Acta Universitatis Sapientiae
Agriculture and Environment, **16** (2024) 12–27

DOI: 10.47745/ausae-2024-0002

Joint management policy as a tool for GIAHS conservation: The Ghout system in the Souf oasis (Algerian Sahara)

Bachir KHEZZANI,[1,2*] Azzeddine HADDAD,[3]
El Amine KHECHEKHOUCHE[1,2]

[1] Department of Biology, Faculty of Natural Sciences and Life, El-Oued University, P.O. Box 789, El-Oued, Algeria; e-mail: bachirkhezzani05@gmail.com; elamine73@yahoo.fr

[2] Laboratory Biology, Environment, and Health, Faculty of Natural Sciences and Life, El-Oued University, P.O. Box 789, El-Oued, Algeria

[3] Department of Agronomy, Faculty of Natural Sciences and Life, El-Oued University, P.O. Box 789, El-Oued, Algeria. e-mail: azzeddine-haddad@univ-eloued.dz

Manuscript received March 13, 2024; revised April 15, 2024; accepted April 20, 2024

Abstract. The Ghout system is a traditional agricultural system classified as a World Agricultural Heritage (GIAHS) by the FOA since 2005. This paper discusses the joint management principle as a tool to preserve the Ghout system as an agricultural landscape in the Souf oasis (Algerian Sahara). The Ghout system has been based on mono-management by the local farmers since it was created in the 15th century, who managed it well all this time. However, this GIAHS suffers from many difficulties, which have led to the demise of a significant part of it. Today, moving to the principle of joint management has become a necessity, not an option. However, besides the local farmers, this principle depends on several stakeholders' involvement in managing this traditional agricultural system. Also, this paper provides a roadmap to help make this proposed principle a success.

Keywords: Ghout, joint management, conservation, Souf oasis, GIAHS, Algeria

1. Introduction

Agriculture is the most important human activity that is closely associated with nature. The operational units of this activity are called agricultural systems, which emerge and develop over time in a socioeconomic and cultural context [4]. Whelan [59] defined the farming system as the significant and constant arrangement of farming activities, the practices of which correspond with the biological, physical, and socio-economic environment in response to the local

community's needs and adjustments to its changing and limiting resources. Traditional farming systems resulted from centuries of biological and cultural exchanges between humankind and the surrounding environment [46]. Furthermore, it is characterized by high efficiency in managing nutrients, water, soil, and biological resources [5].

The Food and Agriculture Organization of the United Nations (FAO) has defined the Globally Important Agricultural Heritage Systems (GIAHS) as "remarkable land-use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development" [6, 34]. The global change affects entire agricultural systems, in which regard, the GIAHS sites are not impervious to this change either [32].

The FAO, jointly with the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP), started the policy of the dynamic conservation and sustainable management of these traditional agricultural heritage systems in 2002 [49, 62]. However, the dynamic conservation and adaptive management of these farming systems have become critical issues [64], mainly because of their abandonment worldwide [47].

At the beginning of the twenty-first century, GIAHS had become a hotspot for scientific research because of its rapidly increasing number of sites [64]. In addition, this heritage has frequently been offered in recent years as a depot of lessons to be learned for future, more sustainable agriculture [17]. Unfortunately, these traditional agricultural systems are under continuous pressure from various sides such as socioeconomic changes, climate change, and increased competition for natural resources worldwide [3]. For example, the new agricultural paradigm focused on mechanization and agricultural intensification has detracted from the traditional agroecosystem, so much so that the latter is in danger of disappearing [6]. So, the disappearance of traditional agricultural systems due to environmental overprotective and changed socioeconomic conditions seriously threatens biological and cultural diversity worldwide [41].

The GIAHS plays a pivotal role in natural balance, especially in the arid environment. The Ghout system is an example of these traditional agricultural systems; the latter is located in an arid environment (Souf oasis, Algeria) (*Fig. 1*) and has been classified by the FAO as a GIAHS since 2005 [9]. Many studies indicate that a significant part of this GIAHS has disappeared (*Fig. 2*), and what remains of it is also threatened with extinction due to the many difficulties it suffers from [25, 27, 28, 30]. So, discovering how to protect GIAHS effectively is important for scientific research and key for sustainable development [39]. This paper discusses the failure causes of the mono-management principle in managing and preserving the Ghout system in the Souf oasis (Algerian Sahara). In addition, it suggests the transfer to the joint management principle as a tool to safeguard

this GIAHS. Furthermore, it will discuss some factors that could contribute to the success of this new type of management.

