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A conceptual framework for characterization of agricultural heritage in desert-prone areas

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Abstract

Purpose – This study aims to propose a comprehensive conceptual framework for the characterization of agricultural heritage in desert-prone areas, with a focus on Siwa Oasis in Egypt.

Design/methodology/approach – The research utilizes a multidimensional approach, integrating perspectives from sustainability principles, stakeholders and the agricultural heritage frameworks of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and Food and Agricultural Organization (FAO). It involves thematic analysis of qualitative data collected through focus group discussions and interviews with a diverse range of participants, including community members, government officials, nongovernmental organizations (NGOs) and researchers.

Findings – The study identifies five key elements of agricultural heritage in Siwa Oasis: cultural, ecological, economic, social and scientific. Cultural elements include traditional farming practices, irrigation systems and architectural features, while ecological elements encompass crop biodiversity, wildlife habitats and traditional landraces. Economically, date palm cultivation, olive production and agritourism activities play crucial roles in livelihood security and local economies. Socially, community cohesion, gender roles and cultural practices shape the social fabric of the oasis, with festivals and rituals fostering a sense of belonging. From a scientific perspective, the integration of traditional knowledge with modern agricultural practices enhances sustainability and resilience.

Research limitations/implications – The study focused solely on Siwa Oasis as a case study, limiting generalizability to other desert-prone areas. Further research could explore additional regions to enhance the understanding of agricultural heritage in diverse contexts. Additionally, the qualitative nature of the study may limit statistical analysis. Future studies could employ mixed-methods approaches for a more comprehensive understanding of agricultural heritage dynamics.

Practical implications – Understanding the multifaceted aspects of agricultural heritage in Siwa Oasis can inform sustainable development initiatives, tourism planning and cultural preservation efforts. Local policymakers and stakeholders can utilize these insights to develop policies that support traditional farming practices, ecotourism and community development. Furthermore, the promotion of agricultural heritage can enhance economic opportunities, food security and environmental sustainability in desert-prone regions.

Social implications – Recognition of the social elements embedded within Siwa Oasis's agricultural heritage highlights the importance of community cohesion, gender roles and cultural practices. By acknowledging and preserving these aspects, initiatives can be developed to empower local communities, promote gender equality and preserve cultural identity. Such efforts can enhance social cohesion, strengthen cultural bonds and promote inclusivity in the development agenda of desert-prone areas.

Originality/value – This study contributes a novel conceptual framework that bridges multifunctionality concepts, sustainability principles and stakeholder perspectives to characterize agricultural heritage in desert-prone areas. It offers insights into the complex interplay of cultural, ecological, economic, social and scientific dimensions of agricultural heritage systems.

Keywords Agricultural heritage, Conceptual framework, Desert-prone areas, Siwa oasis, Sustainability, Stakeholder perspectives

Paper type Conceptual paper

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1. Introduction

The development of agriculture has profoundly shaped cultural heritage, yielding both positive and negative consequences (Merciu *et al.*, 2022). Agriculture facilitated the establishment of settled societies and the emergence of complex cultures, contributing significantly to human civilization (Barak, 1993). Consequently, agricultural landscapes have become integral components of cultural heritage (Redman, 1999). However, the modernization of agricultural practices has often had adverse effects on cultural landscapes, impacting historical, cultural, social and economic values (Dümcke and Gnedovsky, 2013; Snowball, 2013).

The introduction of modern agricultural systems has been accompanied by the loss of traditional knowledge and practices crucial for preserving cultural heritage (Balick, 2017; Cottier, 1998; Dweba and Mearns, 2011).The transition from subsistence farming to commercial agriculture has led to the commodification of cultural heritage, where traditional practices and artifacts are exploited for commercial gains (Smith, 2006; Craith, 2007; Silberman, 2016).

Recognizing agricultural heritage as a distinctive form characterized by complex structures, multifunctionality and engagement of diverse stakeholders, uncertainties persist regarding its theoretical foundations and practical application. Despite progress, there remains a challenge in identifying the constituent elements crucial for the conservation and sustainability of Agricultural Heritage Systems (AHS). This article seeks to address these uncertainties by presenting a novel conceptual framework integrating the multifunctionality of agricultural heritage, sustainability principles and stakeholder perspectives.

The specific research objectives for this study include identifying the key elements of agricultural heritage in such areas, exploring effective conservation and management strategies for these elements and understanding the perspectives of various stakeholders on agricultural heritage in desert-prone regions.

The main objective is to develop an analytical approach aligning with the multifunctionality concept, UNESCO's perspective on cultural heritage and the five criteria outlined by the Globally Important Agricultural Heritage Systems (GIAHS) program of FAO (Altieri and Nicholls, 2004; FAO, 2023a, b). Through this innovative approach, the article aims to significantly contribute to the discourse on agricultural heritage, filling existing gaps and providing a structured foundation for the conservation and sustainable management of these intricate systems.

Recent studies explore the intersection of agricultural heritage, indigenous knowledge, tourism and community development across different regions. Positive associations have been highlighted between indigenous knowledge of environmental changes and small-scale farmers' resilience in regions like the Chiloé Archipelago, underscoring the importance of leveraging local knowledge in addressing social-ecological crises (Caviedes *et al.*, 2024). In Musina Municipality, South Africa, tourism is seen as a potential tool to leverage indigenous resources for community development (Ramaano, 2021).

Responsible tourism and ecotourism are emphasized in addressing environmental degradation threatening natural resource management and rural development in South Africa (Ramaano, 2022). Similarly, access to formal institutions, with informal institutions, especially women's groups, playing a crucial role in providing social support and engaging in economic activities in desert agricultural heritage-prone area in Siwa oasis (Bahnasy, 2024).

