


Article

Unraveling Risk Networks of Cultivated Land Protection: An Exploratory Stakeholder-Oriented Case Study in Xiliuhe Town, Hubei Province, China

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Abstract: The protection of cultivated land plays an important role in ensuring food security, maintaining social stability, and promoting economic development. The protection of cultivated land involves a range of stakeholders (e.g., governments at different levels, farmers, and land-use organizations) and entails intertwined risk factors (e.g., to economic, environmental, social, and political factors). Therefore, it is crucial to identify and assess key stakeholders and associated risks to better align land protection policies. However, previous studies of risk are fragmented, and there has been little research targeting the complex interactions among risk factors in the protection of cultivated land. Taking Xiliuhe Town as an example, this study analyzes complex and intertwined risk factors from a network perspective in an in-depth case study in a major grain-producing area. The results show that: (1) the risk-factor network of cultivated land protection is relatively sparse, with a total of 142 nodes and 253 links; (2) local governments and land flow-out farmers are the core stakeholders, with strong power and connectivity in the network; (3) taking into account key stakeholders and associated risk factors, a framework for mitigating risks is developed, and a network simulation is performed. Using the simulation results, the effectiveness of the risk-mitigation strategies is assessed and validated. These results shed new light on cultivated land protection and sustainable agricultural development in emerging countries.

Keywords: cultivated land governance; risk factor; stakeholder; social network analysis; case study



Citation: Guo, Z.; Guo, Q.; Cai, Y.; Wang, G. Unraveling Risk Networks of Cultivated Land Protection: An Exploratory Stakeholder-Oriented Case Study in Xiliuhe Town, Hubei Province, China. *Land* **2021**, *10*, 1222. <https://doi.org/10.3390/land10111222>

Academic Editors: John Tomaney and Tamara Antonia Krawchenko

Received: 25 September 2021

Accepted: 5 November 2021

Published: 10 November 2021

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1. Introduction

Cultivated land, an increasingly precious natural resource, yields agricultural products, conserves water, mitigates climate change, and provides recreational landscape functions [1]. Thanks to the rapid worldwide economic development that began at the end of the 1970s, as well as the acceleration of industrialization, urbanization, and modernization beginning at that time, the vast population and the excessive expansion of urban and rural construction land (urban–rural construction land is an essential component of land-use type in China. This type of land use serves for the development of buildings and infrastructures) have put huge pressure on the protection of cultivated land resources [2–5]. In emerging countries, land resources have become the main limiting factor constraining economic growth [6]. To ensure continued economic development, local governments are seeking to promote the transformation of agricultural land to construction land [7,8]. In such land transfer, farmers reasonably switch grain production to other types of agricultural production to increase their own profits, improve their livelihoods, and promote rural revitalization [9,10]. However, excessive non-grain production trends lead to significant declines in the quantity and quality of cultivated land. Meanwhile, rural population aging, massive transfers of rural labor, and the expanded scope of abandoned farmland demonstrate a notable trend that threatens food security and agricultural stability [11,12].

The protection of cultivated land is a huge challenge globally [13]. In the Mekong Delta, the overexploitation of land resources and the prevalence of inappropriate agricultural practices by local communities have accelerated land degradation [14]. In northern China's Rocky Mountains, interaction between local governments' improper land use management model and disadvantageous natural conditions affect the sustainable use of land [15]. In the south of Spain, highly intensive olive planting and the large-scale use of pesticides have led to soil pollution and reduced biodiversity [16]. Furthermore, intensive agricultural business models are even triggering the diversification of cultivated land risks [17]. In view of the importance of cultivated land protection and the existing cultivated land risks and potential hazards, the current study aims to shed new light on reducing risks, optimizing cultivated land governance systems, and facilitating sustainable development. The protection of cultivated land involves various stakeholders and intertwined risk factors, therefore, this study is guided by the following two research questions (RQ):

RQ1: What are the relationships between the risk factors at play in cultivated land protection?

RQ2: To what extent do different risk factors interact with each other?

