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Heritage or Livelihoods: Risks and Sustainability in Preserving Agricultural Heritage Systems in Desert Areas

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ABSTRACT

This article investigates the pivotal role of farmers' livelihoods in the conservation of agricultural heritage systems. Agricultural heritage systems face endangerment and traditional farming systems expose farmers to various risks, including economic, natural, and environmental risks. Understanding the impact of these risks, including shocks, trends, and seasonality, on farmers in agricultural heritage sites is essential for sustainable livelihoods and heritage development. The study employs explorative qualitative approach, comprising in-depth interviews and Focus Discussions Groups (FDGs) to explore the underlying risks and sustainability issues in Egypt's vital agricultural cultural heritage, the Siwa Oasis. Findings reveal that farmers in Siwa Oasis experience financial strains due to seasonal income fluctuations tied to their agricultural dependency. To address this issue, diversification into tourism during off-peak seasons is emerging as a promising strategy. in addition, the market's unpredictability compels farmers to compromise on date sales, impacting their financial capital. Access to credit remains challenging due to cultural beliefs, affecting cash holdings. The study provides a holistic understanding of the challenges faced by farmers in similar heritage farming communities and offers lessons on risk management and sustainable livelihoods that can be applied across various cultural contexts. The study offers key insights into agricultural heritage systems, aiding academic research and guiding policymakers and practitioners in sustaining these cultural sites.

Introduction

In the arid expanse of hyper-arid desert regions, Siwa Oasis emerges as a focal point where heritage farmers navigate the complexities of their livelihoods amidst environmental challenges. This attention is often propelled by the convergence of agricultural heritage practices with broader policy goals and systemic implementations (Warner, 2010). While ongoing initiatives aim to revitalize the desert agricultural heritage area for shared prosperity, the centrality of farmers' livelihoods is gaining prominence (Ezcurra, 2006; Hobbs, 2017).

Siwa Oasis, located in Egypt, constitutes the focal point of this study, representing a unique case where the agricultural heritage system has been shaped by the local environment and cultural traditions (Tawfik, 2016; Fathy et al., 2022). The primary objective of the article is to delve into the intricate dynamics of farmers' livelihoods within this distinct agricultural heritage. The study comprehensively explores the risks influencing the livelihoods of heritage farmers, spanning the local context of Siwa Oasis and encompassing diverse agricultural heritage settings. A critical aspect addressed is a noticeable research gap, characterized by the lack of thorough examinations of risk mechanisms impacting the interplay between livelihood capital and outcomes within the realm of agricultural heritage. By addressing this gap, the study not only serves as a pivotal case study but also contributes to a broader understanding of sustainable livelihoods in these unique and culturally rich environments.

At the forefront of the sustainable livelihood discourse stands agricultural heritage—a linchpin for natural resource utilization, ecological protection, and rural/desert development. The Food and Agriculture Organization initiated the "Globally Important Agricultural Heritage Systems" (GIAHS) program, emphasizing the priority of food and livelihood security (FAO, 2002). In Egypt, Siwa Oasis stands as a quintessential example of Egypt’s Important Agricultural Cultural Heritage (EIACH), the Siwa Oasis site has earned its place on the list, underlining the protection of its agricultural cultural heritage through international-level recognition criteria, with a keen focus on food and livelihood security (FAO, 2016). However, as socio-economic development unfolds, the protection and inheritance of this heritage face challenges.

Agricultural heritage, despite its vitality, multifunctionality, and sustainability, grapples with endangerment and vulnerability to natural and human-induced factors, such as natural disasters, urbanization, and industrialization (Lerman, 2001; Agnoletti, 2014). Traditional agricultural systems, inherent to agricultural cultural heritage, expose farmers to market and natural risks. Therefore, understanding the impact of risks, including shocks, trends, and seasonality, on farmers in agricultural heritage sites is essential for their

sustainable livelihoods and the heritage's development.

Research endeavors encompass the complex interplay between livelihood assets, and the subsequent outcomes (Amekawa, 2011; Kolawole, Hambira and Gondo, 2023), investigating the influence of livelihood capital on the transformation of livelihood strategies (Alobo Loison, 2015; Makwindi and Ndlovu, 2022), and exploring how livelihood capital and strategies affect decisions related to agricultural cultivation and land use practices (Tang *et al.*, 2013; Wang *et al.*, 2021). The predominant literature has been directed toward examining the influence of tourism development on farmers' livelihoods (Sims, 2009; Khalil and Fathy, 2021; Asham, Kato and Doering, 2022; Elgammal, 2022). However, the incorporation of risks into the analysis of livelihoods has received relatively limited attention. Additionally, there is a recognized need for more comprehensive investigations into the relationship between livelihood capital and its resultant outcomes.

