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Irrigation practices, prevalence of leishmaniasis and sustainable development: Evidence from the Sidi Bouzid region in central Tunisia

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ABSTRACT

Several studies have pointed out the link between irrigation and the risk of exposure to zoonotic cutaneous leishmaniasis (ZCL). The Elhechria community from the Sidi Bouzid region is particularly concerned with ZCL prevalence. Moreover, the zone experienced anarchic extension of the irrigable areas outside the public irrigated perimeter (PIP), which has worsened the situation. Through adopting an ecosystem health approach, this research aims to identify alternatives to improve the economic and social well-being of farmers in order to decrease exposure risk. To address this issue, a field survey was carried out with 130 farmers. Descriptive analysis allowed the identification of representative farming systems inside and outside the PIP. Through linear programming, we have developed a regional model to determine optimal activities that maximize farmers' revenue. The results showed that farmers' livelihoods depend on irrigated activities and that all farmers are reluctant to limit them. In terms of the economic environment, farmers claimed that having access to more facilities at which to buy inputs and sell their products would benefit them. Through reconfiguring the cropping pattern, the model showed optimal uses of water resources. Substantial improvement of the farmers' revenue might be achieved through enhancing the role of local institutions to build the needed facilities. Hence, one expects an eventual improvement of farmers' well-being toward fighting the disease.

Introduction

The development of agricultural activities should reveal strong and interactive links with human health, showing a two-way impact [1–3]. Agriculture supplies food to the population to ensure their nutrition and health, which supplies agricultural needs in terms of available labor, resources, and capital [4]. On the other hand, an unhealthy rural population may negatively affect agriculture, thereby lowering the productivity of the food supply chain. Hoddinott [5] stated that "the links

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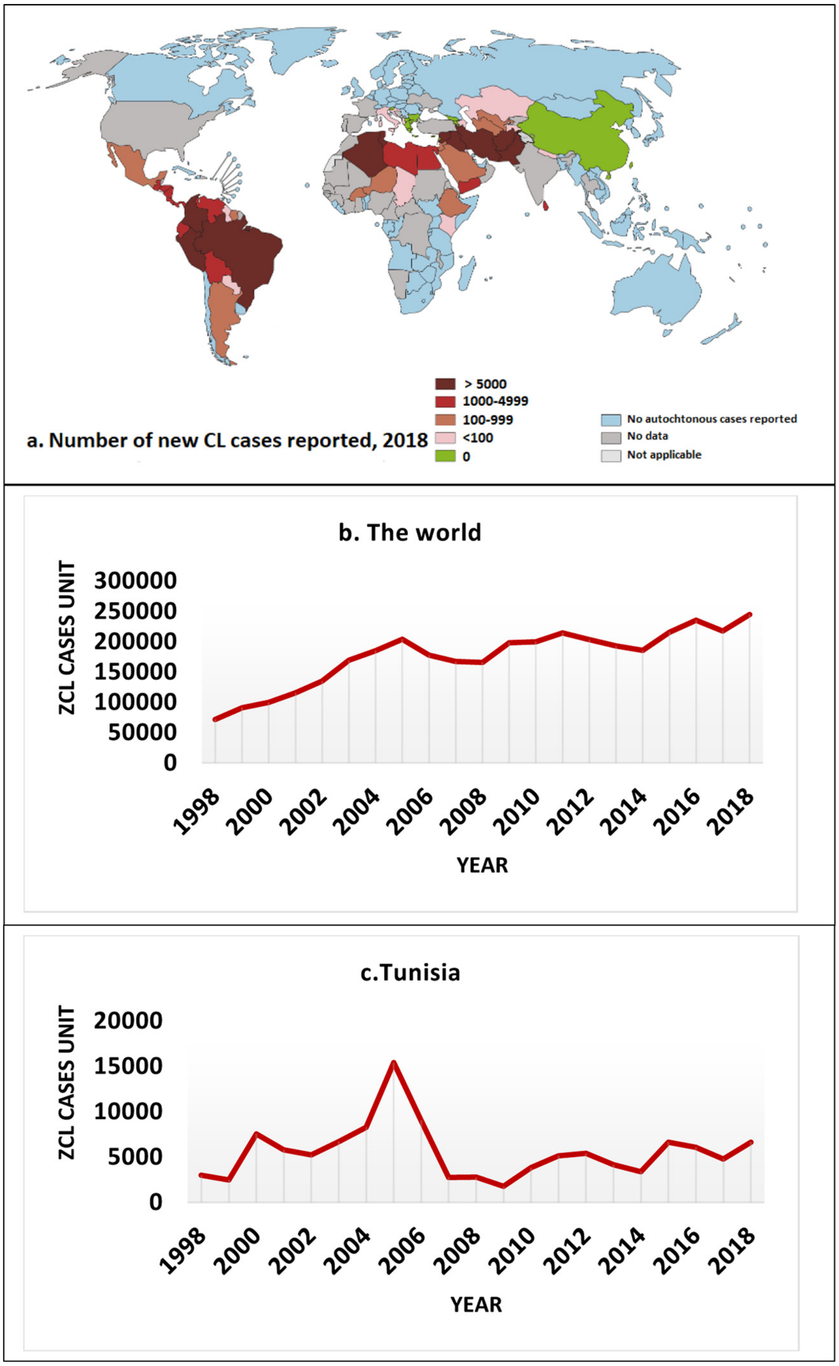