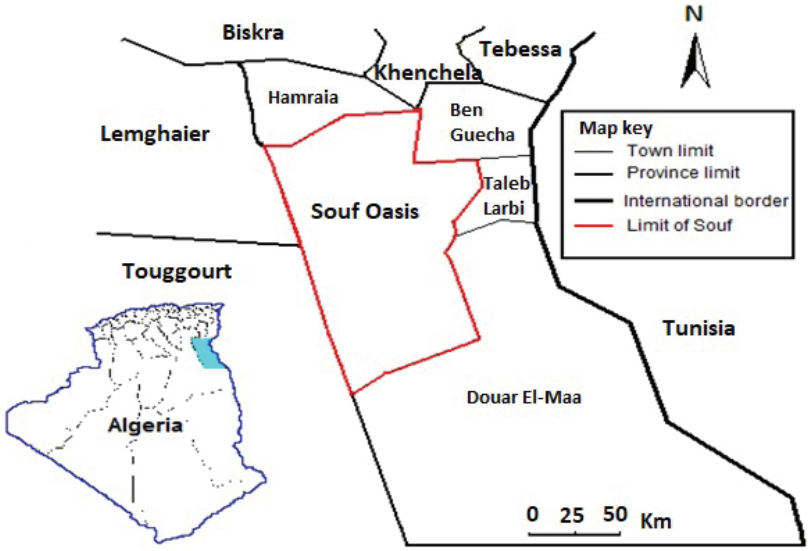

Figure 1. Location of the Souf oasis

Figure 2. A Ghout system a): in a good condition, b): in a deteriorated condition

2. The Ghout system as a GIAHS

Traditional knowledge accumulated among local communities is holistic, encompassing many fields of scientific knowledge such as hydrology, soils,

climate, animals, and plants [42]. This traditional knowledge was the reason for establishing and continuing many agricultural systems that were in harmony with the environment for centuries.

The first inhabitants succeeded in settling in the Souf oasis by practising agriculture through the Ghout system. Historical studies indicate that the establishment of this system dates back to the 15th century when the first Ghout was accomplished in the village of Zgum [26]. In the first step, the farmer chooses an adequate place for his new Ghout, of course, strictly respecting the agricultural laws adopted by the community of local farmers [45, 57]. The drilling process begins vertically with simple and primitive methods until it reaches the aquifer. Next, the farmer prepares the first palm tree for planting, in which the roots are in direct contact with moist soil. After that, the farmer continues the horizontal digging to expand the Ghout surface and continues planting date palm trees [29]. This process may take several years, depending on the geographical location, groundwater depth, and the Ghout surface.

The adopted method enables young date palms to benefit from self-watering without interference from the farmer [37]. However, the farmer is still in permanent combat with sand encroachment. In the spring and autumn, wind leads to the burial of the Ghout edges, as the farmer is periodically forced to re-raise it [22]. The date palm trees occupy the higher floor of the Ghout, which creates a suitable microclimate compared to the harsh external climate. This microclimate allows the farmer to cultivate several fruit trees, such as pomegranates, grapes, lemons, and apples, which occupy the middle floor of the Ghout [29].

On the lower floor, the farmers cultivate various vegetables and fruits such as tomatoes, peppers, eggplant, spinach, onions, and watermelon. Moreover, in the northern part of the Souf oasis, the farmers cultivate tobacco as an industrial crop [48]. Because the crops of the lower and middle floors cannot directly benefit from the phreatic water table, such as palm trees, farmers irrigate them manually through a traditional system for water extraction called, in vernacular terms, Khottara [14]. This agricultural system was combined with the practice of permanent and seasonal crops. Furthermore, it ensured food security during the famine that affected the Algerian Sahara during colonization.

3. Mono-management model: Its development and failing factors

The mono-management by local farmers has succeeded in expanding the Souf oasis, as Khezzani and Bouchemal [28] reported that the number of Ghouts that have been accomplished has reached about 9,800 units. In the past, farmers used to view the Ghout as the only way to ensure food security for their family. However, recently, it has become a way to make a quick profit. In the first case, farmers cannot

achieve food security without preserving the Ghout. In the second case, farmers can achieve food security even in the absence of the Ghout.

