frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 05 March 2026
DOI 10.3389/fsufs.2026.1764633

OPEN ACCESS

EDITED BY
Xin Wang,
Longyan University, China

REVIEWED BY
Enock Siankwilimba,
University of Zambia, Zambia
Helena Juliani Purba,
National Research and Innovation Agency (BRIN), Indonesia
Dwi Ratna Hidayati,
Trunojoyo University, Indonesia

*CORRESPONDENCE
Wenjun Jiao
jiaowj@igsnrr.ac.cn

RECEIVED 10 December 2025
REVISED 15 February 2026
ACCEPTED 17 February 2026
PUBLISHED 05 March 2026

CITATION
Li Y, Jiao W and Min Q (2026) Value-adding pathways for agricultural products in Globally Important Agricultural Heritage Systems: evidence from the Qingtian Rice-Fish Culture System, China.
Front. Sustain. Food Syst. 10:1764633.
doi: 10.3389/fsufs.2026.1764633

Value-adding pathways for agricultural products in Globally Important Agricultural Heritage Systems: evidence from the Qingtian Rice-Fish Culture System, China

Yuwei Li[1,2], Wenjun Jiao[1]* and Qingwen Min[1,2]

[1]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China, [2]College of Resources and Environment, University of Chinese Academy of Sciences, Beijing, China

Introduction: The development of ecologically and culturally significant agricultural products offers promising solutions for enhancing agricultural system sustainability and supporting traditional agricultural landscapes. This study focuses on agricultural products derived from Globally Important Agricultural Heritage Systems (GIAHS), aiming to explore effective value-adding strategies that align with both food quality and sustainability goals.
Methods: This study proposes a conceptual framework rooted in value chain theory to establish value-adding pathways from production to consumption. The framework is applied to the Qingtian Rice-Fish Culture System (QRFCS), a designated GIAHS site in China, through qualitative analysis of semi-structured interviews, with secondary data used for triangulation and supplementation.
Results: The results indicate that promising value-adding measures lie in the development of eco-agriculture and product certification at the production stage, primary processing at the processing stage, and packaging, labelling, and both online and offline marketing at the marketing stage. These measures are linked through defined pathways and supported by an actor interaction model that facilitates coordination among actors and enhances implementation efficiency.
Discussion: This study provides practical insights into how traditional agricultural systems can be integrated into modern markets while maintaining and leveraging their ecological and cultural significance.

KEYWORDS
dynamic conservation, Globally Important Agricultural Heritage Systems (GIAHS), Qingtian Rice-Fish Culture System (QRFCS), value chain, value-adding measures

1 Introduction

Modern agricultural systems are increasingly challenged by environmental degradation, rising production costs, and shifting consumer demands for quality and sustainability. While industrial agriculture has contributed to global food production, it often results in environmental pollution, biodiversity loss, and reduced food diversity (Rana et al., 2010; Acheampong et al., 2022). In contrast, traditional agricultural systems, representing long established examples of successful community-based local agriculture, provide time-tested wisdom to tackle sustainability issues in

agriculture today and in the future (Koohafkan and DelaCruz, 2011; Jiao et al., 2024). Among these traditional systems, the Globally Important Agricultural Heritage Systems (GIAHS), initiated by the Food and Agriculture Organization (FAO) in 2002, stand out as unique models of sustainable agriculture. These systems are defined as remarkable land use systems and landscapes rich in globally significant biological diversity, which have evolved through the co-adaptation between rural communities, their surrounding environment, and their needs and aspirations for sustainable development (FAO, 2022). As of December 2025, 104 traditional agricultural systems have been designated as GIAHS by FAO, distributed in 30 countries and regions around the globe.

GIAHS represent the successful way of human adaptation to and transformation of natural environments, having the ability to dynamically evolve in response to ongoing changes in social-ecological conditions (Fuller et al., 2015; Yotsumoto and Vafadari, 2021). Characterized as complex adaptive systems, GIAHS are not only capable of producing food (Nahuelhual et al., 2014; Yang et al., 2021) and conserving biodiversity (Ren et al., 2018; Vasilescu et al., 2023), along with other ecosystem services (Xie et al., 2011; Wang et al., 2023), but they can also preserve cultural heritages and their centuries-old wisdom (Piras et al., 2022; Caviedes et al., 2024). Therefore, they are considered closely related to the pillars of sustainability - environment, economic, and social, and able to play a critical role in the achievement of the UN Sustainable Development Goals. However, GIAHS conservation is confronted with many challenges in a modern society, such as population migration (Prus et al., 2022), farmland abandonment (Zhang et al., 2017b; Cucchiaro et al., 2020), environmental pollution (Xu et al., 2020), and loss of traditional culture (Reyes et al., 2020; Zhang et al., 2023). In such a context, GIAHS conservation must be conducted in a dynamic way that local farmers benefit from the continuance of traditional agriculture while heritage sites achieving development under the premise of ecological and cultural conservation (Jiao and Min, 2017; Yotsumoto and Vafadari, 2021).

In response to these challenges, a series of dynamic conservation approaches have been put forward for GIAHS, such as payment for ecosystem services (Liu et al., 2019), value adding of agricultural products (Jiao and Min, 2017; Min and Zhang, 2020), sustainable tourism (Song et al., 2022), and industrial integration (Zhang and He, 2021). Among these approaches, the development of agricultural products with ecologically and culturally added values represents a critical one as it directly links heritage conservation with the livelihood of local farmers and the development of heritage sites. However, the existing literature often treats the value-adding strategy as a general recommendation without specifying actionable pathways or operational models (Yotsumoto and Vafadari, 2021; Plaiphum and Tansuchat, 2023). Although some studies have focused on incentivizing organic or green production through compensation mechanisms (Zhang et al., 2017a; Liu et al., 2019, 2020), there remains a notable research gap regarding how the unique ecological and cultural attributes of GIAHS agricultural products can be systematically translated into added value across the entire value chain to tangibly enhance farmer livelihoods and support heritage site development.

This study addresses this research gap by systematically identifying and analyzing value-adding pathways across the entire agricultural value chain in GIAHS contexts. First, we propose a conceptual framework that systematically links the distinctive features of GIAHS agricultural products to actionable value-adding measures along the value chain, demonstrating how these intrinsic attributes can be translated into tangible, consumer-recognized value. The framework is then applied to a representative and well-documented GIAHS, the Qingtian Rice-Fish Culture System (QRFCS), serving both as a validation of the framework and as a source of empirical evidence for pathway implementation. Theoretically, the framework advances understanding by integrating the full value chain into GIAHS analysis and distinguishing between different forms of consumer-perceived value. Practically, it offers evidence-based guidance for designing locally adapted value-adding strategies, showing how traditional agricultural systems can be sustainably integrated into modern markets while preserving and leveraging their unique heritage significance.

2 Methodology

2.1 Theoretical foundations

2.1.1 Agricultural value adding and value chain

The concept of agricultural value adding has evolved from a narrow focus on physical processing (Coltrain et al., 2000; USDA, 2002) to encompass a broader range of strategies that enhance both physical and non-visible attributes (Trienekens, 2011). These include product segregation (e.g., through certification and traceability) and the enhancement of intangible qualities such as ecological benefits and cultural connotation (FAO, 2014; Lu and Dudensing, 2015). Building on this, agricultural value adding can be understood as the process through which producers employ measures across the value chain to enhance product attributes, thereby increasing consumer willingness to pay.

Correspondingly, the attributes of agricultural products can be divided into two categories: physical attributes, such as color, taste, and freshness, and non-visible attributes, such as organic production, cultural connotation and fair trade (Trienekens, 2011). According to the two categories, we identify two core sources of added value based on product attributes. One is physical value, derived from physical attributes that consumers can directly experience; the other is perceived value, which encompasses the inherent meaning and significance that consumers cannot directly observe. The enhancement of these two value dimensions forms the foundation for identifying specific value-adding pathways for agricultural products.

Rooted in value chain theory (Porter, 1985; Dizyee et al., 2017; Muflikh et al., 2021), agricultural value chain refers to a system of all activities and actors associated with the production, processing, and marketing of agricultural products (Miller and Jones, 2010). Serving as an analytical tool, it provides essential concepts and measures for analyzing agricultural industry upgrading, the value adding of agricultural products, and the interests of various actors (Jovania Pereira et al., 2025; Ma and Sexton, 2021; Rich et al., 2011).

From a value-adding perspective, agricultural value chain directs attention to three core analytical dimensions. (1) The design and implementation of value-adding measures at each stage (Argyropoulos et al., 2013; Dong, 2021). Various effective measures for the value adding have been identified in research and practice, including improving quality and uniqueness (Hernandez-Aguilera et al., 2018; Schulze-Ehlers and Anders, 2018; Kaushik et al., 2021), certifying (Bullock et al., 2018; Bairagi et al., 2021; Bartoli et al., 2022), deep and fine processing (Bairagi et al., 2021; Clark et al., 2021; Sani et al., 2023), labelling and packaging (Melović et al., 2020), offline and online marketing strategies (Griffith and Watson, 2016; Bartoli et al., 2022), and agro-tourism (Tarolli et al., 2023). (2) The systemic connection between value-adding stages and corresponding measures (Vroegindewey and Hodbod, 2018; Fusacchia et al., 2022; FAO and UNIDO, 2024). These measures are interrelated with each other and significant exchanges of

resources, products, capital, and information occur between them (Vroegindewey and Hodbod, 2018; Fusacchia et al., 2022; FAO and UNIDO, 2024). (3) The mechanisms of cooperation and benefit distribution among actors (Gómez et al., 2011; Andriesse, 2018; Ma and Sexton, 2021). This structured approach makes the agricultural value chain an essential lens for operationalizing and analyzing specific value-adding pathways.

