoir management, seasonal water allocation between modules, maintenance and O&M financing. The minimum set of indicators proved to limited in assessing changes in system maintenance, which appeared to be one of the most remarkable impacts of IMT in ARLID. In this section only a few examples of the use of external indicators for assessing impacts of intervention are given. Kloezen, Garces and Johnson (forthcoming) provide a detailed analyses of the IMT program in ARLID.

Figure 6. Relative Irrigation Supply (RIS) values, Alto Rio Lerma Irrigation District and Cortazar and Salvatierra modules, winter season 1983-1997



The minimum set of external indicators provide two indicators that evaluate water use: Relative Water Supply and Relative Irrigation Supply. For the purpose of illustration, the RIS indicators is used in this section[10]. Figure 6 shows the historical change in this value for the winter irrigation

[10] The example given here only concerns the winter season, which is the main irrigation season. As seasonal total and effective rainfall

season and for the district and the two modules.

The first observation follows the one made on Figure 3: there is a considerable difference in values between the three examples presented. Particularly, Salvatierra module deviates from the average district values. Some of the reasons for this have been explained above and include, low cropping intensities, high diversity in crops grown, planning and scheduling as if all the crops require the same irrigation as wheat, and an infrastructure in condition of severe disrepair (Kloezen, Ramirez and Malgarejo 1996).

As for the impact of IMT on water use: the average district values continue to be high (around 3.0), which means ample irrigation supply over irrigation requirement, with little difference before and after IMT (average values of 3.0 and 2.8 for the pre and post-transfer periods, respectively). Although, there seems to be a slightly downward trend after IMT, the averages suggests that, at the district level, IMT has not had a discernible impact on the use of irrigation water. This is supported by other observations made during the period of research. Generally, IMT has not brought major changes to the way seasonal planning is done. At the district level, the hydraulic committee adopted the same planning method as was used by CNA. Also, modules continue to follow the methodologies established by CNA before transfer.

The example of Cortazar shows noteworthy differences in pre and post-transfer averages: 3.2 and 2.4, respectively. After its start in 1992, the module has put in a major effort to use its irrigation concession more optimal by training and closely supervising ditchtenders, restricting areas to be irrigated and rehabilitating some laterals and structures. This explains the clear downward trend in RIS values after 1992.

It is apparent that Salvatierra, in its initial years after IMT, could not stop the trend toward higher RIS values that was started under CNA management. Although values are still high in 1996 and 1997, the module unmistakably has made an effort to change its management policies and tries to optimize the use of its irrigation water.

One of the objectives of the Mexican IMT program was to aim at higher O&M cost recovery and financial self-sufficiency. The set of external indicators provide to look at this issue. One of the main reasons why farmers agreed to assume O&M responsibilities was that this would give them direct control over the fees collected from water users. In order to prepare farmers to paying fees that better reflect the actual O&M cost, two year before transfer CNA increased the charge by approximately 400 percent. After transfer the modules did not succeed in keeping up with inflation rates, which explains the fall from approximately US$ 17 per ha-irrigation in 1993 to about US$ 7.5 in 1996[11] and US$13.5 in 1997.

Figure 7 shows a decline in fees paid by farmers after correction for inflation. The fee dropped in terms of total cost per hectare per season, as well as the fee as a percentage of gross value of output (GVO). The figure indicates that the cost of irrigation to farmers has declined from almost 6 percent of the GVO in the year of transfer to two percent in 1996 and has come back to 5 percent in 1997.

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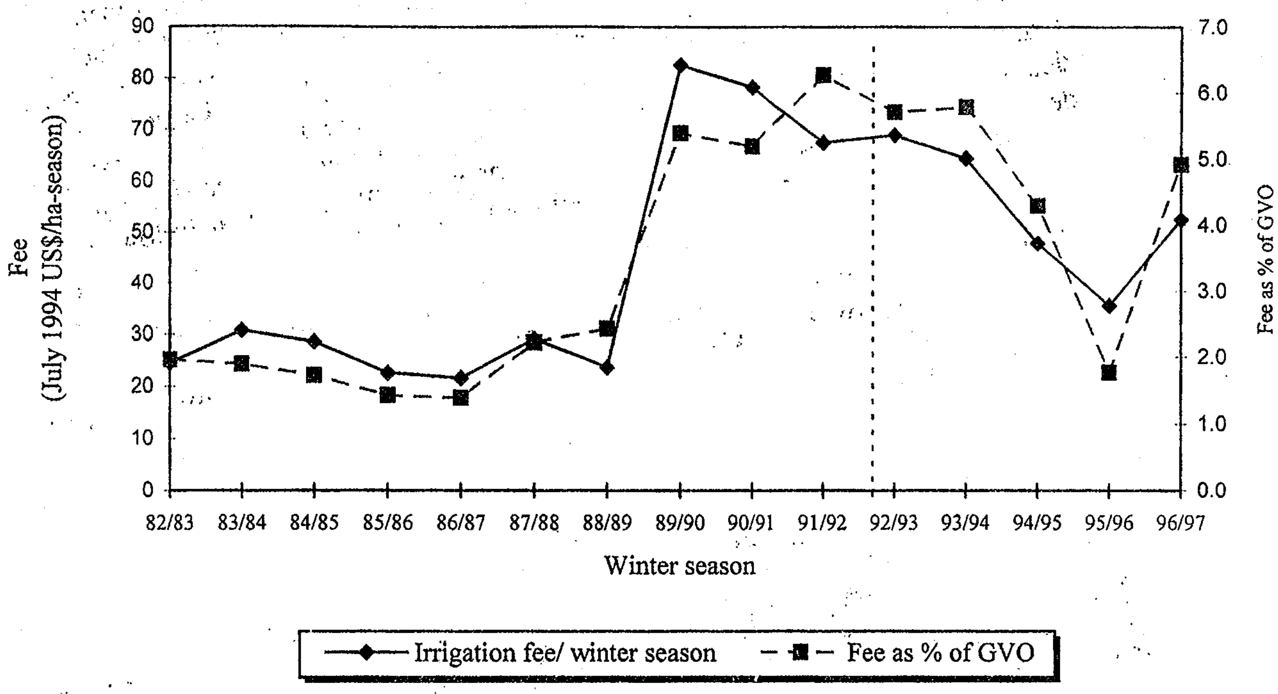
are low, RIS values follow the same trend as the RWS values and are generally a bit higher. Also, for the same reason, the method used to calculate effective rainfall has little effect on the RIS value.

