Water Use Efficiency and Valuation in Agriculture in the Souss-Massa

Fouad Elame, Hayat Lionboui, and Choukr-Allah Redouane

Abstract The Souss-Massa region is experiencing an alarming water shortage, resulting from recurrent drought and overexploitation of water resources, particularly groundwater resources. This situation compromises the production potential and threatens the sustainability of agricultural activities, in particular, irrigated areas.

In this context, irrigation water valuation by crops requires utmost importance in the management of water resources in the region. Improving water efficiency takes multiple dimensions related to the choice of crops that value the water resource better, rationalization of water use, improving the productivity and the economic efficiency of farms, while protecting the environment and limiting the overexploitation of water resources. This chapter presents the results of some water valuation analysis, namely financial valuation (accounting method) and the water use efficiency calculation. The latter is based on the results of the DEA approach (data envelopment analysis).

Keywords Agriculture, Economic efficiency, Souss-Massa, Valuation, Water resources

Contents

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1 Introduction

The issue of water use efficiency and valuation is a topical debate. Water valuation was often approached from the perspective of the farmer; profitability was still confused for the farmer to water efficiency. Several studies estimate the water valuation by the net margin per cubic meter (m^3), whereas the interest of the farmer is not necessarily that of the community which is more interested in the overall income and sustainable development goals and conservation of scarce resources.

Agriculture in Morocco depends on climatic conditions. This makes the water management a technical and an economic requirement and privileged trend for economic and social development. This climate insecurity causes global food insecurity (need for massive imports in dry years) and affects drastically the living conditions of the rural world, with repercussions on other activities [11]. Nowadays, the water issue is crucial in Morocco. However, water losses are high, productivity per hectare has not yet reached the optimum for some crops, and the cubic meter of water is not sufficiently valued by crops.

Indeed, the use and the inefficient allocation of irrigation water is a major constraint to the development of the agricultural sectors in irrigated areas. Incentives for effective and efficient management of water still have a limited impact and the water price does not reflect its scarcity.

In this situation, considerable efforts in scientific research must be undertaken to support the development strategies of Morocco Green Plan in order to ensure a more rational and optimal management of water resources.

In this context, an economic valuation study of water resources in the major districts of the area was conducted. The main objectives of this paper are, first, to analyze the scores of water use efficiency of a sample of farms in the area according to the irrigation water sources (dam, groundwater, and conjunctive water use), and also to assess irrigation water valuation by the main crops based on the financial method (accounting method) and data envelopment analysis (DEA) method.

2 The Irrigation Sector in Morocco

2.1 Introduction

Water is the main factor limiting agricultural production in Morocco. Historically, climatic conditions have made irrigation a technical requirement that has acquired over the years undeniable economic and social dimensions. Although they represent only 13% of the total agricultural area of the country, irrigated areas contribute to the creation of 45% of the agricultural added value, 33% of rural areas employment, and 75% of exports of agricultural products [1].

The development of irrigation has allowed creating a food processing industry. It also led the creation of small trade and service companies inserted in rural areas. Irrigated areas represent an important pillar of development at local and regional level with positive repercussions on the national economy.

Knowing that mobilized water potential is estimated at 20 billion cubic meters of which about 17 billion are reserved to agriculture, irrigation potential is estimated at about 1.664 million hectares plus some 300,000 hectares may benefit from seasonal irrigation and flood irrigation [2]. This potential is still relatively limited compared to the needs of the country. It is therefore appropriate to use it in the best way.

2.2 The Souss-Massa Basin

The agricultural modern sector in the Souss-Massa was developed by a private initiative and holds a prominent place alongside the public irrigated sector developed by the government. The Souss-Massa region is well known for its favorable climate for agricultural development and has an important active population potential.

Agricultural production has an important weight at the national level with, in particular, the production and export of citrus and off-season crops. The economic and social development in this region has led to an overexploitation of groundwater resources. The region is thus faced with a water shortage problem exacerbated by drought effects that becomes increasingly structural.

Looking for solutions to the water economy and conservation is an issue that concerns all development players particularly agricultural water users who consume more than 90% of the resource. It is also one of the Morocco Green Plan priorities.

