IMPACTS OF MANAGEMENT TURNOVER IN TWO IRRIGATION DISTRICTS IN COLOMBIA

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Abstract

In 1975, farmers in the Coello and Saldana irrigation districts in the Tolima Valley, Colombia, petitioned the government for the right to take over management of the districts. They based their argument on the fact that, over the previous 20 years, they had already repaid their agreed 90 percent share of the cost of construction. They were paying water fees to the government and were dissatisfied with the cost and quality of management. They argued that they could manage the systems more cost effectively than the government. In 1976, the government agreed to the farmers' demands, expecting that turnover would save money for the government.

This paper assesses the extenty to which turnover of irrigation management to farmers in the Coello and Saldana irrigation districts in Colombia has had an impact on:

- the cost of irrigation to farmers and the government,
- the sustainability of irrigation, and
- the quality of water distribution.

The sustainability of irrigation is assessed relative to both the financial viability of the districts and the physical condition of irrigation infrastructure 19 years after turnover. The quality of water distribution is assessed relative to efficiency, equity of distribution and productivity of water.

The study found that turnover did achieve the government's main objective of discontinuing government financing for operations and maintenance. However, partly due to continuing partial control over the districts by the government after turnover, declines in staff levels occurred slowly and the cost of irrigation to farmers remained relatively constant after turnover. A detailed inventory of irrigation infrastructure found that the vast majority of structures and canal lengths were in good functional condition.

The districts were able to continue to expand modestly the irrigated area and sustain high levels of production after turnover, partly due to a policy to limit rice production and deliver lower volumes of water per hectare. Perhaps the finding which would be of most concern to farmers, was that, while the cost of irrigation did not increase after turnover, the gross economic value of production per hectare and per unit of water increased dramatically. After turnover, irrigation constituted a relatively small and declining proportion of the total cost and value of agricultural production.

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INTRODUCTION

Irrigated agriculture in Colombia

Colombia is a mountainous country in South America with an area of 1.1 million square kilometers and a population of 31.8 million people (Annex figure 1). The country has relatively abundant water resources, including more than 1,000 perennial rivers. It has both tropical and temperate climates and an average rainfall of 1,500 millimeters per year. A marked bi-modal distribution in April/May and October/November makes the need for irrigation primarily supplemental (Annex figure 2).

Coello and Saldaña irrigation districts are located in the Tolima Valley in Central Colombia. The valley is at an elevation of 380 meters and is surrounded by the Andes Mountains. It sits between the central and west mountain ranges of the country with the large Magdalena River running through the middle of the valley. The valley has mostly a flat topography with undulating terrain toward both mountain ranges and has primarily alluvial soils, fans, terraces and narrow valleys with minor rivers. Main soil characteristics are sandy and loam in Coello and clay and loam in Saldaña. Soil erosion is evident as one moves up the hillsides but is not yet a problem in the valley floor, except that it creates a high silt load in rivers and irrigation canals. Yearly precipitation in the valley is between 1,000 and 1,500 mm. The median temperature is 27.9 ^{0}C. The average relative humidity is 74 percent and the yearly average tank evaporation is 1,800 mm (Annex figure 2).

Agricultural and socioeconomic context

In the 1930s, land reform in the Tolima Valley replaced the old hacienda system of peasant cultivation with landownership for farmers. Irrigation introduced to the area in the 1950s transformed the agriculture of the valley. Cotton became an important crop during the 1950s and 1960s. It was eventually replaced by rice which became the main irrigated crop by the 1970s and remains so today. Maize, sorghum, fruit and vegetables are also now irrigated in the valley.

Today, the Tolima Valley is a relatively prosperous farming area, located at a major transportation crossroads. It has numerous towns where agriculture and agro-business constitute the mainstream of the local economy. A large number of both public and private organizations which provide technical assistance and agricultural support services to farmer-managed irrigation systems are present in the area.

Development of Coello and Saldaña Districts

The construction of the Coello-Saldaña Irrigation District began in 1945 and was completed in 1953, when the district became operational. The total capital cost for the district was $5,500 per hectare (in 1993 dollars). Coello and Saldaña were initially constructed and managed as a single district. They were separated in 1976 only after management was turned over from the government agency to the water users' associations.

Coello Irrigation District is a river diversion system which has a lateral intake with a design capacity of 28 m^3/s. The intake consists of an approach canal formed by an earthen levee, which facilitates flow intake during low river levels in the dry season. The intake has two radial gates with provision for both sediment intake and water depth control (HIMAT 1991a). The intake canal leads to the main conveyance canal (Gualanday) which has a capacity of 25 m^3/s and extends for 5.7 kilometers before reaching the command area. The main canal divides into four branch canals, each of which leads to unlined secondary and tertiary canals. Field turnouts are sliding gates.

Coello District serves an irrigated area of approximately 25,600 hectares, making it one of the largest schemes in the country. The district was not designed with a parallel drainage system, which has resulted in waterlogging and salinity problems on as much as 7,000 hectares. It has 1,347 water users with 1,826 holdings. The average farm size is 14 hectares and in 26.6 percent of farms each is 5 hectares or less in size; in 14.4 percent each exceeds 50 hectares in size (Annex tables 1 and 2).

Saldaña District is also a river diversion scheme, located south of the Coello District. It diverts water from the Saldaña River through a direct intake without an approach levee. The intake also has radial gates and water head controls. It has a design capacity of 30 m^3/s into the main conveyance canal. This canal conveys water to three partially lined branch canals. As in Coello, each branch canal leads to unlined secondary and tertiary canals. Field turnouts are sliding gates (HIMAT 1991b).

Saldaña District irrigates an area of approximately 14,000 hectares. The lack of a complementary drainage system has resulted in waterlogging of up to 1,600 hectares. Its 1,500 water users have 1,850 holdings. The average farm size is 7.5 hectares and in 56.4 percent of the farms in Saldaña each is 5 hectares or less in size; it is only in 5.1 percent of farms that each farm exceeds 50 hectares in size (Annex tables 1 and 2).

The schemes have composite underflow and overflow cross regulators along the main canals which consist of gates and side weirs. This design protects against overcropping and facilitates desilting. It also enables a longer interval between gate adjustments than conventional designs. Hence, the design facilitates turnover by simplifying O&M requirements.

The rehabilitation of both irrigation canals and natural drains was done in Coello and Saldaña well before turnover. In Coello, about $8.69 million (in 1988 dollars) was spent on rehabilitation between 1968 and 1973. In Saldaña, about $2.28 million (in 1988 dollars) was spent on irrigation and drainage works between 1969 and 1972.[1] By the time of management turnover in 1976, the systems were in good physical condition and rehabilitation was not an issue in negotiations between the government and the farmers. Rehabilitation was not done in connection with turnover.

However, the issue of who should be responsible for financing rehabilitation was always a matter of dispute. The users argued that since the government had not turned over ownership of the infrastructure, it was the responsibility of the government to maintain the infrastructure, which belonged to the nation. Despite pressure from the government, farmers refused to repay the cost of rehabilitation in either system, except for an agreement with farmers in Coello to repay the cost of building a feeder canal to supplement their water supply (this is still under construction, today).

TURNOVER PROCESS

In the early 1960s the Government of Colombia entrusted the O&M of its irrigation districts to INCORA, the government land reform agency. The performance of the agency in irrigation management was not satisfactory. Water users of the Coello-Saldaña District were not only unhappy with the poor O&M service provided but were also concerned about the high management costs. In the early stages of development in the 1950s more than 90 percent of the farmers paid the water fee, but this percentage declined over time due to farmer dissatisfaction with the quality of

[1] Drainage systems in both schemes are natural drains No drainage system was ever constructed The rehabilitation and maintenance of drains refer to the desiltation of small streams, the redirection of natural outlets, etc.

management. Declining fee collections further hindered the ability of the agency to provide an effective irrigation service. Inefficient O&M of the system further motivated farmers to take over management of the district.

As a result, the farmers, who had already formed an association, decided in 1975 to make a formal request to the government that management responsibility for the system be transferred to the association of water users. The association argued that the scheme should legally become their property since they had already repaid the government their share for the costs of construction (Vermillion and Garces-Restrepo 1994).

Negotiations for management transfer were completed within a year, between 1975 and 1976. The associations hired their own lawyer to represent them in negotiating the terms of the transfer. Issues to be resolved included the disposition of district staff, ownership status of scheme assets, and the future degree of involvement of HIMAT[2] in the districts. It was finally agreed that most of the existing staff would be retained by the districts and others would be transferred out. The ownership of irrigation structures would remain with the government, although some equipment and facilities were transferred to the farmers' associations. The government concluded that under existing laws it could not relinquish the ownership of scheme assets. HIMAT would retain a role of oversight for district management, to ensure that the systems were properly maintained. In practice, this meant that HIMAT continued to give its advice and consent for annual budgets, O&M work plans, setting water fee levels, and personnel changes. The farmers' association obtained direct control over the O&M of the entire system, including the intakes.

As part of a policy to improve the performance of irrigation districts, the government created HIMAT in 1976. Its initial task was to turn over management of the Coello-Saldaña District to the two farmers' associations. The district was divided into two separate districts, Coello and Saldaña. This was the first case of irrigation management turnover in Colombia (Plusquellec 1989). It set a precedent for later transfers.

The transfer process employed a legal rule in the country's constitution referred to as the "Delegation of Administration," by which a public good (in this case, an irrigation district) could be turned over to a private-sector corporate entity (a water users' association) for administration on behalf of the state. The users were then empowered to recruit staff and organize and manage O&M of the two systems with the proviso that it would be financially self-reliant and government subsidies for O&M would be discontinued. The delegation of administration created a continuing labor relations conflict between the districts and the government which resulted in numerous legal debates and proceedings until the 1990s. Labor laws prohibited the firing of existing staff previously hired by the government. In 1993, a new Land Development Law was enacted, intended to grant full control over irrigation district management to farmers' associations (Ministry of Agriculture 1993).[3]

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[2] HIMAT was the acronym for the Institute for Hydrology, Meteorology and Land Development. In 1994, this acronym was changed to INAT, when meteorology was removed from its mandate

[3] However, this Law is currently being challenged in the courts regarding the issue of releasing staff who were originally hired by the government

CHANGES IN MANAGEMENT

Financial management

Farmers expected that through turnover they would not only improve management but would also contain or reduce the cost of irrigation. However, it soon became apparent that the "delegation of authority" would not give farmers' associations complete control over their budgets and O&M plans. Although the farmers had wanted HIMAT to play an advisory role, the government continued to influence budgeting and staff decisions. After turnover, the districts were unable to reduce staff and costs as much as they wanted, due to resistance from HIMAT.

Two kinds of water charges are assessed, a flat area charge (based on farm area irrigated) and a volumetric charge (based on basic water requirements by crop type). The revenues from the area charge are used to guarantee the coverage of fixed costs such as personnel. The volumetric fees are used more for variable costs such as operations.

Before and after turnover, farmers paid the area-based water fee prior to the season for which water was ordered. The volumetric fee was paid after the season and had to be paid entirely before any irrigation orders could be approved for the next cropping period. Farmers are charged volumetric fees according to the type of crop planted and its respective "base" or target allocation. Since water is only measured routinely down to the heads of secondary canals, volumetric charging is based on theoretical, as opposed to measured, water deliveries. Farmers may complain if they believe that their actual deliveries are less than adequate or less than the assessed amount, in which case district staff may make special measurements at tertiary offtakes with small flumes. This can result in either an adjustment in the volume delivered or in the fee assessment. This system did not change with turnover.

Since the associations did not receive ownership of system assets, and since they had not paid for previous rehabilitation costs, the farmers expected the government to pay for any future c osts of rehabilitation or structural replacement. Hence, after turnover, farmers did not raise a capital replacement fund (although they did raise an equipment replacement fund).

Personnel

One of the more noticeable outcomes of turnover was the significant reduction of personnel. Before transfer, in 1975, the two districts combined had a total of 300 employees. By 1993, the total staff for both districts was 189, which was a 37 percent reduction since transfer (Annex table 3). Accounting for changes in area irrigated, in 1975 there were 62.3 hectares of service area per district staff. By 1993 this had risen to 147 hectares per staff (Annex table 3). Most reductions were made in maintenance and technical support staff. Reductions were gradual and occurred mostly through attrition and non-replacement. Labor laws made it difficult for district managers to release dispensable government employees. Nevertheless, district board members and agency officials reported that paper work was diminished and administration became more efficient after transfer, especially in irrigation scheduling, fee processing and communications between users and district management.

Operation and maintenance

Water is allocated to farmers on the basis of area and crop type. In theory, all users who plant the same crop type receive a basic allotment and are charged area and volumetric charges based on assumed deliveries relative to per hectare targets by crop type. Before turnover, irrigation was

scheduled on the basis of preseason crop plans, modified during the season by water requests submitted by registered farmers. The district management prepared irrigation schedules based on orders received from farmers. Irrigation requests were approved to the extent that predicted water availability met the aggregate demand. The user was responsible for going to the district office before the season to sign an agreement with the seasonal irrigation plan. The user was informed of the day and time of his or her irrigations and the ditch tender made an inspection of the farm to make sure that the canals, turnout and measuring devices (if any) were in working condition. The ditch tender was responsible for delivering water to farm turnouts according to the agreed schedule and to record the total water delivered for the season. This system continued after turnover and was implemented mainly by the same staff as before; thereafter, they were under the hire of the farmers' associations.

The districts estimate water requirements for each crop type, which becomes the "base allocation." The districts measure discharge at the intake and along the main canal at offtakes into secondary canals. Water is distributed according to the base allocation, and sometimes reduced when water is scarce.

Prior to turnover, the agency prepared annual plans for maintenance and repairs. Such plans were prepared by the head of the maintenance unit, based on field inspections and sometimes on complaints from farmers. The most common maintenance works were desilting and cleaning of canals, road maintenance and structural repairs. Targets were established in advance but deviations were common due to funding constraints for repair or operation of heavy equipment.