[11] In actual peso terms the fee has remained the same.

Figure 7. Seasonal irrigation fee per hectare and as percentage of GVO, Alto Rio Lerma Irrigation District, winter seasons 1982-1997.



Irrespective of the recent erosion of the per hectare-irrigation fee, the modules succeeded in dramatically increasing the overall collection rate, as is shown in Table 3.

Table 3. Change in self-sufficiency and fee collection rate, Alto Rio Lerma Irrigation District (constant July 1994 dollars).

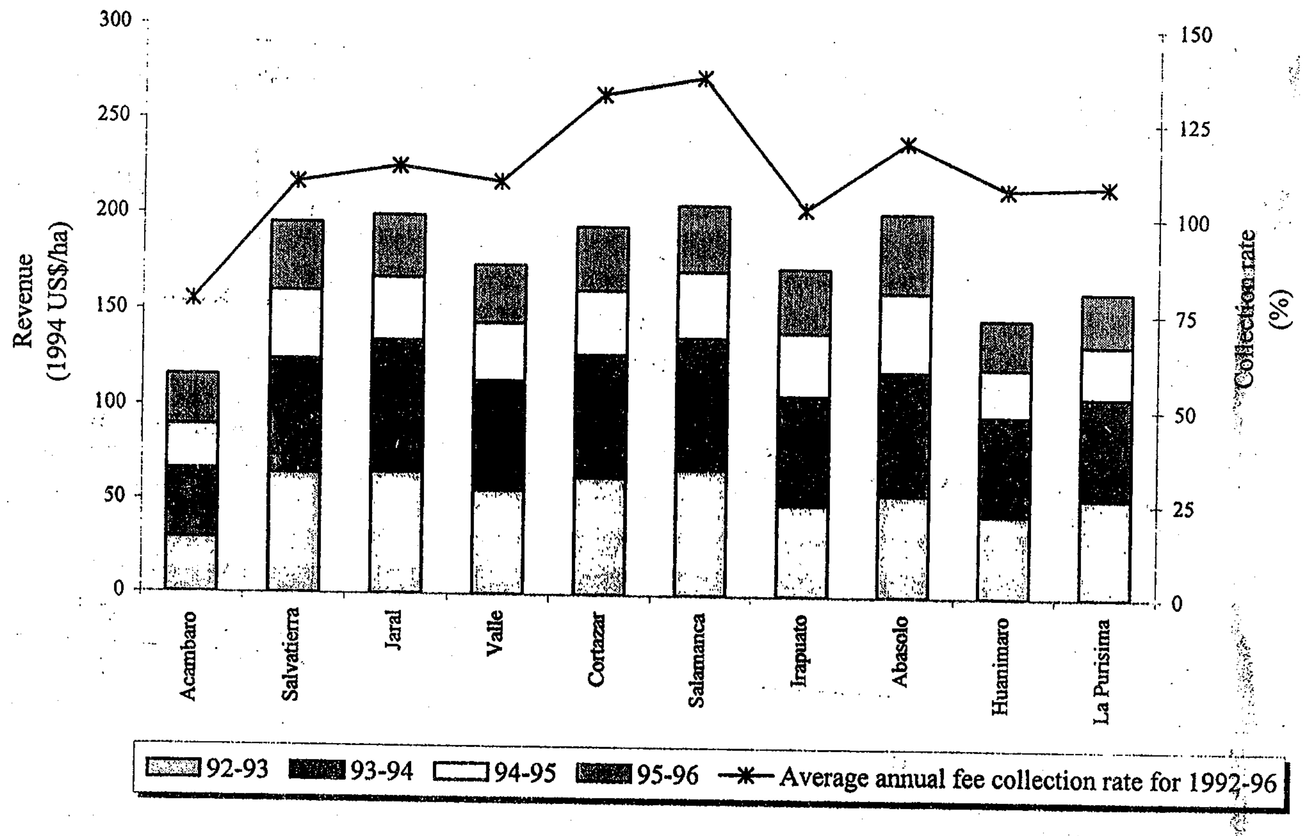
	1	2	3	4	5	6		
	Actual O&M cost		Planned collection		Actual collection		Self-sufficiency	Collection rate
	US$	US$/ha	US$	US$/ha	US$	US$/ha	% (5/2)	% (5/3)
1989	4,074,928	44	na	-	2,030,577	22	50	-
1990	4,144,268	44	na	-	1,742,121	19	42	-
1991	4,993,439	55	na	-	2,933,486	32	59	-
1992	4,796,412	55	na	-	na	-	-	-
1993	3,861,661	44	4,017,071	46	4,963,686	57	129	124
1994	4,233,114	49	4,636,448	53	5,275,288	61	125	114
1995	3,376,913	35	2,991,052	31	3,678,126	38	109	123
1996	2,495,467	26	2,608,077	28	3,180,179	34	127	122