Using social network analysis (SNA) and visualization, the interactions among risk factors are quantified. The key nodes and links in the risk network are determined, providing guidance to alleviate the risk of cultivated land protection and to optimize the overall network. The remainder of the study is structured as follows: Section 2 presents the research background and literature review. Section 3 describes the research methods and data collection process. Section 4 reports the research results, identifying the risk factors and relevant stakeholders. Section 5 discusses the findings and policy implications. Finally, Section 6 shows the limitations and conclusions of the research.

2. Literature Review

2.1. Protection Risk of Cultivated Land

Cultivated land is a valuable resource, importantly related to food security, social stability, and economic development. However, the quantity and quality of cultivated land in emerging countries face diverse risks [18]. On the one hand, there are insufficient cultivated-land resources in reserve. The total amount of cultivated land continues to decline. Although strict cultivated land protection policies have achieved certain effects in China, the continuous reduction of cultivated land remains a huge challenge [19]. The dominant factor here relates to the non-agriculturalization of cultivated land. As urbanization and industrialization accelerate, larger amounts of cultivated land have given way to real estate development, and thus food security is being threatened [18,20,21]. Moreover, cultivated land abandonment has intensified worldwide due to the population growth trends [22], labor transfer [23], and climate change [24]. Due to the improvements in living standards, farmers are abandoning low-income food grain and are switching to high-income fruits and vegetables, and a large amount of cultivated land has lost its original function [10,25]. The decline of cultivated land quality is an urgent problem. The rapid development of urbanization has caused the fragmentation of cultivated land, which is hindering large-scale agricultural production [26]. Long-term overutilization of cultivated land reduces soil heterogeneity, leading to land degradation [27] and severe declines in biodiversity [16]. The "cultivated land requisition-compensation balance" policy is the main governance approach in China, with the aim to maintain the quantity and quality of cultivated land [28]. However, to achieve a dynamic balance in the total amount of cultivated land, local governments tend to transform high-quality cultivated land to nonagricultural uses and develop low-quality cultivated land in hilly or mountainous areas [26].

According to Fan et al. [29] and Xue et al. [30], the risks arising from cultivated land protection affect social, economic, environmental, and policy aspects. First, the economic aspects include questions of the income derived from land resources and agricultural products [31–36]. Farmers are likely to change their utilization mode and the structure of

their cultivated land if they can expect high economic benefits. The principal sources of the economic aspects are the increased demand for construction land [37–39]. Second, the environmental aspects include improper use of chemical fertilizer and other substances, low-lying terrain, geographical limitations, and natural disasters. These issues reduce soil fertility, promote desertification, and pose certain environmental risks to cultivated land. Third, the social aspects involve cultural setting, interpersonal trust, and urbanization changes. Fourth, the policy aspects include the policy setting and implementation, including imperfect incentives and constraint mechanisms [40], inappropriate land planning and management [41], unreasonable land income distribution methods [42], and inefficient implementation of local governmental regulations [43].

2.2. Stakeholders in Cultivated Land Protection

Freeman and Reed [44] broadly defined stakeholders as “any group or individual that can be identified and influenced by realizing organizational goals”. Cultivated land protection involves intertwined stakeholders, including governments [45,46], village committees [36], farmers [36,47], land-use organizations [36], and the public [48].

The government is the regulator of cultivated land protection, representing the maximization of collective interests [49]. However, when the central government’s compulsory land requirements conflict with local government goals of economic growth, the local government tends to behave opportunistically and requisition land unreasonably to attract investment and increase financial revenue. This could damage regional agricultural production and farmers’ interests [50,51].

As the leading implementer of cultivated land protection in China, village committees carry out the decision of local government and also represent the collective interests of farmers [52]. Due to a lack of government supervision, village committees have acquired control and independence [53]. However, excessive use of the control power could cause social problems [54].

Farmers are the most basic unit of and direct participants in cultivated land protection. Their behaviors are affected by the local government, village committee, and land-use organizations. Following the conditions of cultivated land transfer, farmers can be divided into three categories: land non-flow farmers, land flow-in farmers, and land flow-out farmers [55,56]. Farmers exhibit a range of risk preferences as well [57].

