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Agriculture Risks and Opportunities in a Climate-Vulnerable Watershed in Northeastern Taiwan—The Opinions of Leisure Agriculture Operators

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Abstract: This study investigated the agriculture risks and opportunities in a fragile watershed, the Lanyang River Watershed (LRW) in Northeastern Taiwan, under the current situation of climate change. Agriculture in the LRW is a traditional sector, highly vulnerable to climate change, and is a declining economic sector due to the trend of trade liberalization of agriculture. At present, the government of Taiwan encourages local farmers to transform towards recreational farm types. Leisure agriculture operators have successfully transitioned their tilling to a business model of recreational farming. A telephone survey of leisure agriculture operators was applied with a three-stage approach to obtain their opinions. The results showed that climate change may entail risks for agriculture in watersheds. Transformation to leisure agriculture can enhance farm adaptation and increase farm income. The long-term implementation of slope- and geology-based land classification and land use planning can protect the watershed, especially from extreme weather, while enhancing water and soil conservation efforts, and bolstering climate resilience. Innovative agricultural practices offer viable solutions, including greenhouse farming for high-economic-value crops, leisure agriculture, organic farming, and ecotourism. These strategies can rejuvenate the LRW's agriculture industry, foster ecological tourism, and provide opportunities for traditional farmers to thrive in this highly climate-fragile area. The implications of this case study are that appropriate responses can improve local climate resilience, and that correspondingly well-designed adaptation measures can transform threats and risks into new opportunities.

Keywords: industrial transformation; climate change; Lanyang River Watershed; leisure agriculture operator; vulnerability

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1. Introduction

Climate change has been a concern for decades. With targets for the reduction of carbon dioxide emissions rarely met [1–3], climate change is considered the greatest threat to human life [4], and is also regarded as an emergency by the world's scientists [5].

Given the emergency and criticality of the situation, human beings need to respond to climate change. Since completely and immediately mitigating climate change cannot be accomplished, humans are being forced to live with climate change and adapt to it. It is crucial to enhance our resilience and adaptation to climate impacts [6,7], since the huge impacts and threats can strongly impact natural-based agriculture [8,9] and the well-being of communities [10,11]. The potential climate issues range from rising temperatures, extreme heat, drought, and wildfires on rangelands, to heavy downpours and so on. Climate change is expected to have an increasing impact on natural-based agricultural productivity.

The expected increases in challenges could reduce crop yields and quality, and threaten rural livelihoods, sustainable food security, and price stability [10]. The tasks required to adapt to climate change involve interactions between the natural system, agriculture, the risks of climate change, and international trade. Thus, research on climate adaptation is encouraged through multidisciplinary approaches [10,12]. Moreover, human–nature cooperation would mediate the threats and risks to the well-being of communities [13].

Since the Earth has an atmospheric system, the issues of global warming and reducing greenhouse gas emissions are common problems faced by its citizens. However, the impacts of climate change and extreme weather are not uniform across the globe, and the risks and feasible adaptations vary across regions. Although mitigation and adaptation are common issues faced by the citizens of the planet, the spatial diversity of the climate disasters faced by farmers is unevenly distributed [14–18], and farmers' adaptation measures and capabilities are also uneven [19–21].

In addition to climate factors, altitude and terrain characteristics are often key factors in local climate hazards and corresponding adaptations [22]. Zagaria et al. [23] highlighted the importance and necessity of adaptation and transformation. They indicated that in areas where adaptation is most needed, the potential for adaptation, especially transformational adaptation, is low. Zagaria et al. [23] also pointed out that as the limits of adaptation become closer, more reflection on transformation is needed.

Agriculture is one of the most climate-sensitive sectors. Agricultural productivity has greatly advanced with the progression of technology and knowledge over time. In the case of food security, innovative knowledge and technology have significantly enhanced the quantity and quality of food in the agricultural supply system. Vibrant trade has also changed the traditional agricultural production model [24–26]. For the agriculture sector to respond to issues of climate change, professor William Nordhaus highlighted a series of adaptation measures related to the evolution of trade, farm practices, government support, and industry transitions. The measures are viable responses to climate impacts [27]. Because climate patterns, pattern changes, and the corresponding impacts vary from place to place, the most suitable response measures would also vary widely according to local characteristics. Accordingly, new opportunities are likely to be created by feasible measures, and could transform the climate-related threats and risks.

A global network of production chains is tightly interconnected to meet global demand. Trade can effectively reduce cross-border climate risks through swap mechanisms. Conversely, poorly managed trade may increase risks as disaster threats spread across borders. Hence, trade may either increase climate risks or effectively reduce them [10,28]. Transboundary climate risks have been highlighted as key concerns, and have received significant attention in the international policy arena, including the US National Climate Assessment [10] and the European Adaptation Strategy [29], as well as in Article 6 of the Intergovernmental Panel on Climate Change [30]. The knowledge of risk delivery or reduction can help to understand the role of trade in climate adaptation [28].

Trade can serve as a facilitator of biodiversity and climate change impacts. The role of trade in environmental sustainability and climate adaptation has been proposed in the literature. Xie et al. [31] recommended that adaptation policies should consider market and trade responses, since markets contribute to buffering climate change impacts. Huang et al. [32] reported that a well-functioning trade system can support adaptation to the threats of climate change.

Together with the characteristics of local climate and geography, many studies of climate change and natural resource governance are performed in watershed units [33–36]. A watershed is an area of land bounded by ridges, and hence containing a single system of water drainage and flow; it is a hydrological system. A watershed also offers a suitable spatial range to study human–nature cooperation to mediate the threats of climate change to the well-being of communities. It is recommended to adopt an appropriate spatial range that is consistent with the extent of the problem defined by the study of community-based climate governance [37], and by studies that examined the social and natural system proposed by Ostrom [38] and the related literature [39].

In the present study, the climate risks and opportunities of agriculture are studied by selecting a fragile watershed—the Lanyang River Watershed (LRW) in Northeastern Taiwan. As aforementioned, a single river watershed is an appropriate study scale with a physical system of geology, climate, and river flows, and a socioeconomic system of local communities and government policies. At this scale, this study can link the effects of climate change to response measures and strategies for local industry transition. In the area, land classification, planning, and protection infrastructure have long been facilitated by the responsible government agents, including (1) First River Management Agency, Water Resource Agency, Ministry of Economic Affair, Taiwan, (2) Taiwan Forestry Bureau (currently Forestry and Nature Conservation Agency), (3) Water and Soil Conservation Bureau (currently, Agency of Rural Development and Soil and Water Conservation), and (4) Water Resource Department in Yilan county [40–43].

Regarding the social–economic perspective, the high climate vulnerability would strongly impact local agriculture and residents' livelihoods. Moreover, the organisms moved uphill under the increased temperature of climate change [44–46]. The watershed, located in a subtropical area, had problems of uphill and high mountain cultivation [46], as the average temperature in the LRW plain area posed a pressure on vegetable and fruit growing. The issue of agriculture moving uphill contradicts the policy of enhancing resilience toward vulnerable features of the watershed.