na: not available

The table shows the development of both the self-sufficiency (actual collection over actual expenditure[12]) and the fee collection rate (actual collection over planned collection). Clearly, one of the major impacts of transfer in ARLID is the enormous improvement in self-sufficiency: from about 50% in the three years preceding transfer to over 120% in the post-transfer years.

Figure 8 combines time series and comparison across modules and shows the difference between modules in revenue mobilized per hectare from irrigation fees. These revenues range from US$ 116 to US$ 205 per hectare for four years, with an average of US$ 182 per hectare (1994 dollars). Acambaro module, which because of its higher elevation and cooler climate get by with one less irrigation and consequently collects less revenue from the fee. The figure also shows the historical decline in fee revenue as a consequence of the economic crisis that followed the December 1994 devaluation of the peso. Finally, the figure shows that most modules succeeded in maintaining a fee collection rate above 100%[13].

Figure 8. Fee revenue (US$/ha) and average collection rate (%), modules of the Alto Rio Lerma Irrigation District, 1992-96.



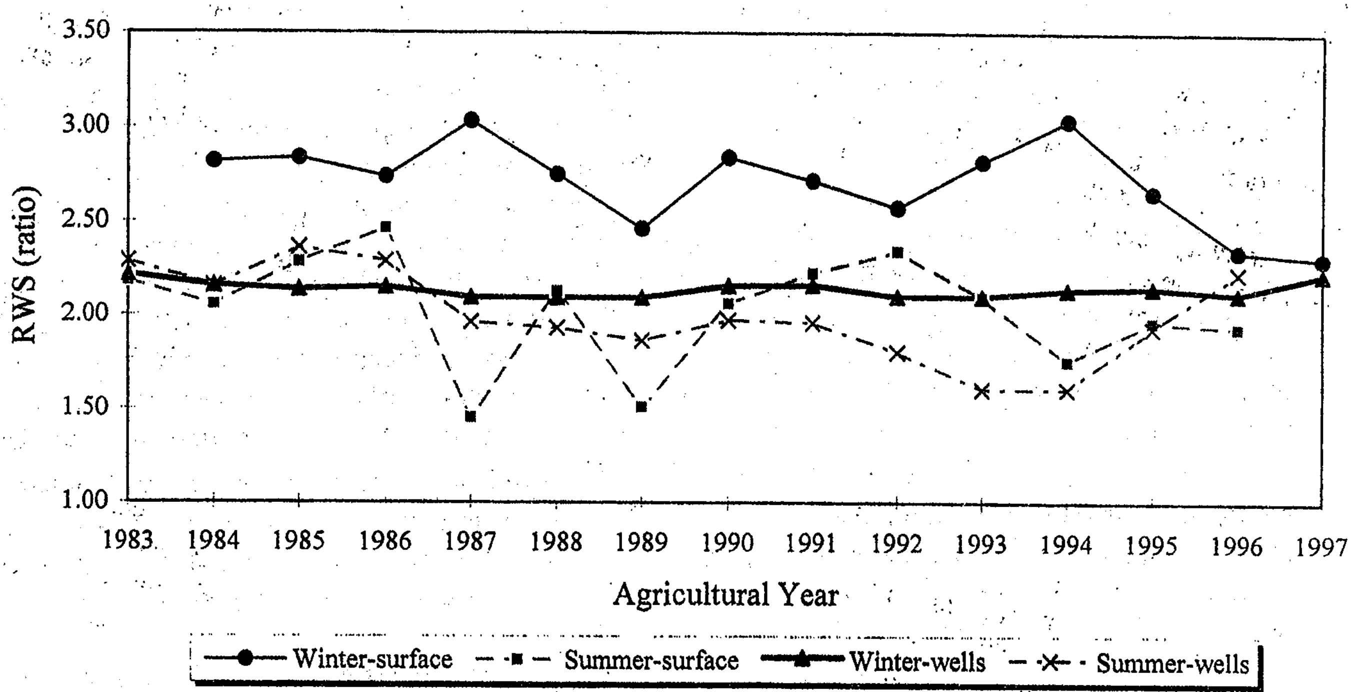
[12] The actual O&M expenditures after 1992 do not include the cost of the staff still employed by CNA as these are all paid out of federal funds rather than out of the fees collected from farmers.