This article concentrates on farmers' sustainable livelihoods, utilizing a sustainable livelihood analysis framework and qualitative analysis. By unraveling the mechanisms through which risks impact farmers' livelihood capital and outcomes, the study aims to identify key livelihood assets influencing livelihood outcomes. The findings are poised not only to offer critical insights and policy recommendations but also to fortify the resilience of farmers and improve livelihood conditions, fostering the sustainable preservation and development of agricultural heritage sites globally.

However, there is limited research or investigation regarding how the concept of sustainable livelihoods applies to farmers in agricultural heritage sites that share similarities with these regions. To address this gap, this article introduces a comprehensive application of the Sustainable Livelihood Framework among heritage farmers, providing a robust mechanism for assessing risks. This framework holds significant relevance in areas characterized by ecological fragility and desert landscapes (Maclean, 2009; Zarafshani et al., 2016).

Sustainable Livelihood Framework (SLF)

Drawing upon the Sustainable Livelihoods Framework (SLF) as a foundational theoretical construct (Scoones, 1998), this research endeavors to construct a nuanced understanding of the intricate dynamics characterizing agricultural heritage sites in Siwa Oasis. The article delves into the multifaceted relationships between various components of the SLF, specifically focusing on risks, livelihood assets, livelihood strategies, and livelihood outcomes.

Within the SLF, risks are acknowledged as pivotal elements influencing vulnerability, necessitating a closer examination of their impact on heritage farmers in agricultural heritage sites (Twigg, 2001). This study, therefore, scrutinizes the risks, probing how they intricately might affect the capitals of farmers within these unique contexts, recognizing their profound implications for the condition and nature of livelihood assets.

Risks, as conceptualized within the SLF, encapsulate a spectrum of uncertainties, including shocks, trends, and seasonality (Adato and Meinzen-Dick, 2002). These

uncertainties expose members of the community to potential losses and encompass various events such as natural disasters, which can result in damages, fluctuating costs, and unpredictable incomes (Hurni et al., 2015; d'Errico, Grazioli and Pietrelli, 2018). Livelihood assets, recognized as fundamental constituents within the SLF, are systematically evaluated, considering five primary categories: natural, physical, financial, human, and social capital (Chambers, 1987). Notably, our study advocates for the inclusion of cultural capital as an indispensable component, particularly pertinent for farmers in agricultural heritage sites given their intrinsic connection to local culture.

Recognizing the need for a tailored approach, the adoption of SLF to the specific environmental and socio-economic conditions prevalent in agricultural heritage sites. This adaptation involves customizing the SLF to align with the unique characteristics of these sites, often located in ecologically fragile areas. In order to empirically unravel these complexities, the article introduces a specialized research framework; this framework serves to delineate the sequential relationships between Risks (RS), Livelihood Assets (LA), and Livelihood Outcomes (LO), providing a comprehensive understanding of the nuanced interactions inherent in these settings (Figure 1).

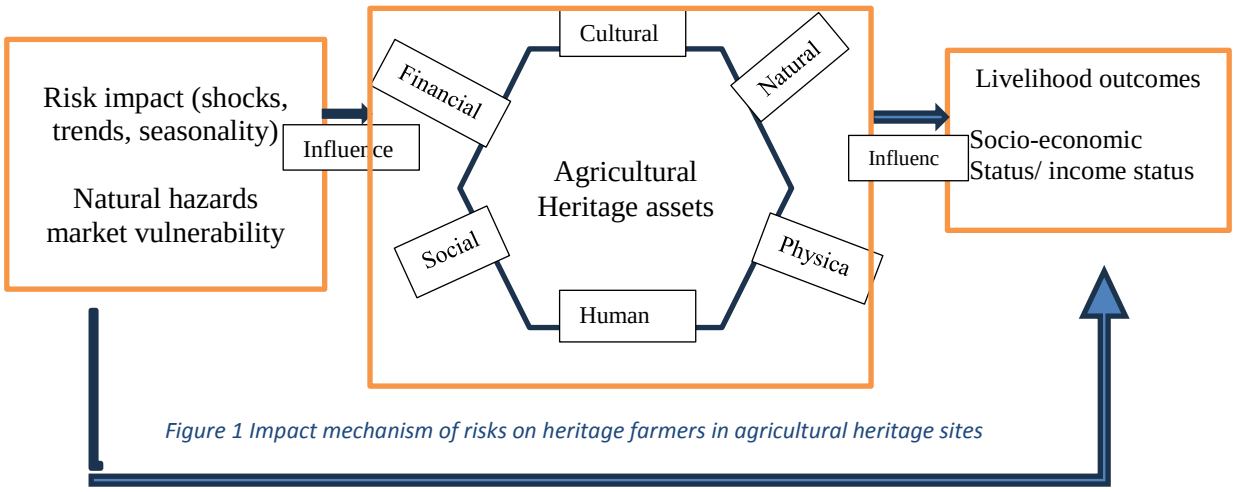

Figure 1 Impact mechanism of risks on heritage farmers in agricultural heritage sites

The framework also investigates and systematically assesses the impact of natural, physical, financial, and social capital on the livelihood outcomes of farmers in agricultural heritage sites. Furthermore, the study conducts a thorough evaluation of risks, offering insights into their specific influence on livelihood outcomes. By delving into these granular analyses, the research aims to contribute significantly to refining the SLF within the context of agricultural heritage sites. Through these examinations, the article offers critical insights that enhance our understanding of the factors influencing the sustainability of livelihoods in these unique and culturally rich environments.