2.1.2 Features of GIAHS agricultural products

According to FAO designation criteria, GIAHS must comprehensively fulfill five key principles: food and livelihood security; agro-biodiversity; local and traditional knowledge systems; cultures, value systems, and social organizations; and landscapes and seascapes features (FAO, 2017). Building on these principles, agricultural products from GIAHS typically exhibit three core features, including excellent physical attributes, significant ecological benefits, and rich cultural connotation.

Excellent physical attributes arise from unique geographical environments, where local farmers have selected numerous traditional varieties through long-term production practices (Nahuelhual et al., 2014). These varieties exhibit superior physical attributes, excelling in taste, color, and nutrition (He et al., 2023). These attributes are further reinforced by traditional eco-agricultural practices that create a favorable environment for the production of high-quality agricultural products and the enhancement of their physical attributes (Agnoletti and Santoro, 2022; Jiao et al., 2016; Zhang et al., 2023). Significant ecological benefits are generated through the continued application of traditional knowledge and adaptive techniques, which simultaneously support agricultural production and ecosystem functions, including soil and water conservation, climate regulation, biodiversity conservation, and reduced carbon emissions (Shen et al., 2021; Li et al., 2023; Tarolli et al., 2023; Jiao et al., 2024). For rich cultural connotation, GIAHS agricultural products are closely associated with local customs, artistic expressions, and religious beliefs (Reyes et al., 2020; Jiang and Zhang, 2023). Moreover, agricultural landscapes shaped by human-nature interactions serve as important carriers of farming culture (Zhang et al., 2017b).

These three features of agricultural products derived from GIAHS constitute the fundamental basis for designing value-adding pathways. The excellent physical attributes lay a solid foundation for enhancing their physical values while the ecological benefits and cultural connotation serve as an important basis for enhancing their perceived values. Therefore, the key content of value adding for GIAHS agricultural products involves fully leveraging these advantageous features to enhance their physical and perceived values through a series of measures, thereby increasing the willingness of consumers to purchase and to pay higher prices.

However, a key challenge persists: consumers often do not fully recognize the features and values of GIAHS agricultural products, reflecting a persistent information asymmetry between producers and consumers. For example, Liu et al. (2019) demonstrated that ecological compensation can support local farmers in continuing traditional, eco-friendly agricultural practices, but consumers remain unaware of the ecological benefits embedded in GIAHS agricultural products. Therefore, there is a pressing need to establish effective value-adding pathways that systematically connect production with consumption, transforming the advantageous features of GIAHS agricultural products into values that can be recognized by consumers.

2.2 Conceptual framework

Building on the theoretical foundations outlined above, we develop a conceptual framework for establishing value-adding pathways from production to consumption, covering the entire value chain to ensure that value could be added at every stage (Figure 1).

2.2.1 Value-adding measures at each stage

The value-adding pathways of GIAHS agricultural products can be divided into three key stages: production, processing, and marketing, each of which involves different measures.

The production stage mainly involves three interrelated measures: eco-agricultural production, grading, and certification. Eco-agricultural production strengthens the physical attributes of products while sustaining the ecological benefits generated by traditional practices. Grading products according to physical attributes facilitates differentiation in selling channels and pricing, emphasizing

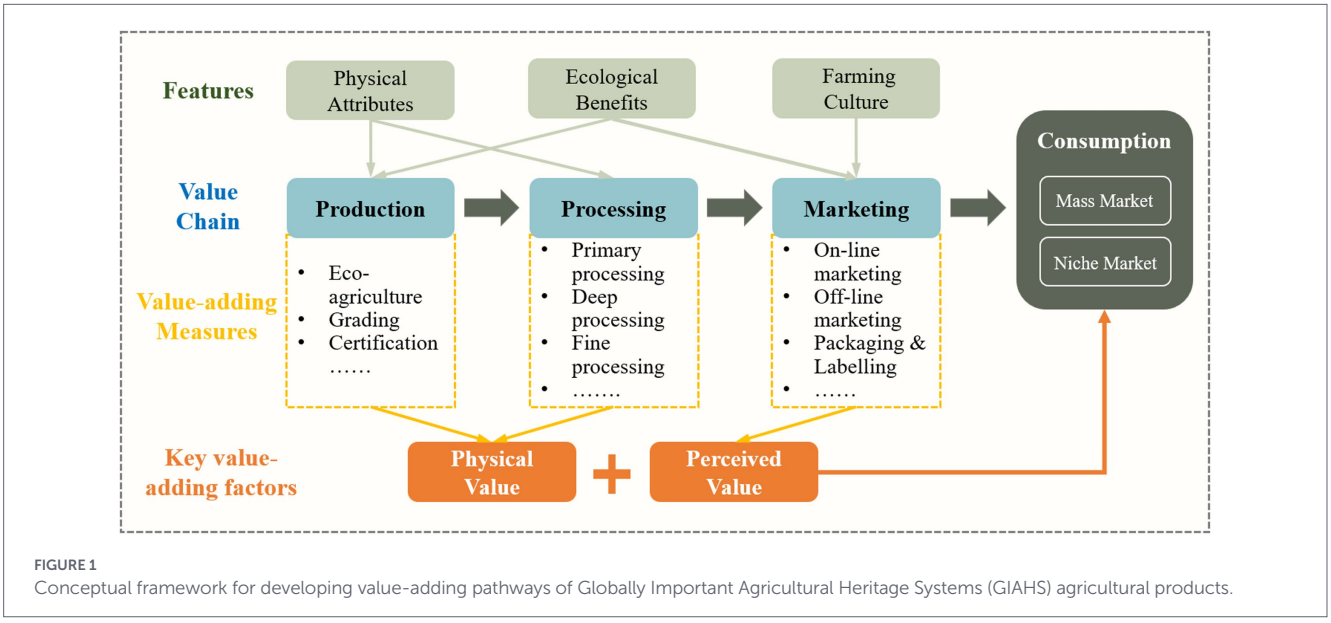

FIGURE 1
Conceptual framework for developing value-adding pathways of Globally Important Agricultural Heritage Systems (GIAHS) agricultural products.

consumer-valued features such as size, sweetness, or aroma. Certification as organic, low-carbon, or GI products reinforces both physical and perceived values, as it typically enforces stricter standards for production practices, origin environment, and product quality.

During the processing stage, agricultural products undergo three types of processing to further enhance their values. The first is primary processing, which involves sorting, washing, drying and other basic handling steps to make products suitable for storage, transport, or direct consumption. During these steps, the physical attributes of agricultural products may be partially altered, however, their appearance remains mostly unchanged and their nutrition is minimally affected. The second is deep processing, which entails more complex handling that often alters the product's form, texture, and nutrition, creating more significant value-adding potential. The third is fine processing, which applies more intricate and precise treatments to produce high-quality products with unique flavors or functionalities. The highly refined products target specific market demands and premium consumer groups, thereby offering the greatest value-adding potential.

The marketing stage is critical for conveying the ecological and cultural significance of agricultural products to consumers, therefore further enhancing the perceived value of agricultural products. One approach is online marketing, which utilizes channels such as the internet and television to highlight the ecological and cultural significance of agricultural products. Another is offline marketing, such as participating in agricultural product exhibitions and establishing physical stores. Notably, integrating agricultural product sales into the tourism experience has become an increasingly important means of value adding. Moreover, labeling and packaging play an important role in enhancing consumers' perception of the values of certified agricultural products. Since the production of high-quality agricultural products (e.g., organic food), may not always be directly represented by their physical attributes, displaying certification logos on packaging can effectively communicate such information to consumers.

2.2.2 Systemic linkages and flows between stages

From a horizontal perspective, the value is accumulated along the value chain by establishing linkages between these stages, maximizing the value-adding effect. All value-adding measures are ultimately oriented toward consumption, with the goal of enhancing consumers' recognition of GIAHS agricultural products and increasing their willingness to purchase at higher prices. For GIAHS agricultural products, the consumption market is broadly distinguished into mass markets and niche markets, based on differences in production scale, market scope, and consumer expectations. Mass markets mainly refer to conventional consumption channels, including local daily consumers, wholesale distribution, and supermarkets, where demand is relatively stable and products entering these markets are typically standardized and rely primarily on physical value adding. In contrast, niche markets target more specific consumer groups, such as tourists and consumers with a strong preference for ecological and cultural significance, and place greater emphasis on perceived value adding. Clarifying target markets is essential for maximizing value adding effect. Aligning value-adding measures with the expectations of specific target markets helps avoid mismatches between investment costs and market returns, thereby improving the effectiveness of value adding of GIAHS products.

From a vertical perspective, the framework transforms the features of GIAHS products into physical and perceived values that can be recognized by consumers, thereby guiding the design and implementation of targeted value-adding measures. From Figure 1, it is clear that the excellent physical attributes and ecological benefits of GIAHS products can be transformed into physical value through measures at the production and processing stages. Similarly, ecological benefits and cultural connotation can be conveyed to consumers as perceived value through appropriate measures at the marketing stage.