As a newly developed economy, the economic role of agriculture in Taiwan is declining. In 2002, Taiwan officially joined the World Trade Organization. With an increasing demand for recreation in the same year, the weekend break increased from 1 to 2 days. Taiwan expanded international produce importation, and import barriers were lowered [47]. Soon after, the Taiwanese agricultural industry began to experience pressure because of the increased importation of agricultural products; some agricultural producers changed their jobs, and some turned to adopt new technologies and recreational farms. To develop Taiwan's leisure agriculture industry, Taiwan's government has initiated a transition away from traditional agriculture, and toward the establishment of recreational agricultural areas and leisure farms.

Agriculture is the traditional livelihood and conventional main work of residents in the LRW. Since 2002, some traditional farmers adhered to the Council of Agriculture's policies and began to transition their farms to leisure farms. As of 2022, in the LRW, 1 leisure agricultural association, 13 agricultural leisure areas, and 60 leisure farms have registered [48]. The operators of these leisure agriculture organizations have successfully transitioned from traditional agriculture to leisure agriculture by creating accommodations, sightseeing tours, and recreational farm facilities. Operators in the agro-leisure industry in the region show resilience and an ability to enact substantial change. Asking for the opinions of leisure agricultural operators can provide valuable information, which reflects the recognition of leisure agricultural operators in the LRW toward the decline of traditional agriculture, the risks of climate change, and transition opportunities. The small population of leisure operators are the stakeholders that demonstrate their perceived risks and how to adapt to threats in transitioning.

The LRW has a unique climate and is fragile yet resilient; in addition, the area is associated with a particular socioeconomic status. Whether local adaptation to climate change is possible is determined by effectively perceiving risks and accurately identifying opportunities for increasing resilience. Hence, the purpose of this study is to explore the local agricultural risks and adaptation, to climate change in the LRW and the impact of this adaptation on residents' livelihoods. Understanding climate change and industrial transformation would help address the challenges and opportunities brought about by climate change.

This study analyzed risks and opportunities in the agricultural industry in the LRW to understand the risks of climate change, the farm practices of adaptation in the region, the key elements of government support for such adaptation, the effects of the transition to leisure agriculture, and the economic benefits of this transition. A three-stage approach was report by Iglesias et al. [49].

The present study adopted a modified three-stage approach, on the basis of Iglesias et al. [49]: Stage 1 field observations, Stage 2 document analysis, and Stage 3 consulting the stakeholders. In Stage 1 and Stage 2, the adaptation measures were explored by document analysis, and the features of the study site are explored by field observation. In Stage 3, a census was conducted on all leisure agriculture operators in the LRW over the phone with a questionnaire, which is designed on the basis of farm adaptation measures by information gathered from Stage 1 and Stage 2. The questionnaire is designed based on the adaptation measures (explored by document analysis in Stage 2), which are screened by features of the study site (explored by field observation in Stage 1).

As aforementioned, leisure agriculture operators have successfully transformed from traditional agriculture to leisure agriculture. Leisure agriculture, transformed from local traditional agricultural production, has demonstrated the resilience and ability to make substantial adjustments to the above-mentioned international free trade and climate change risks, and can successfully reflect that the socioeconomic system is effectively adjusting the natural system to cooperate with the government's soil and water conservation and land planning. For these reasons, the present study conducted a census on this small population to explore their opinions regarding how agriculture is adapting to the changing climate and the associated risks. The census was conducted over the phone to survey opinions of a total of 78 leisure agriculture operators in August 2022. At the end of the phone calls, the respondents were encouraged to share their opinions.

The population, 78 leisure farm agriculture operators in the LRW, was queried over the phone for their opinions. The study was a census of all registered recreational farming operators. There were no issues involving sample size and related parametric statistical tests. The study results can represent the recognition of leisure agriculture operators about climate risks, the adapted changes in planting practices, and the effects on the livelihood of local communities.

Climate change is related to wide range of multidisciplinary issues, with interactions between nature, biodiversity, society and communities, industry, agriculture, and international trade, as suggested by Ortiz et al. [12].

However, a research paper cannot answer all of these questions at once. This research is designed appropriately following the relevant literature, and the focus of this study is set on the risks and adaptation strategies of climate change and the agricultural environment in the LRW. The agricultural environment of the study site is explored and realized by on-site field observation and document analysis (Stage 1 and Stage 2 of the three-stage approach), and the risks and adaptation strategies are assessed by a census of leisure agriculture operators in the LRW. This research can shed light on the issues for which an appropriate design for local climate risks can create new opportunities. However, the highly localized properties of climate impacts limits the generalization and global application of the successful climate governance demonstrated in this study.

2. Materials and Methods

2.1. Study Site

Taiwan is a mountainous island located in Southeastern Asia. The island covers an area of 36,197 km, with an altitude of 3452 m. The mountains in Taiwan are steep, the coastal plains are small, and the population is dense.

The LRW is located in Northeastern Taiwan. The LRW is extremely vulnerable to climate change, illustrating three vulnerable features: (1) a large elevation difference over a short distance, (2) geographical fragility due to highly broken rock formations, and (3) high climate risks due to its location on the windward side, along with rich water resources from monsoon rains.

The watershed area of the Lanyang River is only 978 km^2. The river begins at the northern foot of Nanhu Mountain at an altitude of 3536 m, and the main stream of the Lanyang River is 73 km long (Figure 1). Precipitated water rushes into the Pacific Ocean in a short period of time. The stream drops steeply in elevation over a short distance. In addition, the stream has a fragmented and fragile bedrock structure, and cuts through steep mountainous areas and deep valleys. Rainfall rushes rapidly into the middle and lower reaches of the shallow hills and plains in the area [50–52].

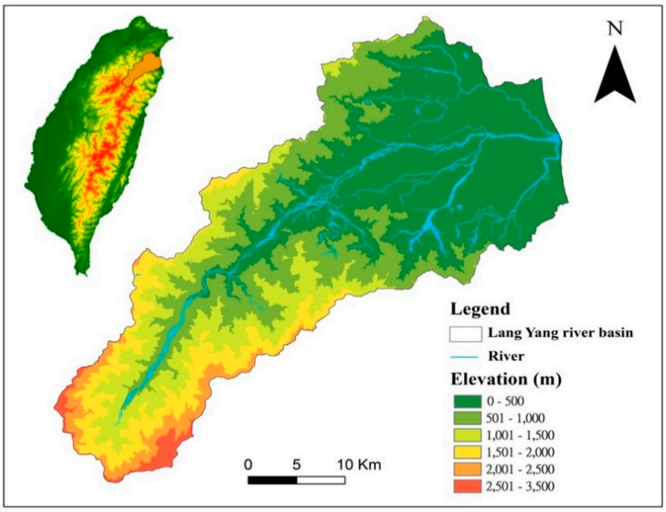

Figure 1. Lanyang River Watershed (LRW). (Source: drawn and prepared by the authors of this paper).