Land-use organizations work with land investment and transfer, with a main focus on economic aspects. Such organizations are key stakeholders and require supervision in terms of cultivated land protection [58]. Under the influence of government regulations and public supervision, land-use organizations are forced to forego part of the potential profits for cultivated land protection [54].

The public are nonagricultural residents. They are usually excluded from the early stages of decision making regarding cultivated land protection [59]. Thus, the public is usually not a direct participant in the protection of cultivated land. The overall economic welfare, social wellbeing, and ecological service value are the main factors that affect their behavior in relation to cultivated land protection [60,61].

The protection of cultivated land requires the coordination of the relationship between different stakeholders (particularly the redistribution of interests) to avoid risk diffusion and chain reactions. Due to the different degrees of power and various roles of stakeholders, conflict is likely to arise between them [52,62]. The decision-making of government, land-use organizations, and farmers and their interactions could trigger changes in cultivated land use. For example, land planning by local governments affects the site selection of land-use organizations [8], and the layout of the land-use organization is likely to influence local economic development [63], leading farmers to transform agricultural structures and make changes in agricultural land use [64]. Thus, the divergence of goals in cultivated land protection is a challenge for aligning decision-making as well as for the smooth implementation of relevant policies. Existing research has mainly focused on a specific type of risk factors and assesses each factor separately. However, there has been a dearth

of research on interactions among risk factors that considers the associated stakeholders from a systematic and holistic network perspective. The primary purpose of this study is, therefore, to narrow research gaps and provide policy implications for cultivated land protection.

3. Methods

3.1. The Framework of This Study

The social network analysis (SNA) provides a quantitative method of describing complexly intertwining relationships among multiple stakeholders and hence enables improvements in management efficiency [65]. The combination of SNA and stakeholders produces systematic insights to align decision making to cope with risks [62,66]. For instance, Hamilton et al. [67] analyzed the degree of fit between landowners and land-use organizations to promote the social–ecological network balance. Penman et al. [68] provided an evaluation framework and modeling method for environmental risk decision-making management using SNA. SNA has been applied to various fields of risk management. Thus, it is reasonable to apply SNA to analyze the risk interactions in cultivated land protection.

Prior risk studies have typically been based on a framework incorporating four steps: risk identification, assessment, analysis, and response [69,70]. By referring to this framework (as shown in Figure 1), the current study begins by identifying risk stakeholders and assessing risk relationships in cultivated land protection. According to the literature review and the semi-structured interview, risks of cultivated land protection are determined. Then, a network is established to map the complex interactions among the risk factors in cultivated land protection. In this study, NetMiner 4 software was used to visualize and analyze the network characteristics. Risk response strategies are developed and verified through a SNA simulation involving risk identification, assessment, and analysis.