2.2.3 Actors within the value-adding pathways

From an actor perspective, value-adding pathways can be viewed as networks of linkages formed through cooperation among different types of actors. The implementation of these pathways involves multiple actors, including farmers (producers), processors, wholesalers, retailers, as well as intermediaries, transporters, and traders who facilitate the movement of products throughout the value chain. In addition, governments, non-governmental organizations, and research institutions often play important guiding and supporting roles.

Interactions among these actors can be broadly categorized into horizontal and vertical linkages. Horizontal linkages occur among actors operating at the same stage and aim to promote cooperation in addressing shared constraints and to benefit from economies of scale. For farmers, cooperative organizations and industry associations represent important institutional arrangements for strengthening horizontal coordination and collective action. Vertical linkages, in contrast, connect actors across different stages and focus on coordinating activities related to production, processing, and marketing. Compared with horizontal linkages, vertical linkages often require stronger coordinating actors and are typically led by enterprises or facilitated through government guidance and support. The effective implementation of value-adding pathways depends on the coordinated functioning of both horizontal and vertical linkages. It is important to note that the establishment of actor linkages needs to be accompanied by appropriate benefit distribution mechanisms. Ensuring that farmers' interests are protected, and enabling farmers to participate in a wider range of value-adding stages, are key to building inclusive and sustainable value-adding pathways.

2.3 Study area

Qingtian County is located in the southeastern mountainous region of Zhejiang Province, China, covering an area of 2,493 km^2, of which 90% is mountainous terrain, and only 5% is arable land. The region is situated in a subtropical monsoon climate zone, with an annual precipitation of 1,739.8 mm and an average annual temperature of 19 °C. In this topography and climate conditions, local farmers have developed a production model known as the rice-fish culture, which involves cultivating rice while raising fish in terraced paddies. This model has a history of over 1,300 years. In 2005, QRFCS was designated by FAO as one of the world's first GIAHS. Fangshan Township, located in the southeastern part of the county, is defined as the heritage site, with Longxian Village as the core area (Figure 2).

Rice and fish are specialty agricultural products of the heritage site. In 2024, the rice-fish culture paddy fields in Fangshan Township reached approximately 237.3 hectares, involving a total of 1,197 farmers, with an average per capita income of 7,842 yuan from rice-fish culture production. Within this township, Longxian Village accounted

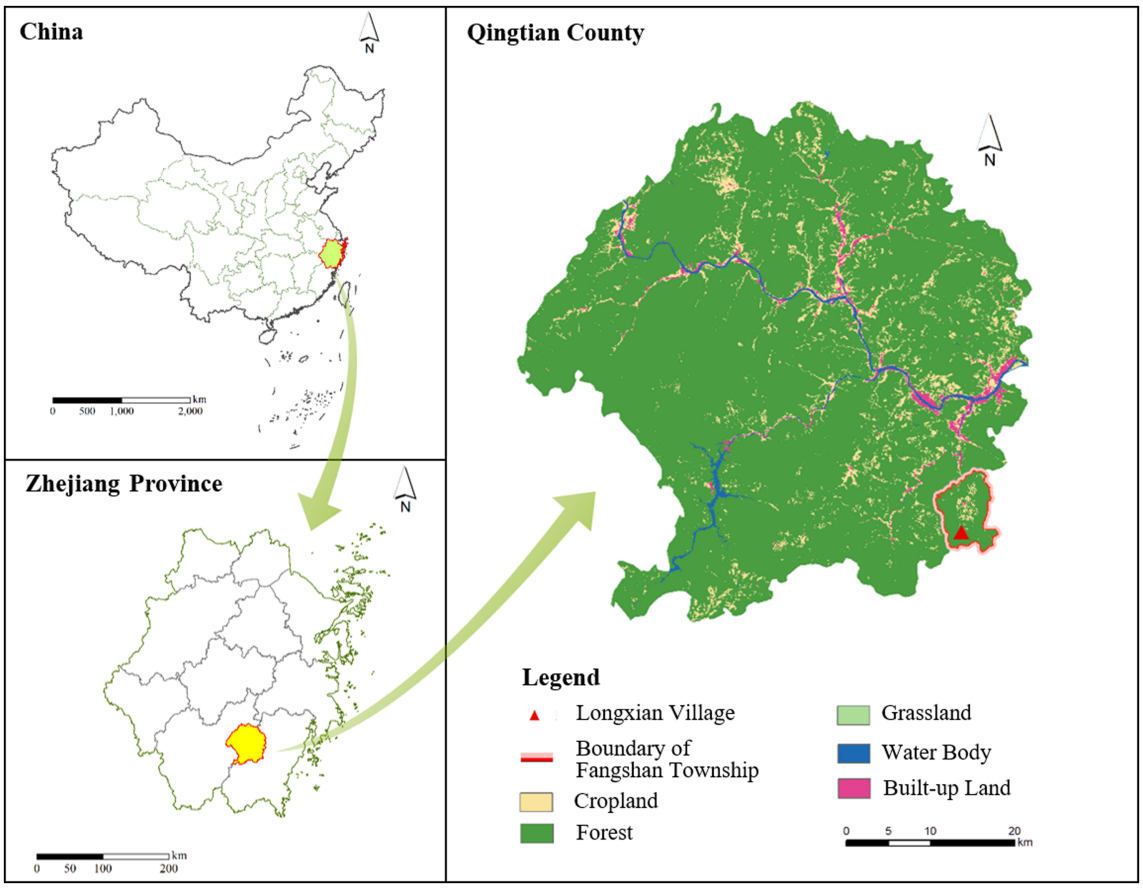

FIGURE 2
Location of Qingtian Rice-Fish Culture System (QRFCS).

for about 25.5 hectares of rice-fish culture paddy fields, with 64 farmers engaged in this production. While rice is harvested once a year, fish can be harvested throughout the year. Approximately 15 days before rice harvesting, field water is drained to facilitate rice harvesting, during which a batch of market-sized fish (about 0.3–0.5 kg) is harvested. After rice harvesting, the remaining small-size fish are returned to the paddy fields. Currently, the average yield of paddy fish is approximately 450 kg per hectare, while rice yield reaches about 6,000 kg per hectare.

Besides providing important economic revenues, the rice-fish culture model yields significant ecological benefits, including carbon sequestration, soil and water conservation, and reduction of non-point source pollution (Xie et al., 2011; Liu et al., 2021; Jiao et al., 2023). Furthermore, the long history of practice has made the rice-fish culture model a cultural system that encompasses not only traditional knowledge and practices but also local customs, festivals, and cuisine. For instance, making dried fish is an important part of the local culinary culture, not only providing a specialty food for locals but also carrying deep emotional significance related to their hometown (Figure 3).

As a pioneering GIAHS site in China and globally, QRFCS offers an ideal representative case for applying our conceptual framework. While Qingtian County has undertaken notable efforts in dynamic conservation over the past two decades, the heritage site still lacks a systematic and effective value-adding pathway from production to market, leaving substantial economic potential unrealized. This study therefore applies the proposed framework to QRFCS, both to validate its analytical utility and to generate actionable, empirically grounded pathways for enhancing product value. By doing so, we aim not only to unlock the specific value-adding potential of QRFCS agricultural products but also to offer a transferable model for other GIAHS sites seeking to integrate heritage attributes into sustainable market systems.

2.4 Data collection and analysis

2.4.1 Data collection methods

To obtain first-hand information on the current value-adding situation of agricultural products from QRFCS, we adopted semi-structured interviews that allow both structured guidance and flexibility, enabling interviewees to reflect on current practices while allowing researchers to pursue unexpected insights. To capture differences in selling price, channels, and value-adding measures, farmers were categorized into smallholder farmers and large-scale farmers. Besides farmers, we also interviewed other actors involved in the value chain, such as enterprise/cooperative managers, government officials, tourism practitioners, and consumers.

Fieldwork was conducted in Fangshan Township, the heritage site, from July 14 to 23, 2024, during which a total of 35 actors were interviewed. Using purposive sampling, 15 farmers (3 large-scale and 12 smallholders) were selected mainly from Longxian Village based on their farm scale and participation in rice-fish production within the heritage site. Smallholder farmers manage an average of

FIGURE 3
Specialty agricultural products of QRFCS (provided by People's Government of Qingtian County).

approximately 0.4 hectares of rice-fish culture paddy fields, whereas large-scale farmers manage about 8.4 hectares. Data saturation was reached after 11 interviews with smallholders, with subsequent interviews yielding no substantially new insights. In addition, 11 government officials from Qingtian County Bureau of Agriculture and Rural Affairs and Fangshan Township People's Government, who are directly involved in the management of QRFCS, were interviewed. 5 enterprise and cooperative managers involved in rice-fish production, processing, and marketing, and 4 tourism practitioners operating within the heritage site were also interviewed as key informants. The interviews focused on four aspects: (1) value-adding measures currently in place; (2) potential measures that could be adopted in the future; and (3) the advantages and limitations of these measures; (4) the cooperation and interest distribution among different actors.

To understand consumer perspectives, 26 consumers were purposively selected to capture variation in geographic origin and familiarity with QRFCS. These included 5 tourists visiting Longxian Village, 8 local consumers familiar with QRFCS, 5 non-local consumers knowledgeable about QRFCS, and 8 non-local consumers unfamiliar with QRFCS. Consumers were asked what factors would motivate them to pay a premium for QRFCS agricultural products.