The district management has administrative and operational manuals detailing roles and responsibilities of staff and users. The districts have kept data on daily rainfall, temperature and relative humidity since the inception of the project. Data on river flows and main and branch canal discharges are also recorded daily. Records of seasonal crop and irrigation plans, fee collection levels, registration of farmers, inventory of equipment and supplies, accounting, and yearly budgets have been kept regularly, before and after turnover.

After turnover, the new district administrations introduced practices to improve irrigation efficiency and enable continued expansion of irrigated area. Attention was paid to reducing staff where possible and revising cropping patterns to be consistent with the relative scarcity of water in the two systems. Water is more scarce in Coello. In 1993, the average target discharge or duty in Coello was 8.64 millimeters per day versus 15.5 millimeters per day in Saldaña. In Coello, the annual water demand was 1,097 millimeters, 948 millimeters of which was supplied by irrigation. In Saldaña, the annual water demand was 1,318 millimeters which was exceeded by an annual irrigation water supply of 1,517 millimeters. During the same year, the relative water supply (i.e., ratio of total supply—including effective rainfall to demand, calculated at the secondary canal level) was 1.4 in Coello and 1.75 in Saldaña (Annex tables 4 and 5). Coello has a relatively scarcer water supply during other years as well.

In Coello, where water supplies were insufficient for planting rice over the entire system, the association introduced a rice rotation and zoning plan to enable all farmers to plant rice at least once per year. In Saldaña, where water was more abundant, the association introduced a continuous, staggered planting arrangement for rice which allowed 2,000 hectares of rice to be planted every month, year round. This improved water distribution and, according to farmers, it also improved profit margins somewhat by spreading rice marketing throughout the year.

Organization

After turnover, the general assemblies of the farmers' associations for Coello and Saldaña districts elected boards of directors to supervise their districts. Each board had, and still has, seven

members with fixed quotas for two categories of farmers—four members, each having a farm size of less than 20 hectares[4] and three, each with a farm size of more than 20 hectares. Each is elected in a general assembly every two years. The board recruits and selects the general manager and participates with the general manager in the selection and releasing of other district staff.

After transfer, each board recruited a general manager who was an engineer. The districts then became responsible for day-to-day O&M of the systems. The reduction in personnel allowed the management to streamline the organizational structure by combining sections and integrating functions. In both districts, the general manager supervises an administrative unit and three technical units--operations, maintenance and technical services (see Annex figure 3).

MANAGEMENT PERFORMANCE AFTER TURNOVER

Through management turnover, farmers hoped to enhance the cost efficiency and quality of O&M, without sacrificing the agricultural productivity and financial and physical sustainability of the districts. Performance of the districts is assessed according to these criteria. The government's main interest was to reduce its own recurrent costs of irrigation without sacrificing agricultural productivity of irrigated agriculture.

Impacts on government

The government's interest in the transfer was initially to accede to political pressures and later to reduce government subsidies to the irrigation sector through a national policy of management transfer. In Coello and Saldaña, the government was successful in discontinuing its subsidies for O&M, which were costing it about $9 per hectare at the time of turnover. However, it continues to fully finance rehabilitation. If farmers defer maintenance costs expecting that the government will finance future rehabilitations, the government may not conserve as much money in the irrigation sector as it would like to.

Financial viability

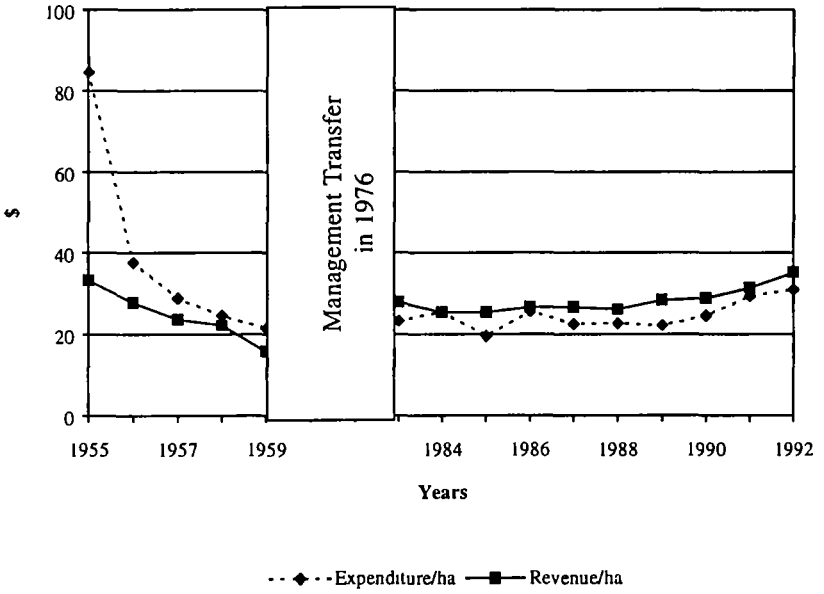
After transfer, the farmers' irrigation policy was essentially to balance the budget, contain the cost of management and achieve a more responsive irrigation service. This was only partially successful. Data on Coello indicate that the farmer districts were fiscally responsible in the sense that expenditures never exceeded revenues after transfer occurred. Figure 1 shows the changing patterns of revenue and expenditure before and after turnover. During the initial stages of scheme development, expenditures exceeded revenues, partially because of external subsidies and development assistance. The early drop in revenue and expenditure was due to the transition from scheme development to scheme management.

Except for 1984, between 1983 and 1992 in Coello, revenues always exceeded expenditures (figure 1 and Annex figure 4). However, its margin of surplus declined during the period, an evidence of improving management efficiency, in a context of continuing expansion of service area while water supply remained relatively static. Expenditures rose in real terms by 51 percent while revenues rose by only 44 percent during the period (Annex table 6). "Sideline" revenue sources—such as rental of farm equipment and district property, technical services, fines against members, sale of materials and charges for transporting equipment and materials--

[4] The previously required quotas for board member positions with farmholdings less and greater than 20 hectares have recently been dropped.

increased from about 10 percent to 20 percent of revenue between 1983 and 1992 (Annex figure 6). Before turnover, revenue was taken to at least regional levels of the government. Part of the reason farmers wanted to take over management was because of their perception that they were financing overhead costs of the government outside the system. After turnover, revenues which are in excess of annual budget costs go into an equipment replacement fund, are allocated to the next year's budget (to help limit the rise of fees) and are used by the water users' association for events and assemblies connected to public relations. Sideline revenues also help limit the level of water fees.

*Figure 1. Revenue and expenditure per hectare, the Coello District, 1955-1993.**



* *In constant 1988 dollars In 1988, $1 00 = 333 Colombian pesos In April 1994, $1.00 = 820 Colombian pesos*

Maintenance costs (including relevant staff costs) account for between 55 and 60 percent of total expenditures in the Coello District. This is followed by costs of administration and operation. The proportion of each to total costs remained roughly the same after transfer (Annex figure 6).

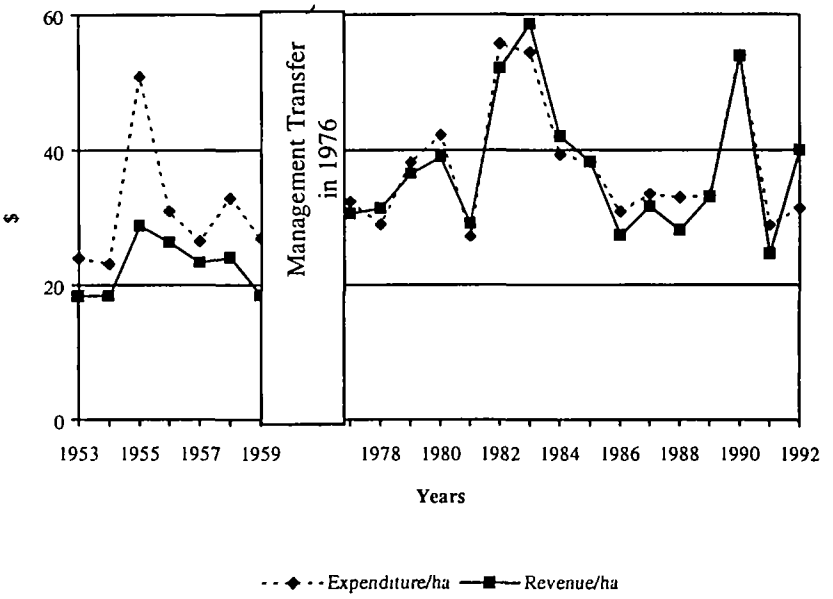
Saldaña District was in a weaker financial position than Coello after turnover, with expenditures exceeding revenues for 6 out of the 10 years between 1983 and 1992 (figure 2). However, the district gradually strengthened its position over time. The level of revenue per hectare in Saldaña fluctuated widely, but between 1983 and 1992 real growth in revenues was 29 percent, compared with the 20 percent growth in expenditures (Annex table 6).

Both districts improved their financial positions after turnover, although from opposite directions. Coello reduced its surplus and enhanced efficiency; Saldaña diminished its pattern of deficits.

Coello and Saldaña both have a fixed area-based water fee and a volumetric water fee. These vary slightly by type of crop and depending on whether the farmer is a smallholder or a large holder (e.g., $\geq$ 20 ha). The emphasis of the farmers on containing the cost of management resulted in a decline in the area fee after turnover. However, the volumetric water fee rose after transfer in real terms (1,988 pesos). In Coello, the area fee for rice has dropped from about P 3,000

per ha ($9) in 1976 (at transfer) to P 1,850 per ha ($5.55) in 1993 (in 1988 pesos) (see figure 3), while the volumetric fee for rice rose from about P 42 per 100 cubic meters (m^3) in 1976 to P 54 per 100 m^3 in 1992 (in constant 1988 pesos) (see figure 4).[5]

*Figure 2. Revenue and expenditure per hectare, the Saldaña District, 1953-1992.**



* *In constant 1988 dollars. In 1988, $1.00 = 333 Colombian pesos. In April 1994, $1.00 = 820 Colombian pesos.*

In Saldaña both area and volumetric fees for rice are higher than in Coello. In Saldaña the area-based fee dropped only slightly after transfer, from P 3,000 per hectare at transfer to P 2,650 ($7.96) per hectare in 1993 (figure 3). The volumetric fee rose from P 42 at transfer to P 63 per 100 m^3 in 1993 (figure 4). The difference in the cost of water between Coello and Saldaña may be due to the fact that Saldaña has a serious problem of siltation in the intake canal and continuously employs costly floating drag lines on boats to desilt the canal year-round. The most significant finding from figures 3 and 4 is that trends in both fees reversed directions at the time of transfer. Volumetric fees rose for two reasons: (1) the need for revenue to be linked to rising operating costs, and (2) board policy to discourage rice production and encourage crop diversification, reduce allocation of water per hectare and encourage expansion of irrigated area.[6]

The rising area-based fee reversed to a long-term decline, while the volumetric fee reversed from a decline to a long-term rise after transfer. Farmer boards in both districts preferred to charge farmers more on the basis of volume of water used than by the flat area rate.

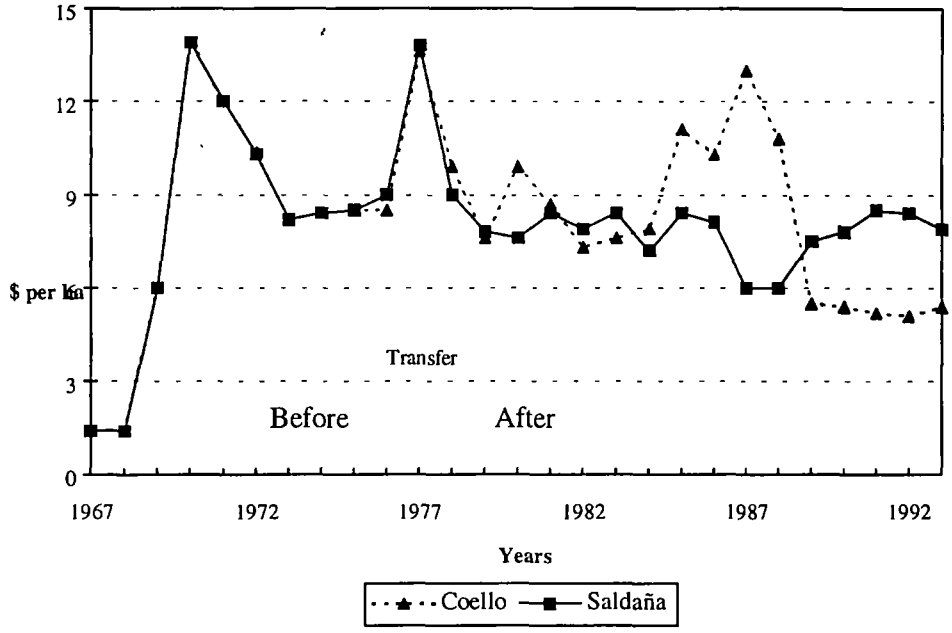
The total amount of area and volumetric fees collected in the Coello District between 1983 and 1992 (for all crops) was $75,990 in 1983 and $92,041 in 1992 (in 1988 dollars). Taking into

[5] These fee levels are for rice for smallholder farmers

[6] It should be noted that fee structure differs by crop and by whether farmers are classified as "small" (< 20 ha) or "large." The rate is higher for larger farms The fee for rice for small farmers is used herein as this has been an important crop in both systems. Seventy six percent of all farmers are "smallholders" in Coello, 90 percent are "smallholders" in Saldaña.