Moreover, digital and creative strategies are identified as key drivers of sustainable development in rural areas, particularly in the Mediterranean region, facilitating learning, enhancing community connections and addressing economic contributions and climate adaptation (Del Soldato and Massari, 2024). GIS technology is recognized for its potential in enhancing sustainable rural tourism and community empowerment, particularly in Musina Municipality, South Africa (Ramaano, 2023).

Additionally, the importance of recognizing and safeguarding agricultural heritage systems, such as GIAHS in China and Japan, has been highlighted, emphasizing their contribution to sustainability (He *et al.*, 2020; Sau-Wa Mak, 2023). Agroecological farming approaches emerge as crucial for achieving sustainable food production and supporting smallholder farmers, aligning with the United Nations Sustainable Development Goals (Akanmu *et al.*, 2023).

Despite these efforts, the impact of the tourism economy on food security in desert-prone agricultural heritage sites, such as Siwa Oasis in Egypt, highlights the need for integrated strategies to enhance food security through sustainable tourism and agriculture (Bahnasy, 2023).

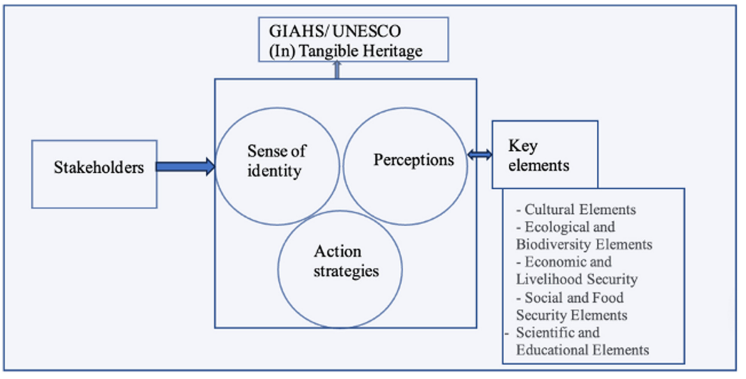
There is a notable gap in studies focusing on desert-prone areas, particularly in Africa, which face unique challenges, including water scarcity and soil degradation, yet possess rich agricultural histories and cultural traditions. Therefore, a critical need exists for a conceptual framework to guide the characterization, conservation and sustainable management of agricultural heritage in these areas. Such a framework would provide a structured approach to understanding the complex interplay between environmental, cultural and socioeconomic factors influencing agricultural heritage in these regions.

The article is organized as follows: first, it presents a conceptual framework for the characterization of agricultural heritage, followed by the background of the case study, materials and methods. The empirical section demonstrates the operationalization of the proposed framework and major findings concerning Siwa Oasis. The last part reflects on the conclusion and limitations of the framework.

1.1 Towards characterization of agricultural heritage framework: constituent elements (CEs)

The existing literature on agricultural heritage has not sufficiently explored the intricate elements and holistic characterization of this unique form of heritage (Singh and Rana, 2019; Li *et al.*, 2021; Jiang and Zhang, 2023; Manrique *et al.*, 2023). Therefore, there is a critical need to develop an analytical framework that comprehensively captures the complexity and multi-dimensional nature of agricultural heritage (Figure 1). By elucidating the diverse components and interconnections within agricultural heritage systems, this proposed framework provides a solid theoretical foundation in the field while bridging the gap between theoretical concepts and empirical applications.

The proposed framework for understanding agricultural heritage encompasses a multifunctional approach that integrates sustainability principles, acknowledging its role



Source(s): The Author

Figure 1. Conceptual frame of constituting elements (CEs) for characterization of agricultural heritage elements (developed from FAO- GIHAS criteria)

beyond mere agricultural production (Huylenbroeck *et al.*, 2007). It recognizes its broader contributions to cultural identity, ecological sustainability, rural development and social well-being (Groenfeldt, 2006; Bjørkhaug and Richards, 2008).

Furthermore, the framework incorporates the sustainability goals of the United Nations (UN) (UN, 2015) to ensure the long-term viability of agricultural heritage systems, aligning with several Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 11 (Sustainable Cities and Communities) (UN, 2015). Agricultural heritage systems play a significant role in ensuring food security, preserving traditional farming methods, contributing to the conservation of terrestrial habitats, supporting sustainable land management and enhancing community resilience (Xie *et al.*, 2011; Reyes *et al.*, 2020; Ferrario, 2021; Hara *et al.*, 2021; Agnoletti and Santoro, 2022).

Central to this analytical framework is the recognition of different stakeholders' perceptions and perspectives on agricultural heritage (Vila Subirós *et al.*, 2016; Gullino *et al.*, 2018; Branduini, 2020). Stakeholders, including indigenous farmers, government entities, heritage organizations, NGOs, researchers and the tourism industry, play crucial roles in the preservation, management and promotion of agricultural heritage.

By incorporating these elements within the proposed framework, this paper contributes to the understanding of agricultural heritage as a dynamic and multi-faceted system. It provides valuable insights into the multifunctional nature of agricultural heritage and the necessity for sustainability principles while recognizing the significance of stakeholder perceptions. This comprehensive framework serves as a valuable tool for academics and policymakers seeking to effectively identify, manage and preserve agricultural heritage systems in a manner that balances ecological, sociocultural and economic considerations.

2. Study area and method

2.1 Location and attributes

Oases are characterized as regions encompassing permanent water sources within expansive arid desert landscapes (Lavie and Marshall, 2017). Siwa oasis is situated in the northern sector of Egypt's Western Desert, approximately 40 km from the Libyan borders, 300 km from the Mediterranean coast, and around 600 km from the Nile Valley is the Siwa Oasis. This oasis is affiliated with the Matrouh Governorate (Figure 2).

