Performance Measurement of FMIS in Soil Conservation and Reclamation

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ABSTRACT

THIS PAPER IS the result of a research carried out at two users' associations located in the Central oasis (Arroyo Claro) and in the Northern Oasis (Tulumaya) of Mendoza Province. Through a knowledge of the factors that cause soil degradation in irrigated areas, attempts have been made to assess the level of participation and efficiency with which the associations deal with these factors. Soil characteristics within each of the associations were analyzed and a survey was prepared with a view to collecting the data needed to quantify and qualify their performance in soil conservation and reclamation.

Eighty-five percent of the farmers belonging to each association were surveyed (14 from Arroyo Claro and 9 from Tulumaya). The results yield different degrees of participation and performance, Arroyo Claro holding the higher ones.

The parameters involved in soil degradation and conservation were correlated. The different performance and participation indexes obtained make it possible to assess the users' attitude towards the problems under consideration.

INTRODUCTION

Mendoza Province is located in the central-western region of Argentina and has a long tradition in irrigation dating from pre-Columbian times. In spite of having only 13 percent of the national water resources, it comprises 360,000 hectares under irrigation, which is equivalent to 30 percent of the total irrigated area in the country.

There are five main rivers originating in the Andes Mountain Range and fed by snowmelt. The use of this resource has given rise to the formation of five irrigated oases.

In 1978, abundant snowfall in the Andes Range led to a rich hydrological cycle. It has resulted in rising water tables and soil salinity problems produced — inter alia — by a high aquifer recharge in river faults, canal seepage and infiltration (90% of the network is made up of earthen canals), and by low irrigation efficiencies because of the important water supply and little groundwater extraction.

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The economic crisis of the viticultural sector, the main agricultural activity in the province, and the fluctuations in the fruit and vegetable growing sectors further aggravate the soil degradation and reclamation problems.

In view of these problems, both the national and provincial governments have supported the agriculture sector by granting subsidies for soil reclamation to farmers who organized themselves into associations, rehabilitating a large network of zonal drainage canals, and by granting canal inspections a higher degree of autonomy (participation in irrigation management). All this led to the setting up of more than 15 users' associations which have carried out soil reclamation activities.

This is why it was necessary to measure the performance of these associations in soil reclamation and improvement, especially because water resources in the province are fully allotted and water rights are appurtenant to the land. Thus, it is imperative for productivity levels of those lands to be maintained.

BACKGROUND INFORMATION

Several authors have dealt with this subject lately. FAO's report on South America focuses on the causes of soil degradation and on the corrective actions required, but it does not take into account the performance of users' associations.

Smedema (1990) points out that the quantification of waterlogging and soil salinity can be used as users' performance indicators in an irrigated area.

M. Bos (1990) analyzes the importance of evaluating water distribution in irrigated areas. Water distribution has a considerable incidence on the degradation of heavy soils or soils with limiting layers due to drainage problems. Bos and Walker (1990) also point out the importance of assessing irrigation efficiency, another factor contributing to soil degradation due to drainage problems.

At FAO's Workshop (1989) on "Soil degradation mechanisms in Latin America," the main causes of the process were identified. These are: accumulation of salts on the profile due to inefficient water use, high water tables because of drainage problems, and the use of inadequate irrigation techniques. A series of recommendations were issued to offset the causes and to further extension activities for the farmers' technical training.

METHODOLOGY

Two users' associations have been selected to evaluate their participation in soil conservation and reclamation. The selected associations are Arroyo Claro (Central Oasis) and Tulumaya (Northern Oasis).

There are 16 farmers (390 ha) in Arroyo Claro and 11 farmers (147 ha) in Tulumaya. After analyzing soil degradation processes in both areas, a questionnaire was prepared containing 25 items dealing with the actions required to combat soil degradation causes and the number of drainage works constructed. The objective pursued was to assess farmers' participation and performance.

Eighty-five percent of the farmers' in each association were interviewed. Both associations share high water table and salinity problems; both have been granted subsidies by the national government to construct soil conservation and reclamation works.