[13] This was possible because modules often could deliver more irrigations over and above the amount upon which the planned collection target was based.

Comparison of Performance between Surface and Well Irrigation

External indicators were also used to compare performance of irrigation with different sources. RWS values for surface and well irrigation are compared in Figure 9. For the winter season, RWS values for wells are generally lower than those for canal water (averages of 2.1 and 2.7, respectively), but equally high for the summer season (average 2.0). However, given that the RWS values for canals are calculated at the intake point of the modules, while those for the wells represent on-farm level water supply, it is concluded that the farmers who use wells apply more water to their fields. Two reasons explain this. First, especially during the summer season, private well owners generally do not wait for the rains to come and start irrigating as soon as they can. As a result, often well users have already applied one or two irrigations when the rainy season sets on. Second, owing to subsidized energy tariffs the per hectare cost of pumping water during the winter season equals that for the irrigation fee paid for surface irrigation (Kloezen and Garces forthcoming).

Figure 9. Difference in RWS values between surface irrigation and well irrigation, Alto Rio Lerma Irrigation District, agricultural years 1983-97.



It is expected that some of the excess pumped water percolates to the aquifers and hence can be re-used. However, in places within the district the aquifers are located 150 meters below field level, which makes measuring recharge from excess irrigation very complicated. As a result, reliable CNA data on this type of recharge do not exist. But even if some of the excessive surface and pumped water recharges the aquifer, the fall of the static aquifer level with 2 to 5 meters per year and the annual over exploitation rate of 1.4 show that the lack of aquifer management policies and strategies.

The total volume pumped increased between 1983 and 1988 as a result of the relatively dry years of the early 1980s and the granting of concessions to new wells. Pumped volumes have dropped since

1989, basically because of the dramatic fall of the water table (*ibid.*). Although new concessions are not granted anymore, a program to upgrade existing pumps and wells was started in 1995 with the aim so use energy and water more efficiently. The first results of this program indicate to lower energy consumption, but it is not yet clear whether farmers pump less water.

The annual standardized GVO per hectare is approximately US$2,900 US$/ha for surface irrigation, and ranges from US$2,900/ha to US$4,000/ha for wells. The higher values for wells reflects the higher value crops usually grown under this technology.

Comparison with Internal Performance Indicators: an Example

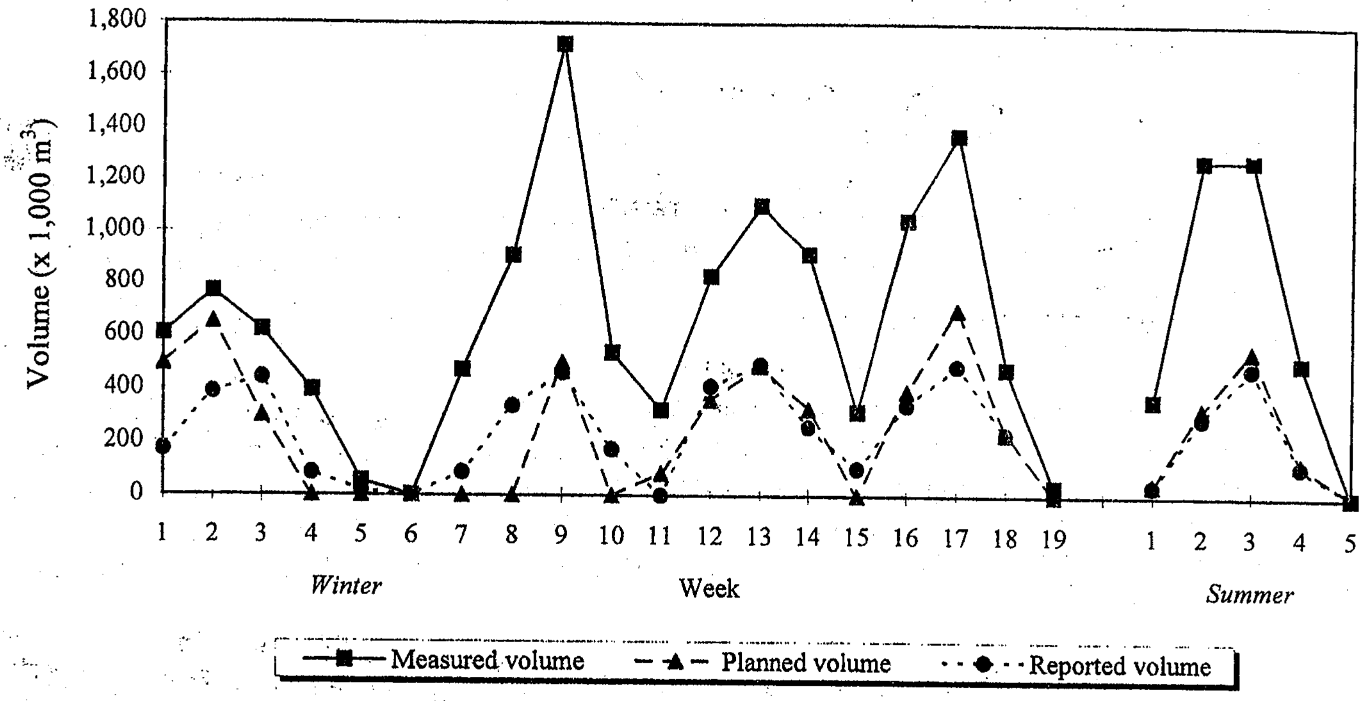
As mentioned in footnote 2, IIMI's research of ARLID also included performance assessments of a range of internal indicators (Kloezen and Garces forthcoming), which measured performance from field to district level and assessed actual performance over planned targets and reported values. In order to compare the type of information that can obtained from internal indicators with the information presented in the previous sections of this paper, one example of an internal indicator is discussed below: the actual supply over planned and reported supplies.