The Morocco Green Plan has developed a national strategy with regional guidelines for water saving and recycling for irrigated agriculture. Indeed, the National Irrigation Water Saving plan (PNEEI) is part of the transverse measures of the Morocco Green Plan. It aims to mitigate water stress, considered as the main limiting factor in improving agricultural productivity. One of the major projects is the modernization of irrigated agriculture through irrigation development

techniques located on a large scale through conversion of existing irrigation with limited efficiency, including surface irrigation. The goal is to fit in drip irrigation for nearly 50% of the total area at national level [3].

Despite its dry climate, the agricultural area in the region occupies 616,500 ha of which 30% is irrigated [4]. These lands are located mainly in the Souss and Massa sub-basins. Irrigation system: The irrigation systems used in irrigated areas of Souss-Massa are, mainly, drip irrigation, surface irrigation in addition to sprinkler irrigation.

According to ORMVASM, areas equipped in 2010 with drip irrigation are around 58,500 ha, which represent 44% of the total area, sprinkling 18%, and surface irrigation 36% [12].

3 Methodology

Assessing irrigation water valuation requires multiple dimensions and scales. At the farm level, water efficiency refers to the productivity and profitability (agronomic and economic dimension). The farmer aims to produce more per cubic meter of water and choose the most profitable crops that can generate the highest profit.

At the community level (region or country), water valuation is assessed according to other factors related to economic and even environmental and social sustainability. This concept is very important and can be used to help decision makers to redefine the appropriate agricultural policies to meet the requirements of socio-economic development and environmental preservation.

In this case, the value added per hectare is used to assess water efficiency levels by farm type in the various areas of the Souss-Massa region.

Since that, at the farm level, the "profit" is the main criteria in the choice of which crop to grow, we will analyze the financial value of irrigation water by farm type and by crop. Then we will compare the different levels of water use efficiency and valuation through the DEA method which is based on the concept of efficiency.

Farrell [5] was the first to clearly define the concept of economic efficiency and to distinguish between efficiency concepts. The relevant work of Farrell [5] served as the basis for several works carried out on the different concepts of efficiency. The issue was whether a farm can increase production simply by improving efficiency and proposed an approach to the estimation of efficiency frontier. The efficient frontier is defined by the most optimal practices of the sample used. To define the frontier as a reference to efficiency measures, it is necessary to define the outputs or aggregated output and production inputs or aggregated input used in a production system [6].

To calculate scores for technical and economic efficiency, an aggregated output of the total production expressed in monetary value was retained. For inputs, five aggregated inputs were considered, namely irrigation water, seed planting, fertilization, treatment plant, labor, and soil preparation. In this study, we choose a variable return to scale (VRS) model, since it is assumed that farms are not all

operating at an optimal level. Using a VRS model of the DEA method provides an efficiency measure free of the scale effect. The data were processed using DEAP software (Data envelopment analysis computer program) which is a free version [7].

Data processed in this work comes from the surveys carried out in 2009 by The ORMVASM in the various areas of the region. Data coming from surveys conducted by the ABHSM [8] (PDAIRE) were also used to compare the different water valuation approaches.

4 Results and Discussion

4.1 Assessing Water Use Efficiency by Farm Type

The valuation concept was recently introduced in the large irrigated areas in Morocco. We were interested before on the concept of water saving that is based on a reduction in irrigation losses, a decrease of applied water quantities, and using modern irrigation techniques. However, the irrigation water valuation aims to look for a maximum of efficiency, of technical and financial productivity of the use of irrigation water [9].

The economic valuation tries to optimize the ratio: the production value, the gross margin or the value added per volume of water consumed.

In this case, the water use efficiency will be assessed by the net added value per water consumption. The results of this analysis show that water valuation varies too much and goes from 5 Dh/m^3 for the "Souss amant public" district, and 22 Dh/m^3 for the "private modern Souss" district. This variability also exists between the different farm types. Indeed, in some districts like "G1," "Massa," and "Issen moderne public," farm areas under 5 ha which are the smallest farms have the highest level of water use efficiency (Table 1).