The middle and lower reaches of the LRW have accumulated soil and rocks over time to form the Lanyang Plain, which is approximately an equilateral triangle. The terrain is flat and wide, with numerous towns and cities, and a concentrated population. In view of the frequent floods, water and soil management and flood control work are policy priorities. The LRW is rich in water and ecological resources. The watershed has been maintained and protected by policies of soil and water conservation, slope- and geology-based land classification, and land use planning [53]. The protection for the LRW is especially valid in extreme weather events.

Climatic, geological, and hydrological conditions of the LRW can be further presented in-depth, as follows, based on government website information and documents [53,54].

The LRW belongs to Yilan County in Taiwan. It rains all year round with more than 200 rainy days in an average year. The annual rainfall exceeds 2700 mm. The LRW has never been short of water, but has often had problems with poor drainage due to too much water.

The LRW is in a monsoon climate zone, which is rainy in autumn and winter. In summer, the temperature increases and convective rain is strong. The terrain, which is high in the west and low in the east, directly receives rainfall from typhoon fronts in summer and autumn.

The monthly precipitation is very evenly distributed, and there is abundant rain water injected into the ground to form groundwater; the underground aquifer is in a layer of coarse sand and gravel, distributed from the top to the center of the alluvial fan. The offshore area of the LRW plain is dominated by relatively impermeable sand layers. Since the top and center of the alluvial fan are highly permeable, abundant rainfall penetrates into the ground, and groundwater flows down the slope to the end of the fan. In the fan end area, underground springs are often formed due to pressure, and springs or artesian wells often occur in areas with terrain contours of 10 to 20 m.

The river water in the upper and middle areas of the LRW carries a large amount of soil and rocks, and accumulates them on the coast. The northeast monsoon is strong in winter, forming a sand dune 23 km long, about 10 m high, and 200 to 700 m wide on the Yilan coastline. During the strong winds associated with monsoons or typhoons, the sand dunes act as an effective barrier. However, during ordinary days, the height of the sand dunes, along with the poorly drained soils, will prevent rivers and groundwater from going directly into the sea, and then forming coastal swamps. The rivers flood and meander to break through cracks in the sand dunes, which then go out to the sea and flow into the Pacific Ocean.

Floods have been serious since ancient times. From 1796 to 1850, there were as many as 19 documented deluges, causing rivers to be diverted and fields to be flooded. Typhoons are often the main factor causing disasters in the LRW. Typhoons that occur in the Southwest Pacific tend to move west or northwest. The LRW, which borders the Pacific Ocean to the east, has no mountain barrier. Once a typhoon lands, it often causes heavy loss of life and property.

The terrain downstream of the river was low-lying, and there were sand dunes along the coast that blocked the water flow, much like a reservoir. By 1989, the flooding problem in the low-lying areas was rectified. River improvement projects have been completed one after another; the flooding problem has been improved, and a waterfront park downstream has been planned and completed, becoming an important tourist attraction and the biggest feature of the waterfront park.

2.2. Three-Stage Approach

Iglesias et al. [49] used a three-stage approach to analyze agroclimatic challenges and solutions in various climatic zones in Europe. Iglesias et al. [49] indicated that the advantage of this three-stage analysis method is that it can be used to clearly define the risks of climate change, and transition to seize new adaptation opportunities in specific climatic regions, which can be used as a basis for in-depth research and an analysis of strategies for adapting to climate change. The three stages of the method are determining appropriate adaptation measures, identifying existing adaptation strategies, and consulting stakeholders. The first stage involves referencing research in academic journals, the United Nations Framework Convention on Climate Change, and experts' opinions to determine the effects of climate change and appropriate adaptation strategies [1]. The second stage involves exploring how farms utilize their limited technology and resources to adapt to climate change by, for example, changing planting periods and planting new varieties of crops. These strategies may entail high costs and long-term commitment, and may require cooperation with other farmers or assistance from government agencies. The third stage involves determining stakeholders' opinions through questionnaires and acquiring information regarding agriculture to understand the local effects of climate change and strategies for adaptation [55].

2.3. Limitations and Advantages of the Three-Stage Approach

The three-stage approach has several limitations, which are mainly related to subjectivity in the evaluation of risks and opportunities. In addition, because of the high uncertainty associated with climate change, this method cannot be used to gather qualitative data or to predict adaptation strategies in different times and places. However, according to Iglesias et al. [1,49], this method is still effective in cases of high uncertainty, and enables an informative and valid initial assessment of risks and opportunities in individual agroclimatic zones, which can help in determining the direction of adjustment processes. Researchers can use the method to identify key problems that require further investigation, and the information they obtain can guide further research on climate adaptation.

This study was conducted to help operators in the agricultural industry of the LRW to adapt to climate change through measures that reduce the vulnerability of the industry to climate change. The risk of climate change is likely to increase over time. This study focused on the current risks to the agricultural industry due to climate change and evaluated mid- and long-term adaptation strategies. Because the LRW is a small climatic region, the three-stage approach can be applied to evaluate the risks and opportunities in the area.

2.4. Modified Three-Stage Approach Used in This Study

This study modified the approach of Iglesias et al. [49] by combining the first two stages of the three-stage approach (Figure 2). This study conducted an on-site field observation to understand the local reality, in order to acquire key contextual details and identify factors that create challenges to adaptation in the agricultural industry in the LRW; a structured framework based on these factors was then developed. This study used the framework to create a structured questionnaire on which responses are given on a 5-point Likert scale, with the Likert scale value 5 representing "strongly agree", 4 "agree", 3 "no opinion", 2 "disagree", and 1 "strongly disagree".

Over the phone, the whole population of leisure agriculture operators were asked to express their opinions on the local effects of climate change and the adaptation process; the use of opinion expression at the end of the closed-question items made the survey semistructured.

The modified three-stage approach comprised the following steps:

(1) On-site field observations to understand the LRW.
(2) Document analysis to organize and extract information from the literature because agriculture and adaptation differ by location.
(3) A semistructured questionnaire survey conducted with agro-leisure operators was used to determine the risks to local agriculture due to climate change, and to identify opportunities for adaptation.

Iglesias et al. [49], Iglesias [55], Iglesias et al. [56], and Darwin et al. [57] revealed that risks due to climate change and opportunities for adaptation often differ considerably by agroclimatic zone and society. Iglesias et al. [55] indicated that some of the climate risks described in the literature have long-term effects on areas, rather than immediately observable ones. Thus, climate risks and adaptation strategies exhibit both temporal and spatial differentiation, and appropriate adaptation measures for each region must be identified; this was accomplished in this study through field observation and document analysis conducted in Stages 1 and 2.

In the third stage, this study consulted local stakeholders by conducting a semistructured questionnaire analysis of agro-leisure operators. The focus of the questionnaire was the current agricultural situation, climate risks, and opportunities in the LRW. The questionnaire was based on information acquired through observation in the first stage, and the review of the literature on climate change and adaptation strategies in the second stage. The results of the questionnaire were used to conduct a thorough analysis of the risks to local agriculture due to climate change, and the technologies and policies that are used to adapt (Figure 2).

