Algerian Irrigation in Transition; Effects on Irrigation Profitability in Irrigation Schemes: The Case of the East Mitidja Scheme

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***Abstract*—**In Algeria, liberalization reforms undertaken since the 1990s have resulted in negative effects on the development and management of irrigation schemes, as well as on the conditions of farmers. Reforms have been undertaken to improve the performance of irrigation schemes, such as the national plan of agricultural development (PNDA) in 2000 and the water pricing policy of 2005. However, after implementation of these policies, questions have arisen with regard to irrigation performance and its suitability for agricultural development. Hence, the aim of this paper is to provide insight into the profitability of irrigation during the transition period under current irrigation agricultural policies in Algeria. By using the method of farm crop budget analysis in the East Mitidja irrigation scheme, the returns from using surface water resources based on farm typology were found to vary among crops and farmers' groups within the scheme. Irrigation under the current situation is profitable for all farmers, including both those who benefit from subsidies and those who do not. However, the returns to water were found to be very sensitive to crop price fluctuations, particularly for non-subsidized groups and less so for those whose farming is based on orchards. Moreover, the socio-economic environment of the farmers contributed to less significant impacts of the PNDA policy. In fact, the limiting factor is not only the water, but also the lack of land ownership title. Market access constraints led to less agricultural investment and therefore to low intensification and low water productivity. It is financially feasible to recover the annual O&M costs in the irrigation scheme. By comparing the irrigation water price, returns to water, and O&M costs of water delivery, it is clear that irrigation can be profitable in the future. However, water productivity must be improved by enhancing farmers' income through farming investment, improving assets access, and the allocation of activities and crops which bring high returns to water; this could allow the farmers to pay more for water and allow cost recovery for water systems.

***Keywords*—**Irrigation schemes, agricultural irrigation policy, farm crop budget analysis, water productivity, Algeria.

I. Introduction

In Algeria, liberalization reforms undertaken since the 1990s have resulted in negative effects on the development and management of irrigation schemes as well as on the conditions of farmers [1], [2], [3]. The low water charge and limited irrigation revenues associated with less investment, and the discontinuance of subsidies for the irrigation costs, have resulted in insufficient expenditures on operation and maintenance (O&M) [4]. This has contributed to the deterioration of the irrigation infrastructure, leading to greater water conveyance losses and reduced delivery efficiency [4], [5]. In addition, the increasing competition for water resources from rapid urbanization and the limited resource availability have become severe constraints in the development and extension of irrigation schemes. At the same time, the financial unsustainability of irrigation schemes [4], [5] and the sharp increase in the price of agricultural equipment, fertilizers, and crop protection products have led to deterioration in the material and social conditions of small farmers [3], and a significant decrease both in the number of water users and the area under irrigation [6].

In response to these issues and due to the increase in oil prices, by the end of the 1990s the government had launched several dam construction projects and irrigation rehabilitation schemes associated with an increase of irrigation water prices in order to increase water availability and the irrigated area, and to ensure the financial viability of the schemes. The most important policy adopted by the government was the national plan of agricultural development (PNDA) launched in 2000. It seeks to improve food security and induce the development and modernization of farms through substantial investments, converting production systems by expanding the irrigated areas, reducing the effects of climatic factors on agricultural production, and encouraging the rational use of natural resources by adopting water-saving irrigation techniques. These different measures have affected the farms within the irrigation schemes. However, after implementation of the reforms during the transition period, questions have arisen regarding their effectiveness and worthiness for agricultural irrigation development.

Thus, the key research questions to ask here include the following: are irrigated agriculture profitable under the current policies of water pricing and agriculture in Algeria, and what are the factors affecting irrigation profitability for farmers in the irrigation schemes? Therefore, the aim of this study is to provide insight into the profitability of irrigation during the transition period under the current agricultural irrigation policies.

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II. Case Study and Methodology

The East Mitidja scheme is a large irrigation scheme located in northern Algeria and managed by the ONID (National Agency of Irrigation and Drainage). The ONID is an autonomous agency attached to the Algerian Ministry of Water Resources. The irrigation system covers an area of 18,000 ha. The climate is Mediterranean, with an average yearly precipitation of 650 mm. The average monthly temperature varies from 10.6°C in winter to 24 °C in summer. Yearly evapotranspiration is approximately 1900 mm, and relative humidity is about 60%. The surface irrigation water is provided by the Hamiz Dam, Reghaia marsh, and Boureah pumping stations, which together have a total storage capacity of 27.5 million cubic meters. The main crops grown in the region are various fruits and assorted annual crops.