Fig. 1. Endemicity of Cutaneous Leishmani asis.

among agriculture, nutrition, and health are more complex when considering smallholder households." Within this context, neglected tropical diseases (NTDs), such as malaria and leishmaniasis, affect rural areas more often than urban populations and decrease agricultural activities [6, 7]. Leishmaniasis is prevalent in more than 87 countries in the world (Fig. 1a) [8]. The World Health Organization (WHO) estimated that 500 thousand to 1 million novice cases occur each year, of which only 19 – 37% are effectively declared [9]. There are three forms of the disease: cutaneous, mucocutaneous, and visceral. Cutaneous leishmaniasis (CL) is the most common form. Globally, the number of CL cases increased from 71,000 in 1998 to 244,000 in 2018 (Fig. 1b) [8].

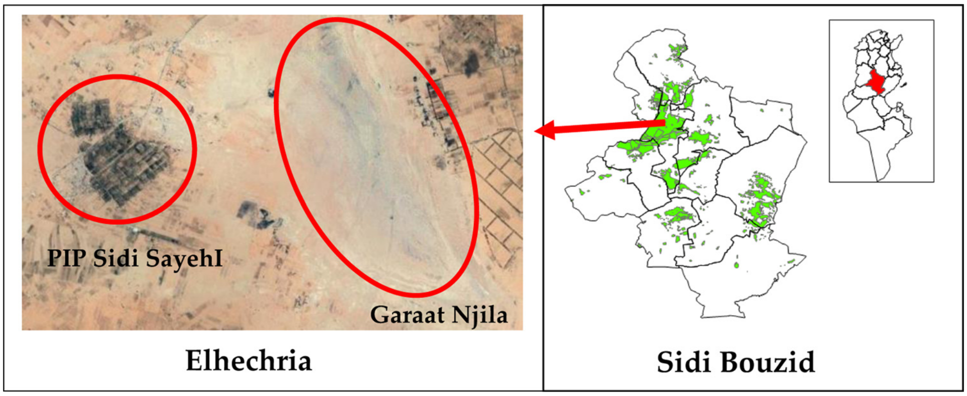

Fig. 2. Site of the study area.

CL leaves a lifelong disfiguring scar in exposed parts of the patient's body. It causes stigma and discrimination, leading to significant psychosocial problems [10] and significant socioeconomic losses [11–13]. Therefore, the quality of life of patients depreciates considerably.

To date, outstanding breakthroughs have been made in the diagnosis, treatment, and prevention of leishmaniasis. Despite advances in medical technologies and the pharmaceutical industry, the spread of the disease worldwide continues to challenge national health systems, particularly in developing countries. The incidence of CL is projected to increase in the future due to factors related to poverty and its various manifestations [7] and environmental changes [14]. Moreover, national and international efforts have failed to reverse the trends and keep the disease under control because of its epidemiological complexity [15]. This complexity is not only biological but also social, economic, and ecological. Oryan and Akbari [16] pointed out that environmental conditions, socioeconomic status, demographics, and human behaviors are important risk factors for human leishmaniasis. Fighting the disease is thus at the core of sustainable development goals (SDGs)[1], especially the goal of health and well-being (SDG 3). In early 2021, the WHO launched the 2030 NTDs Roadmap, which emphasized that successful interventions against NTDs can contribute to various other SDGs in addition to good health and well-being [17]. Hence, research on this topic should adopt holistic approaches such as an ecosystem approach to human health [15]. The approach sets out high-priority areas for the integrated management of ecosystem resources: the environment, the community, and the economy. Transdisciplinary and participatory methods are the main pillars in successfully adopting the ecosystem approach to human health [18]. Community participation in the research process is crucial because local know-how is essential for steering research in the right direction [19]. Hence, the best way to ensure the success of development solutions, whether for health or for other concerns, is to involve members of the community from the start.