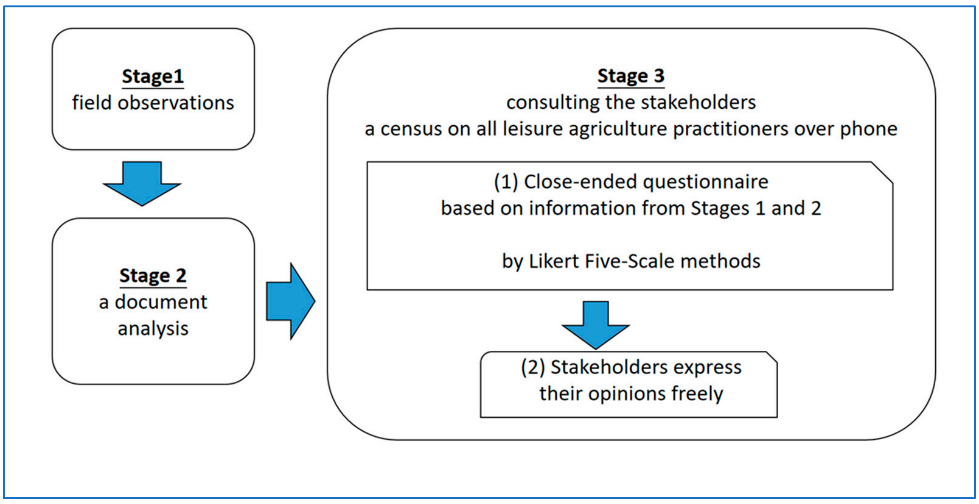

Figure 2. Three-stage approach adopted in this study. (Source: prepared by the authors by modifying information from Iglesias et al. [49]).

2.5. Structured Questionnaire

The items on the questionnaire were rated on a 5-point Likert scale, with 5, 4, 3, 2, and 1 points indicating strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree, respectively; the resulting data were ordinal. The intervals on this Likert scale are not equidistant, which means that the data that were obtained using this scale are not ratio data. According to the report made by Boone and Boone [58], data concentration and dispersion differ between interval and ratio data. Arithmetic means, standard deviations, correlation coefficients, analyses of variance, and t tests are only applicable for interval and ratio data. Following the suggestion of Boone and Boone [58], this study used medians and modes to determine data centralization, and used the frequency of each type of response on the questionnaire to show the discrete nature of the data (Table 1).

Table 1. Relevant statistics for census survey.

	Ordinal/Nominal Data from Likert Scale	**Interval/Ratio Data**
Data concentration	Medians, modes	Means
Data dispersion	Frequency, range	Standard deviation
Other methods	Chi-squared test	Analysis of variance, *t* test, regression

Source: prepared by the authors with open-access information from Boone and Boone [58].

2.6. Census over the Phone by Interviewing Leisure Agriculture Operators

This study administered the questionnaire, which comprised closed-ended question items and follow-up expression of their opinions on risk and adaptation measures, through telephone interviews. The list of registered agro-leisure operators that were contacted is available online on the website for the Agriculture Department of Yilan County [48]. During the telephone interviews, the respondents described their views on risks and opportunities in relation to the key factors of the framework, and responded to the closed-ended items. If respondents were unavailable or unable to complete a phone interview at the first call, a Google Forms questionnaire was provided by email, and follow-up telephone calls were made until the questionnaire was completed. In addition to the structured questions, the respondents were asked to express their opinions on the local risks and adaptation measures. The interviewers then organized the respondents' opinions, and combined them with their responses to the structured part of the questionnaire. The results were used to analyze the risk to agriculture due to climate change and adaptation strategies in the LRW.

3. Results

3.1. Field Observations and Document Analysis as the Basis for Questionnaire Design

A series of studies provided lists of risks due to climate change, and opportunities for adaptation [27,49,55–57,59–64]. Among the literature reviewed in this study, the report of Iglesias et al., published in 2012 [49], provided clear information on the agriculture risks from climate change and the accompanying adaptation strategies. Referring to the organized knowledge that identifies risks and opportunities for adaptation in different climate zones in the literature, the preliminary judgment for their local relevance is made by information from field observations; on this basis, a questionnaire was designed. The measures applied in the LRW would be made clear after consulting the local stakeholders, based on the opinions of leisure agriculture operators.

The information organized from Stage 1 and Stage 2 of the modified approach adopted by this study were used as the basis for creating the framework for the stakeholder questionnaire that would be applied in Stage 3. The results of the observation and document analysis are illustrated in Table 2. In this table, the knowledge of potential local LRW local climate risks, the farm adaptation practices, and supporting government measures are organized by screening the European agriculture inventory of farm adaptation measures listed by Iglesias et al. [49].

Table 2. Risks due to climate change and adaptation strategies in the LRW.

Dimension	Item (Agreement Measured by 5-Point Likert Scale, 5 Representing "Strongly Agree", 4 "Agree", 3 "No Opinion", 2 "Disagree", and 1 "Strongly Disagree".)
Dimension 1: Risks	1. The LRW is highly sensitive to climate change 2. The LRW has been affected by changes in temperature 3. The LRW has been affected by an increased frequency of short extreme rainfall events 4. The LRW has been affected by an increased frequency of long extreme rainfall events 5. The LRW has been affected by insufficient sunshine levels 6. The LRW has been affected by an increase in the frequency of severe typhoons
Dimension 2: Farm measures	1. Changing crop species and varieties 2. Introducing heat-tolerant species 3. Introducing drought-tolerant species 4. Introducing flood-tolerant species 5. Changing farming practices 6. Changing the use of agricultural materials 7. Adopting climate-smart agriculture 8. Diversifying crops 9. Adjusting planting times 10. Using high spatial variation during crop cultivation 11. Changing planting positions 12. Planting in high-altitude mountainous areas to avoid high summer temperatures
Dimension 3: Government support	1. Facilitating agricultural relocation to hilly areas or higher altitudes 2. Mitigating the effects of high-altitude agriculture on the environment 3. Promoting the use of innovative technology 4. Developing and using new varieties 5. Promoting greenhouse planting 6. Adopting new irrigation technology 7. Monitoring the impact of climate on agriculture 8. Providing systems for monitoring climate and land use 9. Developing early-warning systems 10. Providing information and agricultural extension services 11. Establishing a disaster assistance fund to accelerate recovery 12. Promoting insurance for climate disasters 13. Investing in climate adaptation strategies
Dimension 4: Transitions in hilly areas	1. Moving agriculture from plains to hilly areas 2. Developing leisure agriculture in hilly areas 3. Developing ecotourism in hilly areas 4. Developing organic agriculture in hilly areas

3.1.1. Key Factors Elicited from Field Observations and Document Analysis

Agrawala et al. [59] and Shardul et al. [60] indicated that farmers adopt low-cost and commonly used adaptation measures, and new technologies to adapt to such risks. Iglesias et al. [49] revealed that because of budgetary, knowledge, and technological limitations, farmers are more likely to use low-cost strategies to adapt to climate change, such as changing planting periods and planting new varieties. Those adaptation measures beyond the farmers' affordability or capability would be left to the support from the government; such an investment in and the development of new methods of adaptation entail high costs, long-term commitment, and cooperation with other farmers.