The surveys having been analyzed, average values for each of the parameters were calculated. This information made it possible to relate and weigh the most important parameters and to generate participation and performance indexes.

RESULTS

A preliminary analysis of both areas showed that the main problem of the cultivated soils was the rising water tables due to rich hydrological cycles, low irrigation efficiencies, seepage and infiltration in the distribution system (earthen canals), and the discharge of industrial effluents with high salt contents in the irrigation system (Tulumaya). These problems of water table salinization and soil degradation have been further aggravated by a failure to maintain the existing zonal drainage canals and the insufficient number of secondary and farm drainage works. The parameters examined aim at quantifying and qualifying farmers' attitudes towards them (Table 1).

Table 1 shows that Arroyo Claro had more difficulties because — before farmers joined in an association — the water table was at 0.50 m. But the association was able to lower the water table 1.18 m and it has washed a higher percentage of soils affected by salinity. At present (5 years after the association was set up), there is a smaller percentage of soils affected by high water tables (30%) and salinization problems.

This was achieved through greater participation in combatting against the elements which produce soil degradation. This is shown in the results obtained for other parameters: a higher percentage of farmers cleaning the zonal drainage canals (93%), shorter cleaning intervals (1.7 year), a higher percentage (100%) of farmers constructing secondary drainage canals (7,630 m total) and plot drains (100% = 16,670 m).

Table 1. Basic parameters for measuring participation and performance of users' associations.

Parameter	Average value	
	Ao. Claro	Tulumaya
1. Total area (hectares)	390	147
2. Cultivated area (%)	75	69
3. Condition of crops (very good, good, fair, bad)	Good	Fair
4. Water table depth before setting up the association (meters)	0.50	0.67
5. Present water table depth (m)	1.68	1.67
6. Area with water table problems (%)	30	59
7. Salinity problems (slight, normal, serious, excessive, uncultivable)	Normal to Serious	Serious

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Parameter	Average value	
	Ao. Claro	Tulumaya
8. Area with salinity problems (%)	21	25
9. Farmers who clean the zonal drainage canals (%) and cleaning intervals (years)	93 1.7	25 .5
10. Reasons why the zonal drainage canals were not cleaned i. economic problems; ii. should be done by the General Irrigation Department [DGI])	i	ii
11. Farmers who have dug secondary drainage canals % and total meters per association	100 % 7,630 m	100 % 2,604 m
12. Farmers who have dug plot drains (%) and total meters per association	100 % 16,670 m	35 % 2,180 m
13. Meters of plot drains per hectare affected by high water tables	142	25
14. Reasons why plot drains were not dug i. unnecessary; ii. economic problems	–	i (45%) ii (20%)
15. Farmers who clean plot drains (%) and cleaning intervals (years)	79% 1.7 year	35 % 1 year
16. Lowering of water table (meters)	1.18	1.00
17. Farmers who washed soils affected by salinity (%)	50 %	43 %
18. Washed saline soils (%)	90 %	80 %
19. Canal seepage and infiltration according to farmers (%)	1–5 %	5–10 %
20. Irrigation method (S: furrow; M: basin; cd: with runoff; sd: no runoff)	S and M sd	S and M sd (50%) cd (50%)
21. Irrigation water quality according to farmers (excellent, good, fair, bad, excessively saline)	Good to Fair	Fair to bad
22. Farmers' opinion of their irrigation: i. insufficient; ii. well; iii. in excess	i and ii	ii
23. Field water application efficiency (measured)	43 %	43 %
24. Number of meetings of users' associations during the year	12	1
25. Members' attendance at the meetings (%)	70 %	40 %

The results show an important difference in favor of the Arroyo Claro Association (142 m) as regards meters of drains dug per affected hectare. Another important parameter is the number of meetings held by each association and the number of farmers attending them. The Arroyo Claro Association had an average attendance of 70 percent and a monthly meeting, while Tulumaya had one yearly meeting and a 40 percent attendance.