Each interview lasted between 30 to 60 min. Throughout the interviewing process, we strictly adhered to research ethics, ensuring that all interviewers voluntarily participated and were informed of the research purpose and the use of interview information. All personal information was anonymized to protect interviewers' privacy.

We complemented the interview data with second-hand materials, including policy documents, academic studies, and media reports on agricultural development in Qingtian County, to situate micro-level practices within broader institutional and market conditions.

2.4.2 Data analysis: applying the framework

To apply the framework, we first assess the value-adding potential of measures across different stages. Based on the framework's full set of value-adding measures, we synthesize all interview data for each measure. This allows us to comprehensively assess whether and how these measures can transform the features of GIAHS agricultural products into consumer-recognized value. Subsequently, according to the assessment results, value-adding measures with relatively higher potential are first selected. Building on the selected measures and existing measures, we link them across value-adding stages to form integrated value-adding pathways. Finally, considering the existing collaborative relationships and benefit distribution among actors, we propose a more efficient and inclusive actor interaction framework aligned with the established pathways.

In developing the value-adding pathways and the actor interaction framework through interview data, we also draw on secondary data for triangulation and complementary evidence. Integrating these two sources of evidence enables us to assess value-adding potential across different stages of the value chain and supports the development of more robust and context-sensitive value-adding pathways for QRFCS agricultural products.

3 Results

3.1 Potential analysis of value-adding measures

Based on their respective advantages and limitations, we assess the potential of various value-adding measures to enhance both physical and perceived values of the QRFCS products. Through this assessment, value-adding measures with higher potential are identified and used as the foundation for building value-adding pathways.

3.1.1 Potentials of measures at the production stage

At the production stage, eco-agriculture and certification have large potential for enhancing the physical values of QRFCS agricultural products by highlighting their unique physical attributes. From the production side, as an eco-agricultural production model, the rice-fish culture contributes to distinct differences of rice and fish in taste and health attributes compared to the ordinary. These physical attributes provide a solid basis for premium pricing. As one farmer noted, "The fish raised in our rice paddies have far fewer bones than common carp, and their meat is more tender and flavorful, with no fishy smell." Regarding rice production, another farmer explained, "We use very little chemical fertilizer and almost no pesticides, so the rice is cleaner and healthier to eat." From the consumption side, rising awareness of ecological issues and food safety has expanded the market for green and organic products, with 76% of interviewed consumers indicating willingness to pay a higher price for certified products.

However, some limitations constrain value adding through eco-agriculture and certification. Rice-fish culture requires higher financial and labor inputs than rice monoculture, posing risks of abandonment or lack of successors if returns are insufficient. According to Liu et al. (2010), Compared with rice monoculture, the rice-fish culture reduces expenditures on rice seeds, chemical fertilizers, and pesticides. However, these savings are offset by higher costs

for fish fry and feed, which results in an overall increase of cash expenditure of approximately 79.7% compared with rice monoculture. In addition, rice-fish culture requires higher labor inputs, mainly due to fish husbandry activities and increased field maintenance associated with deeper water levels in paddy fields. Another limitation is that the ecological benefits of QRFCS products are not fully recognized by either farmers or consumers. Consequently, products produced through eco-agriculture do not achieve the price premiums associated with their ecological significance. As a smallholder farmer remarked, "Our ancestors have been raising fish in rice paddies for generations, but we farmers do not really understand the ecological benefits of this method." Similarly, a consumer stated, "Although the Qingtian Rice-Fish Culture System is well-known, I do not know the ecological benefits it carries."

For product certification, only a limited number of agricultural products from QRFCS have obtained green food or organic food certifications. Product certification is generally accessible only to enterprises, cooperatives due to the high costs, while most smallholder farmers are unable to afford it. Moreover, the price premium associated with certification remains limited in practice. According to field interviews, certified rice-fish rice is typically sold at about 8 yuan kg^{-1}, whereas the price of non-certified products is approximately 6 yuan kg^{-1}. In response to these limitations, the government has implemented measures such as certification subsidies and farmer training programs. Specifically, a one-time subsidy of 30,000 yuan is provided for first-time acquisition of green food or organic product certification, while certificate renewal is subsidized at 10000 yuan. The subsidy recipients are the certification applicants, which are typically enterprises and cooperatives. Training programs are typically organized by local government and delivered through lectures and on-site guidance by researchers or experienced farmers. Overall, agricultural products produced through eco-agriculture and certification have considerable potential for value adding.

By contrast, grading shows limited potential for value adding, as the physical attributes of rice and fish limit their grading to some extent. For example, the interviewed consumers indicated that the differences in taste and nutrition among fish with different colors and sizes are minimal, leading them to be unwilling to pay different prices. Similarly, while rice does have variations in texture and flavor, these differences are often not easily recognizable to consumers.

3.1.2 Potentials of measures at the processing stage

At the processing stage, current measures are limited to primary processing, such as de-husking rice and drying fresh fish. Specifically, Qingtian dried fish, processed using traditional method, has a moderate market both locally and overseas. However, such primary processing methods make a limited contribution to value adding. According to interview results, the average price of paddy rice is 4.4 yuan·kg^{-1}, while de-husked rice is 6 yuan·kg^{-1}, reflecting a value-adding rate of 36%. The average price of fresh fish is 80 yuan·kg^{-1}, while dried fish is 300 yuan·kg^{-1}, reflecting a value-adding rate of 275%. However, as there are weight losses during de-husking and drying, the actual value-adding rates are much lower than they appear. Specifically, with a milled recovery rate of approximately 75%, the actual value-adding rate for rice is reduced to around 27%. Similarly, since 3 kg of fresh fish yield only 1 kg of dried fish, the actual value-adding rate for fish processing is approximately 25% (Table 1).

Deep and fine processing could offer higher value, but the overall supply of QRFCS products is insufficient to meet large and stable demands. Qingtian has limited arable land, and the area suitable for rice-fish culture is even smaller, which limits the overall yield. Additionally, rice-fish paddies have lower planting densities than monoculture paddies to allow fish movement, resulting in rice yields about 80% of monoculture levels. Fish stocking densities are also lower than in ponds, with fish relying mostly on natural feed, leading to longer growth cycles and lower yields. For smallholder farmers, most rice and fish are consumed domestically, with only surplus sold. Overall, QRFCS represents a small-scale GIAHS with small amounts of agricultural products, and the limited production capacity limits its potential for value adding through deep and fine processing.

3.1.3 Potentials of measures at the marketing stage

At the marketing stage, QRFCS agricultural products have strong potential for value adding through packaging, labelling, and marketing. Their rich cultural connotation and ecological benefits provide a solid basis for enhancing perceived value, allowing these products to be positioned as premium items. Attractive packaging and authoritative certification labels help signal quality and justify higher prices. Currently, most products use simple packages, such as plastic bags, vacuum-sealed packs, or basic boxes, while a smaller number adopt more customized or designed packages featuring the QRFCS logos. However, the lack of uniformity in the logo on current packages hinders consumers from forming a strong impression of the QRFCS brand. The coexistence of QRFCS logos originating from different sources and periods, combined with the absence of clear guidelines for logo use. In practice, producers adopt available logos based on accessibility and familiarity, which has led to the uniformity in logo form across products.

Online marketing benefits from QRFCS's reputation as one of the world's first GIAHS and the region's robust internet infrastructure. Since its designation, QRFCS has been promoted through multiple channels such as television, newspapers and social media platforms. In our interviews, consumers who are familiar with the cultural and ecological significance of QRFCS agricultural products show a stronger

TABLE 1 Price changes and value-adding rates of processing measures in QRFCS.

Product	Processing measure	Price before processing (yuan·kg^{-1})	Price after processing (yuan·kg^{-1})	Nominal value-adding rate (%)	Processing yield (%)	Actual value-adding rate (%)
Rice	De-husking	4.4 (paddy rice)	6 (de-husked rice)	36%	75%	27%
Fish	Drying	80 (fresh fish)	300 (dried fish)	275%	33% (3:1)	25%

willingness to pay compared to those who are unaware. However, the actual online platforms capable of facilitating sales remain limited and most sales channels are still offline. Sales channels are more developed for cooperatives and enterprises, which sell products to restaurants, institutions, or through their own retail stores. In contrast, farmers' overall sales options are limited, particularly for smallholders, which results in the sale of their products at relatively low prices to intermediaries or local households. Nowadays, supported by rich cultural activities and attractive agricultural landscapes, tourism has gradually become a promising offline marketing channel at the heritage site. The number of tourists visiting the heritage site has been steadily increasing. Among the five tourists we interviewed, all expressed willingness to purchase specialty agricultural products during their trip and were willing to pay higher prices. Meanwhile, half of the interviewed farmers also stated that tourists have become an important consumer group for them. However, tourism infrastructure is still developing, and awareness of farmers about marketing specialty products is limited, resulting in no significant price difference between ordinary sales and tourism-oriented sales. Ongoing efforts, such as the QRFCS Museum and expansion of homestays and agritourism businesses, are expected to gradually unlock further offline marketing potential.

Throughout the value chain, measures with notable value-adding potential include eco-agriculture and certification at the production stage, primary processing at the processing stage, and packaging, labelling, as well as online and offline marketing at the marketing stage. Identifying these high-potential measures provides the foundation for designing targeted value-adding pathways along the value chain.

3.2 Value-adding pathways analysis

Based on the potential value-adding measures identified above, QRFCS agricultural products are best positioned for premium and tourism markets, where consumers appreciate the ecological and cultural significance of the products and are willing to pay a higher price. In line with these target markets, we established systematic linkages among value-adding measures across different stages and proposed clear pathways for value adding.