Iglesias et al. [49] emphasized the importance of using available technology for agricultural extension. Iglesias et al. [49] also indicated that farmers rely heavily on agricultural extension in executing their strategies for adapting to climate change.

Iglesias et al. [49] and Nainggolan, Termansen, and Zandersen [64] demonstrated that government intervention in the private sector and related market systems to facilitate adaptation to climate change requires public financing; the public sector generally provides sufficient funding for, and has a strong commitment to, implementing climate change adaptation policies. The government often implements public measures such as land use plans based on scientific methods of land classification, soil and water conservation measures based on ecological engineering, construction of public infrastructure, social insurance, and investment in education and research.

The results of Iglesias et al. [49] and Nainggolan, Termansen, and Zandersen [64] are applicable to the LRW, and the knowledge was screened for consistence with the reality established from local field observations. The government's long-term policies have helped the LRW's society and economy adapt to climate change. Government policy plays a crucial role in facilitating adaptation to climate change, and long-term adaptation is critical. The establishment of relevant infrastructure was set up by dedicated institutions to deal with issues of water and soil conservation and disaster prevention, such as the aforementioned agencies, Forestry and Nature Conservation Agency, Agency of Rural Development and Soil and Water Conservation, and Water Resource Department in local Yilan County. The implemented land classification and land planning policies have boosted soil and water conservation, and environmental education has increased public awareness of environmental problems and conservation. The policy promoted by the government for the transition from conventional agriculture to recreation-oriented agriculture and ecotourism are facilitated to drive the local economy, increase income levels, and mitigate the negative effects of climate change on agriculture in the LRW.

The government providing meteorological information services information and climate warning to farmers in real-time is essential for the adaptation process, because it helps prevent agricultural disasters and improves the response to climate change [65]. According to Iglesias et al. [49] and Nainggolan, Termansen, and Zandersen [64], new technologies, policy action, and agricultural extension can help farmers adapt to climate change. Ecological economists revealed the reality that the ecology and the economy are closely related [66]. Natural solutions to environmental and climatic problems are increasingly being proposed. Ensuring that individuals understand and respect nature can facilitate the coexistence of humans and nature. Hence, natural-based solutions to the problems of climate change and environmental degradation are proposed [67]. Li et al. [68] indicated that well-managed ecosystems that have distinct natural features and local community characteristics contribute to ecological services and economic value. The forest ecosystem of the LRW provides services and various forms of economic value [50,51]. Natural ecosystems can regulate local microclimates, and thereby adapt to extreme temperatures. Forests have cooling effects on hot days because of canopy coverage, shading, evapotranspiration, and reflection. Areas with higher forest coverage have higher value for residents because of these climate-regulating effects.

With climate change resulting in extremely high temperatures in the summer, forests can provide microclimate areas in which people can cool off [69,70] and create benefit to the community [71,72]. The LRW and many other areas in Taiwan are highly developed, and the plains are used for commercial, industrial, and residential purposes. As a result, agriculture in such areas has gradually moved uphill, into higher-elevation regions. Climatic factors strongly affect agriculture. High temperatures cause changes in fruit and vegetable growth, and increase the prevalence of pests and disease [73]. High temperatures in the summer lead to the uphill cultivation of fruits and vegetables. New technologies, research on and development of new crop varieties, and scientific decision-making can ensure the rational use of land. The uphill cultivation often causes soil erosion and landslides after heavy rainfall in the LRW.

Residents of the LRW highly value the environment, due to their conceived high risk of climate disasters. Although no active initiatives for eco-villages have been introduced [74–77], Taiwan has implemented community-based management of marginal forests [78,79] and developed ecotourism in forested areas. Mountainous forests from high to low altitudes in the LRW are under the jurisdiction of the Yilan branch of the Forestry and Nature Conservation Agency (formerly the Luodong Forest District Management Office of Taiwan Forestry Bureau). The government develops forest trails on low-altitude hillsides, which, in addition to community comanagement, has produced high-quality ecotourism. Thus, ecotourism is flourishing in the LRW.

Agriculture is a climate-sensitive sector, and its transitions in response to climate change had been inspected from a wide range of perspectives [80–82]. There are tight linkages between agricultural climate strategies, farm management, and long-term land use [81]. Taiwan is developing ecological, organic, and recreational agricultural industries. However, it is hard to find a place suitable for growing organic products in the plains area [83,84]. Spatial limitations, pests and weeds, pollution from adjacent fields, and negative business reputations with occasionally detected chemical contamination have been barriers to the development of organic agriculture. Nevertheless, it is possible to develop organic agriculture in the low-altitude mountainous areas of the LRW. Research on the development of organic agriculture in the LRW has indicated that the flat areas along the hills of the LRW, which are surrounded by mountains and covered with forests, and offer pure water and soil, are suitable for organic farming and ecofriendly farming.

3.1.2. Questionnaire Based on Knowledge from the Approach in Stage 1 and Stage 2

On the basis of the literature review and field observations, this study developed closed-ended items for the questionnaire that covered the risk, adaptation strategies, government support, and transition strategies in the hilly areas of the LRW. Four transition strategies for the hilly areas were identified: moving agriculture from plains to hills, developing leisure agriculture in hilly areas, developing ecotourism in hilly areas, and developing organic agriculture in hilly areas. The respondents were also asked about their opinions regarding whether these strategies have (1) increased the income of local residents, (2) supported farms, or (3) diversified income streams.

3.2. Consulting Stakeholders

3.2.1. Interviews

In August 2022, 78 leisure agriculture operators were interviewed over the telephone. At the time, COVID-19 was still affecting Taiwan. Of the 78 respondents, 51 completed the structured questionnaire, and 23 provided their opinions.

3.2.2. Socioeconomic Background of the Respondents

The average age of the 51 respondents who completed the structured questionnaire was 55.37 years (Table 3), and their average education level was high school (average of 14 years of education). The distribution of sex among the respondents was nearly even (51% men).

Table 3. Socioeconomic background of respondents of structured questionnaire.

Variable	Mean	Standard Deviation	Maximum	Minimum
Sex (man = 1; woman = 0)	0.51	0.50	1	0
Age (years)	55.37	11.18	75	24
Education level (years)	13.92	2.64	18	9

Note: these statistics represent the 51 respondents who completed the structured questionnaire.

3.2.3. Results of Structured Questionnaire

According to Boone and Boone [58], the results of questionnaires responded to using 5-point Likert scales are not interval or ratio data; for this reason, descriptive statistics of means and standard deviations should not be used to represent centrality and dispersion. Rather, descriptive statistics of medians, modes, and frequency are rather meaningful in the agreement study measured by the Likert five-point scale. Likert scale 5 represents “strongly agree”, 4 “agree”, 3 “no opinion”, 2 “disagree”, and 1 “strongly disagree”.

This study screened out irrelevant items on this basis. A median score being higher than 4 points for an item indicates more than 50% of respondents strongly agreed with the item, and that the item is crucial; items with a median of 4 are considered important in this study. It is considered very important if the median is 5.