Tunisia is one of the main developing countries affected now more than ever by leishmaniasis. Between 1998 and 2018, the average number of CL novice cases reached 5541 per year, up to 15,000 cases in 2005 (Fig. 1c) [8]. Zoonotic cutaneous leishmaniasis (ZCL) is endemic, particularly in central Tunisia, and is more prevalent in rural agricultural areas [20, 21]. Rural and poor populations, which rely on agricultural activities, are the most vulnerable. They are currently experiencing frequent exposure to ZCL infection [22]. Furthermore, several studies have shown a positive correlation between the extension of irrigable areas and ZCL prevalence. Therefore, irrigation practices increase soil moisture and subsequently provide suitable ecological niches for the establishment of sandflies [23–25]. Barhoumi et al. [25] found that the development of irrigation systems in arid regions of Tunisia allowed the development of a favorable environment that sustained the spread of *Phlebotomus perfilewi* and caused the emergence of novel foci of CL. Fares et al. [26] confirmed that the development of irrigation in central Tunisia contributed significantly to the establishment of sustained populations of sandflies. Barhoumi et al. [24] highlighted that the continued increase in irrigated areas in the Middle Eastern and North African arid regions deserves attention, as it is associated with the spread of important leishmania vectors.

Located in central Tunisia (Fig. 2), the region of Sidi Bouzid owes its economic and social development to irrigated agriculture. However, it reveals an important prevalence of ZCLs [27]. The disease is endemic in Sidi Bouzid, and regular outbreaks are common, occurring every 4 to 7 years on average [28]. Moreover, the intensification of irrigated agriculture in the Sidi Bouzid region has led to an overexploitation of water resources, decreasing water availability [29]. Hence, as a result of water shortages, farmers are constrained to irrigate at night when sandflies are active, increasing the exposure risk to the disease [30].

Several researchers have studied ZCL epidemiology in Tunisia, focusing on geographical distribution, clinical form, characterization of the parasite, identification of both reservoirs, and phlebotomine sandfly hosts [23, 24, 26, 31]. However, only

[1] Those that are in relationship directly or indirectly with the occurrence of the disease, such as SDG 1 (reduction of poverty), SDG 2 (promote sustainable agriculture), SDG 3 (health and well-being), SDG 6 (access to water and sanitation), SDG 8 (economic growth and full and productive employment), SDG 13 (climate change), and SDG 15 (protect terrestrial ecosystems).

a limited number of studies have investigated and explored the environmental and socioeconomic conditions related to ZCL prevalence. This research tends to fill the gap by adopting an ecosystem health approach. To investigate how to set up community control of the disease, the purpose of the research is to establish an operational diagnosis of irrigated activities and identify eventual levers to improve the economic and social well-being of farmers that might decrease the exposure risk to the disease.

Materials and methods

Study site

The study was conducted in the governorate of Sidi Bouzid in central Tunisia (Fig. 2). The community Elhechria is one of the main endemic areas of ZCLs, with an average incidence rate of 3157 annual cases per 100,000 inhabitants during the 2009–2014 period [22]. Houses in the community were in poor quality, with unfinished facing walls, cracks in the walls, and windows without screens or with broken screens. The environment surrounding the community was also associated with ZCL transmission (the presence of animal shelters, animal waste and cactus plantation near the houses, living close to irrigated areas and the Sebkha "Garaat Njila," and a high level of humidity). Poor hygiene and a low level of household comfort were positively associated with an increase in the exposure risk to ZCLs [22]. Moreover, the farmer community relies on the irrigated agricultural practices developed since 1958 thanks to the creation of the public irrigated perimeter (PIP) "Sidi Sayeh I." The number of landholders in the PIP reached more than 250 farmers. The owned land per farmer reached an average of 0.6 ha, with a minimum of 0.2 ha and a maximum of 1.5 ha. An Agriculture Development Group (ADG) ensures water sales and provides some input facility supply to farmers. Given the tightness of the irrigated area inside the PIP, more than half of farmers extended their potential irrigable area outside of it. Hence, farmers use their water quota and claim more water to meet their needs of the cropping areas outside the PIP. Such a strategy increases the water demand and thus the water shortage. This pressure on water availability constrained farmers to only irrigate during the night. However, the PIP is located near the Garaat Njila (Fig. 2), an important reservoir of the ZCL vector.