Until the 1950s, the Ghout was the main agricultural food production system in the Souf oasis. The development of groundwater extraction systems catalysed the emergence of a farming sector parallel to the Ghout system. Farmers no longer need to dig a big hole to reach the groundwater but can now plant palm trees directly on the surface and water them with the help of pumps [25]. The discovery of new fossil aquifers in the Algerian Sahara announced the birth of a new agricultural revolution [13]. This agrarian revolution was distinctive in the Souf oasis, as new and varied crops were introduced such as potatoes, olives, peanuts, and many other vegetables [14, 31].

Now, farmers have many options; their choices are controlled by the economic feasibility of the agricultural project. Thus, they can move from one crop to another according to market requirements. For example, some farmers left their Ghouts and oriented towards cultivating new crops; others buried the Ghouts and cut their palms to level the ground and installed the pivot system to irrigate the new crops of potatoes [23]. Still others left the agricultural sector permanently to invest in other activities that guaranteed them a profitable return. This point of view agrees with what was mentioned by Prus et al. [41], who likened this behaviour to reverse migration due to the low economic viability of traditional farming.

The demographic growth witnessed by the oasis led to an increase in the demand for residential real estate, especially in areas adjacent to major population centres. As a result, many farmers buried their fields and converted them into buildable lands by filling them up, dividing them, and selling them as housing lots. Of course, the high and attractive prices offered to farmers catalysed this process [24]. Today, it is clear that the local farmer is the only person who determines the fate of the Ghout according to the individual interests. Furthermore, farmers have never considered the Ghout a world agricultural heritage. Still, the main driver of his behaviour is the economic approach or the arithmetic process that means profit and loss for what will result from their exploitation of the Ghout. This point of view is confirmed by a recent study by Khezzani et al. [30], which reported that only 12.3% of local farmers know that their Ghouts system has become a GIAHS although classified under FAO since 2005.

In conclusion, in the past, the mono-management policy applied by the local farmers was a helpful factor in developing the Ghout system; still, farmers alone can no longer guarantee the survival of this heritage. On the contrary, their behaviours have become harmful and destructive to the Ghout system. This critical situation quickly calls for the intervention of other parties to save what remains of this agricultural world heritage.

4. Joint management model as an alternative tool to preserve the Ghout system

A main challenge in traditional agricultural systems is to develop policies that promote socioeconomic development while at the same time safeguarding ecosystem services, biodiversity, and human values [18]. The FAO programme related to the globally important agricultural heritage systems (GIAHS) focuses on preserving the agricultural heritage system and applying the principle of dynamic conservation to assure food security for local communities and promote rural development [43]. Prus et al. [41] state that any endeavour to preserve GIAHS sites by freezing them in time would surely lead to their demise and weaken the rural communities. So, Daugstad et al. [15] and Chunjiang et al. [12] assumed the system of active agriculture, which means a production system founded on the economic results of food production, as the most sustainable strategy to protect traditional agricultural heritage and other environmental values.

This discussion clearly shows that the joint management policy is optimal for applying the dynamic conservation principle. After classifying the Ghout system as a world heritage, the local authorities in the Souf oasis were supposed to take the initiative to adopt the principle of joint management, but this did not happen for several reasons. Perhaps the most important one is the lack of a clear development policy to manage this agricultural heritage and/or that all the attention was directed to the modern agricultural sector [26, 30]. Many studies have confirmed that the joint management principle or, rather, the participation of multi-stakeholders has a positive effect on dynamic conservation, and it has been widely incorporated into sustainable landscape management [51, 58]. For example, China has made remarkable progress in managing and preserving agricultural heritage sites, mainly due to the policy that adopts the participation of multi-stakeholders [38, 61].

5. The actors and their role in the joint management model

The proposed joint management model focuses on three actors; the first is in the foreground, and the other two are in the background.

– The first and foremost actors are the local farmers and their families.

– The second actors are the local authorities, such as the agricultural services directorate in the first range and then the directorates of tourism, environment, and forest.

– The third actors are the academic researchers.

A. The role of academic researchers

The role of academic researchers is to carry out research that has a direct or indirect relationship with agricultural heritage. The main objective of this research is to make farming through the Ghout system a distinct and economically profitable activity for local farmers that can withstand and compete against the encroachment of other crops. Subsequently, researchers share the results of their research with politicians, decision makers, and policymakers alike. In this context, Qingwen [43] confirms that working within the main research areas directly related to heritage is not sufficient for the success of the preservation process. Indeed, it must extend to other disciplines such as sociology, history, geography, economics, management sciences, and other necessary subjects.