Dimension 1: Risks

Six items were about risks due to climate change in the LRW in the 10 years prior to the date of the questionnaire survey. Table 4 presents the results for these items. More than half of the respondents strongly agreed that the following five statements were important: "The LRW is highly sensitive to climate change", "The LRW has been affected by changes in temperature", "The LRW has been affected by an increased frequency of short extreme rainfall events", "The LRW has been affected by an increased frequency of long extreme rainfall events", and "The LRW has been affected by insufficient sunshine levels".

Table 4. Results for Dimension 1: Risks.

	Agreement on 5-Point Likert Scale					-	
	5	**4**	**3**	**2**	**1**	**Median**	**Mode**
1. The LRW is highly sensitive to climate change	24	19	7	1	0	4	5
2. The LRW has been affected by changes in temperature	22	24	5	0	0	4	5
3. The LRW has been affected by an increased frequency of short extreme rainfall events	18	16	12	5	0	4	5
4. The LRW has been affected by an increased frequency of long extreme rainfall events	21	15	9	5	1	4	5
5. The LRW has been affected by insufficient sunshine levels	11	16	12	11	1	4	4
6. The LRW has been affected by an increase in the frequency of severe typhoons	10	11	24	6	0	3	3

Note: results are based on the 51 respondents who completed the structured questionnaire.

The results indicate that the risks to agriculture due to climate change in the LRW are mainly related to short and long intense rainfall events and insufficient sunshine levels. Because few typhoons have affected Taiwan in the last 5 years due to climate change, the respondents may not have considered typhoons to be a problem for the LRW.

Dimension 2: Farm Strategies

Seven of the twelve items in Dimension 2 exhibited median scores greater than 4 points, indicating that more than 50% of the respondents felt that these strategies were crucial (Table 5). The strategies were changing crop species or varieties, changing farming practices, changing the use of agricultural materials, adopting climate-smart agriculture, diversifying crops, adjusting planting times and dates, and using high spatial variation during crop cultivation.

Table 5. Results for Dimension 2: Strategies.

	Agreement Measured on 5-Point Likert Scale						
	5	**4**	**3**	**2**	**1**	**Median**	**Mode**
1. Changing crop species and varieties	12	18	17	3	1	4	4
2. Introducing heat-tolerant species	13	10	23	4	1	3	3
3. Introducing drought-tolerant species	14	9	23	4	1	3	3
4. Introducing flood-tolerant species	13	12	23	2	1	3	3
5. Changing farming practices	16	14	17	3	1	4	3
6. Changing the use of agricultural materials	15	19	16	1	0	4	4
7. Adopting climate-smart agriculture	12	14	22	3	0	4	3
8. Diversifying crops	16	14	18	3	0	4	3
9. Adjusting planting times	14	15	19	3	0	4	3
10. Using wide spatial variation during crop cultivation	9	18	22	2	0	4	3
11. Changing planting positions	10	14	24	3	0	3	3
12. Planting in high-altitude mountainous areas to avoid high summer temperatures	6	12	23	10	0	3	3

Note: results are based on the 51 respondents who completed the structured questionnaire.

In response to climate change, farmers have begun to plant crops that are more tolerant to high temperatures, drought, and waterlogging. The LRW has a wealth of water resources, the temperatures on its hillsides are mild, and its drainage capacities are high. Because the arable land on the LRW's hillsides has been fully utilized, planting sites cannot be adjusted in these areas. Farms in the high-altitude mountainous areas of the LRW are extremely vulnerable to soil and water hazards. The respondents did not agree that moving to high-altitude mountainous areas to avoid high summer temperatures would be an effective strategy.

Dimension 3: Government Support

Agricultural extension and government support are crucial for enabling agricultural management systems to address problems such as climate change. Dimension 3 of the questionnaire, government support, comprised 13 items. Table 6 presents descriptive statistics for the responses to the items in this dimension. Twelve of the thirteen items exhibited median scores higher than or equal to 4 points. Eight of these items had a median score of 4 points, and four items had median scores of 5 points. The median score for item 1 was 3 points. The results indicate that the respondents disapproved of moving agriculture to hillsides or higher elevations. The items that received median scores of 4 points were mitigating the effects of high-altitude agriculture on the environment, promoting the use of innovative technology, developing and adopting new varieties, promoting greenhouse planting, adopting new irrigation technology, monitoring the impact of climate on agriculture, providing systems for monitoring climate and land use, and developing early-warning systems. The items that received a median score or 5 points were (1) providing information and agricultural extension services, (2) establishing a disaster assistance fund to accelerate recovery, (3) promoting insurance for climate disasters, and (4) investing in climate adaptation strategies.

Table 6. Results for Dimension 3: Government support.

	Agreement Measured on 5-Point Likert Scale						
	5	**4**	**3**	**2**	**1**	**Median**	**Mode**
1. Facilitating agricultural relocation to hilly areas or higher altitudes	11	12	9	18	1	3	2
2. Mitigating the effects of high-altitude agriculture on the environment	16	15	8	12	0	4	5
3. Promoting the use of innovative technology	23	19	8	1	0	4	5
4. Developing and using new varieties	18	17	12	3	1	4	5
5. Promoting greenhouse planting	18	19	10	4	0	4	4
6. Adopting new irrigation technology	21	16	9	5	0	4	5
7. Monitoring the impact of climate on agriculture	24	18	6	3	0	4	5
8. Providing systems for monitoring climate and land use	21	18	9	3	0	4	5
9. Developing early-warning systems	25	16	8	2	0	4	5
10. Providing information and agricultural extension services	33	15	3	0	0	5	5
11. Establishing a disaster assistance fund to accelerate recovery	38	10	3	0	0	5	5
12. Promoting insurance for climate disasters	38	11	2	0	0	5	5
13. Investing in climate adaptation strategies	32	17	2	0	0	5	5

Note: results are based on the 51 respondents who completed the structured questionnaire.

The results reveal the respondents' opinions regarding government support. To address the risks of climate change, farmers rely heavily on government support. The respondents did not believe that the government should promote agricultural expansion to the hilly areas of the LRW, nor did the respondents approve of the movement of agriculture to higher altitudes. According to the results, the respondents had a strong demand for governmental assistance in mitigating the effects of high-altitude agriculture on the environment. In addition, the respondents expressed a desire for the government to promote the use of innovative technology, new crop varieties, greenhouse cultivation, new irrigation techniques, weather, climate, and land use monitoring through geographic information systems, and early-warning systems. In addition, the results indicate that the respondents rely on governmental information, agricultural extension services, disaster relief funds, compensation for crop loss by major natural disasters, climate disaster insurance, and investment in climate adaptation strategies.

Dimension 4: Transition Strategies for Hilly Areas

This study proposed four transition strategies for the agricultural industry in the LRW: moving agriculture from plains to hilly areas, developing leisure agriculture in hilly areas, developing ecotourism in hilly areas, and developing organic agriculture in hilly areas. Table 7 presents the results for Dimension 4. The respondents expressed less support for moving agriculture from the plains to hilly areas, but strong support for the other three strategies (means scores of 4 points for each). The results indicate that the respondents consider developing leisure agriculture, ecotourism, and organic agriculture in hilly areas to be reasonable.

Table 7. Results for Dimension 4: Transition strategies for hilly areas.