As shown in Figure 4, the value-adding pathways for QRFCS agricultural products span the entire value chain, encompassing production, processing, and marketing stages. By implementing corresponding measures, agricultural products gradually move through the value chain and ultimately enter the markets for consumption. Specifically, eco-agriculture, represented as rice-fish culture, serves as the foundation for all value-adding measures. Agricultural products from this system can be enhanced through two primary routes: certification (e.g., green or organic labels) and primary processing (e.g., de-husking rice, drying fresh fish). Certified products can also undergo further processing to increase their value. Together, these measures mainly enhance the physical value of GIAHS agricultural products.

Following production and processing, value adding extends into the marketing stage, where it focuses on enhancing consumers' perceived value. Packaging and labeling differentiate products from undifferentiated bulk commodities and support higher market prices (Figure 3). Subsequently, the products are promoted through both online and offline marketing strategies. Measures such as live streaming, agritourism activities, and targeted promotional campaigns convey the ecological and cultural significance of QRFCS products while facilitating sales. Through these sequential and complementary measures, agricultural products move from production to consumption, translating their ecological and cultural significance into consumers-recognized physical and perceived value.

3.3 Action interaction analysis

The effective functioning of value-adding pathways depends on interaction and coordination among multiple actors. However, field surveys show that linkages among actors involved in QRFCS agricultural products remain weak. Interactions among smallholder farmers are largely informal and lack stable cooperative arrangements. Although cooperatives are widely established and typically led by large-scale farmers, their interactions with smallholders are largely limited to product procurement, with smallholders rarely involved in downstream processing or marketing stages. Enterprises similarly engage with farmers primarily through product procurement. Direct transactions between

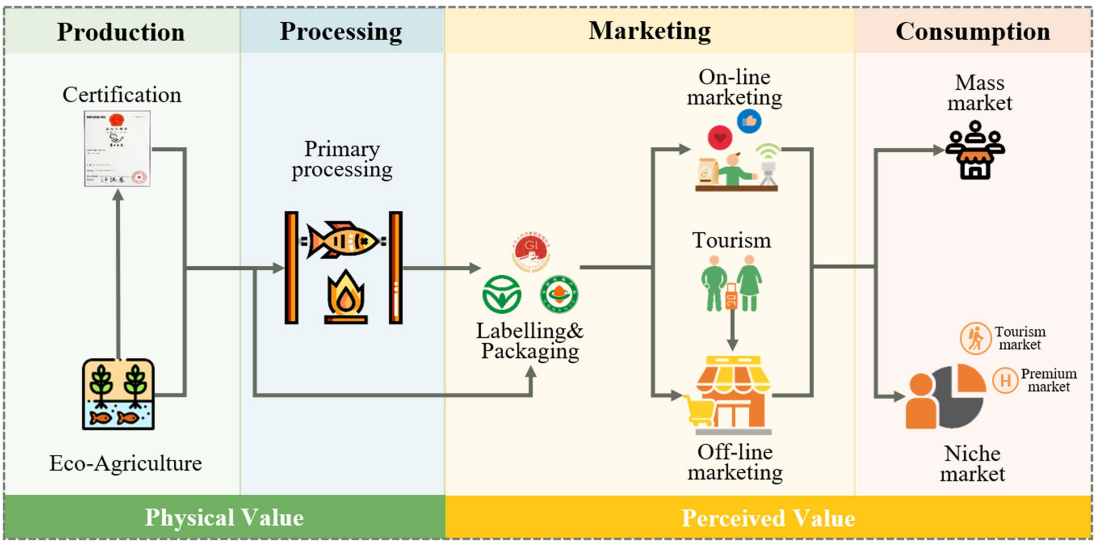

FIGURE 4
Value-adding pathways for QRFCS agricultural products.

farmers and consumers remain marginal and are largely confined to local social networks or occasional sales associated with tourism. At the same time, government interventions, such as certification subsidies and farmer training programs, have been implemented to support agricultural production and sales. Nevertheless, the absence of coordinated mechanisms linking production, processing, marketing, and consumption constrain the further value adding of QRFCS agricultural products.

To better realize these pathways and to enable farmers to engage in more value-adding stages, we propose an actor interaction model for QRFCS agricultural products (Figure 5). This model clarifies the roles and responsibilities, and strengthens both horizontal and vertical linkages among farmers, cooperatives, enterprises, consumers, and government. Farmers are central to producing rice-fish culture products and participating in both online and offline marketing. Through cooperative organizations such as cooperatives and enterprises, farmers, particularly smallholder farmers, are brought together and organized into more structured forms of collaboration. Using cooperatives as an example, farmers engage in cooperatives by contributing resources like products, labor, and means of production, while cooperatives manage agricultural products, finances, and land collectively. This cooperative model helps promote value-adding measures such as certifying, processing, packaging, labelling, and marketing, thereby alleviating constraints related to farmers' limited capital and weak marketing channels. At the same time, cooperatives provide farmers with technical guidance, encouraging them to adopt or continue engaging in eco-agricultural production.

Consumer engagement is another critical dimension of actor interaction. Direct interactions through live streaming, agritourism, or local markets reduce the distance between producers and consumers, enabling farmers to communicate the ecological and cultural significance of their products to consumers. Such engagement enhances consumers' understanding and appreciation of QRFCS agricultural products, ultimately supporting higher willingness to pay.

Throughout the implementation of value-adding pathways, the Qingtian government plays a foundational role as an institutional facilitator and regulator within the actor interaction model. For farmers, the government provides targeted financial support and training programs to enhance production practices and the adoption of eco-agricultural techniques. For cooperatives and enterprises, the government provides financial support while exercising regulatory oversight to ensure standardized operations and fair benefit distribution along the value chain. In addition, the government is responsible for public brand governance by regulating the use of the QRFCS logo, supervising products bearing the logo, and enhancing brand credibility in the market. At the same time, public investment in infrastructure such as processing facilities, logistics systems, and tourism infrastructure provides the material basis for the implementation of value-adding measures.

4 Discussion

4.1 Leveraging certification and logos to add values to GIAHS agricultural products

The case results indicate that the agricultural products from QRFCS have the greatest potential for value adding in the production and marketing stages. This potential can be realized through measures such as eco-agriculture, product certifications, online

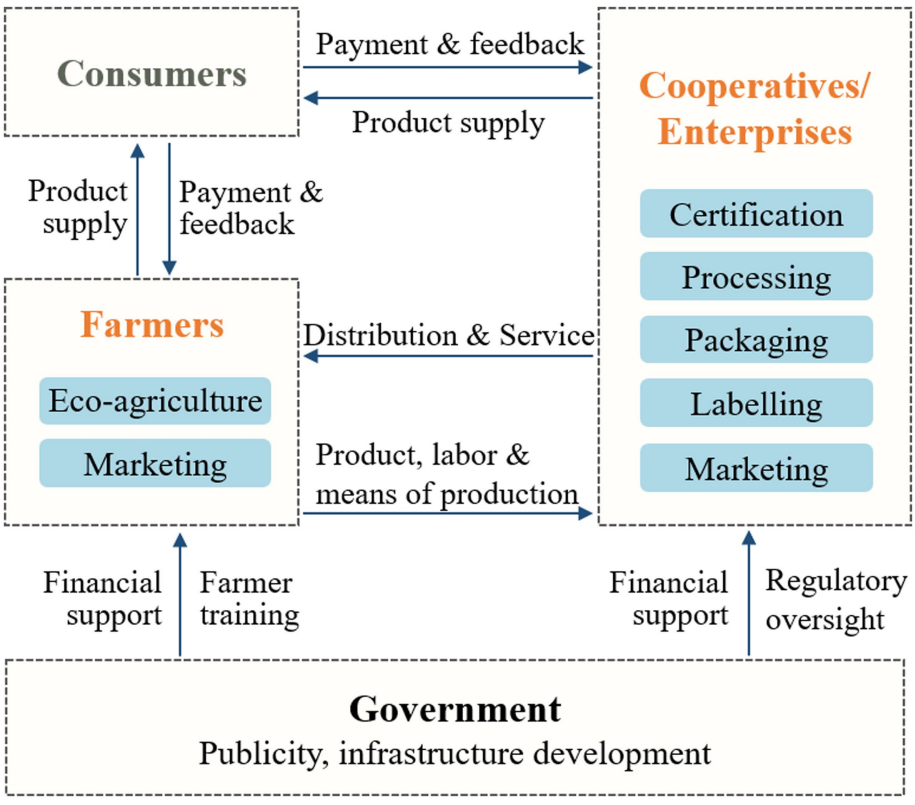

FIGURE 5
Actor interaction model for value adding of QRFCS agricultural products.

and offline marketing. These value-adding strategies for QRFCS agricultural products are proposed based on the current context of small-scale production and limited deep processing capabilities within QRFCS, a common situation of many GIAHS. For agricultural products derived from such systems, value-adding measures should prioritize niche markets, where consumers are more responsive to ecological and cultural significance and are therefore more likely to accept price premiums. The enhancement of physical value forms the fundamental basis for perceived value, while the enhancement of perceived value is crucial for making products' physical attributes and ecological benefits visible and recognized by consumers. Specifically, eco-agriculture and product certification require effective signaling and marketing measures to communicate the distinctive features of their products to consumers.