B. The role of administrative departments and policymakers

In the light of the recommendations made by the academic research bodies, the administrative departments can draw up the appropriate development policy that enables the maintenance and operation of the Ghout system on sustainable development foundations. For example, local authorities should create additional activities that accompany agriculture, which generate additive financial income for farmers and their families.

C. The role of the farmer

Shen et al. [49] focus on the influential role of local farmers in managing and protecting the agricultural heritage and support for rural communities. So, the local farmer will be the central hub and operator of the Ghout system in the joint management model.

6. The factors promoting the success of the joint management model (master plan)

The joint management of the Ghout system is not just administrative decisions issued by local authorities and implemented by farmers; instead, it is an accurate, complex, and multilateral model of preservation joined by farmers, academic researchers, and administrative authorities. The role of each actor is complementary to the others and cannot conflict with them. In the following paragraphs, we will try to lay out a master plan for the success of the joint management model.

A. The accomplishment of a database for GIAHS in the Souf oasis

From a practical point of view, the protection process cannot be materialized without the permanent and adequate follow-up of agricultural heritage status (Ghouts) [24]. Therefore, a database should be quickly established for the traditional agricultural sector. This database would contain all the necessary information such as inventory numbers of existing Ghouts in terms of location, surface, and the number of palms, productivity (quality and quantity); the age of date palm trees, legal status, as well as the identification of property type (collectively or individually). The availability of this vital information with permanent updates will enable the optimal management of this heritage, particularly regarding property transfers resulting from the sale and the purchase or conversion of these Ghouts to lands dedicated to construction or establishing other commercial activities.

B. The privacy of the traditional sector

The Ministry of Agriculture is the main authority responsible for managing the agricultural sector in the country. However, the laws issued by it are largely compatible with the modern agricultural sector, while they are less suitable for the traditional agricultural sector because there are fundamental differences between the two sectors, especially after classifying the latter as a GIAHS [24]. Perhaps this behaviour is explained by the significant contribution of the modern agricultural sector in ensuring food security compared to the traditional sector [26]. Therefore, the specificity of the traditional agricultural sector must be considered by enacting laws appropriate to the state of this heritage.

C. Solving some local problems related to the traditional agricultural sector

The traditional agricultural system in the Souf oasis suffered from many problems, which were the main reason for its abandonment by the local farmers. Perhaps the most critical problems are the disturbances related to the phreatic aquifer [28] and the urban sprawl, especially on the border of urban areas [1, 24]. Furthermore, the expansion of the modern agricultural sector at the expense of the traditional one is another problem; its impact is similar to the urban sprawl, mainly due to the interest of the local authorities in the modern agricultural sector compared to the traditional one [25].

The local authorities should urge the adoption of a plan aimed to solve these problems, which firstly contributed to the deterioration of the agricultural heritage

and, secondly, stood in the way of the renewal process. Directing urban expansion in line with the status of the traditional sector is one of the axes that can be worked on; a recent study by Khezzani and Bouchemal [27] presented several solutions and techniques to deal with water table fluctuations.

D. Making the traditional agricultural sector economically profitable

The conservation of the GIAHS sites is highly relevant not only for their natural biodiversity but also for the sustainable provision of endogenous goods, the very high quality of food and services, and the quality of life different from those practised in large cities [35]. Zhang et al. [63] believe improving farmers' income from traditional agricultural activities is a practical approach to GIAHS conservation policy. So, this approach will make the traditional agricultural sector economically profitable, which is the essence of joint management and a major challenge for local authorities. This process automatically allows local farmers to cling to the traditional sector; through this element, activating the dynamic conservation mechanism becomes possible. Currently, there are two areas in which we can intervene and implement some reforms, which are tourism and organic farming.

Developing the ecotourism sector

In most cases, traditional agriculture alone cannot provide sufficient income to local farmers and their families [46, 60]. Perhaps the best solution is to work on improving and diversifying their income. Pillay and Rogerson [40] believe that using natural resources, such as traditional agriculture landscapes, in tourism supports sustainable rural development and promotes the integration of agriculture and tourism. Many studies worldwide confirm the importance of the GIAHS as a tourist attraction factor [10, 16, 19, 36, 52–56, 60], where many tourists favour visiting rural areas and sharing the rural lifestyle with local communities [21].