	Agreement Measured on 5-Point Likert Scale						
	5	**4**	**3**	**2**	**1**	**Median**	**Mode**
1. Moving agriculture from plains to hilly areas	12	9	10	18	2	3	2
2. Developing leisure agriculture in hilly areas	20	20	8	2	1	4	4
3. Developing ecotourism in hilly areas	25	21	4	1	0	4	5
4. Developing organic agriculture in hilly areas	19	19	4	6	3	4	4

The results in Tables 7 and 8 indicate that the four transition strategies can offer economic benefits in increasing local income, supporting farms financially, increasing residents' income, and diversifying income streams.

Table 8. Economic benefits of strategies in Dimension 4.

	Agreement Measured on 5-Point Likert Scale						
	5	**4**	**3**	**2**	**1**	**Median**	**Mode**
Moving agriculture from plains to hilly areas							
Increasing local income	11	16	5	17	2	4	2
Supporting farms financially	14	13	7	15	2	4	2
Increasing residents' income	15	14	7	13	2	4	5
Diversifying income streams	15	14	6	14	2	4	5
Developing leisure agriculture in hilly areas							
Increasing local income	18	22	5	5	1	4	4
Supporting farms financially	20	24	2	4	1	4	4
Increasing residents' income	20	23	4	3	1	4	4
Diversifying income streams	20	25	2	3	1	4	4
Developing ecotourism in hilly areas							
Increasing local income	21	22	4	4	0	4	4
Supporting farms financially	22	24	1	4	0	4	4
Increasing residents' income	24	22	2	3	0	4	5
Diversifying income streams	23	24	1	3	0	4	4
Developing organic agriculture in hilly areas							
Increasing local income	19	17	5	8	2	4	5
Supporting farms financially	20	17	3	8	3	4	5
Increasing residents' income	20	18	3	7	3	4	5
Diversifying income streams	20	19	2	7	3	4	5

3.2.4. Respondents' Opinions

A total of 23 interviewees expressed their opinions during the telephone interviews. Ten themes were identified from their opinions.

Risks of Climate Change on Agriculture

In the LRW, several aspects of climate change, such as heavy rain, long rainy seasons, and high temperatures, have strongly affected agriculture. However, few typhoons have occurred, and the threat of typhoons has decreased. In 2020, farmers were required to deal with a water shortage. The precipitation and hydrology patterns have changed.

Fallows for Insufficient Sunshine and in Low-Lying Areas

Rice cultivation typically comprises two phases. In the LRW, the second phase involves full fallowing because the area receives insufficient sunshine levels. During the first phase, some low-lying areas are also fallowed.

New Technology and Greenhouses Can Help Adapt

Farmers tend to have conservative attitudes toward new technology, and only use widely accepted technology. For this reason, they require assistance from agricultural extension institutions. The LRW experienced the strong impacts by typhoons, and greenhouses in the area must be strong enough to withstand heavy wind and rain, which entails high costs. The standard government subsidies that the rest of Taiwan receives are thus insufficient for ensuring the structural integrity of greenhouses in the LRW. In addition, greenhouses cost most to build in mountainous areas. Although greenhouse farming is an effective strategy for adapting to climate change, it entails high costs for farmers.

Infeasibility of Large-Scale Farming by Adopting Greenhouse Farming

Large-scale outdoor farms on plains can be strongly affected by climate change. Some of the respondents expressed a pessimistic attitude toward early-warning and preventive measures, since these measures are claimed to have little effect on large-scale outdoor farming.

High Reliance on Government Policy and Disaster Relief

Farmers rely on guidance from the government, and they have expectations regarding the government's policies. Farmers highly value the government's disaster relief subsidies. The respondents of this study expressed positive attitudes toward the government's policies overall.

Moving Agriculture to Hilly Areas Is Unadvisable

Increases in temperature due to climate change have made the farming of vegetables and fruits in the plains of the LRW difficult. Moving agriculture from plains to hills is not a sufficiently effective method for mitigating the effects of increases in temperature due to climate change. This movement would have little effect, and it is possible to have a suitable temperature for planting at high altitudes. The frequent heavy rainfall in the hilly areas of the LRW often causes landslides, which prevents agriculture from completely being moved to such areas. In addition, farming in high-altitude areas may be difficult because of the steep terrain.

Most land in the mountainous areas in the LRW is protected by government land use regulations. In addition, the terrain is steep, and the land is less fertile. Most of the land that can be used for farming is already in use. Moving temperature-sensitive farms from the plains to the mountainous areas of the LRW is unrealistic. It would also be likely to cause landslides and to affect water sources. The use of hilly areas for farming is also limited by the difficult terrain, and pushing the land beyond its natural limits would be unadvisable.

Organic Farming in Limited Hilly Spots

Organic farming requires the monitoring of adjacent fields. Organic agriculture should be well regulated, the farm operators should honestly follow organic farming practices, and the long-term development of the production and marketing systems should be strictly monitored. The regulatory standards for ecofriendly agriculture are less strict than those for organic agriculture. Hilly areas are often surrounded by mountains and forests. Because these adjacent areas have healthy forest ecosystems, organic farming may be possible. Healthy forest ecosystems would enable organic farming. Some farmers in the LRW practice organic farming or ecofriendly agriculture.

Transition from Planting to Recreation to Reduce Climate Change Risk

Some respondents transitioned from agriculture to businesses and practices that are less affected by climate change. Five respondents described the effects of the transition. The first respondent completely transformed their farm into a leisure farm, and implemented (1) greenhouse-based, precision-technology planting, (2) horticultural planting, (3) produce processing, and (4) forest gardens. The farm transitioned out of outdoor farming. The second and third respondents transitioned their farms into recreational aquaculture facilities, and then had fewer problems adapting to climate change. The fourth respondent transformed their farm into an agro-leisure and rural accommodation facility, and began offering rural do-it-yourself experiences. Accordingly, the respondent did not adapt their planting practices to climate change. The fifth respondent focused on developing rural accommodation facilities, and thus did not adapt their practices to climate change.

Positive Effects of Transition to Leisure Agriculture in the LRW

Leisure agriculture can provide farmers with a more stable income than traditional agriculture can. For leisure farmers, the risks due to climate change are lower than those encountered by traditional farmers. Thus, the effects of climate change are weaker for farmers that transition to leisure farming, and such a transition is associated with increased income and stability. Transitioning to leisure agriculture and ecotourism is thus a feasible strategy for adapting to climate change.

Local Viable Measures by Land Classification, Long-Term Land Planning, and Ecotourism

Ecotourism development, as associated with long-term policies of land classification, long-term-land planning, and soil and water conservation, are a feasible strategy for adapting to climate change in the LRW.

4. Discussion

4.1. Feasibility of the Study Scale

A watershed is a single physical system consisting of river flows, and the effects of climate change can be controlled at the watershed scale through socioeconomic adaptation strategies, which include community activities and policy. At this scale, policymakers have access to a sufficient amount of information to formulate feasible climate change adaptation policies. By selecting a location at this scale, the LRW, this study was able to analyze climate risks and opportunities for adaptation in agriculture. This study also linked the effects of climate change to strategies for transitioning agriculture in the LRW. As recommended by Ostrom [38], Cumming et al. [39], Cox, Arnold, and Tomás [37], a feasible range should be determined based on the scope of the problem.