Table 1 Water use efficiency per farm type (Dh/m^3)

Farm type/District	<3 ha	3–5 ha	5–10 ha	10–20 ha	>20 ha	Average
Massa moderne public	22	27	20	24	16	21.7
Massa traditionnelle	13	14	21	13	13	14.8
Massa moderne privé	21	18	17	28	29	22.8
Issen moderne public	15	14	11	10	13	12.5
Issen traditionnel	6	5	5	7	12	7.1
Secteur G1	7	6	8	5	5	6.4
Souss amont public	5	6	5	6	9	6.3
Souss traditionnel	6	6	7	6	10	7.1
Souss privé	8	10	11	8	9	9.3
Sebt al Guardane	7	8	9	15	13	10.5

Table 2 Agronomic and economic valuation according to irrigation type

Crop	Water requirement (m^3)	Yield (t/ha)	Gross margin (DH)	Agronomic valuation (kg/m^3)	Economic valuation (DH/m^3)
Drip irrigation					
Tomato G.H	8000	160	62500	20	7.81
Pepper G.H	7000	80	32000	11.4	4.57
Bananier G.H	12000	60	83000	5	6.92
Tomato	6000	80	10600	13.3	1.77
Pepper	6000	40	6300	6.7	1.05
Potato	6000	60	10200	10	1.70
Peas	3500	8	3300	2.3	0.94
Corn	5000	80	6500	16	1.30
Luzern	14000	100	17000	7.1	1.21
Clementine	10000	30	7500	3	0.75
Olive	6000	12	3000	2	0.50
Surface irrigation					
Tomato	8000	35	1300	4.4	0.16
Pepper	8000	30	800	3.8	0.10
Potato	8000	35	4100	4.4	0.51
Peas	5000	3.5	1000	0.7	0.20
Corn	7000	40	2000	5.7	0.29
Luzern	20000	60	3100	3	0.16
Clementine	14000	22	1000	1.57	0.07
Olive	8000	6	1500	0.75	0.19

Source: ABHSM [10], Rapport mission II. Propositions d'actions pour une meilleure valorisation de l'eau d'irrigation

4.2 Assessment of Water Use Efficiency by Crops

The indices used for the calculation of agricultural and financial values are shown in the table above. These calculations are based on the average values of water requirements, crop yields, selling prices, etc (Table 2).

The comparison between surface and drip irrigation shows that drip irrigation increases yields, water productivity, and also water valuation. Indeed, for the main crops, yields represent more than double: corn (5.7–16 kg/m^3), tomato (4.4–13.3 kg/m^3), and potato (4.4–10 kg/m^3). This fact confirms that the irrigation system is a key component of water valuation.

In terms of water productivity under drip irrigation, corn value water better (16 kg/m^3), followed by tomatoes: 13.3 kg/m^3, potatoes: 10 kg/m^3, Luzern: 7.1 kg/m^3, and peppers: 6.7 kg/m^3.

Clementine, peas, and olive give lower yields per cubic meter of water varying between 3 and 2 kg/m^3.

Regarding the financial valuation, the results show that drip irrigation improves 6 times the financial value of irrigation water. Tomatoes and potatoes are the best crops to value water. Water valuation by tomato is about 1.77 DH/m^3 and 1.7 for potato.

If we compare crops under green houses and crops in the fields, we can clearly notice that crops under green houses have a high productivity per cubic meter and also the highest water use efficiency. Water valuation by tomato is around 7.81 DH/m^3 and can reach more than 10 DH/m^3 for the most competitive farms in the region.

4.3 Water Use Efficiency According to the DEA Method

In addition to farm types, it seems necessary to study the effect of water sources access on the different levels of water use efficiency (Fig. 1).

The figure above shows that farms using surface water for irrigation are more efficient because their technical and economic efficiency levels are highest. They are followed by farms (mixed) that combine the use of surface and ground water, and finally nonirrigated farms are far from equalizing marginal values of their production to the marginal costs of production factors. This confirms that irrigated farms from one water source manage efficiently the technology available and better allocate the water resources. This can be explained by the fact that the water pricing applied by the ORMVASM on surface water forces farmers to use water more efficiently, while those that combine the two water sources have no constraint on