This study employs a methodology of a participatory approach, intricately navigating the agricultural heritage landscape of Siwa Oasis, and delves into the multifaceted relationships of farmers' livelihoods amidst environmental and economic challenges within the Sustainable Livelihood Framework (SLF).

Methodology

Study Area

Siwa Oasis, located in the Western Desert of Egypt, serves as the focal point of this qualitative research. Positioned approximately 300 km south of Matruh Governorate and 365 km from Giza Governorate, it is situated between the Qattara Depression and the Great Sand Sea in the Western Desert (Besler, 2008). With a unique landscape encompassing more than two-thirds of the Egyptian desert, Siwa Oasis stands at a cultural and historical crossroads (Fig.2).

The climatic conditions in Siwa, characterized by high temperatures and minimal rainfall, create a hot desert environment (Abdel Zaher *et al.*, 2018). With an average annual rainfall of 9 mm, the region faces arid conditions conducive to a hot desert climate (Zahran and Willis, 2008). The predominantly sandy soil with varying concentrations of calcium carbonate further characterizes the agricultural landscape, providing good drainage favorable for crops like dates and olives (Salem & Shaltout, 2003).

Affiliated villages, including Ancient Siwa, Aghurmi, Bahy El-Din, El-Maraqi, Abu Shrouf, and El-Qara, each with unique historical significance, contribute to the rich cultural heritage of Siwa (Fig. 3). The villages serve as bastions of traditional knowledge, particularly in the cultivation of dates, and play a pivotal role in preserving the agricultural cultural heritage. El-Qara, designated as part of the Protected Area of Siwa Oasis since 2002, holds a distinctive status within the region (El-Ghani & Monier, 1992).

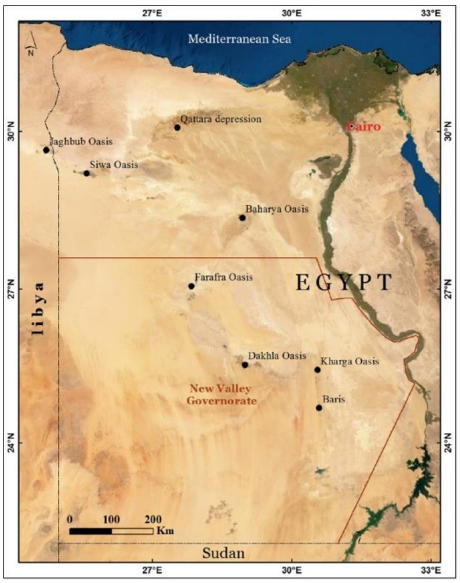

Figure 2 Siwa Geographical Location in Egypt Source: FAO, 2011

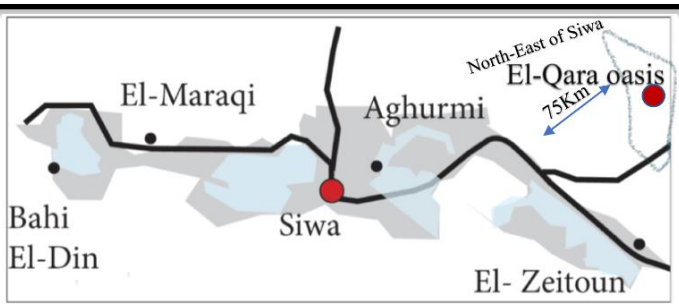

Figure 3 The area studied Villages in Siwa Oasis including El-Qara Oasis, adapted from General Organization for Physical Planning (GOPP, Egypt)

Qualitative Research Approach

This qualitative research employs an exploratory approach to comprehensively examine multifaceted factors influencing risks in heritage farming communities and their subsequent impact on livelihoods. The study engaged participants from diverse sectors, including heritage farmers, government employees, tourism employees, industrial workers, and business owners. The participants were selected through random snowball sampling, enhancing the generalizability of findings (Table 1). Data collection occurred between March and October 2021, employing participatory research methods to actively engage the Siwan community.

Proactive collaboration with key local agencies, institutions, and community leaders was established to build trust, gather local knowledge, and secure necessary permissions. Particularly in a region characterized by political instability, collaboration with governmental representatives from the City Council and the Ministry of Tourism and Antiquities (MoTA) played a pivotal role in facilitating the research process.