4.2. Farm and Government Adaptation Strategies as Measured in the Short- and Medium-Term

The inventories of farm risks and opportunities to climate change in the literature [49,64] were screened by the local reality and opinions of the whole population of leisure agriculture operators as stakeholders. Compared with the literature [49,64], local risks and corresponding adaptations vary due to the locality of varying climatic zones, differing altitude, and terrain characteristics [22]. Although the farm risks and adaptation measures in the LRW differed, this study yielded three similar results. (1) Climate change has imposed risks for farms. (2) In the short-term, farmers adopt available measures, such as adjusting farming practices. Farmers often adopt already available, less costly and less skill-demanding adaptation measures.

(3) Government support is crucial to the farm adaptation process. For this reason, institutions and governmental agencies were suggested to provide advanced technology and investment in infrastructure in the medium-term. Governments should also provide information on climate change, greenhouse technology, and accurate weather forecasts and early-warning messages to facilitate adaptation. Financial aid of disaster relief from the government is also essential.

4.3. Long-Term Agricultural Transition

Zagaria et al. [23] studied transformation to adapt to meet the needs for higher adaptation as the limits of adaptation approach. Transformation would be a strategy, along with appropriate adjustments, to respond to the risks due to climate change, to create new opportunities in the LRW and for the well-being of the local communities [10,11,13].

According to the results from the structured questionnaire, moving agriculture from plains to hilly areas and developing leisure agriculture, ecotourism, and organic agriculture in hilly areas would have economic benefits, namely, increasing local income, increasing residents' income, supporting farmers financially, and diversifying income streams.

Transitioning from traditional agriculture to recreational agriculture and ecotourism represents a key opportunity for the LRW. However, temperature increases due to climate change have caused agriculture in the LRW to move uphill, which has created problems in water and soil conservation. Rural recreation, ecotourism, and small-scale organic farming in hillside forests can balance the multiple needs of (1) increasing local income levels, (2) ensuring soil and water conservation, (3) protecting forests and conserving ecosystem services, and (4) long-term local farm adaptation to climate change in the LRW.

4.4. Encountering Risks and Creating Opportunities for Adaptation in the LRW

Based on the trade liberation of Taiwan in 2002, and the economic role of farming in the LRW, transition is on the way. Tilling is transforming and not yet abandoned. Risks and adaptation measures are important to basin-wide human–nature cooperation [13] for new opportunities, and for the well-being of the communities. It is imperative to study the climate risks and opportunities for adaptation for farming in stream basins. Therefore, basin-wide agroclimate adaptation, transition strategies, and benefits were investigated with a reliable and sound investigation methodology. The results illustrated that transitioning to leisure agriculture and innovation are crucial to adapting to climate change in the LRW. Land grading and land use planning in plains, hilly areas, and deep mountain areas, along with water and soil conservation, can increase the LRW's resilience to climate change. Feasible strategies for adapting the LRW include agricultural extension, the use of greenhouse technologies to plant high-economic-value crops, a transition to leisure agriculture, organic farming, and implementing ecotourism in nearby forests; these strategies can create opportunities for agriculture in the LRW, and help traditional farmers survive in this highly climate-sensitive area. The implementation of leisure agriculture, ecotourism in nearby areas, environmental education, and food and agricultural education would ensure that agriculture can be sustained in this region.

5. Conclusions

Under the current emergency of climate change, humans need to response to climate change by mitigation and adaptation measures. Due to limited success of mitigation in combating climate change, confronting climate change by appropriate adaptation measures can create positive new opportunities. Risk and adaptation vary from place to place, with local characteristics. Climate adaptation measures may deeply involve interactions between nature, local industries, risks of climate change, and trade. Policy design often takes a multidisciplinary approach. Human–nature cooperation would mediate the threats of these risks.

Agriculture is a climate-sensitive sector which encounters risks from climate change. Advance technologies and knowledge are applied to increase agricultural productivity for food security, while vibrant trade changes the traditional agricultural production model.

The evolution of trade, farm practices, government support, and industry transitions are viable responses to climate impacts.

The purpose of this study is to explore agricultural risks and adaptation measures that create opportunities in the Lanyang River Watershed, a climate-vulnerable watershed in northeastern Taiwan. Agriculture is a traditional sector in the watershed, and is highly vulnerable to the impacts of climate change. Due to the trend of agricultural trade liberalization and the removal of international trade barriers in Taiwan, its production role is declining, and the government encourages local farmers to transform into leisure farm types.

The economic importance of traditional tilling farming in the watershed declines in the watershed, while land governance and soil and water conservation become more important during the current climate change emergency. Leisure agriculture operators adjust traditional farming practices into leisure agriculture. They are the ones who successfully transformed. How leisure agriculture operators perceived the risk and adapted to climate change would be critical to decision-makers for enabling feasible local climate adaptation measures.

The opinions of leisure agriculture operators who successfully transformed from traditional tilling are investigated with a three-stage approach, involving (1) Stage 1, field observation, (2) Stage 2, document analysis and literature review, and (3) Stage 3, population census on leisure agriculture operators with a questionnaire designed based on the information gathered in Stages 1 and 2.

Several results reveal the risks and opportunities, along with viable adaptation measures. Farming in the watershed is highly sensitive to climate change, and encounters risks from higher temperatures in the summer, short extreme rainfall events, long extreme rainfall events, and insufficient sunshine. Moreover, due to atmospheric changes in the western Pacific Ocean, the number of typhoons affecting Taiwan has decreased in the past five years, and typhoons are not as serious a problem as before.

Transitioning to leisure agriculture and innovation are crucial to reduce the threats of climate change. Planning through the grading and zoning of land, and water and soil conservation, are essential to increasing climate resilience. Rising temperatures are prompting the shift of agriculture from low-altitude plains to high-altitude mountainous areas, which may be unreasonable in mountainous areas with steep terrain, threatening soil and water conservation and causing landslides.

In addition to transitioning to leisure farming, the agriculture operators hold high agreement on the adaptation measures of (1) using greenhouse technologies to plant high-economic-value crops, (2) engaging in organic farming, and (3) using organic processing methods. These measures can enhance farm adaptation to climate change. Ecotourism can also facilitate the development of leisure agriculture in the area, which is likely to become a crucial and sustaining feature of the region, and to create an important model of human–nature cooperation.

The results obtained using the three-stage method indicate that leisure agriculture and technological innovation can improve earning potential and help climate adaptation. Ecotourism, land zoning and planning, and soil and water conservation are also vital to ensuring the successful adaptation to climate change.

The implications of this case study are that domestic, appropriate responses can improve local climate resilience, and that well-designed adaptation measures can transform threats and risks into new opportunities.

Since the viable adaptations differ from place to place, the results of the present study reflect risks and measures based on unique local features. This study's results represent the opinions and perceptions of the leisure agriculture operators, and reflect the local critical adaptation measures, as well as the local industry transformation model.

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