Data collection

To gather the required data, we carried out a face-to-face survey with a sample of farmers. Based on the list of farmers provided by the ADG, we selected those who owned irrigable area outside the PIP and who bought water during the 2013 cropping year to irrigate crops inside and/or outside the PIP. The sample size reached 130 farmers, representing more than 50% of landholders of the PIP. We conducted the survey during the spring of 2014. The interview guide involves two sections. The first section was devoted to gathering all technical and economic details regarding the farming activities during the 2013 cropping year. The second section addressed the exposition degree of the family to ZCL disease and their eventual strategies to avoid it with regard to irrigation practices.

Farming systems modeling

Given the outstanding development of computer sciences, modeling approaches have become one of the main methods for effective and valuable research. Farming system modeling using mathematical programming has been widely used in the agriculture sector. Jones et al. [32] stated that models can help identify management options to maximize sustainability goals for resource managers and policy-makers across space and time as long as the needed soil, water, climate, and socioeconomic information are available. Depending on the research purposes, there are two methods for modeling farming systems: the positive versus the normative approach. By adopting the positive approach, scientists attempt to reproduce the observed situations, and positive models are seen as empirically reliable [33]. Their sophistication lies in the correct description of the system's structure, which requires a large number of interrelations and parameters. This implies that a thorough knowledge of the system being studied is needed, and much time needs to be spent studying and understanding the system. A normative approach consists of mathematical relationships with constraints that are solved to reach an optimal solution of the system. It provides answers to the believed "what ought to be." The primary objective is to improve the well-being of farmers by increasing the productivity of their farming system given the resources and environment constraints. This approach presents the advantage of no restrictions on the functional form. Dantzig [34] stated that "linear programming is viewed as a revolutionary development giving humans the ability to state general objectives and to find, by means of the simplex method, optimal policy decisions for a broad class of practical decision problems of great complexity." Typically, normative models are not calibrated to historical data, and a basic knowledge of the system being modeled is sufficient. Therefore, we adopt a normative approach to address our research purposes. The primal form of the model is as follows:

$$MaxZ = \sum_j A_j X_j$$

Subject to

$$\sum_j C_{ij} X_j \leq B_i$$

Table 1
Economic results per farm.

		Average (TND)	Min	Max	S.D.
Operational costs	Sample	3025	89	26,637	3172
	Inside PIP	1890	89	5365	1198
	Outside PIP	2690	90	21,638	3260
Production value	Sample	8380	0	50,879	7908
	Inside PIP	6163	0	28,280	4983
	Outside PIP	4582	0	43,522	7177
Gross Margin	Sample	5176	−2643	30,064	5503
	Inside PIP	4238	−1966	23,158	4153
	Outside PIP	1970	−4006	21,884	4439

$$X_j \geq 0$$

Where
$A_j$is the revenue of the activity j
$X_j$is the vector of j activities
$C_{ij}$is the quantity of resource i required to produce one unit of activity j
$B_i$is the available quantity of the resource i
The analyses of the gathered data allowed the characterization of the farming system components performed inside and outside the PIP. Hence, we developed a representative farming system by aggregating data in terms of activities (fruit trees, seasonal crops), inputs (tillage, seeds, labor, water), and achieved production. We solved the model using GAMS (General Algebraic Modeling system).

Results

Descriptive analysis

The results showed that the total of the surveyed irrigable area inside PIP was 98.5 ha. Regarding the irrigation practices, 61 farmers (47%) used a share of the consumed water to irrigate their activities outside the PIP. The irrigable area outside reached 93.5 ha split into 74 plots. These plots are located at an average of 1 km from the PIP. Some plots were located at a distance of 5 km, which might increase water losses. Such behavior stimulates pressure on water resources, limits the development of irrigated activities inside the PIP, and increases irrigation expenditures.

Farming system and water consumption

Inside the PIP, the land is fully planted (olive trees, pomegranates, apricots). Thirty-seven farmers (28%) practiced intercropping to diversify their production and improve their revenue. They were growing durum wheat, barley, or pepper. The total area of the cultivated land was only 3.8 ha.