Data Collection and Analyses

Participatory research methods, including focus groups and in-depth interviews, were employed to gather comprehensive insights into the agricultural heritage system and livelihood issues (Milena, Dainora and Oradea, 2008; Yin, 2009; Stake, 2011; Stewart and Shamdasani, 2014). Seven Focus Group Discussions (FGDs) were conducted, ensuring representation from each village. In-depth interviews were held with representatives from governmental agencies, NGOs, and educational institutions, fostering diverse perspectives. Furthermore, the societal context of the region revealed specific gender roles and expectations, which posed challenges to the participation of women researchers.

Researchers immersed themselves in the daily lives of participants, conducting participant observations during critical agricultural activities. This approach facilitated a deeper understanding of contextual factors, non-verbal cues, and subtleties that might not be fully captured through interviews alone. Relevant documents, including those from the Food and Agriculture Organization (FAO) and governmental reports, were analyzed, adding a valuable dimension to data triangulation.

Interviews were recorded in Arabic, translated into English, and underwent an open-coding process for key concepts related to risks and livelihoods. Thematic analysis was

applied to recognize recurring themes across interviews, participant observations, and document analysis.

The study acknowledges potential limitations, including researcher bias and the dynamic nature of risks, providing context regarding the study's scope and the generalizability of its conclusions. In embracing this qualitative methodology, the study aimed to unearth nuanced insights into the risks faced by smallholder farmers and the consequent implications for their livelihoods. The iterative and reflexive nature of the approach enriched the depth and authenticity of the findings, enhancing their credibility and relevance for academia and beyond.

Table 1 Demographic Characteristics for the Study Participants

(N = 76)	Frequency
Interview type	
In-depth interview (20)	27
FDG group (7 Focus groups for each 8-10) individuals)	74
Gender	
Male	82
Female	18
Age	
18-25yrs	23
26-30yrs	29
31-45yrs	24
46-60yrs	16
Above 60yrs	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, handicraft)	12

Findings

This section presents the key findings derived from an in-depth exploration of the Siwa Oasis and the challenges faced by its residents. Through thematic analysis, the article uncovers critical themes that revolve around livelihood, market vulnerability, environmental issues, and cultural identity. The following findings shed light on the risks and its complex dynamics that affect the livelihood assets and heritage of the Siwan community (Table 2).

Market Vulnerability and Seasonality

Participants expressed that market vulnerability and natural hazards cast a dark shadow over their livelihoods. The unpredictability of date palm sales income and the looming threat of natural disasters, like severe droughts during planting season, impose significant financial burdens on them (FDG 1). A community leader showed that the income derived from agricultural products serves as a lifeline for heritage farmers as harvesting and selling products (especially dates and olives), provide significant income but are seasonal, typically occurring between October and January (Interview 12, local farmer).

In addition, heritage farmers emphasized facing financial difficulties, especially during the summertime, and they expressed that agriculture is a seasonal occupation deeply rooted in their culture and traditions (FDG 2). A community leader has also mentioned a seasonality calendar that provided insights into the vulnerabilities faced throughout the year such as the harvesting seasons, while the rest of the year farmers might involve different income sources such as trade, factory employment, government positions, and tourism-related industries (interview 13, Community leader).

However, participants showed that the tourism season runs only from September to March, which aligns with milder weather conditions (FDG 2). Recognizing the economic potential of tourism, young people expressed that they have started venturing into this field alongside agriculture to enhance their income (FDG 1). The participants stressed there is a cash income gap during the summer months, and the need for access to income during these times, particularly in relation to cultural practices, which affect their livelihood (FDG 2).

To overcome these challenges, it is crucial to develop strategies such as implementing sustainable farming techniques and providing alternative activities during off-peak seasons, which can help mitigate the constraints posed by seasonality and climate, providing a more stable foundation for livelihoods (Interview 4, government representative).

Financial Capital and Market Volatility

Participants also shared that motivation to engage in cash-generating activities to meet their livelihood needs, they often find themselves compelled to sell their dates at lower prices to traders before the harvesting period, in order to obtain cash during the summer months. Thus, the volatility of the market threatens this vital source of financial capital (FDG 1).

Farmers showed that access to credit is a crucial factor in managing their financial capital. However, they expressed that the reluctance of heritage farmers to rely on formal loans from banks stems from their religious beliefs, which prohibit engaging in usury (*Raba*) (The legal action or practice of lending money at high rates of interest) (FDG 2). Consequently, heritage farmers express that often resort to utilizing their savings and reducing cash holdings, resulting in a rapid decline in their savings and cash income, thereby diminishing their financial capital (FDG 1).

Additionally, the market vulnerability affects the workforce capabilities of farmers. A community leader explained that in the event of income instability resulting from fluctuations in date sales, farmers who have higher levels of education and younger ages show a diminished inclination to participate in production activities. (Interview 12, community leader). The prevailing uncertain market conditions discourage their active involvement, which consequently leads to a decline in the overall skills and expertise among farmers who are closely engaged in date production within the Siwa Oasis (Interview 5, government representative).