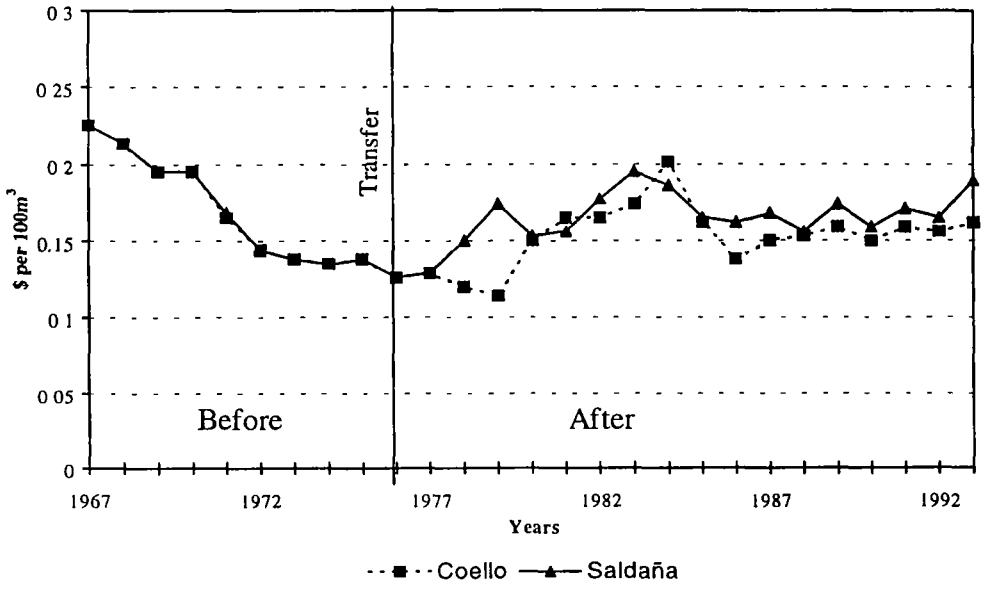
account changes in annual net area irrigated, this means the actual cost of irrigation to farmers declined by 13 percent from $6.63 per ha in 1983 to $5.74 in 1992 (in 1988 dollars) (Annex table 7).

*Figure 3. Area water fee for rice, Coello and Saldaña districts, 1967-1993.**



** In constant 1988 dollars.. In 1988, $1.00 = 333 Colombian pesos. In April 1994, $1 00 = 820 Colombian pesos*

*Figure 4. Volumetric water fee for rice, Coello and Saldaña districts, 1967-1993.**



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Physical sustainability

In both districts, between 55 percent and 60 percent of total district income goes toward maintenance of the irrigation network. This percentage did not change significantly after turnover, since O&M budgets continued to be based on the previous years and continued to be reviewed and approved by the agency. However, district managers reported concern that the strong farmer emphasis on cost reduction was compromising the physical sustainability of the systems.

To answer this question complete surveys of all canals and structures were conducted in 1994 in each district.[7] The survey classified canal sections as either fully functional, partially functional, or dysfunctional. Criteria are distinguished primarily according to the extent to which original hydraulic design conditions are supported. Partially functional canal sections still have at least a 70 percent design capacity; dysfunctional sections have a less-than 70 percent design capacity.

Results from the Coello survey show that 68 percent of the total canal length was fully functional (Annex table 8). This constituted 250.2 km of main, secondary, and tertiary canals. Partially functional canal sections were distributed relatively evenly between main, secondary, and tertiary canals. Eighty one percent of the total canal length judged dysfunctional was in tertiary canals, the rest was along secondaries. Of the 1,666 total structures examined in Coello, 71 percent was considered fully functional; 15 percent was dysfunctional (Annex table 9). Of the 15 percent of the dysfunctional structures, 66 percent comprised small flumes used for measuring water at field turnouts (Annex figure 7). These were installed in the rehabilitation period during the late 1970s and early 1980s. They had not been requested by the farmers' association and are rarely used by the new management. Fifteen percent of dysfunctional structures comprised culverts.

In Saldaña, 48 percent of all canal sections was fully functional (Annex table 8). Seventy nine percent of the main canal was fully functional, whereas only 33 percent of secondaries and 28 percent of tertiaries were judged fully functional. Forty four percent of the total canal length was partially functional, mainly in secondaries and tertiaries. Dysfunctional sections were located only in tertiary canals. Nineteen percent of the total tertiary length was judged dysfunctional. In Saldaña, 69 percent of the 756 structures observed was judged to be fully functional; 12 percent was dysfunctional (Annex table 9). Sixty five percent of dysfunctional structures comprised small measurement flumes at turnouts, 11 percent control structures, and 10 percent larger flumes upstream of turnouts (Annex figure 7).

It is not surprising that the more water-abundant system has a lower rating in maintenance. But the large majority of structures in both districts is still fully functional. In Coello, 98 percent of the total canal length was fully or partially functional; in Saldaña, 92 percent of the canal length was fully or partially functional. This is a remarkable record, given that construction was completed in 1953, that only limited rehabilitation had been done in both districts in the late 1960s and early 1970s, and that management was transferred to the farmers' associations in 1976.

In 1984, HIMAT, in agreement with the users, conducted feasibility studies on modest rehabilitation and system expansion in both Coello and Saldaña. Some portions of the canal and road networks had deteriorated and were in need of repairs. Drainage improvement was needed in Saldaña and a supplemental feeder canal was planned for Coello. Farmers in Coello agreed to pay 90 percent of the cost of the feeder canal while farmers in Saldaña refused to pay any of the cost of the rehabilitation. Construction is underway in Coello but not in Saldaña.[8]

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[7] This was a comprehensive inventory and examination of all structures and canal lengths in both systems. However, due to the timing of the study it was not possible to do an examination before turnover

Irrigation operations

There is no indication that the operational performance of the Coello or Saldaña systems changed significantly as a result of turnover. Water continues to be delivered without being measured below main canal offtakes. In Coello, the average annual discharge at the intake varied from 14 m^3/s in 1977 to 16 m^3/s in 1993, with an average fluctuation between minimum and maximum discharge levels of 4 m^3/s (Annex figure 8). The average annual water supply has not declined over time, but has shown a slight rise. Historical data on discharge at the intake were not available for Saldaña.

The comparison of data from 1982 to 1993 of the annual volume of water diverted at the headworks with the aggregate amount of water delivered to all tertiary canals, provides a measure of what is termed herein, "total conveyance efficiency" (Annex figure 9). The annual average measures of total conveyance efficiency for this period were 60 percent in Saldaña and 69 percent in Coello. Part of the reason for relatively low efficiencies may be the reportedly high sediment loads in main canals. This is the most serious management problem in Saldaña and is a major problem in Coello as well and no doubt inhibits conveyance efficiency in both systems.

As a simple effort to assess equity of water distribution along tertiary canals, a field check was made on 15 July, 1993 comparing actual and target discharges into farm outlets along a tertiary canal located at the Florencia Secondary Canal in the Saldaña District. The ratio between actual and target discharges is termed the Delivery Performance Ratio, or DPR. From the first outlet at the head end to the 18th outlet at the tail, the DPR exhibited a clear downward trend from head to tail, ranging from 260 percent at the head to 75 percent at the tail (Annex figure 10). One such test cannot verify a pattern but it does suggest that a distribution problem may exist in Saldaña at the tertiary level.[9] The distribution arrangement at the time of inspection was continuous flow.

We have noted above the stable or slightly rising trend in annual average discharge at the intake in Coello between 1977 and 1993. Annex figure 11 shows that the annual water supply delivered for the rice crop rose by 25 percent from about 2,000 mm/ha in 1977 to about 2,500 mm/ha in 1991. However, figure 5 shows a decline in the overall average annual volume of water delivered per hectare of 12 percent, from approximately 1,100 mm per season in 1982 to 970 mm in 1991. This was influenced by two basic changes in irrigated agriculture in Coello.

The first is the increase in gross annual irrigated area (total for two seasons) from approximately 21,000 ha in 1977 to between 27,000 and 37,000 ha in the late 1980s and early 1990s (Annex figure 12). The second is the shift away from rice monocropping to crop rotation as administered by the district. After transfer, the districts excluded the sandy area from rice production.[10] This permitted rice to be grown only once per year and led to an expansion of area planted to cotton, sorghum, soybean and other non-rice crops. The area planted to rice was about 19,200 hectares in 1975, the year before turnover. It dropped to about 16,450 hectares by 1991, a drop of 14 percent in area (figure 6).

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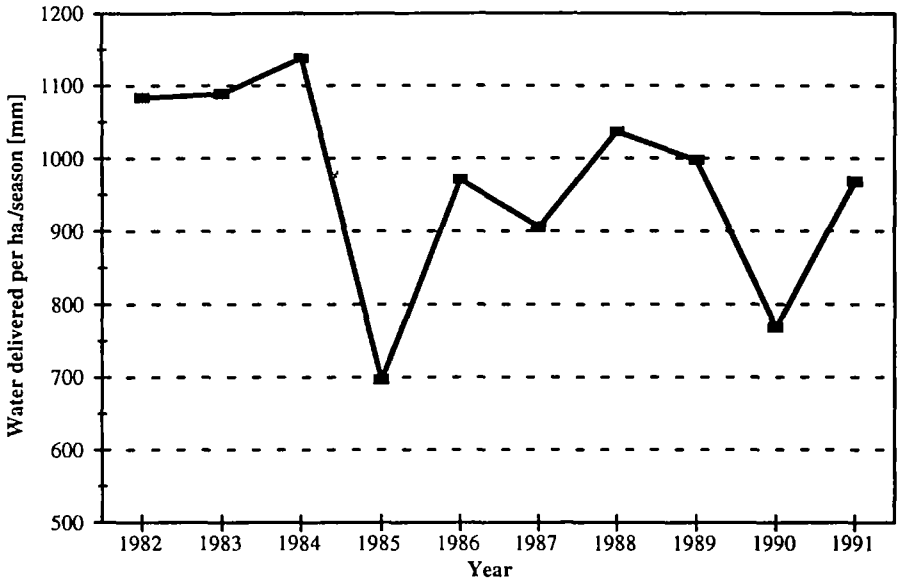
[8] The government has recently dropped its insistence that farmers must pay for rehabilitation after turnover. However, it has a new policy to gradually phase out existing subsidies

[9] Distributional inequity may be partly the result of the siltation problem but it would require additional research to bear this out.

[10] Prior to transfer, some sandy areas were reportedly receiving up to as much as 30,000m^3/ha/year of water supply for rice production After transfer, that water was reallocated for area expansion and for heavy soil areas that were not receiving enough water before transfer

*Figure 5. Water delivered per hectare, the Coello District, 1975-1991.**



** Per season average*

Contrastingly, Annex figures 13 and 14 show the rise during this period in area cultivated to cotton and sorghum, the main non-rice crops in Coello. Average water deliveries for these non-rice crops varied widely, with no apparent increasing or decreasing trend. In Coello, the decrease in the area fee and the rise in the volumetric fee may have encouraged the expansion of irrigated area and a reduction in the volume of water delivered per hectare. The discipline imposed by the district to dramatically reduce the volume of water delivered per hectare encouraged crop diversification and a substantial increase in irrigated area. Rice monocropping was unsuitable for Coello's sandy soils.

In short, operational and maintenance problems appear to be more prevalent at the tertiary and distributary levels than in the main ystem, as indicated by the maintenance survey, DPR analysis and farmer perceptions. While the problems do not appear to be severe, there is clearly room for improvement.

Agricultural productivity

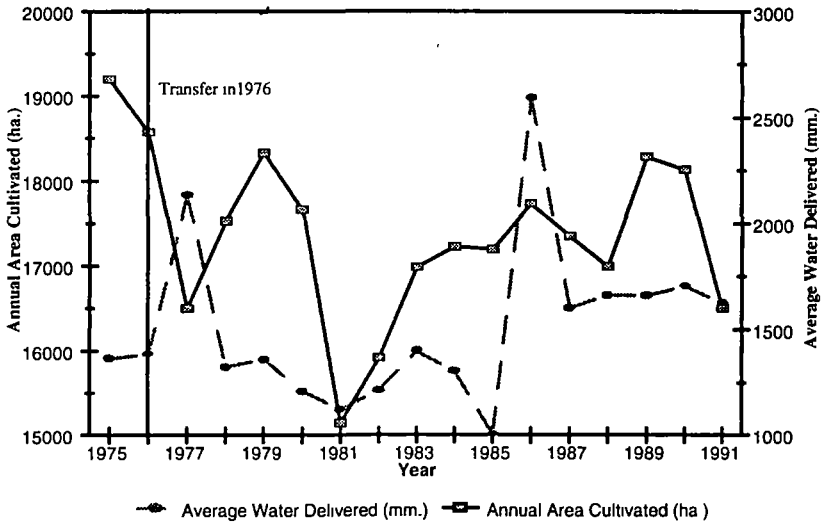
The gradual expansion of irrigated area after construction halted for about four years at the time of turnover, perhaps because of uncertainties and inefficiencies temporarily created by the change in management. But the expansion resumed after this apparent learning period and only began leveling off early in the 1990s (Annex figure 12). The rate of expansion has been higher in Coello, where crop diversification has occurred, than in Saldaña, where it has not.

Area expansion continued over several years, primarily as a result of two factors. First, the tertiary network was extended and improved over time. Second, as farmers gained more experience with irrigation and their livelihoods improved, they increased the area irrigated within their farms. Most of the expansion occurred during the boom of the green revolution.

Largely as a result of the introduction of green revolution varieties in the 1960s and 1970s, average rice yields increased dramatically from approximately 2,500 kg in the mid-1950s to approximately 6,000 kg in 1976, at the time of transfer (Annex figure 15). By the 1990s average rice yields were between 6,500 and 7,000 kg per ha. Most of the increase in yields occurred before

transfer, but high yield levels were sustained afterwards through the early 1990s, with a slightly increasing trend. We conclude that the transfer did not have any noticeable detrimental impact on yields.

*Figure 6. Area cultivated and water delivered per hectare for rice, the Coello District.**



** Per season average.*

Both the cost and value of rice production declined moderately during the 11-year period from 1984 to 1994. The cost declined from about $380/ha in 1984 to about $320/ha in 1994 (in constant 1988 dollars; figure 7). Average net income for rice production varied widely from zero to about $105/ per ha during the period, peaking in 1989 and falling to about $45 per ha in 1994.