In this context, product certification and its associated logos play a critical role as effective signals that help reduce information asymmetry between producers and consumers. Currently, GIAHS agricultural products are primarily associated with two types of product certifications: GI and Green/Organic Food. Certification logos play a crucial role in leveraging the benefits of product certification for value adding. The usage rights of certification logos are generally granted by authoritative organizations and are subject to strict regulation, which is essential for enhancing consumer trust in certification labels. Research indicates that over 70% of consumers consider the presence of specific logos to be a decisive factor when purchasing organic products (Melović et al., 2020).

In addition to these certification logos, GIAHS should strengthen the use of a unified heritage-specific logo that reflects its identity, hereafter referred to as the GIAHS logo. The GIAHS logo comprehensively reflects the connotations of its agricultural products, including features of the origin, physical attributes, ecological benefits, and cultural connotation. However, the case results indicate that the lack of uniformity in GIAHS logo design and application on product packaging weakens the formation of a clear and coherent QRFCS brand image. Therefore, alongside promoting the rich connotations of GIAHS agricultural products, it is crucial to standardize and widely apply the GIAHS logo, so that these connotations can be consistently presented and recognized in the market. Taken together, the coordinated use of GI, Green/Organic Food, and GIAHS logos enables different dimensions of product information to be jointly conveyed, thereby maximizing the value-adding effects of logos and supporting the transformation of GIAHS product features into consumer-recognized value.

4.2 Protecting farmers' interests in multi-actor value chain

Drawing on the case of QRFCS, this study demonstrates that value-adding pathways for GIAHS agricultural products depend on the coordination of multiple actors across different stages of the value chain. Such multi-actor interaction has long been recognized as a core principle of GIAHS conservation and development (Min et al., 2016; Jiao and Min, 2017). The proposed actor interactive model specifies the operational mechanisms through which multi-actor participation in the context of agricultural products value adding. The model identified in QRFCS not only deepens understanding of the cooperative mechanisms underpinning this case, but also provides a reference for other GIAHS sites seeking to develop multi-actor value-adding pathways.

In GIAHS contexts, the majority of producers are smallholder farmers who face persistent constraints in capital availability, technical capacity, and market access. These structural constraints weaken farmers' bargaining power, leaving product prices largely determined by purchasers, while also limiting farmers' participation in downstream processing and marketing stages that generate higher value-adding returns. In contrast to their disadvantaged position in the value chain, these smallholders are the main actors in eco-agricultural production and the key stakeholders in inheriting GIAHS (Jiao et al., 2024; Zhang et al., 2023). Under such conditions, inadequate protection of farmers' interests in the process of industrial development can directly undermine the conservation and continuity of GIAHS. Safeguarding farmers' interests should therefore be regarded as a central concern in the implementation of value-adding pathways. In particular, cooperatives and enterprises should adopt fair benefit-sharing mechanisms and contractual arrangements with farmers. Governmental guidance and regulatory oversight play an indispensable role in this process.

In addition, ecological compensation serves as an important redistributive mechanism in current GIAHS conservation practices. Ecological compensation policies not only encourage farmers to adopt eco-agricultural practices, maximizing the ecological benefits of GIAHS, but also compensate for the increased costs and production losses incurred by using traditional, green, or organic production measures (Min et al., 2016). Current ecological compensation measures for agricultural heritage include cash compensation (Jiao et al., 2021), agricultural product purchasing (Liu et al., 2018), and funding for conservation activities (Yiu, 2014). Among these, cash compensation is the most favored method by farmers (Liu et al., 2018) and is also more suitable for the value chain. Compared to purchasing, it does not restrict agricultural products from entering the subsequent value-added stages; compared to funding for activities, it allows farmers to benefit directly.

4.3 Theoretical contributions and applicability of the conceptual framework

The proposed conceptual framework roots in value chain theory to establish value-adding pathways from production to consumption. Its contributions can be summarized in two aspects. First, rather than treating value-adding measures as isolated interventions, the framework conceptualizes value adding as a set of linked measures spanning production, processing, and marketing stages. These measures are mutually reinforcing: eco-agriculture underpin certification, which in turn support packaging and labelling at the marketing stage. This full-chain perspective allows the framework to clarify how different measures interact to jointly enhance product value. Second, by introducing physical value and perceived value from the consumer perspective, the framework provides a more nuanced explanation of the mechanisms underlying agricultural product value adding. Specifically, it elucidates how the distinctive features of GIAHS agricultural products can be translated into consumer-recognized physical and perceived value, ultimately realizing product value adding. In this sense, the proposed framework enriches and extends agricultural value chain theory by integrating consumer perception and agricultural heritage systems into the analysis of value adding.

The QRFCS case provides empirical validation for the applicability and effectiveness of the proposed framework. By mapping existing value-adding measures along the stages of production, processing, and

marketing, the framework proves effective in systematically organizing diverse measures and clarifying their interconnections in a real GIAHS context. Through field investigation and interviews, the framework facilitates the identification of both the advantages and the limitations of current value-adding measures at different stages, as well as their unrealized potential. In this sense, the framework not only serves as an analytical tool for understanding how value adding is currently implemented, but also provides a structured basis for diagnosing weaknesses and exploring future improvement pathways.

4.4 Limitations and future research directions

The existing limitations of this study are primarily reflected in several aspects. First, this study primarily relies on qualitative analysis, drawing on interviews and secondary data to examine the advantages, constraints, and potential of different value-adding measures. While this approach is effective for revealing interactions and mechanisms along the value-adding pathway, it does not allow for a precise quantification of value added. In particular, the specific contribution of individual measures, the cumulative value added along the entire pathway, and their long-term economic effects have not yet been systematically evaluated. Second, the empirical analysis is based on a single case study, which constrains the representativeness of the findings. QRFCS represents a common type of GIAHS characterized by small-scale production, under which processing remain limited. However, GIAHS sites exhibit substantial heterogeneity in their value-adding pathways. In some cases, such as the Soave Traditional Vineyards, processing plays a central role, with high-quality wine production generating significant adding value (FAO, 2018; Tarolli et al., 2023). This heterogeneity indicates that the relative importance of different value-adding measures varies across GIAHS sites depending on local resource endowments and development conditions.

Building on these limitations, several directions for future research can be identified. First, extending the application of the proposed framework to multiple GIAHS cases would facilitate its empirical validation and further refinement. On this basis, comparative analyses across different types of GIAHS could be undertaken to explore variations in value-adding pathways. Such comparisons could clarify which elements of the framework are broadly applicable and which require adjustment to local ecological, cultural, and market conditions. Second, future research could adopt a consumer-centered approach by quantifying preferences and willingness to pay for specific value-adding measures. Scaled measurements, such as those used to assess consumer intention for organic food (Petrescu et al., 2017) may help estimate the potential value adding by different measures. Third, longitudinal studies are needed to track the long-term effects of value-adding pathways, particularly with respect to ecological sustainability and the transmission of local knowledge and farming culture. Such studies would allow for a more comprehensive assessment of whether value adding in GIAHS can achieve not only short-term economic gains but also long-term socio-ecological resilience.

5 Conclusion

Adding value to agricultural products is a vital strategy for promoting the dynamic conservation of GIAHS. In response to the current lack of systematic value-adding models, this study develops a conceptual framework for developing value-adding pathways for GIAHS agricultural products along the value chain, identifying two consumer-recognized values, physical value and perceived value, as the core sources of added value. Using the QRFCS as a case study, this framework is applied to construct specific value-adding pathways for GIAHS agricultural products based on field research. The results indicate that the promising measures lies in the development of eco-agriculture and product certification in the production stage, primary processing in the processing stage, and packaging, labelling, online and offline marketing in the marketing stage. Secondly, we integrate these measures into a systematic structure and build the value-adding pathways for QRFCS agricultural products. Additionally, we propose an actor interaction model designed to facilitate implementation and address existing limitations.

This study contributes to the understanding and practice of agricultural product value adding in several ways. First, it develops a conceptual framework that clarifies the mechanisms through which the distinctive features of GIAHS agricultural products are transformed into consumer-recognized value, integrating the entire value chain from production to consumption. Second, by applying this framework to the QRFCS, the study provides concrete, actionable pathways for implementing value-adding measures at heritage sites, illustrating how theoretical insights can be translated into practice. Third, the framework offers broader relevance for other traditional agricultural systems, showing how they can leverage their unique ecological, cultural, and product advantages to achieve value adding, and eventually promote sustainable development. Collectively, these contributions support both the dynamic conservation of GIAHS and the sustainable transformation of traditional agricultural systems in diverse contexts.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

YL: Writing – original draft, Investigation, Visualization, Conceptualization, Writing – review & editing, Methodology. WJ: Conceptualization, Writing – review & editing, Funding acquisition, Supervision, Resources, Methodology. QM: Writing – review & editing, Resources, Funding acquisition, Supervision.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Acheampong, E. O., Sloan, S., Sayer, J., and Macgregor, C. J. (2022). African forest-fringe farmers benefit from modern farming practices despite high environmental impacts. *Land* 11:145. doi: 10.3390/land11020145

Agnoletti, M., and Santoro, A. (2022). Agricultural heritage systems and agrobiodiversity. *Biodivers. Conserv.* 31, 2231–2241. doi: 10.1007/s10531-022-02460-3

Andriesse, E. (2018). Primary sector value chains, poverty reduction, and rural development challenges in the Philippines. *Geogr. Rev.* 108, 345–366. doi: 10.1111/gere.12287