Although the Ghout system as an agricultural landscape has many ingredients that make it a tourist resort by excellence, touristic activities related to traditional farming are currently absent in the study area. It is worth noting that this type of tourism was at the height of its activity 30 years ago, when the oasis annually received a considerable number of tourist groups, especially from European countries. To restore this essential activity, experts in the tourism sector should adopt a programme. These tasks fall on the shoulders of the provincial tourism directorate in the first place.

Perhaps the intangible heritage and cultural background are the elements that can be associated with tourism activities. The study by Alhamidi et al. [4] confirmed that the cultural background was the cause of the sustainability of the traditional farming system in the Ghouta oasis, Syria. Also, Chen et al. [11] reported that the quality of life in one Japanese rural community improved after introducing some ecotourism activities although the economic benefits were marginal to most host households.

Introducing the Ghout system as a pioneer in organic farming

Given its positive environmental impact, organic farming is vital for ensuring sustainability and shifting to a green economy [2]. Nowadays, organic farming is getting more interest worldwide [20] because it can contribute to mitigating the global warming effect through its ability to sequester carbon in the soil [33]. It also effectively controls pollution [8] and promotes public health [7]. Food production through the Ghout system has many advantages that we do not find in other local production systems.

In this system, local farmers do not use just any pesticide or chemical fertilizer, but they fertilize the soil in a natural, organic manner (camel droppings) [26]. Although organic farming produces less amount of crops than conventional agriculture, it is more lucrative, environmentally friendly, and delivers an equal amount of or even more nutritious foods with less pesticide residue [44, 50].

Food production through the Ghout system should be valued and supported. It can also generate significant income to the farmers if it is introduced properly and managed well. This point of view is consistent with what was reported by Zhang et al. [63]. So, by introducing this method of food production to producers and consumers, the traditional agricultural system will be able to withstand the competition of modern farming systems. It is locally recognized that the dates produced traditionally (Ghout system) are distinguished by their large size, good taste, and long storage period. Unfortunately, there are no academic studies that prove these observations.

Due to globalization and changes in agricultural and production systems, agricultural heritage needs, more than ever before, a new approach and a wise policy to manage and preserve it. Obviously, conserving traditional farming systems cannot be accomplished in isolation from the local communities' traditional knowledge, culture, and social organization. However, the joint management principle of GIAHS will be part of this policy.

7. Conclusions

The Ghout is a traditional agricultural system located in the Souf oasis (Algerian Sahara) and has been classified as a GIAHS by the FAO since 2005. The Ghout system has been based on mono-management by the local farmers since it was created in the 15th century. The local farmers alone managed this system for several centuries. However, the socioeconomic and land-use changes in the oasis system since the second half of the 20th century have made the mono-management model impotent and unable to keep pace with the new conditions. This study proposes a joint management model as a tool to activate the dynamic conservation and sustainable management of this traditional agricultural system, including local farmers, administrative authorities, and academic researchers. However, this new management model needs several reforms, which together aim to make the traditional agricultural system economically profitable. Politicians and decision makers can use the results of this study to formulate a dynamic conservation policy for this local agricultural heritage.

References

[1] Abdaoui, G. R., Tabet, A. A., Bouaicha, F., Bousmaha, A., Bouchemal, S. (2020), Sprawl, specificity and dynamics of inter-municipal urban agglomerations of the Souf Valley (south east Algeria): Using GIS techniques. *Int. J. Innov. Appl. Stud.* 29(4), 991–1014.

[2] Aceleanu, M. I. (2016), Sustainability and competitiveness of Romanian farms through organic agriculture. *Sustainability* 8(3), 245.

[3] Agnoletti, M., Emanueli, F., Corrieri, F., Venturi, M., Santoro, A. (2019), Monitoring traditional rural landscapes. The case of Italy. *Sustainability* 11(21), 6107.

[4] Alhamidi, S. K., Gustafsson, M., Larsson, H., Hillbur, P. (2003), The cultural background of the sustainability of the traditional farming system in the Ghouta the oasis of Damascus, Syria. *Agric. Human Values* 20(3), 231–240.

[5] Altieri, M. A. (1991), Traditional farming in Latin America. *Ecologist* 21(2), 93–96.

[6] Arnes Garcia, M., Yague, J. L., de Nicolas, V. L., Diaz-Puente, J. M. (2020), Characterization of globally important agricultural heritage systems (GIAHS) in Europe. *Sustainability* 12(4), 1611.