Outside the PIP, the irrigable area was planted with olive trees. Approximately three-quarters of those orchards were planted during the 1990–2013 period. Thirty-one farmers (24%) practiced intercropping by growing fodder crops (4 ha) and pepper under greenhouses (3 ha).

In terms of irrigation practices, farmers adopted flood irrigation systems. However, this irrigation system causes huge water losses. The water use efficiency did not exceed 60%. The total water consumption reached 11,689 h[2], of which 2679 h were used outside the PIP. Hence, the water consumption was rated at 6340 $m^3 ha^{-1}$ inside the PIP and at 1920 $m^3 ha^{-1}$ outside the PIP. However, we must highlight that inside the PIP farmers mainly used the water to effectively irrigate the fruit trees while they used it mainly to grow crops outside the PIP. In fact, the results showed that crops outside the PIP consumed 1836 h, which increased the water consumption to reach 19,000 $m^3 ha^{-1}$. The latest result revealed unwise use of water irrigation mainly due to the importance of water losses through the canals that delivered to the plots.

Economic analysis

The results showed that during the 2013 campaign, farmers spent an average of 3025 TND[3] to cover operational costs such as seeds, tillage, fertilizers, irrigation, and labor (Table 1).

These operational costs reached an average of 1890 TND inside the PIP versus 2690 TND outside the PIP. The irrigation costs account for 25% of the total operational costs, up to 27% outside the PIP. The results showed that the expenditures of pumping water outside the PIP reached an average of 0.083 $TNDm^{-3}$ while farmers bought water at 0.085 $TNDm^{-3}$. Therefore, outside the PIP, the water irrigation costs are almost double that inside.

[2] One hour equals 72 m^3 of water
[3] One TND equals 0.36 USD

Regarding the production assessment, the results showed that farmers earn an average of 8380 TND. Inside the PIP, the activities earned 6163 TND, while those outside allowed only earned 4582 TND.

Given these results, the gross margin per farm reached an average of 5176 TND. This margin was estimated at 4238 TND earned by the activities inside the PIP and 1970 TND earned by those outside (Table 1).

Economical and institutional environment

In terms of the input market, farmers revealed some difficulties regarding the availability and control of price levels. In fact, all farmers operate with private providers at the local and/or regional level. Eighty-eight farmers (68%) highlighted that they bought inputs with the lowest price without taking into account the quality. Usually, they sought for the lower price. Only 29 farmers (22%) were truly concerned with input quality. Ninety-two farmers (71%) stated no difficulties about input availability, but they were facing serious difficulties funding their needs. Sometimes, they were constrained to accept higher prices dictated by retailers providing loans. The ADG has set up limited services to provide farmers with inputs, mainly fertilizers and plastic film for greenhouses. The ADG sells inputs with a discount of 5 to 10% less than the market price. Furthermore, the ADG offers an interest-free sale credit. Given this context, all farmers revealed their preference for obtaining ADG as the main input provider of the community and express their willingness and commitment to succeed in such a project.

In terms of selling products, 100 farmers (77%) sell on site. Given the unavailability of transport means, farmers avoid selling their products in regional and national markets. Eighty-six farmers (66%) stated that transport remains the main issue of the marketing process. They are aware that perhaps they are losing money because of the low price dictated by the intermediaries, but selling on site ensures full cash with a 0% tax. All farmers appreciated the suggestion to set up a local platform for sales, and they recommended the ADG to lead such a project.

ZCL prevalence and farmers' perception

The results showed that among the 130 farmers interviewed, ZCL occurred in 50 households (38.5%) between 1975 and 2014. In total, 87 farmers' family members were affected, of which 20 were farmers (23%) and 37 were wives and daughters (43%). Forty-two members (48%) were affected during the 1990s. The results also revealed that only 41 members (47%) received medical care. Ninety-nine farmers (76%) were aware of the disease, of which 78 farmers knew that ZCL was transmitted through sandfly bites. Despite the higher exposure risk through irrigation during the night, all farmers were reluctant to change their practices to minimize this risk or to live far from their irrigated field. However, they stressed their willingness to collaborate with both health care facilities and nongovernmental organizations (NGOs) to eradicate the disease. In fact, 49 farmers (38%) were aware of the importance of the activities led by NGOs in the region. Twenty-seven farmers (21%) believed that NGOs remained the most effective way to fight against ZCL. In addition, all farmers expected that an eventual improvement of their livelihoods might strengthen their commitment to this collaboration. Regarding ZCL preventive measures, 121 farmers (93.1%) agreed and expressed their willingness to follow the instructions of the health care facilities.