The total cost of water relative to the cost of rice production dropped from approximately 4.4 percent during the 1950s, before turnover, to between 3.1 percent (in Saldaña) and 3.3 percent (in Coello), largely due to increase in the cost of production. However, during the post-transfer period it has been rising, from 2 percent in 1984 to 3.3 percent in 1993 (in Coello).

In Coello, under post-transfer management during the 1980s, the total cost of irrigation remained essentially constant in real terms from $50.57 in 1983 to $50.63 per hectare in 1991 (in 1988 dollars; Annex table 9).[11] However, the total gross value of output per hectare for all irrigated crops rose over fourfold (figure 8) during the same period, from $944 to $4,300 per ha. The cost of irrigation as a percentage of the gross value of output was relatively small and dropped still further, from 5.4 percent to only 1.2 percent by 1991 (figure 9).

Coello District also achieved impressive gains in gross value of output per unit of water, which increased 298 percent, from $2.35 per 100$m^3$ in 1983 to $9.35 per 100$m^3$ in 1991 (figure 8 and Annex table 10).[12] This reflects the gain in output relative to water resulting from crop diversification and the intensification brought on by the "green revolution."

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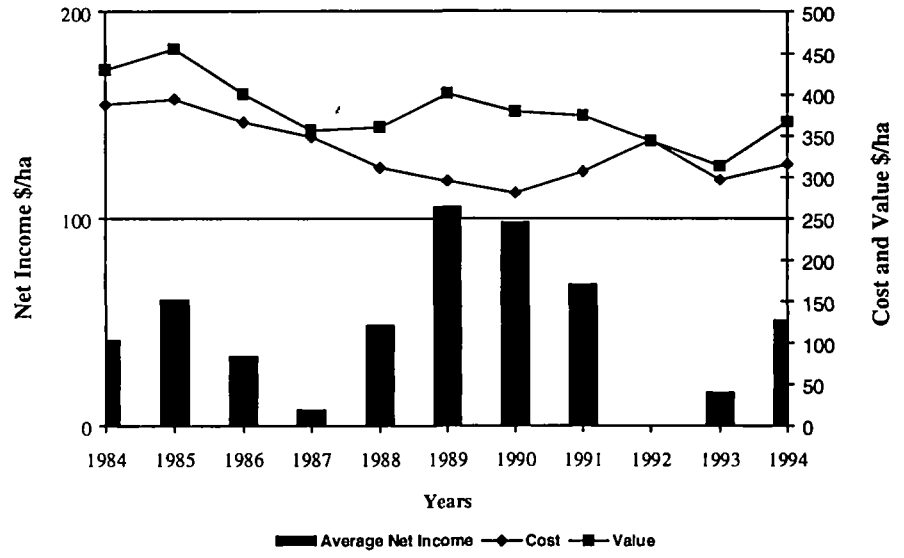
[11] Cost of irrigation to farmers is the total revenues from all water charges collected by net irrigated area per year.

[12] Unfortunately, similar data were not available for Saldaña

*Figure 7. Cost and value of rice production, Coello and Saldaña districts, 1984-1994**



* *In constant 1988 dollars Based on total production data for both systems*

PERSPECTIVES OF STAKEHOLDERS

Farmers

Interest in turnover. The initiative for turnover came from the water users rather than from the government. Farmers assessed the implications of turnover and gave their collective approval in the General Assembly meetings in September 1976. By the time of turnover farmers were already financing most of the cost of O&M and expected that they would be able to keep the irrigation fees from rising, or even reduce them.

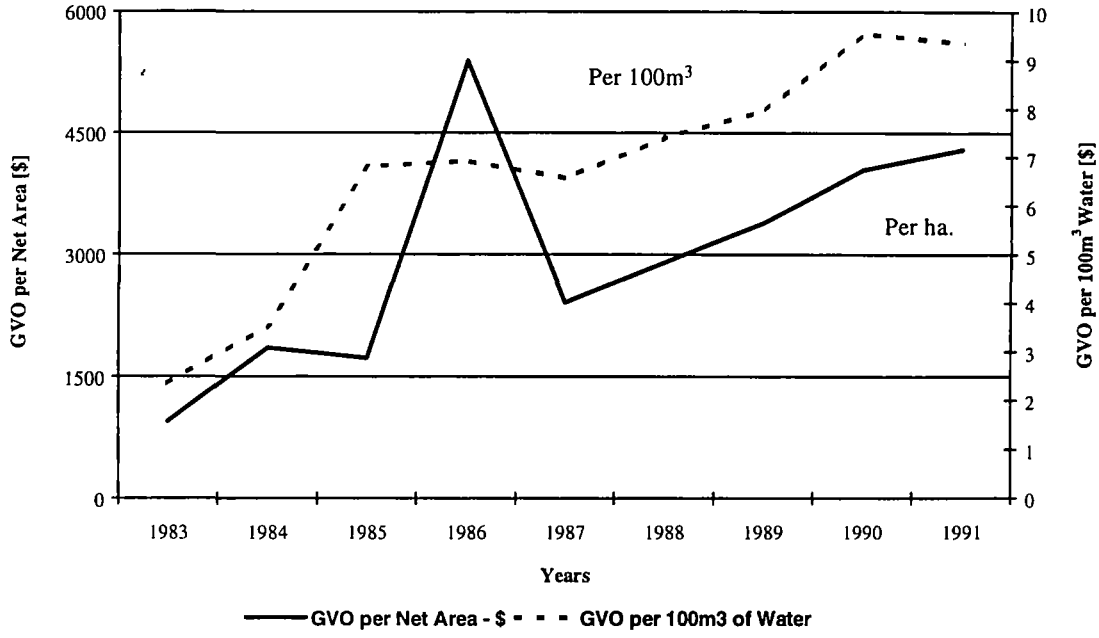
Role of government. In 1976, farmers agreed that HIMAT should continue to provide oversight and advice to the farmers' associations about management of the districts. But it soon became apparent that HIMAT's role in the districts after turnover was more than just "oversight." Many farmers saw HIMAT as restricting their ability to further reduce staff and budgets, as the associations had wanted. Therefore, farmers perceived the transfer as being only partial and not enough to give them full control.

A stratified random sample of 93 farmers (44 in Coello and 49 in Saldaña) was drawn in 1994, taking half from the upper third area and half from the lower third area in each system. It was found that in Coello, only 29 percent of the farmers sampled wanted the government to withdraw completely from working with the district; 48 percent wanted the government to continue to be partially involved in assisting the irrigation district; and 21 percent stated that the government should take over management again (Annex Figure 16). In Saldaña, only 14 percent favored complete government withdrawal: 68 percent favored continuing partial government involvement; and 16 percent favored g vern nt takeover.

The most commonly mentioned roles which sample farmers said they would like the government to continue to play in the irrigation districts were to provide technical guidance, settle

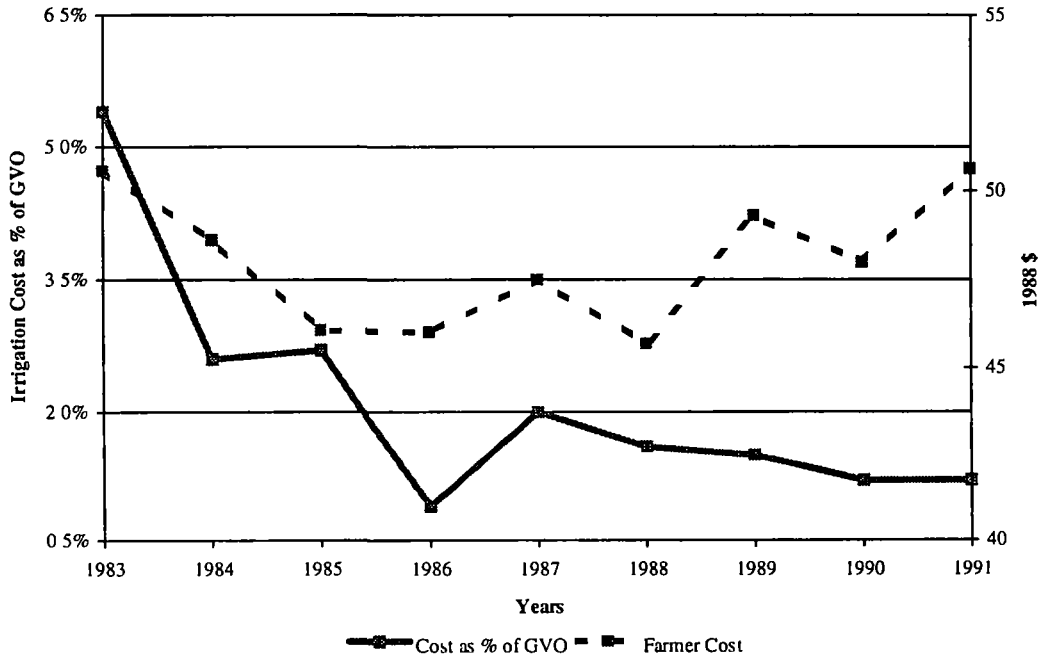
disputes among farmers, regulate water allocation in the river basin, manage the intake and main canal, and help rehabilitate the system.

Figure 8. Gross value of output (GVO) for the Coello District, 1983-1991.



** In constant 1988 dollars.*

Figure 9. Cost of irrigation per ha to farmers and irrigation cost as a percentage of gross value of output (GVO), the Coello District, 1983-1991.



**In constant 1988 dollars.*

Ownership. Sample farmers were also asked about who they think should own the irrigation infrastructure. In Coello, 76 percent thought the farmers' association should own it; in Saldaña 80 percent thought the farmers should own it (Annex figure 17). Only 19 percent in Coello and 18 percent in Saldaña thought that the government should own the structures.

Outcomes of turnover. Sample farmers were asked the question, "Has the 1976 transfer of management for the irrigation district from the government to the farmers' organization improved, worsened, or not changed much of the management of the irrigation district?" In Coello, 53 percent responded that it had not changed much, 40 percent said it had improved, and only 7 percent said it had worsened. In Saldaña, 39 percent said management had improved after turnover, 36 percent said it had not changed much, and 25 percent said it had worsened. In Saldaña, 7 of the 11 farmers who stated management had worsened were tail enders. In Coello, there was no significant difference between head and tail enders.

The most common ways in which management had improved, according to the farmers of both systems were (i) in communication between district staff and farmers, (ii) in responsiveness of district staff to farmers, and (iii) in water distribution. About 70 percent of the sample farmers in Coello and 91 percent in Saldaña stated that they had attended a district association meeting within the last year.

Impacts on maintenance. Sample farmers were asked, "Has the functional condition of the secondary canal which delivers water to your field improved, worsened, or stayed about the same over the past ten years?" In Coello, 81 percent said it had stayed about the same, 17 percent said it had improved, and only 2 percent said it had worsened (Annex figure 18). In Saldaña, 73 percent said it had stayed in about the same condition, 15 percent said it had worsened, and 13 percent said it had improved (with no significant difference between head and tail enders).

Impacts on operations. Sample farmers were asked the question, "Over the last two years was the irrigation water delivered to your farm always enough for your crop water requirement, enough most of the time, not enough most of the time, or never enough?" In Coello, 45 percent said it was always enough and 32 percent said it was enough most of the time. Only 20 percent said it was not enough most of the time and 2 percent said it was never enough. In Saldaña, 59 percent said water was always enough, and 31 percent said it was enough most of the time. Only 4 percent said it was not enough most of the time, and 2 percent said it was never enough. In Coello, a surprising 96 percent said water was delivered to their field on time all or most of the time. In Saldaña, 90 percent said water was delivered on time all or most of the time. This question did not address the issue of change, but it did demonstrate that widespread satisfaction exists among farmers about water distribution after turnover.

Regarding water theft or disputes over water, only 6 sample farmers (14 percent) in Coello stated that they were aware of cases of water theft or disputes over water which had occurred in the last two years. Of the sample farmers 86 percent was not aware of any such cases. In Saldaña, only 2 sample farmers stated that they were aware of the occurrence over the last two years of any such theft or dispute. Forty seven sample farmers (96%) were not aware of any such occurrence.

Impacts on agricultural productivity and profitability. Farmers did not indicate that management turnover had had a significant impact on either the productivity or the profitability of agriculture.

District Staff

District managers expressed concern that the strong farmer disposition toward cost reduction was resulting in some decline in service and that this would eventually result in the visible deterioration of the system. Experienced senior personnel had been replaced by younger, inexperienced staff; key technical positions had been eliminated or merged and little or no expenditure was being made in training or replacement of equipment or structures. Some noted occasional undue influence by large-scale farmers over field operations staff in the distribution of water.

Agency Staff

At first, members of the HIMAT staff at the district and higher levels were generally resistant to the transfer. They perceived that jobs would be lost and the role and power of the agency would diminish as a result of management turnover, first in Coello and Saldaña, and eventually elsewhere as well. For several years after turnover, the agency pressured the farmers' associations in Coello and Saldaña against releasing staff and reducing budgets. This resulted in law suits between the farmers and the agency, mainly over the issue of releasing staff. After the new Land Development Law of 1993, the government granted full authority over district staff and budgets to farmers' associations.

CONCLUSION

Perception

Most farmers see turnover as having produced a more responsive and cost-efficient management. Most, however, favor a continuing limited role for the agency, primarily in providing technical advice and in helping with dispute resolution. The majority believe that the association should own the irrigation infrastructure. However, most farmers appear satisfied with the performance of O&M tasks. Many believe that management performance, especially cost efficiency, would have improved even more had the users been granted full control over staff and budgets after turnover. Board members perceived that the partial turnover brought only partial benefits.

Professional staff in the districts are less sanguine about the results, expressing concern that cost-cutting measures are compromising the quality of O&M. The agency was concerned about the implications of turnover on agency staff and budgets.