[7] Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G. B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C., Gromadzka-Ostrowska, J., Rembialkowska, E., Skwarlo-Sonta, K., Tahvonen, R., Janovska, D., Niggli, U., Nicot, P., Leifert, C. (2014), Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: A systematic literature review and meta-analyses. *Br. J. Nutr.* 112(5), 794–811.

[8] Biao, X., Xiaorong, W., Zhuhong, D., Yaping, Y. (2003), Critical impact assessment of organic agriculture. *J. Agr. Environ. Ethics* 16(3), 297–311.

[9] Bouchemal, S., Khezzani, B. (2019), New forms of agricultural development in the Algerian Sahara and their impact on water resources and the environment. In: *Proc. 10th Academic International Conference on Multidisciplinary Studies and Education (AICMSE)*, Boston, USA. 64–65.

[10] Chang, X., Wu, D., Qiao, N. (2008), Ecotourism development of agricultural heritage. *J. Beijing for. Univ.* 7(4), 33–38.

[11] Chen, B., Qiu, Z., Usio, N., Nakamura, K. (2018), Tourism's impacts on rural livelihood in the sustainability of an aging community in Japan. *Sustainability* 10(8), 2896.

[12] Chunjiang, A., Mengfan, C., Christophe, G. (2020), Rural sustainable environmental management. *Sustainability* 12(16), 6688.

[13] Côte, M. (1998), Des oasis malades de trop d'eau? *Secheresse* 9(2), 123–130.

[14] Côte, M., (2006): *Si le Souf m'était conté: Comment se fait et se défait un paysage*. Saïd Hannachi, Média–Plus, Constantine, Algérie.

[15] Daugstad, K., Ronningen, K., Skar, B. (2006), Agriculture as an upholder of cultural heritage? Conceptualizations and value judgements—A Norwegian perspective in international context. *J. Rural Stud.* 22(1), 67–81.

[16] Farsani, N. T., Ghotbabadi, S. S., Altafi, M. (2019), Agricultural heritage as a creative tourism attraction. *Asia Pac. J. Tour. Res.* 24(6), 541–549.

[17] Ferrario, V. (2021), Learning from agricultural heritage? Lessons of sustainability from Italian "Coltura Promiscua". *Sustainability* 13(16), 8879.

[18] Fischer, J., Hartel, T., Kuemmerle, T. (2012), Conservation policy in traditional farming landscapes. *Conserv. Lett.* 5(3), 167–175.

[19] George, E. W. (2013), World heritage, tourism destination and agricultural heritage landscape: The case of Grand-Pré, Nova Scotia, Canada. *J. Resour. Ecol.* 4(3), 275–284.

[20] Halberg, N., Sulser, T. B., Hogh-Jensen, H., Rosegrant, M. W., Knudsen, M. T. (2006), The impact of organic farming on food security in a regional and global perspective. In: Halberg, N., Alroe, H. F., Knudsen, M. T. (eds.), Global development of organic agriculture: Challenges and prospects. CABI. 277–322.