Perspectives of livelihoods improvement

The results showed that the farming system involved four different irrigation activities:

(i) Fruit trees (98.5 ha) and crops (3.8 ha) inside PIP
(ii) Olive trees (93.5 ha) and crops (7 ha) outside PIP

These activities consumed 11,689 h of water irrigation. The gross margin of the whole sample reached 641,840 TND. However, given the water distribution contingent (10 h/month/ha), the available water reached 11,820 h. Taking into account the activity parameters and to optimize the water and land use, we have developed the regional model as follows:

$$Max\,TGM = \sum_{i,j} \mathrm{Pr}\,od_{i,j} * X_{i,j} - \left[\sum_{i,j} Chrg_{i,j} * X_{i,j} + \sum_{i,j} waterQ_{i,j} * X_{i,j} * Pwater_{i,j} \right] \tag{1}$$

Subject to

$$\sum_{i,j} X_{i,j} \le \sum_{i,j} Spirrig_{i,j} \tag{2}$$

$$\sum_{i,j} waterQ_{i,j} * X_{i,j} \le waterT \tag{3}$$

$$X_{\mathrm{tree,in}} = Spirrig_{\mathrm{tree,in}} \tag{4}$$

$$X_{i,\mathrm{out}} \le Spirrig_{i,\mathrm{out}} \tag{5}$$

$$X_{i,j} \ge 0$$

Table 2
Results of simulations.

	Crop area inside PIP (ha)	Olive trees area outside PIP (ha)	Water Shadow price (TND/hour)	TGM (TND)
Baseline	3.81	93.5		641,840
Optimal Solution	8.40	0	1.064	850,268
S1 −10%	8.40	0	2.182	885,762
Chrg −15%	2.23	93.5	2.742	911,896
−20%	2.23	93.5	3.301	925,482
−25%	2.23	93.5	3.860	945,919
−30%	2.23	93.5	4.419	966,356
S2 +10%	8.40	0	2.901	979,101
Prod +15%	2.23	93.5	3.819	1045,227
+20%	2.23	93.5	4.738	1112,392
+25%	2.23	93.5	5.656	1179,557
+30%	2.23	93.5	6.574	1246,722
S3 −10%,+10%	4.46	92.8	3.396	1026,342
Chrg −15%,+15%	4.46	92.8	4.551	1121,444
Prod −20%,+20%	4.46	92.8	5.705	1202,842
−25%,+25%	4.46	92.8	6.860	1291,091
−30%,+30%	4.46	92.8	8.015	1379,341

Prod: the production value per hectare;
Chrg: the running costs per hectare; waterQ: the water consumption per hectare;
Pwater: the water price per m^3;
Spirrig: the observed irrigated area; waterT: the total available water for the farm sample;
X: the vector of activities' areas;
i: the observed activities (tree, crops);
j: location inside or outside PIP (in, out).

The objective function (Eq. (1)) maximizes the total gross margin (TGM). The first constraint (Eq. (2)) ensures that the sum of the expected optimal areas' activities could not exceed the sum of the effective irrigated area revealed by the survey. The second constraint (Eq. (3)) indicates that the total consumption of water could not exceed the available water allocated following the water distribution rule. The third constraint (Eq. (4)) keeps the area of the fruit trees inside of the PIP unchanged. Finally, the fourth constraint (Eq. (5)) ensures that the land use outside the PIP could not exceed the observed area.

By solving the model, the optimal solution showed that farmers should stop growing olive trees outside the PIP. The model kept the crop area outside the PIP unchanged, while the crop area inside the PIP reached 8.4 ha. The model uses the total available water resources, showing a dual value of only 1.064 TND/hour. The optimal TGM reached 850,268 TND, representing an improvement of 32% compared to the observed TGM.

According to the preferences of farmers confirmed through the meeting organized to discuss the survey results, three scenarios were simulated with regard to the reinforcement of the ADG role to better control the economic environment of the inputs as well as that of the outputs.

Scenario 1 (S1): By charging the ADG to be the main input provider, farmers expected a decrease in input expenditures.

Scenario 2 (S2): By setting up a local platform to sell crops, farmers expected that the ADG could negotiate the best prices, allowing an improvement of their revenue.

Scenario 3 (S3): Combines S1 and S2.