Main Results

The following are the study's main conclusions about performance changes after turnover.

1. Management turnover achieved the government's objective of discontinuing subsidies and making the districts financially self-reliant for O&M. The "delegation of authority," however, did not result in full turnover of authority to the farmers' associations. The agency continued to exercise partial influence over budgets and staffing. Nevertheless, after turnover the districts began a gradual process of reducing staff, while continuing virtually the same level of management intensity as before turnover. Most sample farmers felt that communications with district staff and their responsiveness to farmers had improved after turnover.

2. The districts have been only partially successful in containing costs. Staff levels have been reduced 35 percent since transfer. However, the cost of irrigation remained relatively constant for a decade after turnover. Coello District has been financially solvent ever since turnover, with a decreasing margin of budget surplus over time. It has also diversified its revenue sources beyond water charges. Saldaña, however, has had continuing problems balancing its budget, but has made progress toward solvency with growth in revenues outpacing growth in expenditures over time. Both districts raised irrigation fees for rice over time and costs of irrigation to farmers rose, in real terms—although as a percentage of the total cost of rice production, or gross value of output, the cost of irrigation dropped substantially. In Coello, financial viability has been achieved by spreading the cost of irrigation among more farmers through expansion of area, by increasing volumetric fees for rice, and by diversification of revenue sources.

3. Nineteen years after the transfer only 2 percent of total canal length in Coello, and 8 percent in Saldaña, were dysfunctional (mostly in tertiary canals). Of all water control and measurement structures, only 15 percent in Coello and 12 percent in Saldaña were dysfunctional. The vast majority of dysfunctional structures were field outlet measurement structures (which were not normally used). We conclude that the districts have been able to sustain preventive maintenance so far. And owing to statements by sample farmers, we conclude that system maintenance has not yet been ill-affected by turnover. The intensive and costly maintenance investment the districts have been able to support, relative to the serious siltation problem, has been impressive.

4. However, since the government retained ownership of the scheme assets, farmers insist that the government should finance future rehabilitation and modernization. Neither association is raising a capital replacement fund. It is apparent that this arrangement is preventing the associations from achieving complete local financial sustainability. Although the systems have been well maintained until the present, this may lead to some deferred maintenance in the future.

5. After turnover, the farmers' associations soon established new crop rotation and irrigation scheduling arrangements designed to permit extension of irrigated area while decreasing the average amount of water delivered per hectare. The Coello District was able to substantially expand its area irrigated through steadily delivering less water per hectare and diversifying cropping. Saldaña, which had heavier soils, continued to irrigate only for rice, though it staggered planting dates in order to spread out irrigation demand over the year.

6. It is apparent that the transfer did not inhibit long-term expansion of the area irrigated or the ability of irrigated agriculture to sustain high levels of rice yields. Despite rising costs of agricultural production and a decline in crop prices, yields and area irrigated remained stable after transfer. However, the study indicates there is a moderate problem of inequitable water distribution to tail enders, which is due partly to siltation and some lack of control at the tertiary level.

7. Perhaps the most important finding of the study was that increases in the gross value of output per hectare and per unit of water increased dramatically while the cost of irrigation to farmers remained roughly the same after turnover. Irrigation constituted a relatively small and declining proportion of the total cost and value of production. Improvements in economic performance after turnover can only be partially attributed to broader factors such as cultivation improvements and crop prices. After turnover, new district policies to restrict rice production in sandy areas and reduce average volume of water delivered per hectare supported crop diversification and improved the value of irrigated output. Cost containment policies such as reductions in staff and cessation of flow of funds outside the schemes undoubtedly helped prevent rises in the cost of irrigation to farmers.

ANNEXES

Annex table 1. Number of farms by size, Coello and Saldaña districts, 1968 and 1993.

Farm size	1968				1993			
	Coello		Saldaña		Coello		Saldaña	
	Number of farms	Percentage of total	Number of farms	Percentage of total	Number of farms	Percentage of total	Number of farms	Percentage of total
0-5 ha	264	26.6	589	56.4	703	38.5	1,255	63.9
5.1 - 10 ha	200	20.1	146	14	386	21.1	279	14.2
10.1 - 20 ha	207	20.8	141	13.5	300	16.4	231	11.7
20.1 - 50 ha	180	18.1	115	11	322	17.6	181	9.2
> 50 ha	143	14.4	54	5.1	115	6.4	19	1
Total	994	100	1,045	100	1,826	100	1,965	100

Annex table 2. Basic information, Coello and Saldaña districts.

District	Coello	Saldaña
Item		
State	Tolima	Tolima
Period built	1949-1953	1949-1953
Transferred	September 1976	September 1976
Design area (ha)	44,100	16,428
Irrigated area (ha) (1993)	25,628	13,975
Water users' association	Usocoello	Ususaldana
Main soil type	Sandy, loam	Clay, loam
Main crop(s)	Rice, soybean, cotton	Rice
Water source	River Coello	River Saldaña
System type	Run-of-the river	Run-of-the river
Intake structure	Radial gates	Radial gates
Irrigation structures	1,666	756
Lowest water measurement point	Secondary canal	Secondary canal
Water delivery efficiency (%)	69.2	69
Length of main canal (km)	69.1	60.8
Total length of canal network (km)	250.2	162
Hectare served/km canal	102.4	86.3
Turnout type	Sliding gates	Sliding gates

Annex table 3. Staff levels before and after transfer, Coello and Saldaña districts, 1975 and 1993.

Program	Before turnover (1975): Coello and Saldaña combined	After turnover (1993)		
		Coello District	Saldaña District	Both
Administration	36	18	18	36
Maintenance	161	60	50	110
Operation	51	19	24	43
Technical	52	0*	0*	0
Total staff members	300	97	92	189
Irrigated area (ha)	18,700	15,300	12,500	27,800
Area/staff member (ha)	62	158	136	47

* *Several "technical staff" members were retained but shifted to other departments These include staff for hydrologic measurement, design and financial matters.*

Annex table 4. Basic system parameters, Coello and Saldaña districts, 1993.

	Data set	Value	
		Coello	Saldaña
A	Irrigation water supply	948 mm	1,517 mm
B	Effective rain	554 mm	793 mm
C	Pumped water supply	0	0
D	Irrigation duty	8.64 mm/day	15.5 mm/day
E	Maximum irrigation demand	9 mm/day	8.5 mm/day
F	Annual demand	1,097 mm	1,318 mm
G	Seasonal maximum irrigation intensity	54.4%	93.7%
H	Annual irrigation intensity	101%	161%
I	Production (rice)	$ 7 t/ha	$ 7 t/ha
J	Gross margin	$ 1,146.45 ha/yr	$ 1,593 ha/yr
K	Total area	25,628 ha	13,975 ha
L	Regulation area	10 ha	10 ha
M	Farmer management area	50 ha	50 ha
N	Farm size	14 ha	7.5 ha
O	Capital cost	$ 5,500/ha	$ 5,500/ha

Annex table 5. Basic performance indicators, Coello and Saldaña districts, 1993.

Number	Name	Formula*	Units	Coello	Saldaña
1	Return to land	J	$/ha	1,146.45	1,593
2	Return to irrigation	J/(A+C)/10	$/m³	0.12	0.105
3	Return to water	J/(A+B+C)/10	$/m³	0.076	0.069
4	Return to economy	J/O	%	20.84	28.96
5	Fee/cost ratio	P/Q	%	101.9	108.9
6	Water use efficiency (WUE)	G/(A+B+C)	%	73.00	57.00
7	Relative water supply	1/WUE	Ratio	1.37	1.75
8	Delivery efficiency	F/(D+D_1)	%	104.0	54.8
9	O&M area/staff		ha/staff	324	189

* *Letters refer to those in Annex table 4 P = Irrigation fee Q = Cost of irrigation. D_1 = Duty for wells.*

Annex table 6. Total revenue and expenditure, Coello and Saldaña districts, 1983-1992 (In 1988 dollars).*

Year	Coello District		Saldaña District	
	Total revenue	Total expenditure	Total revenue	Total expenditure
1983	756,760	633,930	715,920	664,560
1984	705,710	711,410	700,900	655,560
1985	860,060	660,660	842,940	842,940
1986	855,260	825,530	578.380	652,550
1987	936,640	791,890	657,360	695,8,00
1988	936,040	795,200	647,150	757,360
1989	1,054,650	822,220	733,930	737,540
1990	1,063,060	904,200	711,410	713,210
1991	1,014,950	948,050	624,320	730,930
1992	1,086,790	955,260	923,420	725,230
Percentage change	+44	+51	+29	+20

**$1 00 = 333 Colombian pesos in 1988.*

Annex table 7. Annual cost of irrigation to farmers, Coello District, 1983-1992.

Year	Fixed charge paid	Volumetric charge paid	Total water charge paid	Net irrigated area (ha)	Cost to farmers per ha (in 1988 dollars)
	In 1988 $				
1983	246,246	439,039	685,285	13,550	50.57
1984	259,459	414,830	675,375	13,890	48.62
1985	292,793	486,786	779,579	16,925	46.06
1986	281,081	458,258	739,339	16.070	46.01
1987	342,643	491,591	834,234	17,565	47.49
1988	342,642	494,294	817,417	17,900	45.67
1989	330,330	584,384	914,714	18,550	49.31
1990	306,306	577,177	883,483	18,410	47.99
1991	319,219	496,996	816,216	16,120	50.63
1992	309,909	520,120	830,030	15,410	53.86

* *In 1988, $1.00 = 333 Colombian pesos.*

Annex table 8. Results of canal maintenance survey, Coello and Saldaña districts, 1994.

Description		Coello				Saldaña			
		Maintenance condition*				Maintenance condition*			
		Length	Functional	Partially functional	Dysfunctional	Length	Functional	Partially functional	Dysfunctional
Main canal	KM subtotal	69.1	46.8	22.3	0	60.8	47.8	13	0
	Percentage (%)	100	68	32	0	100	79	21	0
Secondaries	KM subtotal	71.9	54.6	17 3	0	44.6	14.6	27.6	2 4
	Percentage (%)	100	76	24	0	100	33	62	5
Tertiaries	KM subtotal	109.2	68 5	35.7	5	56 6	15.2	30.8	10.6
	Percentage (%)	100	63	33	4	100	28	53	19
Total network		250 2	169 9	75.3	5	162	77.6	71.4	13
Percentage (%)		100	68	30	2	100	48	44	8

Maintenance condition

Fully functional Original hydraulic design conditions are intact, including canal capacity, bed slope, side slopes and freeboard. Any canal erosion, breaches, cave-ins, siltation or weeds are not significant enough to noticeably interfere with operational objectives

Partially functional Original design conditions are compromised by some deterioration in bed slopes, side slopes, freeboard, etc , although operational capacity is still at least 70 percent of original design

Dysfunctional_ Operational capacity is below 70 percent of design capacity, Major rehabilitation is needed

Annex table 9. Results of structure maintenance survey, Coello and Saldaña districts, 1994.

	Coello District				Saldaña District			
	Maintenance condition				Maintenance condition			
	Functional	Partially functional	Dysfunctional	Total number	Functional	Partially functional	Dysfunctional	Total number
Headgates*	30	16	4	50				
Control-drop**	40	7	18	65				
Control	53	24	2	79	100	17	10	127
Drops	121	14	0	135				
Distribution box	15	1	1	17				
Culverts	102	20	38	160	16	3	2	21
Siphon	25	6	0	31	40	5	0	45
Aqueducts	10	0	0	10				
Radial gates					36	3	2	41
Box culverts					0	0	2	2
Fumes					0	0	9	9
Gates	496	32	9	537				
Bridges	91	11	0	102	120	20	7	147
Regulation dam***	7	0	0	7				
Canaletas****	186	88	166	440	210	98	56	364
Measuring	2	17	14	33				
Total	1,178	236	252	1666	522	146	88	756
Percentage (%)	71	14	15	100	69	19	12	100

* Headgates for main canals include radial gate structures, all others are sliding gates

** The 65 control-drop structures combination includes 4 types of drops. (i) vortices [14], (ii) box [23], (iii) vertical [23] and shute [5].

*** Regulation dams are small dams that capture drainage, which is reutilized in the system

**** Flume-type measuring structure

Maintenance condition

Fully functional Keeps design conditions, no elements missing, no modifications apparent or needed

Partially functional Some deterioration is evident, minor components missing, requires minor maintenance [painting, grease], still functions with 15 percent of design requirement

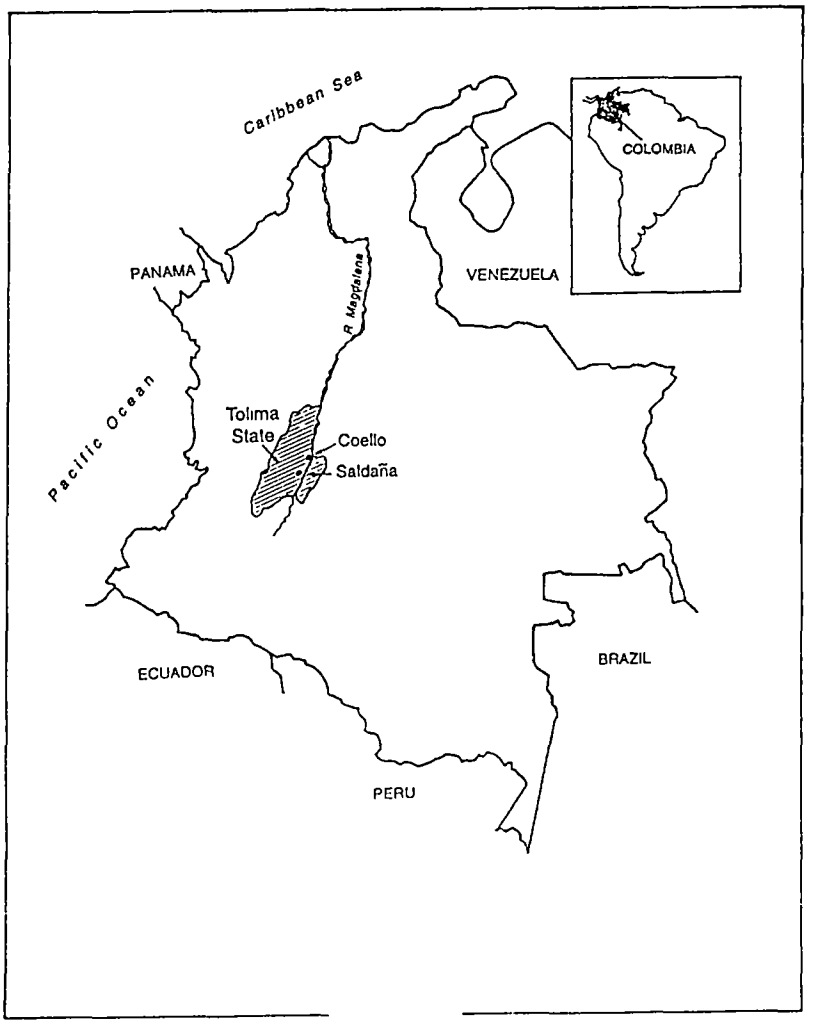
Dysfunctional Heavy deterioration, broken, damaged or missing components, is not functional at all

Annex table 10. Total cost of irrigation to farmers and gross value of output, 1983-1991 (in 1988 dollars).