The choice of type of farms is based on the typology of irrigation farms in the East Mitidja irrigation scheme [7].

Group1: (22 farms) Large collective farms in division fragmented into smaller parcels between its members due to conflicts. Areas are greater than 12 ha. Between 25 to 50% of the total area is abandoned. The main farming system is based on citrus crops. Gravity is used as the irrigation technique.

Group2: (22 farms) Large collective farms in division with an area greater than 12 ha and farming system based on association of industrial crops and vegetables. Gravity is used as the irrigation technique.

Group3: (7farms) Farms using water saving technologies and conjunctive use of water resources, with varied farming systems and sizes. Subsidized farms.

Group4: (5 farms) Medium private farms with farming systems based on intensive and extensive vegetable production. Subsidized farms. Gravity is used as the irrigation technique.

Group5: (21 farms) Small private farms based on extensive vegetable farming where the irrigated area is less than 50%. Not subsidized. Gravity is used as the irrigation technique.

Group6: (27 farms) Collective farms in union-land are not fragmented and members are still united in farming activities and decision-making. Areas are less than 7 ha. The farming system is based on citrus crops. Subsidized farms. Gravity is used as the irrigation technique.

Group7: (30 farms) Small private farms with areas less than or equal to 2 ha. Farming system based on either citrus crops or grapes. Not subsidized. Gravity is used as the irrigation technique.

Fig. 1: Characteristics of farm groups in the East Mitidja scheme

The typology was elaborated, using data from 134 farms, by a stratified random sampling procedure. Surveys were conducted between June and August 2007. Based on technical and socio-economic characteristics and using multivariate analysis, the typology highlighted the diversity of irrigation farms within several homogeneous groups in the irrigation scheme. The main features of the farmers' groups are summarized in Figure 1 above.

III. Data Analysis

Irrigation profitability at the studied farms was analyzed with the farm crop budget method [8]. This method, also known as the residual valuation technique, is the most common deductive method applied to irrigation water valuation [9]. It seeks to find the maximum return attributable to the use of water input. The total crop revenue minus non-water input costs is the residual, or the maximum amount the farmer could pay for water and still cover the costs of production. It thus represents the on-site value of the water. This maximum amount divided by the total quantity of water used represents the maximum average willingness to pay [8].

This method can be applied to estimate the value of water in the East Mitidja scheme. However, in our case, the farm budget approach was not used to derive the marginal returns to water (total revenues minus all non-water costs generated by applying one more unit of water). In general, under conditions of water scarcity, the average value is a reasonable proxy for the marginal value because farmers are trying to maximize the return on the scarce resource [10].

For the data analysis, Group 7 was subdivided into two subgroups, 7a, based on grape farming, and 7b, based on citrus farming (see Table 1 below). Group 3 was excluded from the data analysis, as the purpose of this study is to estimate the value of surface water only, in relation to payments made by the farmer to the agency (water revenue that contributes to the financial viability of the irrigation scheme).

The data collected from the different groups consist of cropping systems, area irrigated, production cost data (seeds, tillage, fertilizers, pest and disease control products, labor, repair and maintenance, harvesting, marketing costs and amortization), and total value (based on total production and farm gate price). The information gathered by the groups (number of farms with similar attributes) was aggregated to produce average values of production costs and revenues, which varied between the groups, assuming that all other factors, such as soil type, climate, and product prices, are similar. The quantity of water used was derived from ONID irrigation data (water bills).

IV. Results and Discussion

Table 1 below describes the groups' average characteristics, such as size, percentage of irrigated area, and irrigated crops area.

Table 2 shows the results of total non-water costs, revenues, net income, returns on water calculation at the farm level for each group across the irrigation scheme. The prices of different crops used here were quoted by the farmers during the survey.

Analysis of the returns from using water resources shows that returns to water vary not only among crops but also between the farm groups. The average return on water in the irrigation scheme was Da44.78per m^3. The highest values were found in Group 4, with average returns of Da99.51 per m^3, and the lowest values were found in Group 5, with average returns of Da15.37 per m^3