Argyropoulos, C., Tsiafouli, M. A., Sgardelis, S. P., and Pantis, J. D. (2013). Organic farming without organic products. *Land Use Policy* 32, 324–328. doi: 10.1016/j.landusepol.2012.11.008

Bairagi, S., Custodio, M. C., Durand-Morat, A., and Demont, M. (2021). Preserving cultural heritage through the valorization of cordillera heirloom rice in the Philippines. *Agric. Hum. Values* 38, 257–270. doi: 10.1007/s10460-020-10159-w

Bartoli, C., Bonetti, E., and Mattiacci, A. (2022). Marketing geographical indication products in the digital age: a holistic perspective. *Br. Food J.* 124, 2857–2876. doi: 10.1108/BFJ-03-2021-0241

Bullock, R., Gyau, A., Mithoefer, D., and Swisher, M. (2018). Contracting and gender equity in Tanzania: using a value chain approach to understand the role of gender in organic spice certification. *Renew. Agric. Food Syst.* 33, 60–72. doi: 10.1017/S1742170517000151

Caviedes, J., Ibarra, J. T., Calvet-Mir, L., Álvarez-Fernández, S., and Junqueira, A. B. (2024). Indigenous and local knowledge on social-ecological changes is positively associated with livelihood resilience in a globally important agricultural heritage system. *Agric. Syst.* 216:103885. doi: 10.1016/j.agsy.2024.103885

Clark, J. K., Jablonski, B. B. R., Inwood, S., Irish, A., and Freedgood, J. (2021). A contemporary concept of the value(s)-added food and agriculture sector and rural development. *Community Dev.* 52, 186–204. doi: 10.1080/15575330.2020.1854804

Coltrain, D., Barton, D., and Boland, M. (2000). Value added: opportunities and strategies. Kansas City: Department of Agricultural Economics, Kansas State University. Available online at: https://www.agmanager.info/sites/default/files/VALADD10%25202col.pdf (Accessed January 24, 2024).

Cucchiaro, S., Fallu, D. J., Zhang, H., Walsh, K., Van Oost, K., Brown, A. G., et al. (2020). Multiplatform-SfM and TLS data fusion for monitoring agricultural terraces in complex topographic and landcover conditions. *Remote Sens.* 12:1946. doi: 10.3390/rs12121946

Dizyee, K., Baker, D., and Rich, K. M. (2017). A quantitative value chain analysis of policy options for the beef sector in Botswana. *Agric. Syst.* 156, 13–24. doi: 10.1016/j.agsy.2017.05.007

Dong, L. (2021). Toward resilient agriculture value chains: challenges and opportunities. *Prod. Oper. Manag.* 30, 666–675. doi: 10.1111/poms.13308

FAO (2014). Developing sustainable food value chains: guiding principles. Rome: FAO. Available online at: https://www.fao.org/sustainable-food-value-chains/library/details/en/c/265156/ (Accessed April 2, 2024).

FAO (2017). Globally important agricultural heritage systems (GIAHS)-selection criteria and action plan. Available online at: https://www.fao.org/giahs/become-a-giahs/selection-criteria-and-action-plan/en/ (Accessed June 3, 2024).

FAO (2018). Soave traditional vineyards, Italy. Available online at: https://www.fao.org/giahs/giahsaroundtheworld/designated-sites/europe-and-central-asia/soave-traditional-vineyards/detailed-information/zh/ (Accessed June 3, 2024).

FAO (2022). Twenty years of globally important agricultural heritage systems. Rome: FAO. Available online at: https://openknowledge.fao.org/handle/20.500.14283/cc2385en (Accessed June 15, 2024).

FAO and UNIDO (2024). *Developing sustainable food value chains—practical guidance for systems-based analysis and design: SFVC methodological brief*. Rome, Italy: FAO, United Nations Industrial Development Organization.

Fuller, A. M., Min, Q., Jiao, W., and Bai, Y. (2015). Globally important agricultural heritage systems (GIAHS) of China: the challenge of complexity in research. *Ecosyst. Health Sustain.* 1, 1–10. doi: 10.1890/EHS14-0007.1

Fusacchia, I., Balié, J., and Salvatici, L. (2022). The AfCFTA impact on agricultural and food trade: a value added perspective. *Eur. Rev. Agric. Econ.* 49, 237–284. doi: 10.1093/erae/jbab046

Gómez, M. I., Barrett, C. B., Buck, L. E., De Groote, H., Ferris, S., Gao, H. O., et al. (2011). Research principles for developing country food value chains. *Science* 332, 1154–1155. doi: 10.1126/science.1202543

Griffith, G., and Watson, A. (2016). Agricultural markets and marketing policies. *Aust. J. Agric. Resour. Econ.* 60, 594–609. doi: 10.1111/1467-8489.12161

He, X., Wen, Y., Li, Z., Zhou, Y., Hu, W., Sun, J., et al. (2023). Body color selection of domesticated carp (*Cyprinus carpio*) in traditional agricultural systems: insight provided by growth performance, nutritional quality, and genetic diversity. *Aquaculture* 572:739528. doi: 10.1016/j.aquaculture.2023.739528

Hernandez-Aguilera, J. N., Gómez, M. I., Rodewald, A. D., Rueda, X., Anunu, C., Bennett, R., et al. (2018). Quality as a driver of sustainable agricultural value chains: the case of the relationship coffee model. *Bus. Strat. Environ.* 27, 179–198. doi: 10.1002/bse.2009

Jiang, Y., and Zhang, R. (2023). Characteristics of urban agricultural heritage sites: policies and management methods for their conservation in China, Germany, and Italy. *Habitat Int.* 131:102710. doi: 10.1016/j.habitatint.2022.102710

Jiao, W., Cui, W., and He, S. (2023). Can agricultural heritage systems keep clean production in the context of modernization? A case study of Qingtian Rice-fish culture system of China based on carbon footprint. *Sustain. Sci.* 18, 1397–1414. doi: 10.1007/s11625-022-01274-0

Jiao, W., Cui, W., Min, Q., and Zhang, Y. (2021). A review of research on agricultural heritage systems and their conservation (in Chinese). *Resour. Sci.* 43, 823–837. doi: 10.18402/resci.2021.04.16

Jiao, W., Fuller, A., Xu, S., Min, Q., and Wu, M. (2016). Socio-ecological adaptation of agricultural heritage systems in modern China: three cases in Qingtian county, Zhejiang province. *Sustainability* 8:1260. doi: 10.3390/su8121260

Jiao, W., and Min, Q. (2017). Reviewing the progress in the identification, conservation and management of China-nationally important agricultural heritage systems (China-NIAHS). *Sustainability* 9:1698. doi: 10.3390/su9101698

Jiao, W., Yang, X., and Li, Y. (2024). Traditional knowledge's impact on soil and water conservation in mountain agricultural systems: a case study of Shexian dryland stone terraced system, China. *Ecol. Indic.* 159:111742. doi: 10.1016/j.ecolind.2024.111742

Jovania Pereira, C., Muller, J., and Rodrigues de Freitas, R. (2025). The blue crab (Callinectes spp.) value chain in Laguna (Santa Catarina, Brazil) under the perspective of Local Agri-Food Systems. *Environ. Dev.* 54:101173. doi: 10.1016/j.envdev.2025.101173

Kaushik, N., Yadav, P., Khandal, R. K., and Aggarwal, M. (2021). Review of ways to enhance the nutritional properties of millets for their value-addition. *J. Food Process. Preserv.* 45:e15550. doi: 10.1111/jfpp.15550

Koohafkan, P., and DelaCruz, M. J. (2011). Conservation and adaptive management of globally important agricultural heritage systems (GIAHS). *J. Resour. Ecol.* 2, 22–28. doi: 10.3969/j.issn.1674-764x.2011.01.004

Li, W., Zhang, Q., Fan, Y., Cheng, Z., Lu, X., Luo, B., et al. (2023). Traditional management of ancient Pu'er teagardens in Jingmai Mountains in Yunnan of China, a designated globally important agricultural heritage systems site. *J. Ethnobiol. Ethnomed.* 19:26. doi: 10.1186/s13002-023-00598-0

Liu, M., Bai, Y., Yang, L., and Jiao, W. (2020). Impacts of eco-compensation on the farmers' production behavior of Hani Rice Terraces in China (in Chinese). *Chin. J. Eco-Agric.* 28, 1339–1349. doi: 10.13930/j.cnki.cjea.200239

Liu, D., Feng, Q., Zhang, J., Zhang, K., Tian, J., and Xie, J. (2021). Ecosystem services analysis for sustainable agriculture expansion: rice-fish co-culture system breaking through the Hu line. *Ecol. Indic.* 133:108385. doi: 10.1016/j.ecolind.2021.108385

Liu, M., Liu, W., Yang, L., Jiao, W., He, S., and Min, Q. (2019). A dynamic eco-compensation standard for Hani Rice terraces system in Southwest China. *Ecosyst. Serv.* 36:100897. doi: 10.1016/j.ecoser.2019.100897

Liu, M., Yang, L., Bai, Y., and Min, Q. (2018). The impacts of farmers' livelihood endowments on their participation in eco-compensation policies: globally important agricultural heritage systems case studies from China. *Land Use Policy* 77, 231–239. doi: 10.1016/j.landusepol.2018.05.054