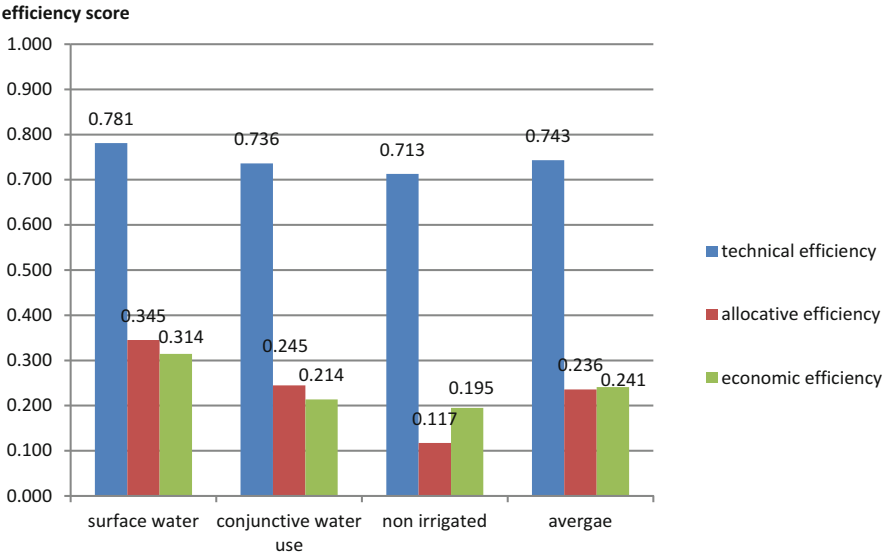

Fig. 1 Technical, allocative, and economic efficiency of farms according to the water access

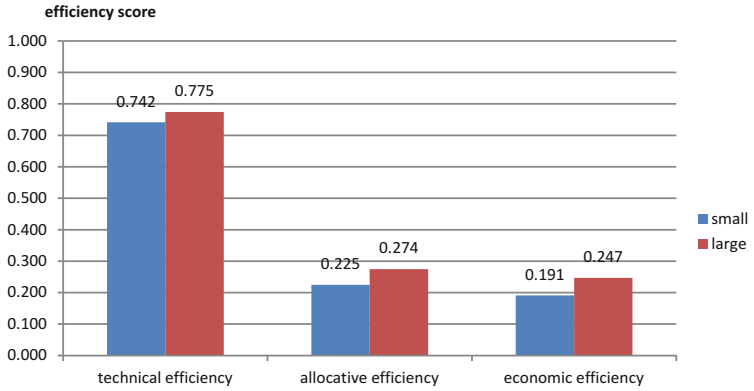

Fig. 2 Water use efficiency depending on the farm size

pumping groundwater except the cost of pumping energy and therefore they value the water resources to a lesser degree.

Figure 2 shows that large farms are more efficient than smaller ones.

Large farms have allocated in an optimal way the technology available and are also more efficient in terms of water use valuation. Small farms are also allocating the technology available and value water resource in a good manner but not at the same extent as large farms. We can explain this situation by the concept of economies of scale, meaning that large farms tend to rationalize the use of inputs and thus earn more on production costs.

5 Conclusion

The issue of water resources management has always been a major concern for decision maker in the Souss-Massa basin. Indeed, the increasing demand of water resources due to the economic development, the overexploitation of the aquifers, and climate change impact make the water resource very scarce. With regard to this, adapted policies of management and water valuation are required in order to better allocate and value the water resources.

This work aims to compare different levels of water valuation taking into account farm type and water sources. Two main methods were applied, the DEA approach and water valuation by the accounting method according to the calculation of the added value. This work was applied to a sample of 30 farms located in the Souss-Massa region.

The results of efficiency levels depending on the access to water sources show that farms using surface water are more efficient than other types of farms. This means that farms that use surface water allocate water resources better than those that combine surface water and groundwater. This can be explained by the fact that

the water pricing applied by the ORMVASM on surface water forces farmers to use water more efficiently, while those that combine the two water sources have no constraint on water pumping and tend to pump more water and therefore less value this resource.

As a conclusion, these farmers should improve their knowledge of available technologies and optimize their allocation of water resource in order to increase their efficiency level. Similarly, water valuation and optimal allocation should be among the main concerns of these farmers knowing that the limiting factor in the study area is the water resource. In addition, the government, through its extension services, should also invest in rationalizing the use of resources and technology transfer to least efficient farmers.

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