Although the parameters give a clear idea of the associations' participation and performance in soil conservation and reclamation, the most important ones were related and weighed according to their incidence upon the problems analyzed. The following indexes were obtained:

Performance Index

D1 = (% hectares affected by salinity problems that were washed x 0.4) + (water table lowering attained (m) x 0.2) + (meters of plot drains per ha affected by rising water tables x 0.4)

D2 = (% hectares affected by salinity problems that were washed x 0.4) + (meters of plot drains per ha affected by high water tables x 0.6)

D3 = (application efficiency x 0.4) + (external conveyance efficiency x 0.2) + ((100/cleaning interval of the zonal drainage canal - in years) x 0.4)

Participation Index

P1 = (Farmers (%) who washed soils affected by salinity x 0.35) +
+ (farmers (%) who cleaned zonal drainage canals x 0.2) +
+ (farmers (%) who dug plot drainage canals x 0.45)

P2 = ((Farmers (%) who cleaned zonal drainage canals / cleaning interval) x 0.3) +
((farmers (%) who cleaned secondary drainage canals / cleaning interval) x 0.35) +
((farmers (%) who cleaned tertiary drainage canals / cleaning interval) x 0.35)

P3 = (Condition of crops x 0.2) + (cultivated area (%) x 0.2) +
+ ((1/area affected by salinity problems (%)) x 0.3) +
+ (1/area affected by rising water tables (%)) x 0.3)

P4 = Number of annual meetings x (average attendance per meeting/100). The parameters involved in each index were then analyzed. This was done to quantify the possible maximum and acceptable minimum values for each of them according to the problems and characteristics of the area. The maximum and minimum acceptable values for each of the indexes are the following:

Performance

Max = (100 x 0.4) + (1.5 x 0.2) + (100 x 0.4) = 80.3
D1
Min = (50 x 0.4) + (0.75 x 0.2) + (50 x 0.4) = 40.1

Max = (100 x 0.4) + (100 x 0.6) = 80
D2
Min = (50 x 0.4) + (50 x 0.6) = 50

Max = (90 x 0.4) + (100 x 0.2) + ((100/1) x 0.4 = 96
D3
Min = (75 x 0.4) + (85 x 0.2) + ((100/2) x 0.4) = 67

Participation

Max = (100 x 0.35) + (100 x 0.2) + (100 x 0.45) = 100
P1
Min = (50 x 0.35) + (50 x 0.2) + (50 x 0.45) = 50

Max = ((100/1)x0.3)+((100/1)x0.35)+((100/1)x0.35) = 100
P2
Min = ((50/1)x0.3)+((50/1)x0.35)+((50/2)x0.35) = 41

Max = (4 x 0.2) + 100 x 0.2) + ((1/0)x 0.3) + ((1/0)x0.3) = 20.8
P3
Min = (3 x 0.2) + (80 x 0.2) + ((1/20)x0.3) + ((1/20)x0.3) = 16.6

Max = 12 x (100/100) = 12
P4
Min = 1 x (60/100) = 0.6

As may be observed, for index D1, the percentage of hectares affected by salinity problems yields a maximum value of 100 percent and an acceptable minimum of 50 percent.

It has been determined that the optimum lowering of the water table is 1.5 m in view of the fact the water table levels, prior to the implementation of reclamation activities, were at 0.50–0.70 m. By lowering the water table to a depth of 2–2.20 m, the crops will not be affected. As regards index D3, the application efficiency parameter has been assigned a maximum value of 90 percent and an acceptable minimum of 75 percent.

The external conveyance index has a maximum value of 100 percent and an acceptable minimum of 85 percent. The annual zonal drainage canal cleaning parameter ranges between an optimum of once a year (as recommended) and an acceptable minimum of once every two years.

The percentage of farmers participating in different activities has been included among the participation indexes. The maximum has been set at 100 percent and the acceptable minimum at 50 percent, with the exception of index P4 (attendance at meetings parameter) which has been assigned a minimum value of 60 percent.

For index P2, both the maximum and minimum values of the cleaning interval parameter for the different drainage canals is 1 year. This is so because the farmers are unable to clean the canals more frequently, and because experience shows that a longer interval results in the deterioration of the canals.