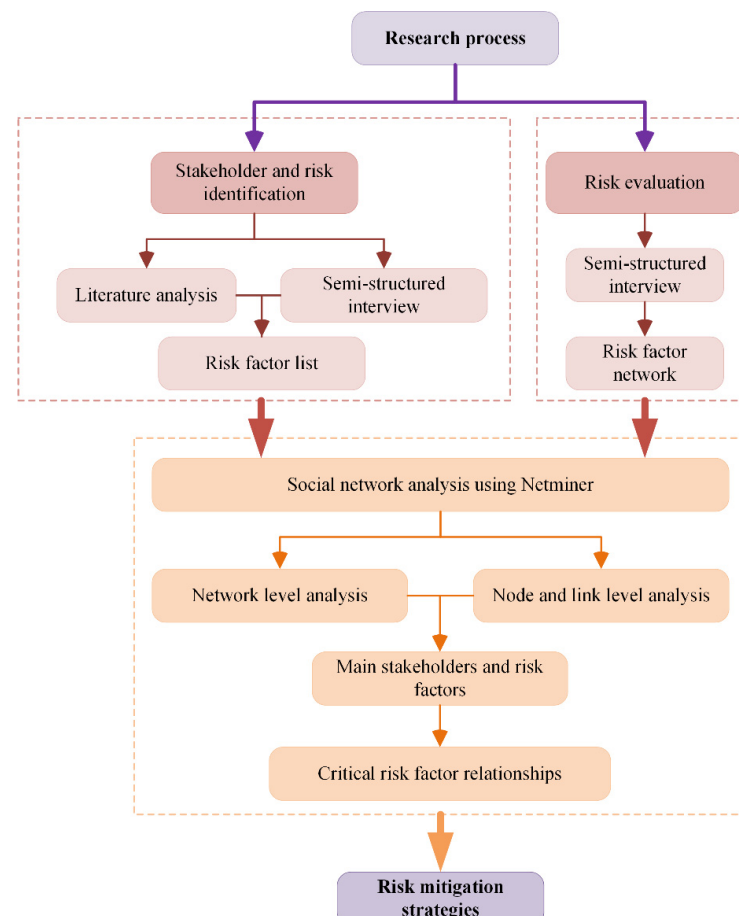


Figure 1. The research process.

3.2. Research Area

The research area is the town of Xiliuhe, in the hinterland of the Jiangnan plain, a main grain-producing area in Central China (as shown in Figure 2). With an area of 245 square kilometers, a registered population of 110,000, and 147,000 mou (Chinese unit of land measurement that varies with location but is commonly 666.7 square meters) of cultivated land, Xiliuhe has jurisdiction over 64 administrative villages. In recent years, the agricultural development in Xiliuhe has taken the road of localism and green industrialization and has actively popularized the cultivation of shrimp and eels in a net cage. Thanks to the success of its industrial economy, Xiliuhe developed an industrial park covering an area of 3000 mou. The contradiction between construction and cultivation uses of land in Xiliuhe is typical for developing rural areas in China.

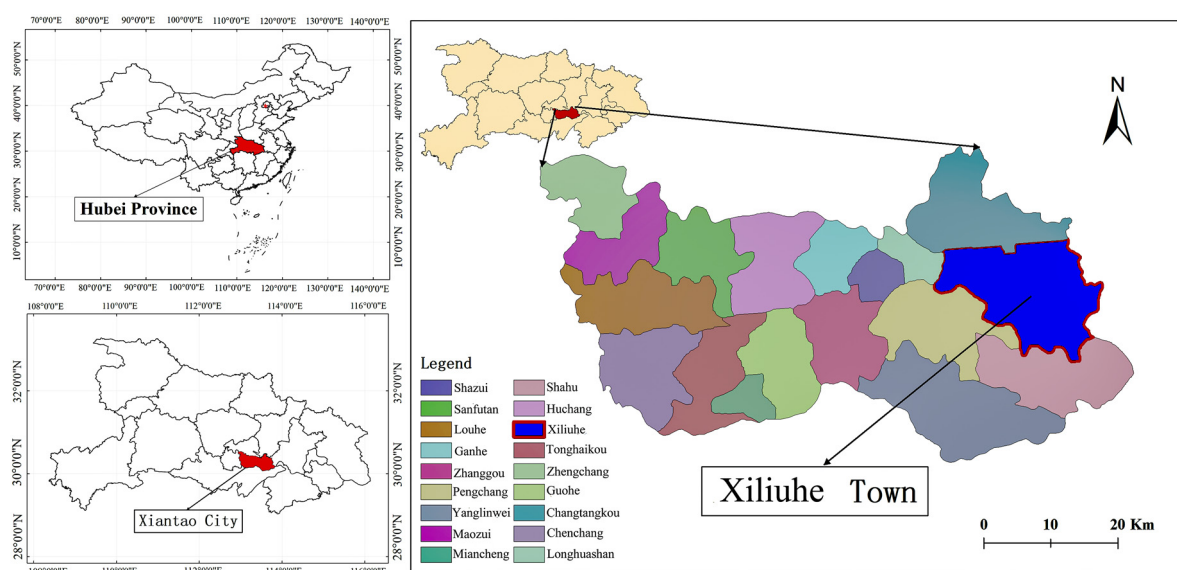


Figure 2. Study area.