Liu, M., Zhang, D., and Li, W. (2010). Evaluation of comprehensive benefit of rice-fish agriculture and rice monocropping—a case study of Qingtian County, Zhejiang Province. *Chin. J. Eco-Agric.* 18, 164–169. doi: 10.3724/sp.j.1011.2010.00164

Lu, R., and Dudensing, R. (2015). What do we mean by value-added agriculture? *Choices* 30, 1–8. Available online at: https://www.jstor.org/stable/choices.30.4.05

Ma, M., and Sexton, R. J. (2021). Modern agricultural value chains and the future of smallholder farming systems. *Agric. Econ.* 52, 591–606. doi: 10.1111/agec.12637

Melović, B., Cirović, D., Backovic-Vulić, T., Dudić, B., and Gubiniova, K. (2020). Attracting green consumers as a basis for creating sustainable marketing strategy on the organic market—relevance for sustainable agriculture business development. *Foods* 9:1552. doi: 10.3390/foods9111552

Miller, C., and Jones, L. (2010). *Agricultural Value Chain Finance*. Rugby: Practical action publishing. Available online at: https://practicalactionpublishing.com/book/42/agricultural-value-chain-finance

Min, Q., and Zhang, B. (2020). Research progress in the conservation and development of China-nationally important agricultural heritage systems (China-NIAHS). *Sustainability* 12:126. doi: 10.3390/su12010126

Min, Q., Zhang, Y., Jiao, W., and Sun, X. (2016). Responding to common questions on the conservation of agricultural heritage systems in China. *J. Geogr. Sci.* 26, 969–982. doi: 10.1007/s11442-016-1310-3

Muflikh, Y. N., Smith, C., and Aziz, A. A. (2021). A systematic review of the contribution of system dynamics to value chain analysis in agricultural development. *Agric. Syst.* 189:103044. doi: 10.1016/j.agsy.2020.103044

Nahuelhual, L., Carmona, A., Laterra, P., Barrena, J., and Aguayo, M. (2014). A mapping approach to assess intangible cultural ecosystem services: the case of agriculture heritage in southern Chile. *Ecol. Indic.* 40, 90–101. doi: 10.1016/j.ecolind.2014.01.005

Petrescu, A. G., Oncioiu, I., and Petrescu, M. (2017). Perception of organic food consumption in Romania. *Foods* 6:42. doi: 10.3390/foods6060042

Piras, F., Fiore, B., and Santoro, A. (2022). Small cultural forests: landscape role and ecosystem services in a japanese cultural landscape. *Land* 11:1494. doi: 10.3390/land11091494

Plaiphum, S., and Tansuchat, R. (2023). Cultural capital of sea salt farming in ban Laem District of Phetchaburi Province as per the globally important agricultural heritage systems (GIAHS). *Sustainability* 15:11947. doi: 10.3390/su151511947

Porter, M. E. (1985) Competitive advantage: creating and sustaining superior performance New York Free Press. Available online at: https://books.google.com/books/about/Competitive_Advantage.html?id=7UqQXsQ_dj4C

Prus, B., Uruszczak, M., and Hernik, J. (2022). Arguments based on biocultural diversity to cease abandonment of traditional agricultural systems: lessons from Poland. *Biodivers. Conserv.* 31, 1–26. doi: 10.1007/s10531-021-02297-2

Rana, N., Rana, S. A., Khan, H. A., and Sohail, A. (2010). Assessment of possible threats to soil macro-invertebrates diversity in wheat fields from high input farming. *Int. J. Agric. Biol.* 12, 801–808. Available online at: https://api.fspublishers.org/viewPaper/20715_..pdf

Ren, W., Hu, L., Guo, L., Zhang, J., Tang, L., Zhang, E., et al. (2018). Preservation of the genetic diversity of a local common carp in the agricultural heritage rice-fish system. *Proc. Natl. Acad. Sci.* 115, E546–E554. doi: 10.1073/pnas.1709582115

Reyes, S. R. C., Miyazaki, A., Yiu, E., and Saito, O. (2020). Enhancing sustainability in traditional agriculture: indicators for monitoring the conservation of globally important agricultural heritage systems (GIAHS) in Japan. *Sustainability* 12:5656. doi: 10.3390/su12145656

Rich, K. M., Ross, R. B., Baker, A. D., and Negassa, A. (2011). Quantifying value chain analysis in the context of livestock systems in developing countries. *Food Policy* 36 214–222. doi: 10.1016/J.FOODPOL.2010.11.018

Sani, I. K., Masoudpour-Behabadi, M., Sani, M. A., Motalebinejad, H., Juma, A. S., Asdagh, A., et al. (2023). Value-added utilization of fruit and vegetable processing by-products for the manufacture of biodegradable food packaging films. *Food Chem.* 405:134964. doi: 10.1016/j.foodchem.2022.134964

Schulze-Ehlers, B., and Anders, S. (2018). Towards consumer-driven meat supply chains: opportunities and challenges for differentiation by taste. *Renew. Agric. Food Syst.* 33, 73–85. doi: 10.1017/S1742170517000059

Shen, J., Huang, F., and Chou, R. (2021). Agricultural-heritage-oriented rural revitalization: experiences from the ancient tea town of Xiping. *Land* 10:927. doi: 10.3390/land10090927

Song, H., Chen, P., Zhang, S., Chen, Y., and Zhao, W. (2022). The impact of the creative performance of agricultural heritage systems on tourists' cultural identity: a dual perspective of knowledge transfer and novelty perception. *Front. Psychol.* 13:968820. doi: 10.3389/fpsyg.2022.968820

Tarolli, P., Wang, W., Pijl, A., Cucchiaro, S., and Straffelini, E. (2023). Heroic viticulture: environmental and socioeconomic challenges of unique heritage landscapes. *iScience* 26:107125. doi: 10.1016/j.isci.2023.107125

Trienekens, J. H. (2011). Agricultural value chains in developing countries a framework for analysis. *Int. Food Agribus. Manag. Rev.* 14, 51–82. doi: 10.22004/ag.econ.103987

USDA (2002). Farm security and rural investment act of 2002. Available online at: https://www.congress.gov/107/plaws/publ171/PLAW-107publ171.pdf (Accessed June 2, 2024).

Vasilescu, A. G., Pleşoianu, A., and Pătru-Stupariu, I. (2023). Aspects of traditional agricultural landscapes: potential alternative development paths for sustainable agriculture—a review. *Biodivers. Conserv.* 32, 3703–3730. doi: 10.1007/s10531-023-02658-z

Vroegindewey, R., and Hodbod, J. (2018). Resilience of agricultural value chains in developing country contexts: a framework and assessment approach. *Sustainability* 10:916. doi: 10.3390/su10040916

Wang, W., Straffelini, E., and Tarolli, P. (2023). Steep-slope viticulture: the effectiveness of micro-water storage in improving the resilience to weather extremes. *Agric. Water Manag.* 286:108398. doi: 10.1016/j.agwat.2023.108398

Xie, J., Hu, L., Tang, J., Wu, X., Li, N., Yuan, Y., et al. (2011). Ecological mechanisms underlying the sustainability of the agricultural heritage rice-fish coculture system. *Proc. Natl. Acad. Sci.* 108, E1381–E1387. doi: 10.1073/pnas.1111043108

Xu, J., Zhang, Z., Zhang, X., Ishfaq, M., Zhong, J., Li, W., et al. (2020). Green food development in China: experiences and challenges. *Agriculture* 10:614. doi: 10.3390/agriculture10120614

Yang, L., Yang, J., Jiao, W., Liu, M., and Li, W. (2021). The evaluation of food and livelihood security in a globally important agricultural heritage systems (GIAHS) site. *J. Resour. Ecol.* 12, 480–488. doi: 10.5814/j.issn.1674-764x.2021.04.006

Yiu, E. (2014). Noto peninsula after GIAHS designation: conservation and revitalization efforts of Noto's Satoyama and Satoumi. *J. Resour. Ecol.* 5, 364–369. doi: 10.5814/j.issn.1674-764x.2014.04.012

Yotsumoto, Y., and Vafadari, K. (2021). Comparing cultural world heritage sites and globally important agricultural heritage systems and their potential for tourism. *J. Herit. Tour.* 16, 43–61. doi: 10.1080/1743873X.2020.1758116

Zhang, Y., Guan, C., Li, Z., Luo, J., Ren, B., Chen, C., et al. (2023). Review of rice-fish-duck symbiosis system in China—one of the globally important ingenious agricultural heritage systems (GIAHS). *Sustainability* 15:1910. doi: 10.3390/su15031910

Zhang, Y., and He, L. (2021). Protecting important agricultural heritage systems (IAHS) by industrial integration development (IID): practices from China. *J. Resour. Ecol.* 12, 555–566. doi: 10.5814/j.issn.1674-764x.2021.04.013

Zhang, Y., Min, Q., Li, H., He, L., Zhang, C., and Yang, L. (2017a). A conservation approach of globally important agricultural heritage systems (GIAHS): improving traditional agricultural patterns and promoting scale-production. *Sustainability* 9:295. doi: 10.3390/su9020295

Zhang, Y., Min, Q., Zhang, C., He, L., Zhang, S., Yang, L., et al. (2017b). Traditional culture as an important power for maintaining agricultural landscapes in cultural heritage sites: a case study of the Hani terraces. *J. Cult. Herit.* 25, 170–179. doi: 10.1016/j.culher.2016.12.002