Year	Irrigation cost per ha ($)	GVO per ha ($)	GVO per 100m³ water	Irrigation cost as percentage of GVO
1983	50.57	944	2.35	5.4%
1984	48.62	1,844	3.53	2.6%
1985	46.06	1,722	6.81	2.7%
1986	46.01	5,394	6.92	0.9%
1987	47.49	2,410	6.57	2.0%
1988	45.67	2,909	7.41	1.6%
1989	49.31	3,391	7.96	1.5%
1990	47.99	4,046	9.54	1.2%
1991	50.63	4,300	9.35	1.2%

Note: $1.00 = 333 Colombian pesos in 1988.
GVO = Gross value of output.

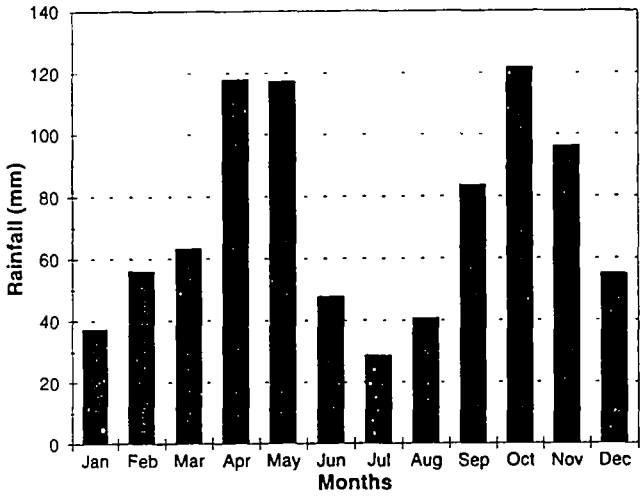
Annex figure 1. Map of Colombia, with Coello and Saldaña irrigation districts.



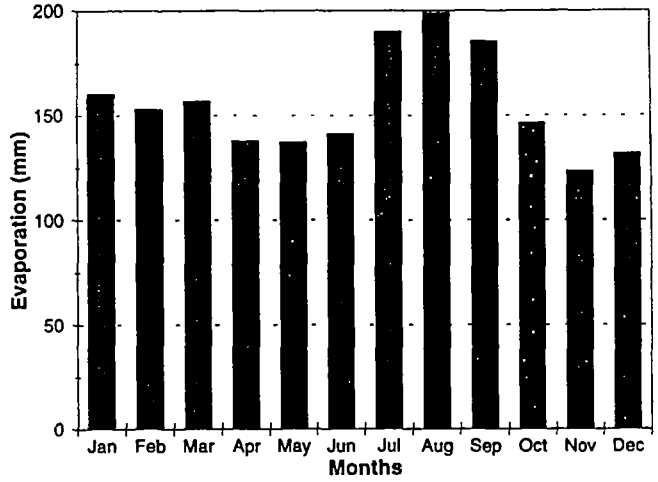
Annex figure 2 Climatic data for the Tolima Valley, Colombia.

Average monthly rainfall - 1962-1992

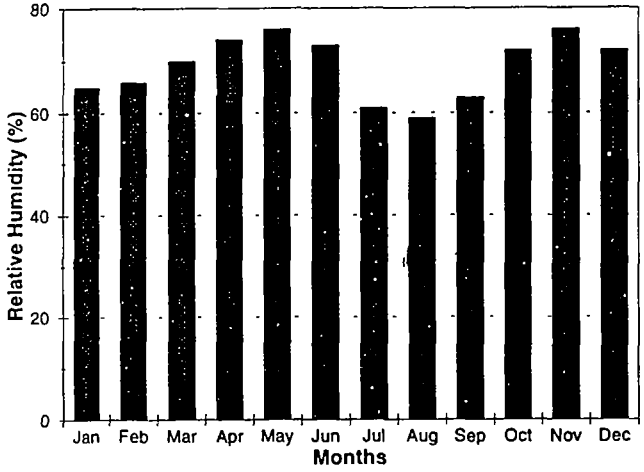
(1976 data not available)



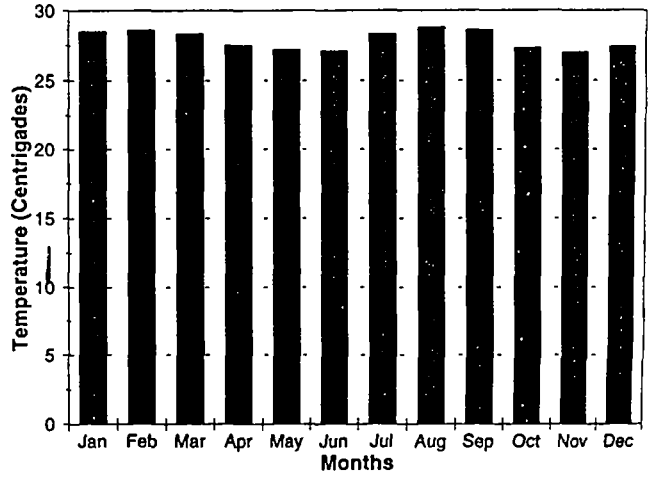
Average monthly evapotranspiration - 1971-1981



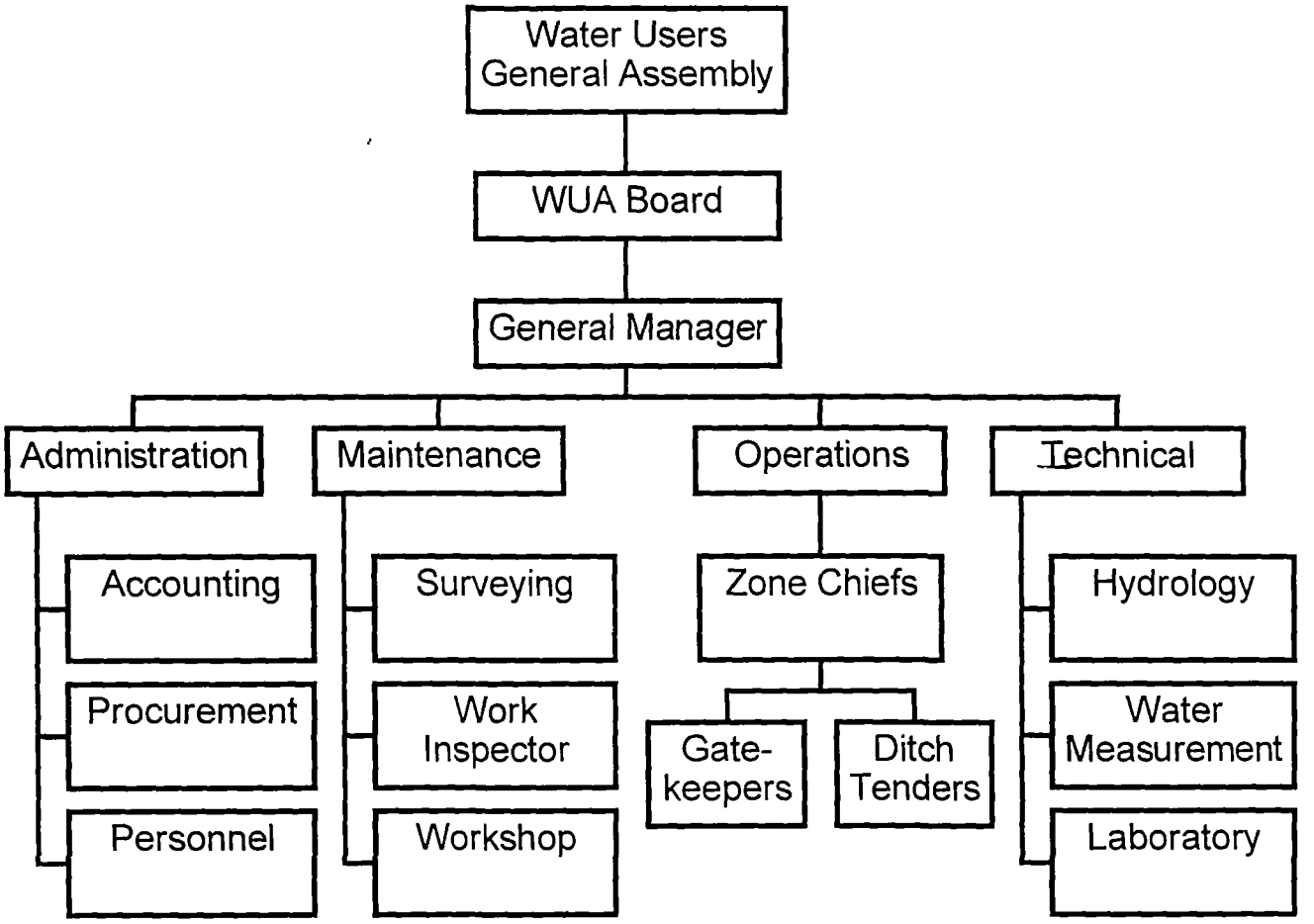
Average monthly relative humidity - 1971-1981