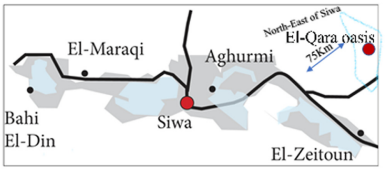
Siwa Oasis holds the distinction of being the oldest oasis in Egypt and is one of the five oases, namely (Siwa, Baharya, Elfarafra, Eldakhla and Elkharga), which originated from natural depressions within the Western Desert (El-Ghani *et al.*, 2017). Occupying an area of 1,088 km2, Siwa Oasis lies 18 meters below sea level (Nicholson, 2011). The depression of Siwa Oasis is demarcated to the north by a series of hills and plateaus, rising nearly 100 meters above the depression's surface, while its southern boundary is defined by dunes that are part of the Great Sand Sea (Zahran and Willis, 2008). Within the Siwa depression, four salt lakes are found: El Zeitoun to the east of the oasis, El Maaser to the northeast, Siwa Lake to the west of the city of Shali and El Maraqi to the west of the oasis.

The research was conducted in the Siwa Oasis region, a region recently under developmental focus, situated in the Matrouh Governorate. The study encompassed the city of Siwa and five villages: Al-Marqah, Aghormi, Bahy Al-Din, Abu Shuruf and Umm Al-Sughayr (El-Qara oasis) (Figure 3).

Siwa Oasis has a population of approximately 33,491 individuals, comprising 16,816 males and 16,675 females (Information and Decision Support Centre, 2020). The predominant ethnic group in the region is the Amazigh (Berber), fostering a unique desert culture with a distinct language known as Siwi, separate from other languages spoken in Egypt. Additionally, the Siwan community is fluent in the Egyptian dialect (Hagan, 2001; Harris, 2017).

Source(s): Modified by the author from GOPP. GOPP (2020)

Figure 2.
Siwa geographical location in Egypt



Source(s): Modified by the author GOPP (2020)

Figure 3.
Area studied villages in Siwa

Siwa Oasis as an Agricultural Heritage Site (SOAHS) is of international importance since it was selected as one of the Protected Areas (PA) in 2002 (EEAA, 2006), designated as GIAHS in 2016 (FAO, 2016) and listed in the tentative list of World Cultural and Natural Heritage in 1994 (UNESCO, 2023). The site is intricate and varied, consisting of numerous natural and human-made components, possessing notable features such as scenic landscapes, abundant date varieties and olives and profound ethnic and cultural traditions of the Berber community.

Shali Fortress, dated back to the 12th century, is constructed from karshif, a traditional mixture of salt and mud, showcasing the ancient building techniques of Siwa Oasis in Egypt. (Fakhry, 1973; Goodman, 2005). The 7000-year-old Siwa Oasis holds significant historical and cultural value as an agricultural heritage site (Fakhry, 1973; GOPP, 2020). Furthermore, in 2014, the discovery of ancient human footprints dating back 3 million years provides evidence of the enduring human connection to agricultural practices 9 (GOPP, 2020).

The agricultural heritage of Siwa is intricately woven into the oasis landscape, featuring meticulous date palm gardens, traditional irrigation systems and the cultivation of olives. The traditional farming practices involve a deep understanding of the desert environment, with a focus on sustainable techniques passed down through generations (Serreli and Schiattarella, 2021). The Siwan farmers, predominantly of Amazigh (Berber) descent, employ age-old methods for planting, cultivating and harvesting, showcasing a harmonious coexistence with the challenging arid conditions (Harris, 2017).

In addition to the traditional agricultural patterns, the study area also exhibits unique industrial structures that contribute to the region's economic fabric. These structures, influenced by the cultural and environmental context, encompass facilities for date processing, olive oil extraction and artisanal crafts (FAO, 2016). The intricate connection between traditional agricultural practices and industrial structures underscores the resilience and adaptability of the Siwan community, making Siwa Oasis a captivating study area for understanding the intricate interplay between cultural heritage, agriculture and industry.

However, there is a dearth of research dedicated to the analysis of component elements and the identification of elements specific to the SOAHS site. To address this research gap, this study focuses on five villages within the Siwa Oasis area in the Matrouh governorate. This selection is based on the region's exceptional landscape and its status as a key protected area. Additionally, the Berber community, representing a minority group in Egypt, has successfully preserved its traditional culture within the region. Including their perspectives as stakeholders provide valuable insights into the comprehensive understanding of the SOAHS.

2.2 Data and methods

The article adopts a qualitative exploratory design involving in-depth interviews and focus group discussion (FGD) with different stakeholders to gain insight into the characteristics of agricultural heritage elements in Siwa Oasis. The approach helps to provide in-depth details on specific crops, irrigation methods, farming tools, cultural practices and other tangible and intangible elements associated with agriculture in the oasis (Makri and Neely, 2021). In-depth interviews and focused group discussions were conducted in the Siwa Oasis area with the approval of the Antiquities Administration Bureau of Siwa and Matrouh governorate as well as the Siwa Protected Area Administration Bureau.

The time frame selected for data collection, spanning from March to September 2021, was strategically chosen to align with the local agricultural production calendar in Siwa Oasis. Siwa experiences distinctive seasonal variations that significantly influence agricultural practices. March marks the transition from winter to spring, a crucial period for planting and early cultivation. As the season progresses, the oasis enters a phase of heightened agricultural activities, including irrigation, tending to crops and the commencement of harvesting in certain cases. This period continues through the summer months, with the culmination of harvests and the celebration of festivals such as the Siwa Festival and the Harvest Celebration (Eid El Siyaha) in late September.