[21] Horner, S., Swarbrooke, J. (2004), *International cases in tourism management*. Butterworth-Heinemann, Oxford, UK.
[22] Januel, Y. (2010), *Dans le contexte d'une nouvelle dynamique agricole: quels avantages du système traditionnel des Ghoutes par rapports au système oasien évolué*. Centre d'Etudes et de Recherche sur le Développement International (CERDI), Clermont-Ferrand, France.
[23] Khezzani, B. (2007), *Ecology and development in the Souf oasis: The use of water resources and sustainable development*. Mgister Thesis, University of Oum El-Bouaghi, Oum El-Bouaghi, Algeria.
[24] Khezzani, B. (2015), The problem of green spaces and urban sprawl in the cities of the Algerian oasis: The case of the El-Oued city, Algeria. *1st International Symposium on Urban Sprawl in the Arab World and Sustainable Development*, 2–3 November 2015. University of Oum El-Bouaghi, Oum El-Bouaghi, Algeria.
[25] Khezzani, B. (2018), *The use of water resources in the Souf oasis: A study for a sustainable management of the environment.* Doctoral Thesis, University of Oum El-Bouaghi, Oum El-Bouaghi, Algeria.
[26] Khezzani, B. (2022), A new type of management to conserve the Ghout system as a world agricultural heritage, *1st National Seminar: Biotechnology, Health and Agro-Environment*, 14–15 March 2022. El-Oued University, El-Oued, Algeria.
[27] Khezzani, B., Bouchemal, S. (2018), Development and conservation of water resources for agriculture in an arid environment: A case study of the Souf oasis (Algerian Sahara). *Ann. Arid Zone* 57(1–2), 1–11.
[28] Khezzani, B., Bouchemal, S. (2018), Variations in groundwater levels and quality due to agricultural over-exploitation in an arid environment: The phreatic aquifer of the Souf oasis (Algerian Sahara). *Environ. Earth Sci.* 77(4), 142.
[29] Khezzani, B., Bouchemal, S., Halis, Y. (2016), Some agricultural techniques to cope with the fluctuation of the groundwater level in arid environments: Case of the Souf oasis (Algerian Sahara). *J. Aridland Agri.* 2(2016), 26–30.
[30] Khezzani, B., Khechekhouche, E. A., Bousbia Brahim, A. (2023), Community awareness of agricultural heritage systems (GHIAS) sites: The case of the Ghout system in the Souf oasis. *J. Rural Community Dev.* 18(1), 19–31.
[31] Khezzani, B., Zitouna Messaoud, H., Ghezal, H., Halis, Y. (2019), An assessment study of olive a new crop adopted in Algerian oases: A case study of the Oasis of El-Oued province, *Ann. Arid Zone* 58(3–4), 79–89.
[32] Kohsaka, R., Matsuoka, H., Uchiyama, Y., Rogel, M. (2019), Regional management and biodiversity conservation in GIAHS: Text analysis of municipal strategy and tourism management. *Ecosyst. Health Sustain.* 5(1), 124–132.
[33] Liu, H., Li, J., Li, X., Zheng, Y., Feng, S., Jiang, G. (2015), Mitigating greenhouse gas emissions through replacement of chemical fertilizer with organic manure in a temperate farmland. *Sci. Bull.* 60(6), 598–606.

[34] Liu, M., Yang, L., Bai, Y., Min, Q. (2018), The impacts of farmers' livelihood endowments on their participation in eco-compensation policies: Globally important agricultural heritage systems case studies from China. *Land Use Policy* 77, 231–239.
[35] Martins, J., Gonçalves, C., Silva, J., Gonçalves, R., Branco, F. (2022), Digital ecosystem model for GIAHS: The Barroso agro-sylvo-pastoral system. *Sustainability* 14(16), 10349.
[36] Mi, T., Qingwen, M., Hui, T., Zheng, Y., Lu, H., Fei, L. (2014), Progress and prospects in tourism research on agricultural heritage sites. *J. Resour. Ecol.* 5(4), 381–389.
[37] Miloudi, A. M., Remini, B. (2018), The Ghout of Souf: An original hydro-agricultural system. *GeoSci. Eng.* 64(3), 30–37.
[38] Min, Q., Zhang, B. (2020), Research progress in the conservation and development of China-nationally important agricultural heritage systems (China-NIAHS). *Sustainability* 12(1), 126.
[39] Nan, M., Lun, Y., Qingwen, M., Keyu, B., Wenhua, L. (2021), The significance of traditional culture for agricultural biodiversity—Experiences from GIAHS. *J. Resour. Ecol.* 12(4), 453–461.
[40] Pillay, M., Rogerson, C. M. (2013), Agriculture-tourism linkages and pro-poor impacts: The accommodation sector of urban coastal KwaZulu-Natal, South Africa. *Appl. Geogr.* 36, 49–58.
[41] Prus, B., Uruszczak, M., Hernik, J. (2022), Arguments based on biocultural diversity to cease abandonment of traditional agricultural systems: Lessons from Poland, *Biodivers. Conserv.* 31, 1–26.
[42] Pulido, J. S., Bocco, G. (2003), The traditional farming system of a Mexican indigenous community: The case of Nuevo San Juan Parangaricutiro, Michoacán, Mexico. *Geoderma* 111(3), 249–265.
[43] Qingwen, M. (2021), Agri-cultural heritage: An interdisciplinary field with development prospects. *J. Resour. Ecol.* 12(4), 437–443.
[44] Reganold, J. P., Wachter, J. M. (2016), Organic agriculture in the twenty-first century. *Nat. Plants* 2(2), 15221.
[45] Remini, B., Souaci, B. E. (2019), The Souf: When the drilling and the pivot threaten the Ghout! *LARHYSS J.* 37, 23–38.
[46] Reyes, S. R. C., Miyazaki, A., Yiu, E., Saito, O. (2020), Enhancing sustainability in traditional agriculture: Indicators for monitoring the conservation of globally important agricultural heritage systems (GIAHS) in Japan. *Sustainability* 12(14), 5656.
[47] Santoro, A., Venturi, M., Agnoletti, M. (2020), Agricultural heritage systems and landscape perception among tourists: The case of Lamole, Chianti (Italy). *Sustainability* 12(9), 3509.