TABLE I FARM GROUPS' CHARACTERISTICS

Group1	*Size (ha):* 16. *Irrigated area (%)*: 62.50. *Irrigated crop (ha)*: Citrus; 10
Group2	*Size (ha):*16.28. *Irrigated area* (%): 87. *Irrigated crop (ha)*: Industrial tomato: 5.4, Potato: 2.3, Sweet Peppers: 0.75, Eggplant: 1, Carrot: 0.5, Turnip: 0.15, Zucchini: 1.1, Salad: 0.2, French Beans: 1.8, Onion: 0.2, Cabbage: 0.7
Group4	*Size (ha):* 4.92. *Irrigated area (%)*: 93. *Irrigated crop (ha)*: Greenhouse: 1.07, Potato; 0.68; Tomato; 0.59; Sweet pepper; 0.37; Eggplant; 0.2; Carrot; 0.12; Zucchini; 0.67; French Beans; 0.42; Cabbage; 0.46
Group5	*Size (ha):* 2.47. *Irrigated area (%)*: 40.42. *Irrigated crop (ha*): Potato 0.164; Sweet Peppers; 0.077; Eggplant 0.067; Carrot; 0.192; Turnip; 0.038; Zucchini; 0.365; French Beans; 0.096
Group6	*Size (ha):* 6.18. *Irrigated area (%)*: 100. *Irrigated crop (ha)*: Citrus; 6.18
Group7a	*Size (ha):* 2ha. *Irrigated area (%)*: 100. *Irrigated crop (ha)*: Grape; 2
Group7 b	*Size (ha):* 0.83ha. *Irrigated area*: 100%. *Irrigated crop (ha)*: Citrus; 0.83

*All figures are averages

TABLE II RESULTS OF RETURNS TO WATER IN EAST MITIDJA SCHEME.

	Total non-water costs (10^3Da)	Total revenue (10^3Da)	Net Income (10^3Da)	Total water volume (m^3)	Returns to water (Da/m^3)*
G1	848.5	2,600	1,751.5	51,000	34.34
G2	1,599.8	2,713.7	1,113.8	34,924.6	24.32
G4	1,146.4	3,829.5	2,683.1	13,622.9	99.51
G5	79.48	111.13	31.64	1,900.44	15.37
G6	934.41	3,708	2,773.5	33,124.8	83.73
G7a	184.2	540	355.8	10,000	35.58
G7b	69.59	199.2	129.6	4,233	30.61

*return to water = average returns to water from combined crops per group of farms. Da1=$72.64 (2006)

For vegetables crops, the return to water for Group 5 was lowers (with Da15.37 per m^3) than for Groups 2 and 4 (Da24.32 per m^3 and Da99.51 per m^3, respectively). The lower returns of Groups 2 and 5 were due to technical and natural factors, such as the use of poor quality seeds, lack of agricultural equipment, very low level of mechanization, less and non-use of fertilizers, and the non-use of pesticides because of high prices. The resulting yields per hectare were much smaller (average yield of 75.05 Qx per ha) than those of Group 4 (average yield of 335.05 Qx per ha), which is characterized by the optimal utilization of fertilizers and intensification. However, in Group 2 the diversification of the industrial tomato-vegetable cropping system was positively affected by the increase in productivity. It was found that 1 ha of industrial tomato production yielded an average of 250qx/ha, while vegetable crops yielded an average of 91.4qx/ha.

For orchard farms, returns to water in Groups 1, 7a, and 7b were low, with average returns of Da34.34 per m^3, Da35.58 per m3, and Da30.61 per m^3, respectively, while it was Da83.73 per m^3 for Group 6. These differences in returns were because in Groups 1, 7a, and 7b, orchards are poorly managed with a lack of maintenance for a long period, use less fertilizers and pest and disease control measures, and experience problems with aging trees, while in Group 6 the orchards are managed with modern techniques of tillage, biological control, fertilizers, and pest and disease control products until harvest. Higher production costs per hectare in Group 6 (Da165.000 per ha) resulted in higher yields of 300 Qx per ha compared to Groups 1, 7a, and 7b, where average of production costs of Da100.000 per ha resulted in yields less than 135 Qx per ha. It should be mentioned that Group 6 and Group 4 are the only groups who are in permanent contact with extension services which help them to increase their productivity, and as result their profits. The other groups do not belong to any active farmers association; therefore, they have no access to agricultural information or contact with extension services. These groups have a constraint of land ownership (no ownership title for Groups 5, 7a, and 7b) or ownership complications for Groups 1 and 2. In the latter groups, before subdivision of collective farms, the head or representative of the collective farms owns an agricultural farmers' card (with the agreement of all members) which allows the farm access to subsidies and credits, but after subdivision the card is seized, and the farm is therefore in the same situation as the private farms of Groups 5, 7a, and 7b. Because these groups do not own title to their land, they do not have the collateral that would provide them access to credit. Hence, investment, and therefore, profitability, on the farm is limited.