The actual supply was obtained through field measurements by IIMI (for the selected fields and canals) and by CNA for the intakes to the modules. Planned irrigation supplies are obtained from daily and weekly schedules of the modules and CNA and are the result of the monitoring activity by these agencies as discussed above. Similarly, reported volumes were obtained and aggregated from the daily field reports of the ditchtenders.

Figure 10 shows an example of weekly irrigation supplies to a selected lateral in Cortazar, which serves 650 hectares. The first observation is that planned and reported values show a very high correlation; on the average reported supplies are 97 percent of planned supplies. The reason for this is that at the level of the laterals and fields ditchtenders estimate but do not measure volumes. Although each delivery should provide a uniform planned irrigation depth to each farmer who requested an irrigation, the time allocated to irrigate one hectare is fixed by the ditchtender. The duration of supply is determined by the ditchtenders experience and the relationship with the individual water users. As a result, actual supplies can deviate considerably from planned deliveries. Yet, generally ditchtenders only report roughly the time farmers receive water. The ditchtender's main concern is to report the area a farmer had requested and paid an irrigation for, rather than the actual volume supplied. Using the planned water depth, he then calculates back the theoretical discharge (m^3/s), which is what they record in their daily irrigation reports to the modules. Measurements in 20 selected fields along this canal during a period of two irrigation seasons confirm this practice: during the winter season measured volumes were on the average 30% higher than reported, while for the summer season this was 33% (Kloezen and Garces forthcoming).

The second observation from the graph is the almost consistently higher measured values compared to planned values: on the average they are 194 percent higher. This can be explained through a combination of poor control at the intakes of the selected canal, lack of a measuring device and failure to adjust gate settings after conditions of the infrastructure had changed as a result of intra-season maintenance, as was the case in week 7.

Figure 10. Measured, planned and reported weekly volumes for a selected canal in Cortazar module, winter 1995-96 and summer 1996.



This example learns that application of an internal indicator provides information that would not have been obtained when only external indicators had been applied. For instance, only by applying the indicator for two years, IIMI could make observations on the way supplies are monitored and reported. These observations proved to be of crucial importance to be able to understand the source, the quality and the reliability of the data collected and reported by the modules and CNA, which in theory could form the basis of some the external indicators. The way irrigation deliveries are reported by ditchtenders blurs the actual adequacy of irrigation supplies in official CNA and module reports. As these reported volumes are the basis of the monitoring done by CNA and the modules, from the field upto the district level, this practice has also considerable consequences for the quality of the performance monitoring.

Also, after applying the internal indicators, IIMI has a better understanding of the priorities CNA and the modules have in their irrigation management practices. For instance, although in theory water distribution within the module is arranged by volumetric demands, the modules are more concerned about meeting the committed area to be irrigated. The priority of area over flows is consistently found at different system levels: from the level of module management (responsible for weekly planning) to the ditchtender at the field level (responsible for daily records), and is conducive to high levels of adequacy, not only to the module, but also within fields.

Finally, the example points strongly to two limitations of internal indicators. First, the example is very site (and in this case, canal) specific and does not provide information on actual performance in other canals or modules. Although, IIMI has done similar exercises in other canals and other modules, it is very reluctant to make far reaching conclusions on the management of entire modules or the district.

Second, measuring actual over planned supply at any given system level is one of the most simple exercises of assessing internal performance. Yet, what is the use of it, if system managers themselves have not included this activity it in their daily monitoring program? As mentioned above, the only supply actually monitored is at the intake of the module. Like the example of reporting deliveries shows, monitoring is more geared towards meeting administrative accountability than to managerial accountability.

Evaluation of Data Collection Procedures

This section evaluates the data collection procedures that were used to obtain the performance results presented and discussed above. It provides a comparison between the time and resources needed for calculating IIMI's external indicators to the effort needed to measure the limited set of selected internal indicators.