By focusing on these months, the study aimed to capture the dynamic nature of agricultural practices, including planting, growth and harvesting, as well as any associated rituals or celebrations. Throughout these seasons, variations in farming techniques, crop types and cultural practices were anticipated, providing an understanding of the agricultural heritage elements in Siwa Oasis.

However, since this study is based on the component elements of AHS, the in-depth interviews and FGDs covered four types of stakeholders: First indigenous local farmers. Second; officials who have been directly engaged in heritage management at the levels of the province and city council city. Thirdly, researchers who have been engaged in relevant

scientific research around SOAHS heritage sites and protected areas. Fourth, NGOs have effectively impacted the area.

Different stakeholders' views have been interviewed for the identification of elements of SOAHS. There was no a prior assumption before the interview but analyzed the data based on possible generalizations that may arise from the thematic categories initially developed from the conceptual framework. For this reason, thematic analysis has been adopted which allows us to code and analyze based on the key constituent elements of AHS. The procedures for characterizing the agricultural heritage elements include repeated reading, theme coding, identification, organization and writing (Floersch *et al.*, 2010).

Table 1 shows the demographic characteristics of the study participants but also interview types. In-depth interviews constitute 32% of participants while focus group discussion represents about 68% of participants. There were more men who participated in the study than women. This has a link to cultural practices in the areas in which more men

(N = 113)	Frequency
Interview type	
In-depth interview (33)	29
FDG (avg. of 8 per discussion) (8*10)	71
Gender	
Male	77
Female	23
Age	
18–25 yrs	23
26–30 yrs	29
31–45 yrs	24
46–60 yrs	16
Above 60 yrs	14
Marital status	
Single	18
Married	67
Window	9
Divorced	6
Level of education	
No degree	6
Primary education	46
Secondary (high) education	36
University education	8
Post-graduate education	4
Job status	
Permanent	22
Intermittent	27
Temporary	21
Seasonal	31
Source of income	
Government employee	11
Agriculture	41
Tourism employee	16
Industrial employee	21
Self-employed (business, trade and handicraft)	12

Source(s): The author

Table 1. Demographic characteristics of the study participants

engaged farming than women. While the representation of the study participants in terms of age appears even on average, more young people between 26–30 years (29%) participated in the study. In terms of other characteristics of the study participants, the majority of the participants are married (67%) and less educated (primary level); most participants are intermittent workers (27%) and their main source of income is mainly from agriculture (41%).

3. Results

The thematic analysis of Siwa Oasis's agricultural heritage serves numerous functions that can be classified mainly into five elements: cultural elements, ecological and biodiversity, economic and livelihood security, social and food security and scientific and educational elements (Table 2).

For cultural elements, some participants shared that the planting of date palms, the traditional irrigation system and oasis architecture hold significant cultural values in Siwa Oasis. On ecological elements of agricultural heritage, some participants shared that Siwa Oasis is rich in agricultural biodiversity, supports a diverse range of wildlife, attracts various bird species and has unique animals that contribute to the region's ecological richness.

Interview category	Features	Stakeholders
Cultural elements	Tangible and intangible elements. Tangible elements such as distinct Siwa Landscape, date palms and olives, traditional Irrigation Systems, traditional Agricultural Tools, and Oasis Traditional Architecture. Intangible elements such as traditional farming knowledge, date palm cultivation, cultural practices, sustainable practices, and festivals and rituals	Farmers, local communities and researchers
Economic elements and livelihoods security	Significance of Agriculture Heritage in Siwa's Economy and Livelihoods include Economic Fruits, Agricultural products, and Agricultural production organization/ economic activity//Economic potential of tourism in Siwa Oasis/the importance of sustainable development in preserving agricultural heritage while promoting economic growth	Farmers, local communities, government agencies and NGOs
Ecological elements	crops and traditional cultivar/date palm genetic diversity/variety of crops in Siwa Oasis/heritage of olive cultivation/species biodiversity include livestock and wildlife	Farmers, local communities, government agencies and NGOs
Social and food security elements	Food security include nutritional, culinary and medicinal Value of Dates/ Crop Diversity and Challenges/ Traditional folklore/Traditional values/ social organization/local identities, traditions, and cultural practices	Farmers, local communities, government agencies, NGOs, cultural and heritage organizations
Scientific and educational elements	Indigenous ecological knowledge, and historical and cultural contexts/Research institute/outreach activities	Researchers, educators, students, farmers, non-governmental organizations and cultural and heritage organizations

Table 2. Identified elements of agricultural heritage in Siwa Oasis

Source(s): The author

In addition, social elements and food security, recreation, clean air and water, friendly relationships, accessibility to heritage assets and a sense of belonging. Economic elements and livelihood security encompass agricultural products, food self-sufficiency, marketing and agritourism. Scientific elements and education, AH raises awareness, promotes knowledge transfer and involves educational institutions and museums. However, the educational aspect often focuses on information dissemination without fully integrating it into the broader framework of agricultural heritage definitions.

3.1 Cultural elements

The intricate fabric of Siwa Oasis's agricultural heritage, as unveiled by the participants, intertwines tangible and intangible elements. These dimensions, as classified by the community, encompass the cultivated landscape, traditional irrigation systems, ancient agricultural tools and the iconic Oasis traditional architecture as tangible representations. Concurrently, the intangible facets embrace traditional farming knowledge, the utilitarian value of date palms and the vibrant celebration of seasonal festivals. These elements illustrate the holistic nature of Siwa's cultural identity.

3.1.1 Tangible cultural elements. 3.1.1.1 The cultivated Siwan landscape. Participants illuminated the profound significance of date palm gardens, epitomizing the resourcefulness and wisdom of the local community (FDG 1). The carefully cultivated landscape, featuring a diverse mix of crops strategically arranged in three tiers; tall date palms, fruit-bearing plants in the middle and other crops closer to the ground, served as a testament to human ingenuity shaping the environment (Interview 3, government representative). The presence of date palms provides shade and protection for other crops, creating a unique environment suitable for cultivating a variety of plants (Interview 14, local farmer).