Through these scenarios, we increased (decreased) the production value (input expenditures) by several rates ranging from 10% to 30% (Table 2).

The results of S1 showed that decreasing the inputs' expenditures by 15% or more will not change the activities outside the PIP, while the crop area will decrease to 2.23 ha inside the PIP. Compared to the observed profit, this scenario allowed a profit improvement of up to 50%. On the other hand, the full use of the available water reveals a positive shadow price of the water up to 3.86 TND/hour, which is lower than the water price applied by the ADG (6.12 TND/hour). The simulation of S2 revealed the same results as those of S1 in terms of the cropping system. However, the increase in the TGM is more important than that obtained by the S1 simulation and reached 94%. The shadow price of water will exceed the applied price only when the production value is increased by 30%. Finally, the S3 simulation showed little decrease in the olive tree area outside the PIP, while the area of crop activities increased to 4.46 ha. By decreasing the input value and increasing the production value at a rate of 25%, the shadow price of water reached 6.86 TND/hour, exceeding the water price applied by the ADG but lower than the water cost paid to irrigate outside the PIP.

The results of the three scenarios showed an improvement in the TGM. Nevertheless, we must highlight that by decreasing the inputs' value and increasing the outputs' value at the rate of 10%, the profit reaches 1026,342 TND, which represents an improvement of 60% compared to the observed value.

Discussion

This research provides a comprehensive analysis of the irrigated activities led by the Elhechria community that revealed ongoing low socioeconomic living standards. The average revenue earned per farm (5176 TND) remains lower than the agricultural guaranteed minimum wage in Tunisia (6027 TND/year). Given that the average expenditure in rural areas reached 2585 TND per capita in 2015, of which 9% is reserved for health care [35], farm revenue could not cover all household needs, particularly to cope with leishmaniasis. Okwor and Uzonna [36] highlighted that "The connection between poverty and the risk of developing leishmaniasis is very strong and mediated through many factors: ecological factors such as poor housing conditions, including cracked walls that provide resting places for sandflies, damp earthen floors that enhance vector survival, and improper doors that allow sand fly entry." Moreover, even with free diagnosis and treatment, households may suffer catastrophic health expenditures from direct and indirect medical costs, which compounds existing financial strain in low-income families [11]. On the other hand, several studies have highlighted that leishmaniasis had a considerable impact on patients' routine activities and resulted in loss of income to the household, either by wage loss to both patients and the accompanying people or by means of losses in agricultural output or other earnings. It is considered that if an expenditure exceeding 10% of annual household income is catastrophic, this means that it drives households into destitution [12].

Therefore, the strategy of fighting ZCL disease should jointly focus on minimizing the exposure risk and improving community welfare. Based on the observed farming system, the results of simulations showed positive trends toward livelihood improvements in the community. Through reconfiguring the cropping pattern, the model showed optimal uses of water resources with substantial improvement in revenue. The results are consistent with those reached by Toorop et al. [*37*], who used the FarmDESIGN model, in terms of water use and revenue improvement.

Hence, we point out that strengthening the ADG role and enhancing the active involvement of NGOs at the local level is crucial for advancing sustainable development [38, 39]. Moreover, these institutions should play a central role in leading eco-health approaches within the context of climate change [40]. The challenge is to build a wide partnership commitment between different stakeholders from different sectors (agriculture, health departments, education, and social facilities) as well as from the local to the national level. This partnership should increase community awareness about disease prevention and how to minimize the exposure risk linked to irrigation practices. Moreover, farmers toned to introduce an economic irrigation system. The government should support such a strategy and promote wise use of irrigation water.

Conclusion

The intensification of the cropping system through irrigation allowed farmers to increase their revenue and to improve their well-being. However, it has been proven that the development of irrigation increases ZCL prevalence. The Elhechria community is especially at risk for this disease due to unsustainable agricultural activity. Wise use of irrigation water might decrease the pressure on the water resource and minimize the exposure risk. Hence, regional authorities should enhance the technical and financial capacity of farmers to introduce economic irrigation systems.

In addition, the results showed that putting forward economic environmental control through strengthening the ADG role in providing farmers with facilities for purchasing their required inputs and ensuring the best marketing pathway of their products allowed an outstanding improvement of their revenue. Such alternatives should bring together all actors (farmers, administration, health care services, NGOs, etc.) to set up community action to control the disease by raising awareness about the best practices that minimize exposure risk.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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