External indicators. The external indicators rely heavily on the availability of secondary data. Once contacts and good working relationships with CNA and the modules were established, IIMI was provided full and unconditional access to the requested data. As CNA and most modules use computers to enter and process their data, often computerized data files could be copied and used. Yet, data collections took more time than the one month anticipated. There are several reasons that explain this.

- In theory, most of the data could have been obtained at the district level (collected and aggregated by CNA). This would have required considerable less time input. However, it was felt that for the purpose of cross-checking and quality control, data should be collected as much as possible at the primary source. This has improved the reliability of the data presented in this study. However, logistically this meant that many time consuming visits had to be made to the modules. Furthermore, it takes CNA and the modules months to process their seasonal data.

- Often, different modules use different formats to enter their data. This makes comparison of module data and aggregation of module data to district level data difficult.

- Rather than using reported and aggregated volumes from the ditchtenders' reports, total volumes supplied to the modules had to be calculated by adding daily water measurements taken at a large number of control points. This is a time consuming process.

- Yields and farm gate prices vary from module to module and needed to be cross-checked with data from other sources.

- Converting yields and prices of more than 30 crops to a base equivalent crop at several system levels, for two seasons over a period of 15 years and for both surface irrigation and wells, required the development and management of large data bases.

- Given the differences in climate within the system, climate data from several stations had to be collected. Visits to more than 10 stations were made to check the quality of the collection procedure used by the stations. Because of the poor quality of the equipment used or awkward location of the station, several weather stations were rejected. Also, the remaining stations appeared to have considerable data gaps.

- Sometimes historical data were difficult to find, mainly as a result of the three administrative changes that the Ministry of Agriculture and CNA faced over the last 10 years. As a result, archives and files were lost or data formats had changed frequently. This complicated historical comparisons.

- Collection of financial data proved to be time consuming because it takes time to understand, interpret and cross-check the different line items and monetary flows presented in the books. In addition, financial years and agricultural years do not always correspond.

Development and modification of the spread sheets to enter and process the data took approximately two weeks. Data collection and checking took about four months. A secretary was hired and trained to enter the data, on which approximately one month was spent.

Internal indicators. In comparison to the external indicators, data collection procedures for applying internal indicators are more complex and time and resources consuming. Distinction must be made between data required for applying internal indicators at the module and district levels, and applying indicators at the level of selected canals and fields.

For the former purpose, in addition to the data required for the external indicators, secondary data on amongst others dam storage, dam releases and volumetric concessions, as well as planned and reported values data were collected, which took approximately one additional month.

Three engineers worked full time for more than a year to collect primary data and make measurement at the level of selected canals and fields. In addition, a M.Sc student and a part time assistant-engineer were hired to take the twice daily staff gauge readings and to provide assistance with the calibration of the staff gauges. Calibration of the staff gauges installed by IIMI proved to be the most time consuming activity. In addition, much time was spent on visiting the selected fields and taking several flow measurements per field, per irrigation. Calibrating selected wells, measuring flows from wells, taking energy consumption readings, as well as applying the farmer survey to obtain crop budgets, production costs and cost of water, appeared to be a relatively easy activity. An additional five months were spent on entering, cleaning and processing primary data.

Conclusions

The first objective of this paper was to test the usefulness of external indicators. The examples presented above clearly point out that internal and external indicators are fully complementary rather than competing and that they serve different research and monitoring purposes.

Application of external indicators at the district provides some idea of the 'health' of the system by looking in general terms to water use, agricultural and economic outputs, level of financial self-sufficiency and environmental impacts. However, this only proved to be possible because of the author's access to information about other system that could be referred to. The use of external indicators provides good information on the differences in quality of water management performance between the modules and water sources and hence on general performance of the entire district as well. Furthermore, it proves to be a powerful tool to assess the impact of intervention programs like IMT not only on system management, but on the agricultural and economic outputs if the management strategy as well. Finally, information obtained from applying external indicators help to point potential gaps in irrigation management policies, such as the way planned irrigation depths are calculate and the management of aquifers that serve the district.

The most important drawback of the external indicators is that they do not provide sufficient information on the reasons behind and the mechanisms of different types and quality of performance. Nor do they provide information on the logic behind management priorities and the nature of gaps in irrigation management policies. But they were not meant to do that.

In addition to measuring what they are supposed to measure (actual over planned performance), internal indicators fill in some of those analytical gaps and help to raise new questions that with the help of other research techniques, such as attending module and hydraulic committee meetings, observations of module-farmer relationships and interviews, can be answered. Yet, as the one example presented above shows, the most important problem with internal indicators is that they are very site specific and do not allow comparison with other systems, or even other sub-units within the same system. Furthermore, they are often used to assess actual performance relative to management targets that were set by researchers rather than system managers themselves.

Having worked with both external and internal indicators learns that both sets support and strengthen each other. Daily measurements and observations of irrigation management practices at lower system levels appeared to be necessary to understand the logic behind and the quality of the secondary data obtained from module, district and more central levels. For instance, it clearly pointed out the poor quality of the reported data, and consequently the low reliability of CNA's and the module's own monitoring data. These observations made IIMI to decide to take the extra effort explained above to cross-check the secondary data required for the external indicators. We strongly believe that this has considerably helped to improve the data used for the external indicators.