In addition, other factors were found to affect the profitability of irrigation in the irrigation scheme. Farm income is subject to market price conditions and to intermediaries (price fluctuations). It was found that the "sell at the farm" method was practiced by almost all farm groups in the scheme, predominantly those that have fruit farming systems. Due to a lack of resources and the uncertainty of the market, farmers found it convenient to sell their crops on the farm itself, which limits the risks of harvesting, storage, and transportation. However, this marketing system made farmers dependent on intermediaries for access to information on the market, limiting their chances to improve their income, and discouraged them from making investments in their farms. Indeed, the large profit margin that emerges between the prices in "sell at farms" and consumer prices (at the market) shows that the intermediaries get more advantages in terms of benefits.

Using sensitivity analysis, the price fluctuations were shown to affect the farm groups differently. As shown in Table 3, a 10% decrease in crop price will reduce the returns to water for Groups 2 and 5 by more than 37% in average, while it reduces the returns to water by 18.44% for Group 4 and less than 16% in average for Groups 1, 6, 7a, and 7b (orchard farms) because of their higher revenues per hectare. Moreover, reducing crop price by 30% will result in negative returns for Groups 2 and 5, a decrease of 29.37% in average for Groups 1, 6, 7a, and 7b (orchard farms), and a decrease of 36.88% for Group 4. This indicates that the sensitivity to price variations is higher for Groups 2 and 5 than the other groups.

TABLE III PRICE FLUCTUATIONS AND RETURNS TO WATER IN THE IRRIGATION SCHEME.

	Returns to water*	Returns to water* if crop prices drop 10%	Returns to water* if crop prices drop 20%	Returns to water* if crop prices drop 30%
G1	34.34	29.24	24.15	19.05
G2	24.32	14.51	4.70	-5.10
G4	99.51	81.16	62.81	44.47
G5	15.37	9.91	4.46	-0.98
G6	83.73	72.53	61.34	50.15
G7a	35.58	30.18	24.78	19.38
G7b	30.61	25.91	21.2	16.5

* Returns to water in Da/ m^3

In order to determine the effect of the increase of water price on farmers' income (total revenue - total costs (including water costs)) in the different farm groups, we levied the water price to O&M costs and the marginal cost of providing irrigation water in the scheme to the farm. The calculation of O&M cost is based on the energy, operations, and maintenance costs of providing the irrigation service, excluding capital expenditures and depreciation. In 2006, the annual water volume distributed in the scheme amounted to 5,117,868 m^3. The costs incurred by O&M were about Da15,576,751 (see Table 5). Thus, the supply of 1 m^3 in the scheme cost Da3.04 per m^3 (greater than the current water price of Da2.5 per m^3).

TABLE V OPERATION AND MAINTENANCE COSTS IN 2006 IN EAST MITIDJA SCHEME

Costs	Energy costs (10^3Da)	Maintenance (10^3Da)	Operating (10^3Da)	Total O&M costs (10^3Da)
Cost &%	5,792.96 (37.18%)	890.8 (5.71%)	8,893 (57.1%)	15,576.7 (100%)

An analysis of the cost structures of irrigation showed that 57.1% of costs were for operating, 37.18% for energy, and only 5.71% for maintenance; moreover, in 2005 the share of maintenance costs also did not exceed 6% of the total O&M costs. The low maintenance expenditures affected the irrigation system and resulted in deterioration of the irrigation infrastructure, which led to greater water conveyance losses and reduced delivery efficiency [11]. Maintenance is generally carried out only in the case of an emergency. The conveyance efficiency ratio (Volume delivered*100 / Volume diverted) was calculated to be only 51 % in both 2005 and 2006. These excessive water losses could have irrigated double the actual irrigated area in the scheme, where only 1,311.5 Ha was irrigated in 2006 (irrigation ratio of only 12.5%). In addition, irrigation water theft regularly occurs in the scheme; in 2006, more than 1.1 million m^3 of water was stolen, which represents more than 23% of the total water losses, compared to an average of less than 20 % i.e. 350,000 m^3/ year from 1996 to 2005. Besides, the irrigation agency has diversified its operations and expanded into other areas. These include civil works as well as the sale of goods (irrigation equipment and accessories) and services. This has helped to create new sources of income for the agency. The good sales and civil work represent more than 70 % of the total income of the agency; therefore, these are major new sources of revenue which are not the principal function of agency, where income has been based on collection of recovery charges [11]. This has had a negative effect on the water users. The agency is less concerned about the farmers' problems, which in return causes the farmers to lost trust in the agency's services [12].