Date palms, prominently featured in these gardens, not only provided sustenance but also played a multifaceted role in daily life, supplying materials for construction and fibers for various purposes (Interview 22, local farmer). Participants emphasized the centuries-old connection between the meticulous cultivation of date palm gardens and the community's deep-rooted ties to the land (FDG 1).

Furthermore, study participants underscored the emblematic role of date palms and olives as symbols deeply intertwined with Siwa Oasis's historical heritage. Both crops were identified as integral to the cultural identity of the local community, holding immense significance in the region (FDG 1). Beyond their agricultural value, date palms and olives were celebrated for their enduring presence, reflecting a rich heritage dating back to ancient times that have shaped their identity (Interview 2, government representative). Siwa Oasis's agricultural landscape as a resilient narrative of human adaptation in the face of a challenging desert environment, showcasing the enduring connection between the community and their land, affirming their identity (Interview 8, Government representative).

3.1.1.2 Traditional irrigation systems. Participants underscored the pivotal role of traditional irrigation systems and ancient agricultural tools in sustaining the region's agriculture and preserving cultural heritage (FGD 3). The careful management of water distribution, overseen by an Ahisab, ensures fairness among garden clusters, known as Hateya, while conflicts are addressed by the respected observer Rikab (Interview 3, government representative). This traditional system is regarded as the lifeblood of Siwa Oasis, fostering a sense of community and sustainable agriculture over generations (Interview 7, NGO).

Additionally, local farmers in Siwa Oasis maintain a profound attachment to ancient agricultural tools, such as axes, pickaxes, hoes, plow machines and the traditional olive oil press (Interview 5, government representative). These tools, deeply ingrained in the cultural heritage of the community, symbolize the connection to the land and the reliance on manual

labor (Interview 6, NGO). Participants emphasized that the preservation of these tools is essential for passing on traditions to future generations, highlighting their immense cultural significance (FDG 3).

3.1.1.3 The Oasis's traditional architecture. Participants shed light on the significance of traditional oasis architecture in Siwa Oasis, expressing a deep connection to the ancient fortress of Shali (FDG 4). Shali fortress showcases the evolving nature of architectural practices in Siwa Oasis while acknowledging the natural and economic factors influencing the choice of construction materials in the 12th century (interview 7, NGO).

The ancient Shali represents more than just a historical site to us, it symbolizes our Siwan identity and preserves the stories of our ancestors and the challenges they encountered in this oasis (Interview 20, local farmer). Our traditional oasis architecture holds great value in our cultural heritage, while the use of Karshif and date palm trunks in building our homes was more common in the past, nowadays we are using modern materials due to the cost constraints associated with Karshif techniques (FGD 4).

The use of karshif (mixing of salt and clay) and date palm trunks in construction techniques demonstrates the resourcefulness and adaptation of the Siwan people to their environment (Interview 5, government representative). However, the brittleness of karshif walls and the lack of maintenance have led to the deterioration of buildings, emphasizing the need for conservation efforts (Interview 5, government representative). Despite its current state of ruins, the Shali fortress remains an iconic feature, with its towering presence above the modern town (Interview 7, NGO).

3.1.2 Intangible cultural elements. 3.1.2.1 Traditional farming practices and knowledge. Study participants in Siwa Oasis expressed the profound significance of intangible cultural elements and traditional farming practices, emphasizing their pivotal role in cultivating and managing date palm and olive trees (FDG 3). The participants conveyed a collective opinion that the wealth of traditional farming knowledge, passed down through generations, serves as the foundation of Siwa's cultural identity and contributes significantly to the sustainability of inherited agricultural practices (FGD 3).

The participants articulated the importance of traditional knowledge in critical decision-making related to planting and harvesting times, crop selection and water management strategies (FGD 2). Through clonal propagation techniques, such as utilizing offshoots from the best female trees, farmers in Siwa Oasis demonstrated their unique approach to date palm cultivation (Interview 4, government representative). Manual pollination emerged as a preferred practice among farmers, allowing them precise control over the fruit set and ensuring a successful harvest.

Despite recognizing the challenges associated with managing tall date palm trees, such as the physical demands of frequent climbing for tasks like pollination, harvesting and pruning, participants underscored the necessity of these practices for a successful harvest (FDG 3). Climbing trees as tall as 15 meters was acknowledged as a skill-demanding but essential aspect of date palm cultivation in Siwa Oasis (Interview 25, local farmer).

Participants provided valuable insights into the intricate art of date palm harvesting and post-harvest techniques (FGD 3). Siwan farmers cultivated those dates through a meticulous process, evolve through four distinct stages: Agingin (immature and green), Irgawin (fully colored and mature), Isimimin (soft and brown) and Infit (hard and raisin-like), this nuanced understanding reflects the participants' collective wisdom and knowledge regarding the diverse characteristics and uses of dates at different ripeness stages (Interview 4, government representative).

The participants underscored the comprehensive utilization of all parts of the date palm, celebrating its multipurpose nature.

> The date palm is a truly multipurpose tree for us. We reserve palm cabbage (Gummar in local Siwi, which is the tender top part of the palm) for special religious celebrations and weeding, as cutting down the palm is necessary. As well as Palm juice (Lagbi) is obtained by making careful cuts in the top part of the palm without harming the tree. It's a sweet drink that we often enjoy during festive occasions (FGD 3).