The second objective was to evaluate the applicability of external indicators. Several observations can be made in this respect.

- Compared to applying internal indicators (which generally requires daily measurements at different system levels), the application of external indicators is less time and resources consuming. Yet, given the large size of the system, the several system levels, the high diversity in cropping patterns, the several irrigation technologies and the overlap in irrigation seasons of most Mexican irrigation system, collecting, verifying and processing the basic data needed to calculate the external indicators proved to be more complex and time consuming than anticipated.

- The water-based external indicators rely on a water balance approach, as it aims to consider non-beneficial ET, flows to groundwater and so on. However, in many systems reliable secondary data on these components are not available. If comparisons are made across systems or countries it is necessary to know if the excess water in a particular place can be used elsewhere or not. A value of 2.0 is not necessarily better than 2.5 if in the latter case there is no opportunity to utilize the extra resource somewhere else. Compared to other systems, ARLID has good data. Yet, even with a relatively large research team and a good group of collaborators, IIMI-Mexico did not have the expertise, equipment and budget to better understand the hydraulic position of ARLID within the huge Lerma-Chapala water basin, nor to better understand the interaction between surface irrigation and recharge of the aquifers.

- In systems like ARLID cropping patterns as well as yields and prices vary from module to module. For this study we were fortunate that both CNA and all modules keep very good seasonal records on these agricultural data. For similar systems, but in different settings or countries with less well maintained secondary data and trained irrigation staff, applying even the minimum set of external indicators will be a difficult task.

- Using external indicators for time series proves to be difficult in cases like Mexico, which suffered from two economic crisis in the years recorded for this study. Devaluation of the national currency against the dollar as well as high annual inflation rates that generally follow these crisis, make it difficult to convert standardized GVOs to constant dollar prices.

- Using international world market prices in stead of local farm gate prices to calculate standardized GVOs only is useful when across country comparisons are made. For across system comparisons within one country and for comparisons over time it is better to convert local prices to a standard year using a local price index as it avoids that variations in world market prices distort actual local prices and outputs.

- Using standardized GVO to make over time comparisons of outputs and cost of irrigation to farmers is only possible if the correlation between GVO and NVO is constant over time as well. However, it is not clear whether this holds for countries like Mexico, which under went several economic reforms that affected the cost of production to farmers. The relation between GVO and NVO requires further study and the methodology to collect data on cost of production needs to be standardized.

- Although Molden, Sakthivadivel and Perry (forthcoming) combine different seasons to yearly values, in this case study it was necessary to apply the indicators to individual cropping seasons since the climate conditions for the winter and summer season are very different in terms of irrigation needs. Aggregation of seasonal information to yearly values does not provide useful information on system performance and potential gaps in irrigation management practices and policies. Likewise, as canal water and ground water are essentially managed separately it was also necessary to calculate individual indicators per water source. This meant a substantial increase in time needed to collect and process the data.

- An important parameter of the RIS is the effective rainfall. However, there exist several methods to calculate this. The results of each method might differ considerably and hence affect the RIS value. The main irrigation season in ARLID is the winter season, with very little rainfall.

Therefore, the method used to calculate effective rainfall hardly affects the RIS value. However, in seasons with more heavy storms and in hilly areas, the method to be chosen becomes very important and has to be standardized across systems.

The objectives of this paper were to evaluate the usefulness and applicability of external indicators relative to internal indicators. A next step in the research process would be to correlate types and quality of internal performance to external performance. This would require a much larger sample of years, modules, fields, and possibly systems and countries. From a methodological point of view, this enforces the need to standardize external indicators, which is currently attempted by IIMI. Moreover, it would require standardization of the enormous set of existing internal indicators and methodologies to calculate them.