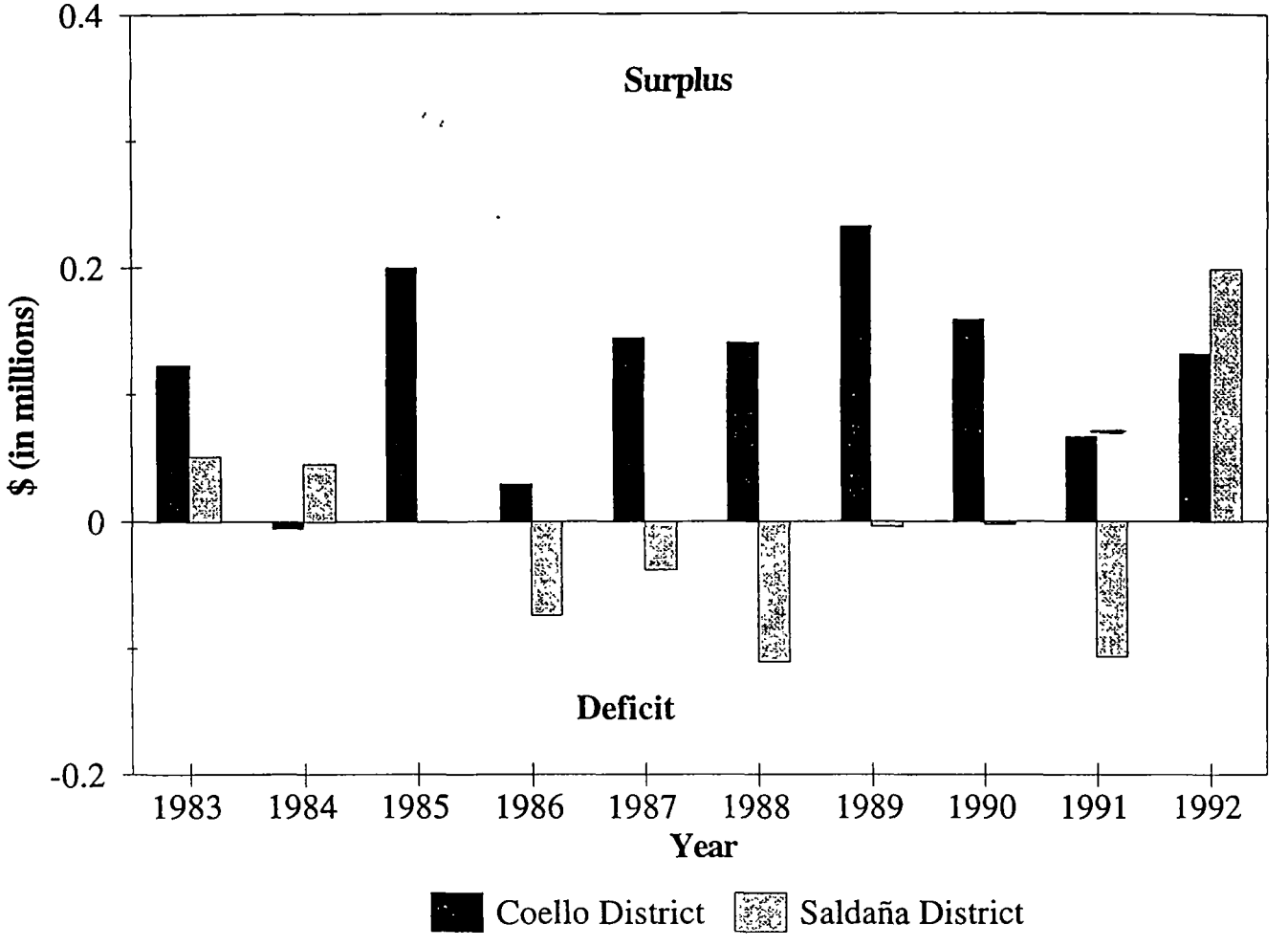
Average monthly temperature - 1971-1981



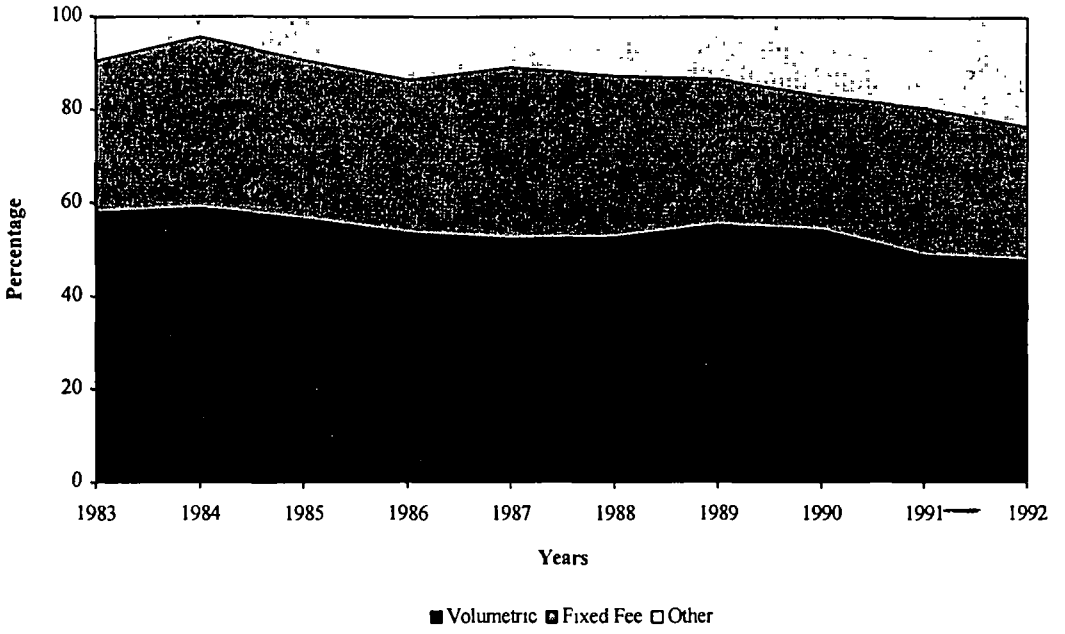
Annex figure 3. Organizational structure, the Coello District.



Annex figure 4. Budget balances in Coello and Saldaña districts, 1983-1992.

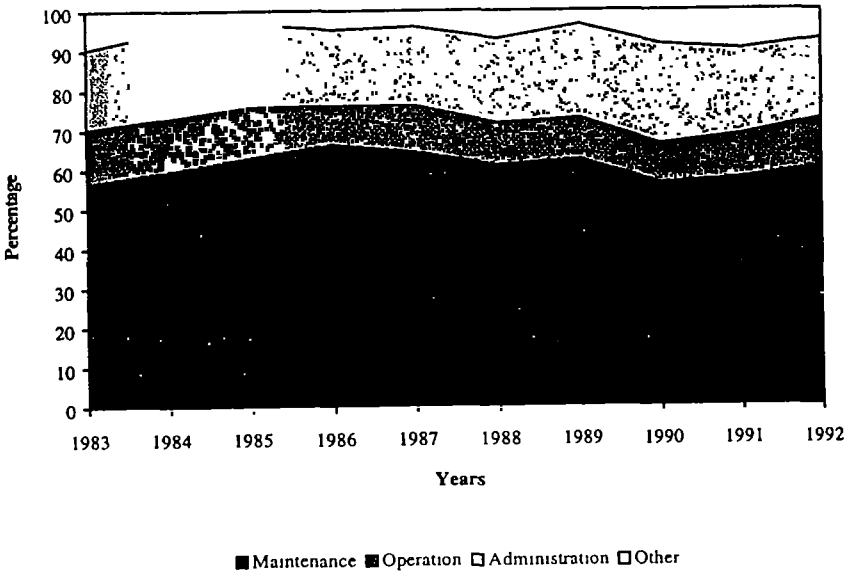


*Annex figure 5. Revenue sources, the Coello District, 1983-1992.**



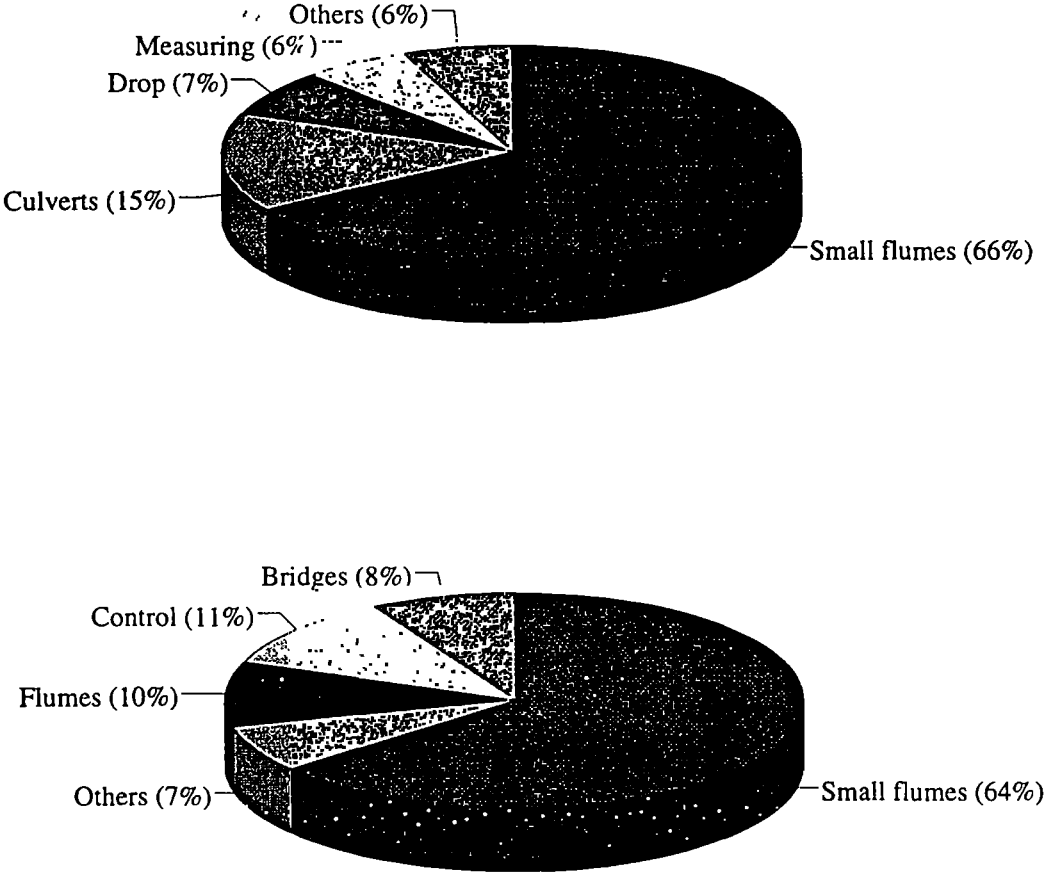
**In constant 1988 Colombian pesos*

*Annex figure 6. Types of expenditure, the Coello District, 1983-1992.**



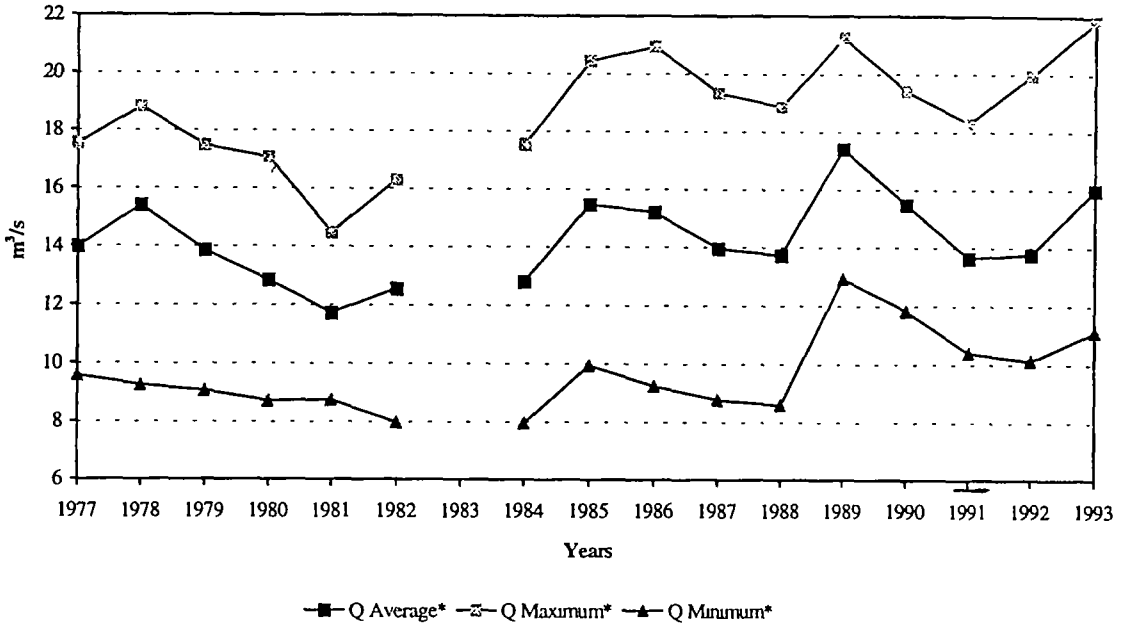
**In constant 1988 Colombia pesos.*

*Annex figure 7. Composition of dysfunctional structures.**



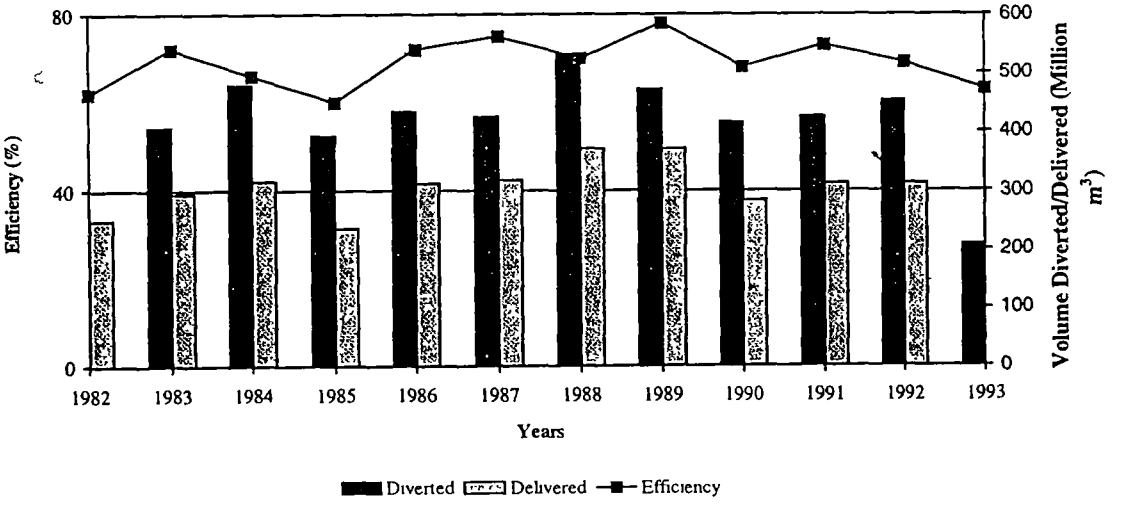
**15 percent or 252 of all structures are "dysfunctional." "Dysfunctional" is defined as: heavy deterioration; broken, damaged or missing components; is not functional within 70% of design requirement.*

*Annex figure 8. Discharge at intake, the Coello District, 1974-1993.**



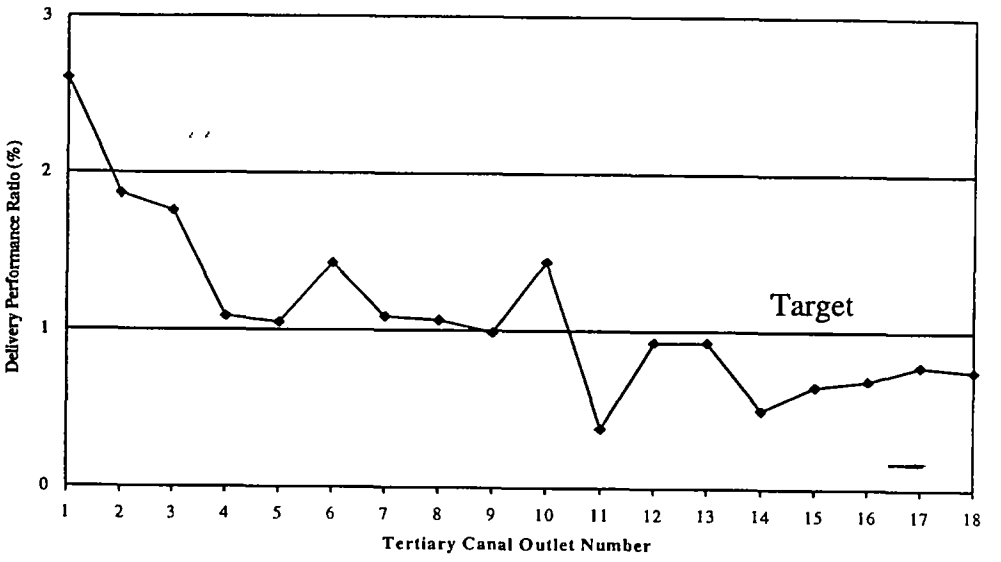
**Average 12 months.*
Note: Data not available for 1983.