> When the income from date sales becomes unstable, the younger farmers are hesitant to invest their time and effort. They seek more stable sources of income, fearing the unpredictability of the market (Interview 12, community leader).

Environmental Challenges: Agricultural Drainage System

Participants highlighted the impact of a troublesome agricultural drainage system, originally designed to support agriculture but now posing a significant challenge. Weak infrastructure and planning contribute to rising water levels and increased soil salinity, jeopardizing agricultural heritage products in Siwa Oasis (FDG 3).

The inadequacy of the drainage system, tracing back to ancient eras, has led to lakes covering approximately 35,000 acres, raising concerns about the oasis being consumed by surging waters (Interview 7, NGO). Efforts to address the issue, including drilling new wells,

proved temporary and created new problems. Proposals for a radical solution, using Tabaghbagh as a drainage outlet, underscore the urgent need for substantial financial resources (Interview 6, NGO; Interview 1, government representative).

Furthermore, inadequate drainage not only affects the historical significance of the land but also directly impacts crop quality, especially for date production. The excess water negatively influences date quality, posing a threat to a staple crop in Siwa Oasis (Interview 5, government representative).

Unplanned Urban Development and Aesthetic Concerns

Participants expressed concerns about unplanned urban development, with new buildings in Siwan villages mismatching the color and harmony of the ancient cultural heritage, diminishing the authentic beauty of the oasis (FDG 4). In addition to that, stakeholders emphasized the importance of authenticity in urban planning, calling for careful regulation of development projects aligned with the oasis's nature and cultural identity (Interview 6, NGO; Interview 10, government representative).

An official representative confirmed that the oasis's urban planning with its authenticity and beauty is crucial; the tourism industry sector is essential to the oasis and is home to several significant hotels that surpass those found in any other oasis or the New Valley region in both quantity and quality (Interview 7, NGO). Furthermore, Siwa has been receiving more than 70.000 tourists each year, which is double the number of its population, the need for urban planning and strong infrastructure is essential for cultural identity, otherwise, Siwa will be like a flower blooming and then diminishes (Interview 10, government representative).

Another state official mentioned that it is worth noting that Siwa Oasis was relatively isolated before the construction of the road connecting it to the main cities, Matrouh and Siwa. This road's opening in the 1990s led to an increase in the tourism industry, particularly at the beginning of the new millennium (Interview 3, government representative).

In addition to that, officials shared several obstacles that Siwa faces in developing the tourism sector, especially limited infrastructure. Siwa Oasis lacks the necessary infrastructure to support tourism initiatives. This includes inadequate transportation systems, insufficient accommodations, and a lack of facilities for hosting agricultural activities, rendering the development of this essential sector a significant hurdle (Interview 6, NGO).

Tourism Trends, External Pressures, and Cultural Impact

While Siwa Oasis faced external pressures, such as the political crisis and the COVID-19 pandemic, participants showcased resilience. Interestingly, participants revealed a remarkable resilience. While there was a minor decrease in revenue for businesses that rely heavily on tourism, such as hotels and other tourism-related establishments, the impact was

relatively small due to Siwa's isolated geographical location (FDG 5; Interview 2, government representative). Diversification emerged as a central strategy to buffer the Siwan community from the decline in tourism. Participants noted that their livelihoods were not significantly dependent on tourism, and they had diversified their income streams to reduce their reliance on this sector (FDG 1).

Furthermore, Participants expressed concerns about the potential negative consequences of tourism expansion, including the commodification of culture, loss of authenticity, and environmental impacts. Traditional ceremonies transformed into staged performances for tourists raised questions about cultural preservation (Interview 10, government representative; Interview 7, NGO).

Participants were also concerned about the introduction of tourism that brought new social dynamics and challenges, including pressure on residents to adapt to tourist preferences. Environmental concerns, such as increased demand for land resources, strained the ecological balance of the oasis, threatening its long-term sustainability (Interview 6, NGO).

Eco-Lodges and Employment Alarms

Participants expressed concerns about the impact of eco-lodges on the local environment, with specific emphasis on the over-exploitation of land resources and the isolation of Siwan people from employment opportunities within these hotels (FDG 6). However, a community leader expressed that the limited training and capacity of local Siwi in hospitality and customer services prevent them from participating in several tourism activities; training programs and capacity-building initiatives are lacking or insufficient in Siwa (Interview 15, Community leader).

Stakeholders also expressed that Eco-lodges, despite marketing themselves as ecological, faced scrutiny for disregarding guidelines, particularly in hiring non-local staff. Skepticism regarding collaboration with international organizations for Siwan development added another layer of concern (Interview 8, government official; FDG 5).