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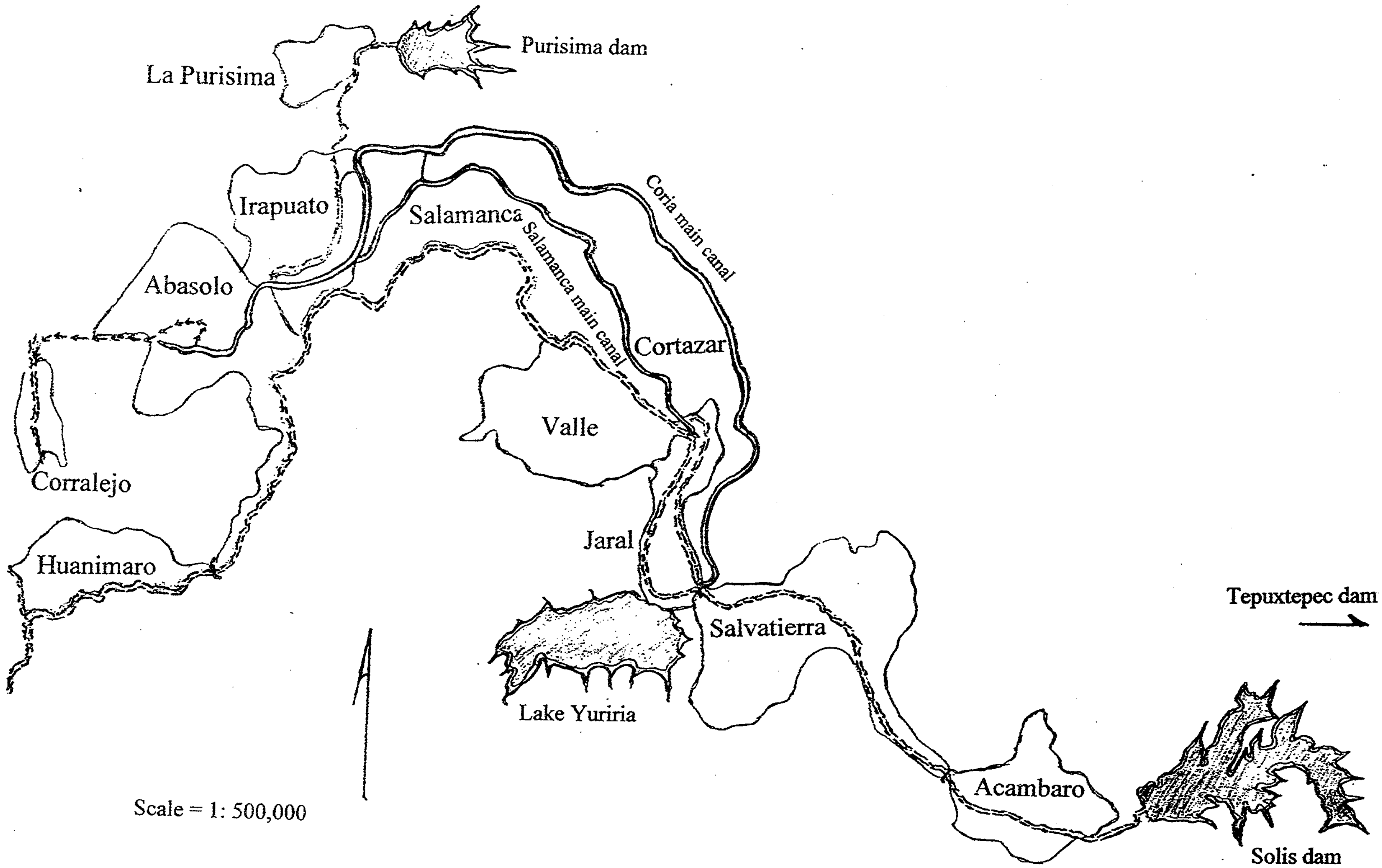
Purisima dam
La Purisima
Irapuato
Salamanca
Coria main canal
Salamanca main canal
Abasolo
Cortazar
Valle
Corralejo
Jaral
Huanimaro
Tepuxtepec dam
Salvatierra
Lake Yuriria
Acambaro
Solis dam
Scale = 1: 500,000

\nnex 1.

¦alient features of the 11 modules in the Alto Rio Lerma Irrigation District

	Area (ha)			Number	Number of users			Area by irrigation source (ha)				Irrigation network (km)			Drainage network (km)		
fodule	Ejido sector	Private growers	Total	of ejidos	Ejido sector	Private growers	Total	Surface	Public wells	Private wells	Total	Main canals	Second. canals	Total	Main drains	Second. drains	Total
.cambaro	6,545	2,304	8,849	23	1,622	308	1,930	6,727	257	1,724	8,708	43	101	144	28	96	123
alvatierra	13,561	2,336	15,897	44	5,082	972	6,054	12,775	565	2,753	16,093	116	120	236	42	176	218
ıral	3,236	3,453	6,689	16	1,062	401	1,463	4,381	371	1,992	6,744	60	73	134	12	80	92
alle	7,359	6,319	13,678	31	1,773	536	2,309	7,990	778	3,955	12,723	31	162	193	52	83	135
ortazar	9,781	8,668	18,448	35	2,169	993	3,162	10,934	1,964	5,796	18,694	75	238	312	23	85	108
alamanca	5,165	8,992	14,157	37	1,178	1,534	2,712	12,109	573	3,426	16,108	61	174	235	10	91	101
apuato	4,078	4,312	8,391	19	984	285	1,269	4,810	688	3,090	8,588	18	102	120	18	43	61
basolo	5,229	11,136	16,365	38	1,164	1,259	2,423	10,911	1,152	3,390	15,453	28	141	169	33	39	72
uanimaro	2,261	1,470	3,731	18	611	229	840	2,802	430	491	3,723	20	20	40	15	41	56
orralejo	1,219	297	1,516	5	264	11	275	653	643	217	1,513	12	0	12	0	1	1
ı Purisim:	3,437	982	4,419	15	936	118	1,054	3,605	0	820	4,425	11	52	63	27	27	54
otal	**61,871**	**50,269**	**112,140**	**281**	**16,845**	**6,646**	**23,491**	**77,697**	**7,421**	**27,654**	**112,772**	**475**	**1,183**	**1,658**	**260**	**761**	**1,021**