As shown in Table 6, the increase of irrigation water price to O&M costs (from Da2.5 per m^3 to Da3.04 per m^3) resulted in an insignificant decrease of 2.73% of the farmers' income on average.

TABLE VI FARMS' INCOME AT WATER PRICE, O&M COSTS AND MARGINAL COSTS

	Income (10^3Da) at Da2.5/m^3	Income (10^3Da) at Da3.04/m^3	Income variation (%)	Income (10^3Da) at Da19.2/m^3	Income variation (%)
G1	1,920	1,892.4	-1.43	1,068.3	-44.35
G2	1,020.9	1,002.	-1.84	437.7	-57.13
G4	2,647.2	2,639.9	-0.27	2,419.7	-8.59
G5	26.5	24.6	-7.17	-5.2	-119.78
G6	2,688.3	2,670.4	-0.66	2,135.1	-20.57
G7a	330	324.6	-1.63	163	-50.6
G7b	118.7	116.4	-1.92	47.9	-59.55

This low effect is because the irrigation costs currently account for an average of 8.31% of farm's income (see table 7). Although there are considerable variations across the farm groups, it is less than 1% for Groups 4 and 6 and less than 2% for Group 1, 2, 7a and 7b.

The higher share of water costs for Groups 1, 2, 7a, 7b, and particularly group5 induce more effect on their farm income when the water price increases (see table 7). Indeed, they use less fertilizers on their farms (high price), while in Groups 4 and 6 the fertilizers and pest and disease control products represents more than 48% of total production costs (maximizing revenues depends mainly on these inputs).

TABLE VII SHARE OF WATER COSTS TO PRODUCTION AND INCOME IN THE SCHEME

	Income (10^3Da)	% water costs to income	Production Costs (10^3Da)	% water costs to production costs
G1	1,920	8.11	980	13.41
G2	1,020.9	9.10	1,692.8	5.50

G4	2,647.2	1.36	1,182.3	3.03
G5	26.5	19.44	84.6	6.08
G6	2,688.3	3.17	1,019.7	8.36
G7a	333	7.81	210	12.28
G7b	118.7	9.19	80.5	13.56

However, if the farmers have to pay marginal costs, which are estimated by the World Bank to be Da19.20 per m^3 [13], and it is likely to be an underestimation [14], the income will decrease by more than 50% on average and more than 119 % for group 5. Group1, 2, 5, 7a, and 7b will be adversely affected since they will have to produce higher yields through increases of production inputs, which is not possible because of the several constraints explained earlier.

V. Conclusion

From the obtained results, irrigation under the current situation of the transition period is profitable for all farmers in the irrigation scheme, including those who benefit from subsidies and those who do not. A comparison of all groups shows that Groups 4 and 6 outperformed in terms of profitability among all the farm groups. This is due to higher yields of crops due to intensive farming development compared with all the other groups in the irrigation scheme. This allowed Groups 4 and 6 to produce higher net returns when compared to the other groups.

In addition, the returns to water were found to be very sensitive to crop price fluctuations, particularly for Groups 2 and 5, and less for the others whose farms are based on orchards. Therefore, the profitability depends on the development of crop prices and intensifying farming associated with better water management.

The PNDA policy did not achieve its objective in the irrigation scheme. Indeed, the irrigation scheme (at the farm level) resulted in less agricultural investment and low intensifying, and the most commonly used irrigation technique is still the gravity fed system. The socio-economic environment of the farmers contributed to less significant impacts of the policy. In fact, the limiting factor is not only the water, but also the lack of land ownership title. In addition, market access constraints led to less investment in agriculture, and therefore low water productivity. Furthermore, increasing the water price to O&M costs resulted in an insignificant decrease of farmers' average incomes; however, if it is levied to the marginal cost, the farmers with low returns will be adversely affected and may not be able to irrigate.

The financial viability of the irrigation system and the sustainability of the resource are of serious concern to the irrigation agency and farmers. By comparing the irrigation water price, returns to water, and O&M costs of water, it becomes clear that irrigation can be profitable in the future. In addition, the PNDA incentives can be an important factor in resolving the problem of financial viability. To ensure the financial sustainability of the scheme, the water price should reflect at least the O&M costs. It is financially feasible to recover annual O&M costs in the irrigation scheme, but this must be conditioned by the improvement of the productivity of water by improving farmers' income through farming investments, improving access to markets, and utilizing activities and crops which bring high returns to water. This could allow the farmers to pay more for water and allow a cost recovery for the water systems.

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