3.1.2.2 Festivals and rituals. Participants emphasized the significance of festivals and rituals as integral components of the intangible agricultural heritage in Siwa Oasis. The Siwa Festival and the Harvest Celebration (Eid El Siyaha) emerged as pivotal events, playing a crucial role in fostering the community's cultural identity and reinforcing its profound connection to the land (FDG 4).

According to participants, these festivals serve as powerful platforms for unity, reconciliation and gratitude within the community. The gatherings provide a space for community members to come together, celebrate shared traditions and partake in communal meals, enhancing the sense of togetherness among Siwans (Interview 7, NGO).

The festivals' historical and cultural value, emphasizing that these events not only symbolize the community's shared history but also function as mechanisms for conflict resolution and the cultivation of peaceful relations among Siwans (Interview 4, government representative). Moreover, the festivals were recognized as powerful agents in strengthening the community's sense of unity and contributing to the preservation of cultural continuity (Interview 6, NGO).

3.2 Social elements and food security of Siwa Oasis's agricultural heritage

Participants revealed the intricate social elements embedded within the community of Siwa Oasis, encompassing Qabila, gender roles and cultural practices related to local crafts, festivals and celebrations. As well as, the findings reveal the intricate interplay between crop diversity, economic challenges and the cultural significance of agricultural practices in Siwa Oasis. These elements play a crucial role in shaping the community's rich heritage and contributing to its unique identity.

3.2.1 Qabila and governance structure. Participants emphasized the significance of Qabila, social groups formed based on shared family backgrounds (FDG 9). The Sheikhs, selected by older family members, were identified as pivotal figures in local governance (Interview 1, government representative). Responsible for handling community matters and settling disputes between Qablas, the governance structure led by Sheikh leaders ensures community cohesion and effective decision-making processes, reflecting a system deeply ingrained in Siwan social dynamics (Interview 4, government representative).

3.2.2 Gender roles and cultural practices. Participants highlighted the presence of strict gender roles, with men primarily engaged in external activities like farming and trading, while women, particularly married women, predominantly stay at home. Despite their involvement in household chores, women contribute to activities like weaving and embroidery (FDG 10). The separation between genders has influenced the development of a distinct culture in Siwa (Interview 1, government representative). However, women have a great impact on craft traditions, including intricate embroidery, colorful clothing and silverwork jewelry, bear symbols associated with blessings of good health, fertility and protection against misfortune. (Interview 7, NGO).

3.2.3 Unique festivals and cultural celebrations. Participants underscored unique festivals and cultural celebrations that go beyond Islamic traditions (FDG 4). The Eid El Siyaha festival, honoring the traditional patron saint Sidi Sulayman, takes place during the harvest season (FDG 4). Additionally, the feast of Ashura, historically the principal celebration, has transformed into a feast for children. These festivals involve the decoration of houses with tall palm branches, torches soaked in oil and the singing of particular old songs. Children

actively participate by carrying decorated frameworks of palm branches adorned with fruits, nuts, sweets and cakes, symbolizing a blend of cultural, religious and agricultural elements (FDG 4).

3.2.4 Crop diversity and challenges in Siwa oasis. Participants shared that social elements within Siwa Oasis's agricultural practices extend to crop diversity and the challenges in sustaining horticultural production (FDG 2). While dates and olives dominate the orchards and significantly contribute to the local economy, participants acknowledged the cultivation of a variety of vegetables, fruits and medicinal plants (FDG 2). The smaller significance of these crops, attributed to factors such as saline soils, limited competitiveness and Siwa's comparative advantage in producing dried and storable food products, underscores the unique agricultural landscape of the oasis (Interview 5, government representative).

Despite the challenges posed by saline soils and the limited competitiveness of certain crops, participants expressed a commitment to cultivating a diverse range of crops alongside dates and olives. Crops like grapes, tomatoes and cucumbers were identified as providing additional income for households and introducing variety to the agricultural landscape (Interview 4, government representative). The resilience of local farmers in the face of challenges highlights the importance of crop diversity not only for economic purposes but also for the cultural richness it brings to Siwa's agricultural practices ((Interview 7, NGO).

3.2.5 Nutritional, culinary, and medicinal significance of dates. Dates emerged as a vital component of Siwan livelihoods, contributing significantly to the local diet. Rich in carbohydrates, proteins, fats, essential salts, minerals, vitamins and dietary fiber, dates provide a substantial portion of the recommended daily intake of essential nutrients (Interview 8, government representative). Beyond their nutritional value, dates were emphasized for their medicinal properties, serving as a remedy for intestinal troubles and being used in formulations against colds, sore throats and coughs (Interview 2, government representative).

Participants underscored that dates are not merely a source of income but are deeply ingrained in the culture and diet of Siwan people (FDG 10). Their significance extends beyond economic considerations, forming an integral part of culinary traditions and serving as a symbol of cultural heritage and identity (Interview 3, government representative).

3.3 Ecological elements

3.3.1 Crop Biodiversity and adaptation. Participants highlighted the region's rich biodiversity, emphasizing the stability of traditional crops cultivated by local farmers over time (FDG 6). The introduction of new crop species since 1986 has added to the agricultural diversity, expanding the range of crops cultivated in Siwa Oasis (interview 9, Government representative). Despite these introductions, participants expressed a strong commitment to preserving and cultivating traditional crops well-adapted to the local alkaline soil conditions, considering them integral to the local cuisine (FDG 6).

3.3.2 Date palm genetic diversity. Local farmers in Siwa Oasis have successfully cultivated native date palm varieties, with the Saidi type being particularly popular and contributing significantly to Egypt's date production (interview 5, government representative). The genetic diversity of date palms in Siwa reflects centuries of interaction between farmers and the unique characteristics of palm trees (Interview 6, NGO). The preservation of traditional landraces underscores the importance of these crops in Siwan agrobiodiversity (Interview 10, government representative).