[48] Senoussi, A., Bissati, S., Leghrissi, I. (2012), Le Ghout dans le Souf: L'agonie d'un système ingénieux. *Rev. Bioressour.* 2(1), 65–80.
[49] Shen, J., Huang, F.-T., Chou, R.-J. (2021), Agricultural-heritage-oriented rural revitalization: Experiences from the ancient tea town of Xiping. *Land* 10(9), 927.
[50] Smith, O. M., Cohen, A. L., Rieser, C. J., Davis, A. G., Taylor, J. M., Adesanya, A. W., Jones, M. S., Meier, A. R., Reganold, J. P., Orpet, R. J., Northfield, T. D., Crowder, D. W. (2019), Organic farming provides reliable environmental benefits but increases variability in crop yields: A global meta-analysis. *Front. Sustain. Food Syst.* 3, 82.
[51] Stenseke, M. (2009), Local participation in cultural landscape maintenance: Lessons from Sweden. *Land Use Policy* 26(2), 214–223.
[52] Sun, Y.-h., Cruz, M. J. D., Min, Q.-w., Liu, M.-c., Zhang, L.-y. (2013), Conserving agricultural heritage systems through tourism: Exploration of two mountainous communities in China. *J. Mt. Sci.* 10(6), 962–975.
[53] Sun, Y., Jansen-Verbeke, M., Min, Q., Cheng, S. (2011), Tourism potential of agricultural heritage systems. *Tour. Geogr.* 13(1), 112–128.
[54] Sun, Y., Min, Q., Cheng, S., Zhong, L.-s., Qi, X.-b. (2010), Study on the tourism resource characteristics of agricultural heritage. *Tour. Tribune* 25(10), 57–62.
[55] Tian, M., Min, Q.-w., Jiao, W.-j., Yuan, Z., Fuller, A.M., Yang, L., Zhang, Y.-x., Zhou, J., Cheng, B. (2016), Agricultural heritage systems tourism: Definition, characteristics and development framework. *J. Mt. Sci.* 13(3), 440–454.
[56] Vafadari, K. (2013), Planning sustainable tourism for agricultural heritage landscapes. *Ritsumeikan J. Asia Pac. Stud.* 32, 75–89.
[57] Voisin, A. R. (2003), *Le Souf, monographie*. El-Walid, El-Oued, Algérie.
[58] Vos, W., Meekes, H. (1999), Trends in European cultural landscape development: Perspectives for a sustainable future. *Landsc. Urban Plan.* 46(1), 3–14.
[59] Whelan, W. (1983), Farming systems research and development: Guidelines for developing countries. *Soil Sci.* 136(3), 191–192.
[60] Yotsumoto, Y., Vafadari, K. (2020), Comparing cultural world heritage sites and globally important agricultural heritage systems and their potential for tourism. *J. Heritage Tour.* 16(1), 43–61.
[61] Zhang, Y., He, L., Li, X., Zhang, C., Qian, C., Li, J., Zhang, A. (2019), Why are the Longji Terraces in Southwest China maintained well? A conservation mechanism for agricultural landscapes based on agricultural multi-functions developed by multi-stakeholders. *Land Use Policy* 85, 42–51.
[62] Zhang, Y., Li, X., Min, Q. (2018), How to balance the relationship between conservation of important agricultural heritage systems (GIAHS) and socio-economic development? A theoretical framework of sustainable industrial integration development. *J. Clean. Prod.* 204, 553–563.

[63] Zhang, Y., Min, Q., Li, H., He, L., Zhang, C., Yang, L. (2017), A conservation approach of globally important agricultural heritage systems (GIAHS): Improving traditional agricultural patterns and promoting scale-production. *Sustainability* 9(2), 295.
[64] Zhao, F., Huang, M. (2020), Exploring the non-use value of important agricultural heritage system: Case of Lingnan Litchi cultivation system (Zengcheng) in Guangdong, China. *Sustainability* 12(9), 3638.