Annex figure 9. Main canal total conveyance efficiency, the Coello District, 1982-1993.



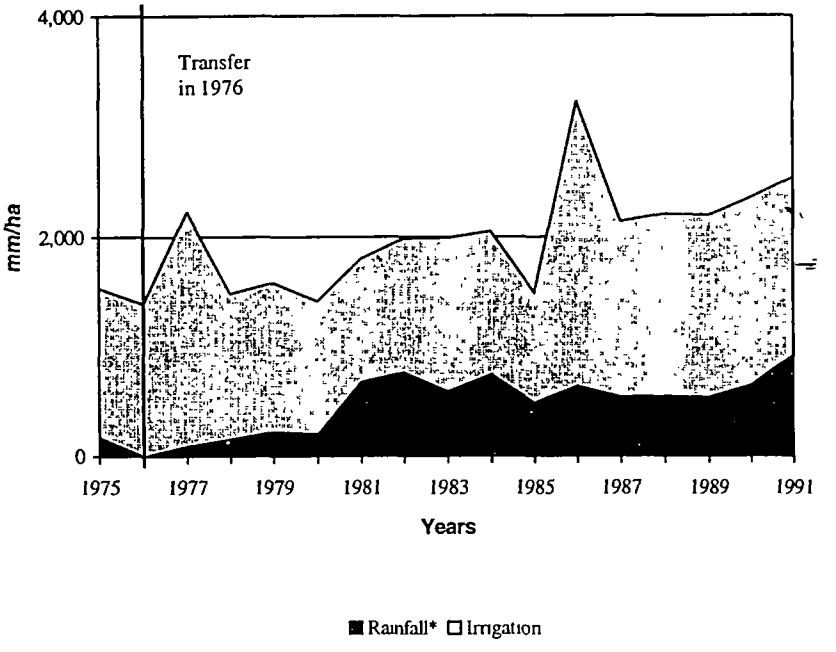
**Ratio of water diverted to delivered water 1982-1993*

Annex figure 10. Water delivery performance ratio along sample tertiary canal, the Saldaña District.



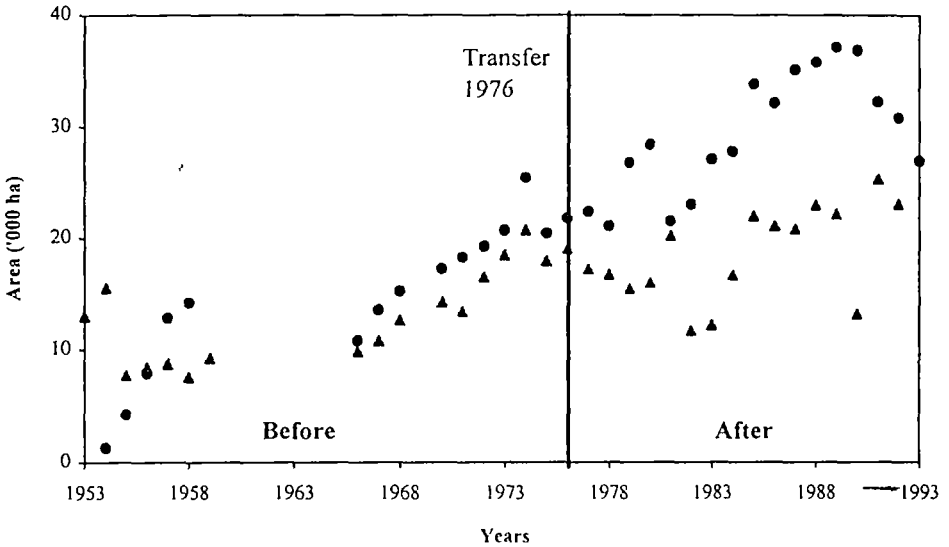
Note: Ratio of water delivered to targeted delivery. Measured July 15,1993.
Distance from tertiary head increases as outlet number increases.

*Annex figure 11. Annual water supply for rice crop, the Coello District, 1975-1991.**



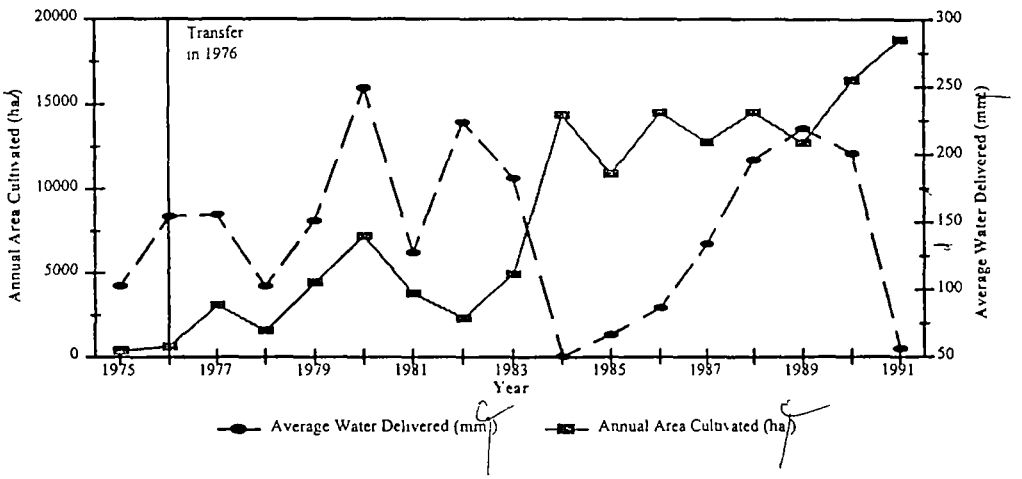
**Main growing season - March, Apnl, May, June and July*

Annex figure 12 Gross annual irrigated area before and after transfer, Coello and Saldaña districts, 1953-1993 **



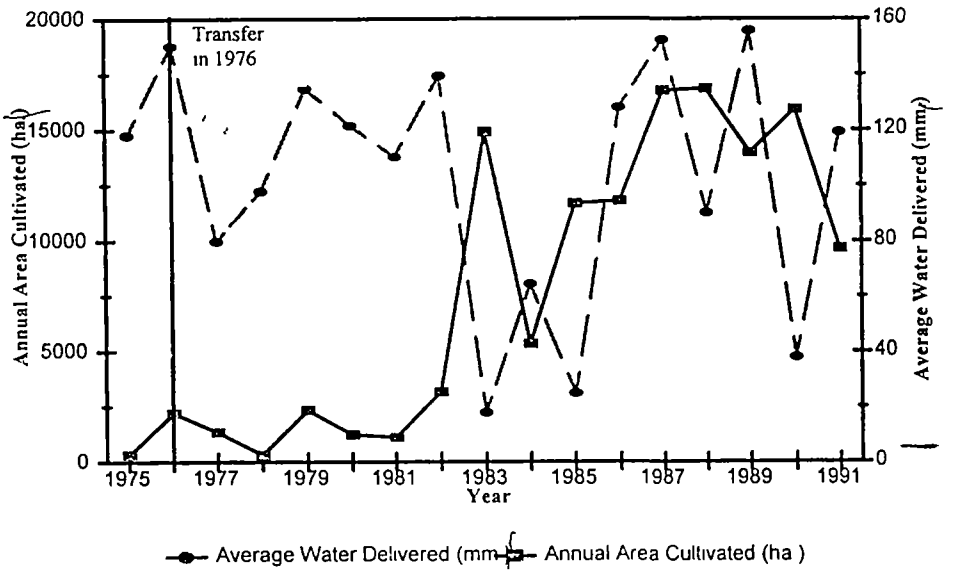
**Summation of irrigated area for both crop seasons*
Note Data for 1960-1964 are missing

*Annex figure 13. Area cultivated and water delivered per hectare for cotton, the Coello District **



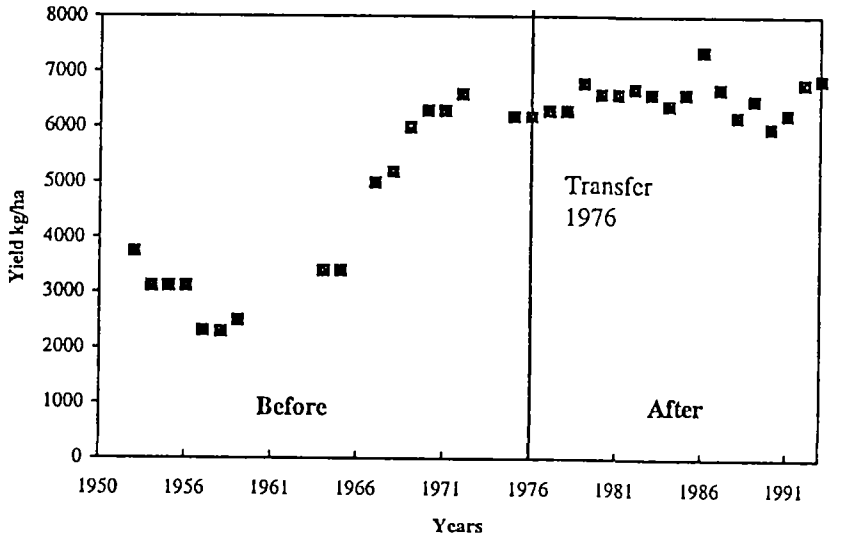
**Per season average*

*Annex figure 14. Area cultivated and water delivered per hectare for Sorghum, the Coello District.**



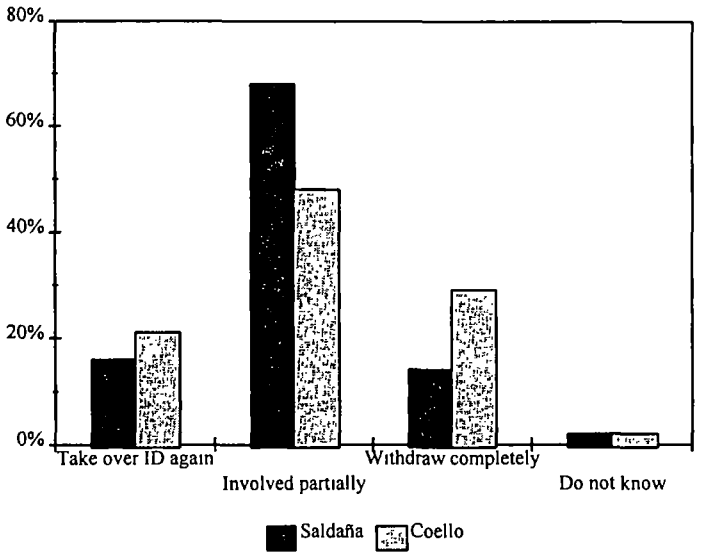
**Per season average.*

*Annex figure 15. Average annual rice yields before and after transfer, Coello and Saldaña districts. 1953-1993.**



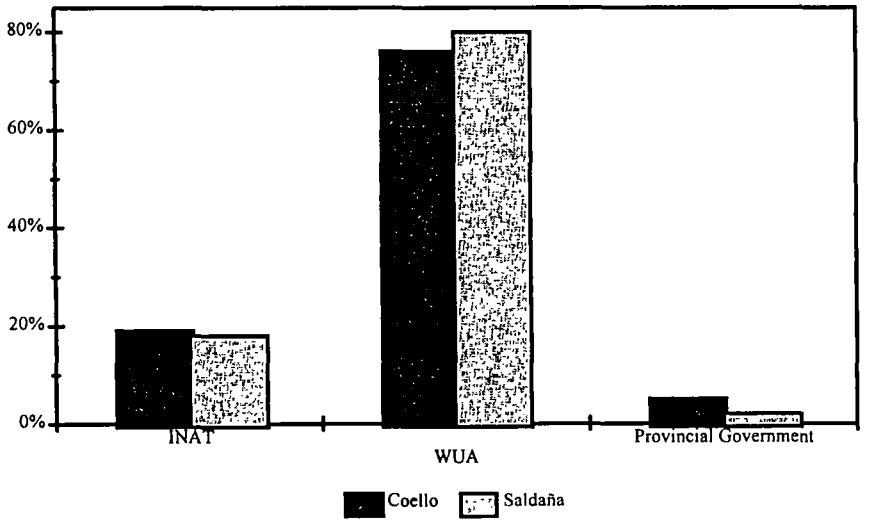
Note For year 1963-1993.

*Annex figure 16. Farmer perspective about withdrawal of the irrigation agency.**



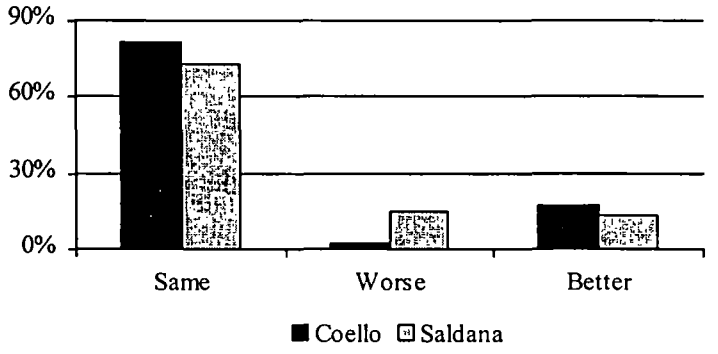
**Sample farmer responses to question, "Should INAT or a government agency continue to be involved with the irrigation district or leave it up to the farmer organization entirely"? N=44 in Coello and 48 in Saldaña.*

*Annex figure 17. Farmer perspective about ownership of irrigation structures.**



Sample farmer responses to the question, "Who should own irrigation district structures?" N=42 in Coello and 48 in Saldaña.

*Annex figure 18. Farmer perceptions about secondary canal maintenance.**



N=42 in Coello and 48 in Saldaña.

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