3.3.3 Diverse crop varieties and olive cultivation. Siwa Oasis hosts several different crop species, with apples, guavas and zucchini squash introduced after the construction of paved roads (Interview 7, NGO). Traditional landraces of certain crops have been preserved,

emphasizing their significance in Siwan agrobiodiversity. Olive cultivation, with heirloom varieties like Hamud, Wategen and Maraqi, has a long history in Siwa Oasis, serving both culinary and oil production purposes (Interview 4, government representative). Additionally, the oasis is home to other plant species such as the lote tree and Siwan spearmint (Interview 10, government representative).

3.3.4 Livestock and wildlife contribution economic. Study participants highlighted the vital role of livestock animals, including donkeys and pigeons, in Siwan ecological elements, contributing to agricultural practices through manure for fertilization (FDG 7). Siwa Oasis supports various wildlife species, including Dorcas's gazelles, desert foxes, Saharan sand snakes and a diverse array of bird species (Interview 10, government representative). The region's ecological richness extends beyond agriculture, attracting diverse wildlife that contributes to the overall biodiversity of Siwa Oasis (Interview 9, government representative).

3.4 Economic elements and livelihood security

3.4.1 Agriculture as the backbone of the economy. Participants emphasized that agriculture takes center stage in the Siwan economy, not only sustaining the community but also providing crucial employment opportunities (FDG 7). In addition to that, locally produced dates are pivotal for food security, echoing the sentiment that agriculture is the lifeblood of Siwa's livelihoods (Interview 3, governmental representative).

3.4.2 Tourism and economic opportunities. Participants noted the increasing interest in organic and locally produced goods, underscoring their higher value in both domestic and international markets (FDG 8). As well as, tourism plays a crucial role in Siwa's economy. Visitors are drawn to the authentic rural experience, traditional farming practices and cultural festivals, providing income for local farmers and contributing to the preservation of agricultural heritage (Interview 10, governmental representative).

3.4.3 Sustainable practices and economic opportunities. Participants expressed that embracing sustainable farming practices is not just about economic gain but a conscious effort to preserve heritage (FDG 7). Through eco-friendly initiatives like organic farming, agroforestry and eco-tourism, Siwa Oasis creates economic opportunities while aligning with environmental sustainability goals (Interview 6, NGO).

3.4.4 National economic contributions of agricultural production. Participants acknowledged the significant contribution of Siwa's agricultural production, particularly dates and olives, to the national economy (FDG 7). The drying and packaging operations associated with agricultural produce, particularly olives, were noted as significant economic contributors (Interview 4, governmental representative). Participants highlighted the generation of employment opportunities and the added value to Siwa's agricultural produce through processing olives into pickles and producing high-quality olive oil. These operations were recognized not only for their economic impact on the local community but also for contributing to the national economy (Interview 7, NGO).

3.5 Scientific and educational elements

Study participants emphasized the integral role of scientific elements, encompassing the preservation of traditional knowledge, ecological diversity and conservation, the integration of traditional and modern practices and educational initiatives. These elements form a critical part of the conceptual framework for agricultural heritage in the region.

3.5.1 Preservation of traditional knowledge. Local farmers highlighted the significance of preserving traditional knowledge. The wisdom passed down from ancestors covers adapting to the desert climate, optimizing limited resources and ensuring the continuity of agricultural heritage (FDG 9). This traditional knowledge, deeply rooted in the region, contributes not

only to sustainable farming techniques but also presents valuable educational opportunities for future generations (Interview 5, governmental representative).

3.5.2 Ecological diversity and scientific research. Participants reflected that Siwa Oasis's ecological diversity, including a diverse range of crops, provides a fertile ground for scientific research and educational endeavors (FDG 6). The oasis as a treasure trove for scientific studies on plant genetics, adaptation to arid environments and the conservation of endangered plant species (Interview 10, governmental representative). This ecological diversity serves as a unique learning environment for students and researchers interested in agroecology and sustainable land management (Interview 9, governmental representative).

3.5.3 Integration of traditional and modern practices. Participants expressed the integrated traditional agricultural practices with modern scientific approaches. This integration involves adopting efficient irrigation techniques, organic farming methods and sustainable pest management strategies (Interview 10, governmental representative). The harmonious coexistence of ancient wisdom and modern knowledge contributes to the scientific understanding of agroecosystems and provides educational opportunities for learning about sustainable agriculture. (Interview 9, governmental representative).

3.5.4 Educational initiatives and capacity building. Educational initiatives in Siwa Oasis, including vocational training programs, workshops and awareness campaigns, play a pivotal role in fostering scientific curiosity and enhancing agricultural education, these initiatives aim to empower the community, particularly the youth, with scientific knowledge in agriculture (Interview 7, NGO). The goal is to equip the younger generation with the necessary skills for engaging in sustainable farming practices and becoming future agricultural leaders (Interview 6, NGO).

4. Discussion and implications

The proposed conceptual framework for understanding agricultural heritage in desert-prone areas provides a comprehensive analytical approach that integrates sustainability principles and multifunctionality concepts. The framework offers a structured methodology for characterizing and managing agricultural heritage. This framework acknowledges the multifaceted nature of agricultural heritage, recognizing its role beyond mere agricultural production and encompassing broader contributions to cultural identity, ecological sustainability, economic development and scientific research. Understanding the perspectives of various stakeholders is crucial for the effective conservation and management of agricultural heritage sites. Stakeholders play distinct roles in shaping the conservation strategies and policies for agricultural heritage.