Population Growth and Salt Mining Exploitation

Participants shared that Population growth, driven by migration and investment, emerged as a challenge affecting heritage farmers. Increased competition for land and resources limits access to income-generating activities, leading to income inequality between investors and local farmers using traditional methods (FDG 7). An official expressed that the migration of young people to Siwa Oasis from different parts of Egypt for investment led to population growth. The whole population in Siwa is now about 36,000. The indigenous population is 31,400 thousand; the rest are immigrants, including about 2,000 government employees and 2,400 investors with their families (Interview 10, An educational institutional representative).

Another participant mentioned that the increase in population has affected their

traditional farming techniques, and organic production methods, and indigenous knowledge is being marginalized or neglected in favor of more commercially-driven approaches. This not only threatens the preservation of the unique agricultural heritage of Siwa Oasis but also undermines the sustainability and resilience of the farming heritage system (Interview 7, NGO).

Furthermore, a community leader added that population growth has created challenges for heritage farmers as expressed in terms of livelihood opportunities; the competition for land and resources among the growing population has made it more difficult for traditional farmers to sustain their practices and earn a decent income (Interview 16, Community leader). One participant revealed that the influx of investors and large-scale farming operations limit access to income-generating activities, leading to income inequality between investors and local farmers who use the traditional method (Interview 17, Local farmer).

Furthermore, the growing exploitation of salt mines from Siwan Lakes raised concerns about its impact on the oasis's ecological and cultural integrity. Excessive pumping activities led to a decline in water levels, negatively affecting ancient farmlands and disrupting traditional farming practices (Interview 18, local farmer; Interview 7, NGO).

Participants noted a visible impact on agricultural lands near salt lakes, with palm trees and olives showing signs of dryness due to increased salinity. The images vividly depicted the strain on the land and the potential loss of agricultural heritage (Interview 3, government representative). In addition, the big trolley of transportation salt to another region of Egypt affected the entrance road of the oasis, as a large quantity of slats fell on the ground making the road winding (Interview 7, NGO).

> If one were to capture images of the agricultural lands situated near the salt lakes, a noticeable effect would be evident. The palm trees and olives in particular exhibit signs of dryness, which can be attributed to the increased salinity of the water. The elevated salinity levels exert pressure on the land and the trees, adversely impacting the original heritage represented by these palm and olive trees (Interview 7, NGO).

Discussion and Implications

This section embarks on an in-depth analysis of the study's findings, dissecting their profound implications for heritage farmers in Siwa Oasis guided by the Sustainable Development Framework (SLF). It explores the intricate relationship between diverse risks, livelihood capitals and their impact on livelihood outcomes, and the overall impact of risks on livelihood assets and outcomes.

Additionally, it investigates the Oasis's extraordinary resilience in the face of external disruptions, such as political unrest and pandemics, and how demographic shifts shape its cultural heritage and livelihoods. Furthermore, it addresses the threats posed by urbanization,

burgeoning tourism, and private sector involvement.

The Impact of Risks on Livelihood Capitals in Siwa Oasis

The analysis focused on the impact of risk shocks, seasonality, and trends on of various capital types (Table 2).

The Impact of Risks on Financial Capital

The financial capital of heritage farmers in Siwa Oasis is subject to several influential factors. Market fluctuations, drought, and seasonality all play significant roles in determining their financial well-being. The income derived from date palm sales, a primary income source, remains uncertain, and the potential risks associated with severe droughts during planting season add to the financial burdens faced by these farmers. This situation is particularly challenging in arid environments and has substantial effects on the sustainable livelihoods of heritage farmers (Daoud et al., 2016; Jiri et al., 2016; Mavhura et al., 2015). The unpredictability of income sources, such as date palm sales, makes financial planning a complex endeavor for these farmers, especially in the majority of sub-Saharan African regions (Corluka, 2019;Kotir, 2011).

Cultural Beliefs and their Impact on Financial Capital

Heritage farmers in Siwa Oasis predominantly rely on informal loans, often bypassing formal banking institutions due to cultural and religious beliefs prohibiting engagement in usury (Obaidullah and Khan, 2008). This practice aligns with research in Muslim-majority countries, where cultural and religious norms significantly shape financial practices and access to credit (Kabir Hassan, Hossain and Unsal, 2018). As a result, farmers frequently resort to utilizing their savings, leading to a rapid depletion of financial capital.

The Influence of Market Risk on Human Capital

Market risk significantly impacts the human capital of farmers, reducing the inclination of those with higher education and younger ages to engage in production activities during periods of income instability. This reduced engagement in production activities affects the region's labor force, which can have broader socio-economic implications. A study conducted by S. Liu et al. (2017) supported these findings, demonstrating that the profitability of low production factors has weakened the labor force and capital within agricultural heritage systems, thereby affecting the human capital of the Global Important Agricultural Heritage Systems of the Rice-Fish System in China (Liu et al., 2017).