As regards index P3, the parameter concerning crop condition was rated as follows: 4 — very good; 3 — good; 2 — fair; 1 — bad. The maximum is 4 and the acceptable minimum is 3. With respect to soils with rising water tables and salinity problems, the optimum value is 0% and the acceptable minimum is 20%.

Once the optimum or maximum and acceptable minimum values had been determined, the indexes for both associations were quantified by calculating the different indexes with the average values obtained from field surveys.

The calculations and results are given in Table 2.

Table 2. Performance and participation quantification in the users' associations under study.

Association: Arroyo Claro
Indexes : Performance (D)
D1 (90x0.4) + (1.18x0.2) + (142x0.4) = 93
D2 (90x0.4) + (142x0.6) = 121
D3 (43x0.4) + (95x0.2) + ((100/1.7)x0.4) = 59
Subtotal: 273
Participation (P)
P1 (50x0.35) + (93x0.2) + (100x0.45) = 81
P2 ((93/1.7)x0.3) + ((100/1)x0.35) + ((79/1.7)x0.35) = 67
P3 (3x0.2) + (75x0.2) + ((1/21)x0.3) + ((1/30)x0.3) = 16
P4 11 x (70/100) = 8
Subtotal: 172
Association: Tulumaya
Indexes: Performance (D)
D1 (80x0.4) + (1x0.2) + (25x0.4) = 42
D2 (80x0.4) + (25x0.6) = 47
D3 (43x0.4) + (90x0.2) + ((100/5)x0.4) = 43
Subtotal: 132
Participation (P)
P1 (43x0.35) + (20x0.2) + (35x0.45) = 30
P2 ((35/5)x0.3) + ((60/2)x0.35) + ((35/1)x0.35) = 25
P3 (2x0.2) + (69x0.2) + ((1/25)x0.3) + ((1/59)x0.3) = 14
P4 1 x (40/100) = 0.4
Subtotal: 69

With respect to performance indexes, the Arroyo Claro association exceeds the maximum values for D1 and D2, which results from the digging of a certain length of drains necessary to lower the water table and wash the salts in the soil. On the other hand, D3 yields values below the minimum. This shows that, although zonal drainage canal cleaning intervals and external conveyance efficiency can be considered adequate, it is the low application efficiency on the irrigation unit which affects the index. The Tulumaya performance indexes are below the minimum, with the exception of D1, which is slightly above minimum (42 points versus 40 points).

The analysis of participation indexes reveals that the values of the Arroyo Claro association are above the minimum, with the exception of P3, which is slightly below minimum (16.6 points versus 15.6 points). This is due to the fact that the soils are being reclaimed and improved. It is expected that these values will exceed the minimum once soil reclamation has been completed.

With these indexes it is possible to classify the performance and participation of soil conservation and reclamation associations. The objective is to compare them and identify the causes that lead to such a classification by means of each of the parameters that defines the different indexes.

By adding up the minimum and maximum values of D1, D2 and D3, and P1, P2, P3, and P4, the following rating system was established:

Index Score Rating	–157 Bad
	157–170 Fair
Performance (D)	171–210 Good
	211–256 Very Good
	111–160 Fair
	–111 Bad
Participation (P)	161–180 Good
	181–232 Very Good

According to this rating system, the Arroyo Claro association's performance is "very good" as regards soil conservation and reclamation operations (273 points) while participation is "good" in problem-solving (171 points). On the other hand, performance and participation at the Tulumaya association are rated as "bad" (132 points — 69 points, respectively).

CONCLUSIONS

The results obtained show that good performance depends on good participation. The Arroyo Claro association is a good example as it combines a good physical management of the problem with the members' interest in solving it.

As regards the Tulumaya association, its performance can be expected to improve if greater users' participation in soil reclamation and conservation activities is achieved.

This paper can be considered as a starting point to evaluate the performance and participation of users' associations in soil conservation and reclamation. Further analyses of a larger number of associations will help to correct the methodology and turn it into an effective tool.

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