Applying the conceptual framework on Siwa Oasis's agricultural heritage that reveals encompasses a rich of tangible and intangible cultural elements that reflect the region's unique identity and history. Tangible elements include traditional farming practices, such as the cultivation of date palms, the use of ancient irrigation systems and the architectural heritage of the Shali fortress (Palang *et al.*, 2005). Intangible elements, such as traditional knowledge, seasonal festivals and communal celebrations, further contribute to the cultural significance of agriculture in Siwa Oasis (Jansen-Verbeke *et al.*, 2020).

In addition, the ecological richness of Siwa Oasis is evident in its diverse crop varieties, unique wildlife and traditional landraces adapted to the local environment. Findings highlighted the stability of traditional crops cultivated by local farmers over time, as well as the importance of preserving biodiversity for sustainable agricultural practices (De Grenade and Nabhan, 2013). Additionally, the coexistence of ancient and modern farming practices underscores the resilience of Siwa's agrobiodiversity and its significance for ecological conservation (Agnoletti and Santoro, 2022).

Furthermore, agriculture serves as the backbone of the economy in Siwa Oasis, providing crucial employment opportunities and contributing to food security at both local and national levels (Green and Giese, 2004). The region's agricultural products, particularly dates and olives, have significant economic value and support livelihoods for local communities. As well as, the tourism industry plays a vital role in generating income and promoting the preservation of agricultural heritage through sustainable tourism practices (Kamal, 2019).

In addition to that, Siwa Oasis's agricultural heritage also encompasses scientific and educational dimensions, including the preservation of traditional knowledge, ecological research and educational initiatives. The integration of traditional farming practices with modern scientific approaches highlights the importance of combining traditional wisdom with contemporary knowledge for sustainable agriculture (Balick, 2017).

Educational programs and capacity-building initiatives further empower local communities with the skills and knowledge needed to manage and preserve their agricultural heritage for future generations (Anand *et al.*, 2023). The findings of this study have several implications for socio-economic, practice, policy, theory and further research in the field of agricultural heritage conservation:

4.1 Socio-economic implications

The preservation and sustainable management of agricultural heritage in desert-prone areas have significant socio-economic implications for local communities. Involving indigenous farmers and other stakeholders in conservation efforts, the framework empowers communities to take ownership of their cultural and natural resources (Gullino *et al.*, 2018). In addition to that, Agricultural heritage conservation can diversify livelihoods and create new economic opportunities for rural communities in desert-prone areas. As well as, the framework emphasizes the economic value of agricultural heritage sites as tourist attractions, highlighting their potential to generate income for local communities. Safeguarding indigenous farming techniques, rituals and festivals, communities can maintain their cultural identity and transmit intergenerational knowledge. This cultural continuity fosters a sense of belonging and pride among community members and reinforces social cohesion (Bahnasy, 2024).

4.2 Practical and policy implications

The framework provides a systematic approach for heritage managers and policymakers to identify, assess and manage agricultural heritage sites in desert-prone areas. The framework offers a standardized methodology for evaluating the significance and sustainability of these sites. This practical tool facilitates decision-making processes related to heritage conservation and ensures that interventions align with internationally recognized standards.

The framework informs conservation strategies by highlighting the importance of preserving not only physical structures but also intangible cultural practices and ecological systems. Managers can use the framework to prioritize conservation efforts based on the most critical elements of agricultural heritage, such as traditional farming knowledge, cultural rituals and biodiversity (Fischer *et al.*, 2012; Rayman-Bacchus and Radavoi, 2019).

As well as, the framework emphasizes the importance of education and capacity building in heritage conservation and sustainable agriculture. Educational institutions can use the framework to develop training programs and workshops that build local capacity in heritage management, agroecology and sustainable farming techniques. Policymakers can use the framework to inform the development of policies and regulations that support the conservation and sustainable management of agricultural heritage in desert-prone areas.

4.3 Theoretical implications

The framework aligns with the multifunctionality theory, which emphasizes the diverse roles and functions of agricultural systems beyond mere food production (Huylenbroeck *et al.*, 2007). By recognizing the cultural, ecological, economic, social and scientific dimensions of agricultural heritage, the framework provides a comprehensive understanding of its multifaceted nature. This theoretical perspective underscores the importance of considering multiple functions and stakeholders in heritage conservation and management in desert communities over time. This theoretical lens deepens our understanding of how agricultural heritage systems evolve in response to environmental challenges and social dynamics. It underscores the importance of ensuring the sustainability of agricultural heritage systems and adaptive management.

5. Conclusion

This study introduces a novel conceptual framework for understanding Agricultural Heritage Sites (AHS) through the construction of Constituting Elements (CEs) rooted in and multi-functionality of agricultural heritage and sustainability principles. The examination of Siwa Oasis as an Agricultural Heritage Site (SOAHS) applies this framework, revealing cultural, ecological, economic, social and scientific elements. The study highlights crucial role in comprehending AHS dimensions, emphasizing traditional practices, festivals and rituals. Ecologically, Siwa Oasis showcases biodiversity balance, interconnecting traditional and introduced crops with wildlife and scientific research.

The presented conceptual framework advances AHS discourse by unifying element characterization addressing scholarly voids and managing AHS challenges. Future research can refine and expand the framework, validating its applicability across diverse AHS contexts. Investigating dynamic changes in Siwa's agricultural heritage and assessing long-term sustainability, along with comparative analyses in arid regions, will enrich our understanding of diverse agricultural heritage system.

Future research could explore adaptation strategies for agricultural heritage in desert-prone areas, focusing on innovative approaches to mitigate the impacts of climate change, water scarcity. investigating the role of agricultural heritage in building community resilience could provide valuable insights for future research. Future research should also focus on comparative studies across different desert-prone regions to enhance our understanding of agricultural heritage conservation on a global scale.

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