Agricultural Drainage Risks and their Impact on Natural Capital

The inadequate drainage system has resulted in rising water levels and increased soil salinity, posing risks to the agricultural heritage of olive and palm trees in the region (Misak, Abdel Baki and El-Hakim, 1997; Samy, 2010; Hedia, 2015; Hussein, 2021). In Siwa Oasis, the situation is unique due to an excess of water resulting from inadequate drainage. Furthermore, Siwa benefits from a year-round water supply for irrigation through spring water, ensuring an abundance of water resources ((Ramdani and Flower, 2010). This is in stark contrast to many other agricultural heritage desert regions that often contend with water scarcity challenges. For example, the Xuanhua Grape Garden, an Agricultural Heritage Site in China, grapples with water scarcity, leading to relatively barren land due to insufficient water availability (Koohafkan and Altieri, 2016).

The Impact of Various Risks on Cultural Capital

Unplanned urban development poses challenges to preserving the cultural identity of Siwa Oasis and attracting tourists (Asham et al., 2022; Nofal, 2011; Rovero et al., 2009). Effective planning and infrastructure development are essential to maintain the authentic cultural identity of the region and to support its economic growth through tourism.

In addition to that, the growth of tourism and the commercialization of cultural practices can compromise the unique cultural heritage of Siwa Oasis. This issue aligns with findings from various studies. For instance, the Ifugao Terraced landscapes in the Philippines have suffered destruction due to the engagement of many farmers in tourism activities, leading them to abandon their agricultural terraces (Bantayan et al., 2012; Calderon, Bantayan and Dizon, 2015). Similarly, a similar phenomenon has been observed in the Hani Terraces of Yunnan Province, China, where rice cultivation is being replaced by the cultivation of dry crops due to the lower cost of tourism associated with it. This change poses a threat to the Hani rice-terraced landscapes and the rice-based cultures (Zhang et al., 2017).

The influence of Eco-Lodges on Natural and Human Capital

The findings uncovered that the excessive utilization of land resources by corporate entities operating eco-lodges poses a risk to both the environment and the community's well-being. The community's human capital is jeopardized by the influx of external employment, which is argued to hinder local capacity building. Nonetheless, various studies have championed the presence of eco-hotels in the region, particularly emphasizing their architectural merits (Class and Local, 2007; Maher, Mohamed and Al-Mandra, 2021; Fathy et al., 2022).

The Influence of Livelihood Capital on Livelihood Outcomes

The findings shed light on the influence of different livelihood capitals on the livelihood outcomes of heritage farmers in Siwa Oasis. (Table 3).

Financial capital emerged as a crucial factor with a significant impact on livelihood outcomes among heritage farmers. The availability of savings, income from lending, and social exchange contributed to increased funds for income improvement through financial capital (Souryai, 2011). Natural risks, such as losses caused by natural disasters during agricultural production, were found to have long-lasting consequences on livelihood outcomes (Caruso, 2017).

Market fluctuations, on the other hand, directly influenced farmers' income, highlighting the vulnerability of heritage farmers to market volatility (O'Brien and Leichenko, 2007). These findings indicate the differential effects of market and natural risks on livelihood outcomes and suggest the need for targeted interventions to address these challenges. As well as, Physical capital, including factors such as agricultural drainage, played a significant role in shaping livelihood outcomes among heritage farmers (Hussein, 2021). Improved production quality and access to necessary resources were identified as crucial elements for income improvement. In addition to that, social capital, characterized by larger social networks and active participation in social organizations, facilitated access to support for income enhancement (Casson and Della Giusta, 2007).

In contrast, the impact of human capital and cultural capital on livelihood outcomes was relatively weak. Factors such as lower levels of education limited the influence of human capital, while the underutilization of cultural resources failed to yield significant benefits for income improvement (Liu *et al.*, 2018). These findings suggest the need for targeted interventions to enhance human and cultural capital among heritage farmers. Understanding the strengths and limitations of different livelihood capitals is crucial for policymakers and stakeholders in developing effective strategies to enhance livelihood outcomes among heritage farmers in Siwa Oasis. Addressing constraints related to financial capital, physical capital, social capital, and natural capital can contribute to positive changes in livelihood outcomes. Targeted interventions that promote financial inclusion, improve infrastructure, foster social networks, and utilize natural resources sustainably can support the livelihoods of heritage farmers and contribute to the overall development of the region.

Resilience to External Factors

Siwa Oasis has demonstrated remarkable resilience to external factors, notably the Egyptian Revolution in 2011 and the COVID-19 pandemic, in contrast to other Egyptian regions. This resilience, as indicated by the study's findings, is primarily attributed to the geographic isolation of Siwa Oasis and the proactive approach adopted by the community to diversify income sources, reducing their dependence on tourism as the primary revenue stream (Medhat and Kassas, 2020). The study's findings are further corroborated by research

conducted by Khalil and Fathy (2021), which underscores the potential for agri-tourism recovery within agricultural heritage sites during crises, given tourists' increasing preference for natural, less crowded, and eco-friendly destinations (Khalil and Fathy, 2021). These unique circumstances set Siwa Oasis apart, highlighting the varying impact of external factors on its tourism sector and livelihood outcomes compared to other parts of Egypt.

Population Growth and Demographic Trends

The study's findings underscore the uniqueness of Siwa Oasis in terms of population growth, primarily driven by immigration and investment, setting it apart from the conventional trends observed in many other agricultural heritage sites (Ayad & Shujun, 2013). In contrast to the prevailing outmigration observed in other heritage sites globally, Siwa Oasis presents a unique demographic pattern (Bodegom & Van Schoubroeck, 2007). The influx of people to Siwa Oasis has implications for the preservation of cultural heritage and livelihood outcomes in the region. Furthermore, the findings highlight the detrimental effects of excessive salt mining by investors on Siwan Lakes, impacting the agricultural heritage system (Hussein & Mohamed, 2021). The over-extraction of salt has led to a decline in water levels, adversely affecting the ancient farmlands nearby that rely on water for irrigation. This decline in water availability has resulted in reduced productivity, and decreased crop yields, and poses a potential threat to the agricultural heritage. Moreover, the transportation of salt to other regions has impacted the entrance road of the oasis, creating challenges for physical capital and infrastructure.

Implications and Policy Recommendations

The study underscores the necessity for policies aimed at improving drought resilience, market stability, and financial inclusivity, while respecting cultural and religious contexts. Policies should focus on stabilizing income sources, enhancing infrastructure, and supporting community-based networks.

Sustainable Tourism Management

Balancing tourism growth with the preservation of cultural and environmental heritage is crucial. Effective tourism management strategies should prioritize sustainable practices that protect and promote the unique cultural identity and natural resources of the region.

Community Empowerment

The findings highlight the importance of strengthening community-based support networks and adaptive strategies to enhance resilience against external shocks. Empowering local communities is vital for sustaining livelihoods and preserving heritage in agricultural regions like Siwa Oasis.

Practical Applications

Practitioners can use the study's insights to design and implement sustainable practices that support the well-being of heritage farming communities. Integrating traditional agricultural practices with modern sustainable development initiatives is essential for the long-term sustainability of these regions.

Academic Contributions

This research expands the Sustainable Livelihood Framework (SLF) to include unique elements pertinent to desert agricultural heritage sites. It provides a foundation for further academic inquiry into sustainable livelihoods, contributing to heritage studies, sustainable tourism, and agricultural development.

These implications collectively aim to foster the long-term sustainability and prosperity of heritage farming communities in unique settings like Siwa Oasis, promoting inclusive and resilient development.

Table 2 The Impact of Risks on Livelihood Assets

Risk Categories	Livelihood Assets
Market Vulnerability	Financial Capital
Natural Hazards (e.g., droughts)	Natural Capital (Agricultural Heritage Products), Financial Capital
Seasonality of Agriculture	Human Capital, Financial Capital
Financial Difficulties	Financial Capital
Reluctance to Formal Loans	Financial Capital
Agricultural Drainage Crisis	Natural Capital
Unplanned Urban Development	Cultural Capital
Tourism Growth	Social Capital
Overpopulation and Resource Exploitation	Natural Capital (Traditional Farming Techniques, Organic Production Methods), Human Capital
Salt Mining Impact	Natural Capital

Table 3 The Influence of Livelihood Capital on Livelihood Outcomes

Livelihood Capitals/Resources	livelihood Outcomes
Financial Capital: Economic uncertainty	Creating income insecurity and limiting the ability to invest in livelihood improvements.
Physical Capital: Inadequate infrastructure	Limiting agricultural productivity, which impacts income and livelihood instability
Human Capital: Limited education and skills	Limiting opportunities for economic advancement and financial security
Social Capital: Larger social networks and community support	Enhanced livelihood outcomes through increased social support and collaboration,
Cultural Capital: Neglecting cultural resources and traditions	Loss of cultural value, authenticity, identity, and heritage preservation.

Conclusions

This article examines the complex challenges faced by heritage farmers in Siwa Oasis, focusing on their sustainable livelihoods. Guided by the Sustainable Livelihood Framework (SLF), the study reveals that heritage farmers face significant risks that threaten their cultural heritage and economic stability. It highlights the impact of risks such as market volatility, financial strain, and seasonality on these farmers, emphasizing the need for income diversification to enhance financial resilience.

Key findings include the critical role of agricultural income, the necessity for innovative financial solutions respecting cultural beliefs, and strategies to mitigate the adverse effects of urbanization and tourism. The research underscores the importance of preserving traditional knowledge and practices, contributing valuable insights to agricultural heritage literature.

Understanding these challenges is crucial for preserving cultural and agricultural heritage in a changing world.

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