3.3. Interviews and Data Collection

Data was collected using semi-structured interviews with different stakeholders to investigate risk factors in cultivated land protection. First, a systematic literature review and preliminary investigation allowed us to identify seven categories of stakeholders in the protection of cultivated land, including village committee (S1), local government (S2), land-use organization (S3), land non-flow farmers (S4), land flow-in farmers (S5), land flow-out farmers (S6), and the public (S7). The information from all the interviewees can generate an acceptable stakeholder risk network.

The second step is the summary of risks and the selection of stakeholders. A list of 35 risks was preliminarily identified based on the literature review and pre-survey. We followed the studies of Xiao et al. [71], Raissa et al. [72] and Approach et al. [73] and employed their snowball technique to expend the interview sample size across different types of stakeholder groups. Initially, we got in touch with the deputy mayor in Xiliuhe Town (S2). This deputy mayor was promoted from Xiliuhe Town and had a comprehensive understanding of cultivated land protection. Thereafter, the deputy mayor suggested several staff members from the land management office (S2) and village committee (S1). Additionally, we had a series of conversations with local residents to form a deep understanding of Xiliuhe Town. Furthermore, the orchardists and the managers of the agricultural cooperative in Xiliuhe Town (S3) were willing to participate in our interview. In addition, visiting tourists were also included in our interviews.

Third, after being contacted through field visits in Xiliuhe, 26 people were selected through the in the Xiliuhe town survey (Approximately 1.5 h per person) who had sufficient information of cultivated land protection: four people from the village committee (S1),

including the Wakou village headman, the Hefeng village headman, the Shuguang village headman and the village account; three people from the local government (S2), the deputy mayor in Xiliuhe town and the staff from the land management office; two people from a land-use organization (S3), four people who were land non-flow farmers (S4), three people from land flow-in farmers (S5), and seven people from land flow-out farmers (S6) were jointly involved in the use of cultivated land; three people from the general public (S7) (i.e., visiting tourists). According to the response of interviewees, potential risk factors that were not identified in the given area were deleted, and new risk factors obtained from the interviews were added. Ultimately, 36 risks were identified in cultivated land protection in the subsequent analysis.

Fourth, in the semi-structured interview, we determined the likelihood of the relationship between two risk factors and the extent to which one risk factor influenced the other risk factor. For example, if the interviewee indicated that there is a potential influencing relationship between two risk factors, he or she was required to answer two further questions. (1) What is the likelihood of this relationship? (2) What is the degree of influence? A five-point scale was used to measure each relationship, whereby “1” indicated a low level and “5” indicated a high level. Thus, the strength of the relationship between two risk factors was determined by multiplying the probability of linkage with the degree of influence. In the data processing, we used the mean value of the evaluation results from different stakeholders. The network data obtained from the semi-structured interviews captured the interactions between the risk factors.

Fifth, the risk-factor matrix was imported to a powerful network analysis software, NetMiner 4, for network visualization and analysis. According to previous studies [74–76], five indicators were used to reflect the key characteristics of the holistic network and to identify critical risks, as well as the relationships and corresponding stakeholders. These metrics included the following: network density, status centrality, closeness centrality, degree difference, betweenness centrality. They are widely used in SNA-related studies to effectively describe the key characteristics of the network, nodes, and links.

Finally, from the network analysis, this study derived a mitigation strategy and developed policy implications for coping with the risk factors. In particular, this study analyzed the risk management of key risk factors in cultivated land protection.

4. Results

4.1. Identification of Social Risks

The 36 risks were classified into the following six categories (Table 1): (1) environmental aspects, including C1 (the natural conditions of cultivated land) and C2 (utilizing status of cultivated land); (2) policy aspects, including C3 (policy setting) and C4 (policy implementation); (3) economic aspects, namely, C5 (the status of agricultural development and the livelihood level of farmers); and (4) social aspects, that is, C6 (behavior and professional quality).

Table 1. Risk factors and corresponding stakeholders in cultivated land protection.

Risk Category	Risk	Risk Description	References	Risk Factor
C1	R1	Lack of irrigation and conservancy infrastructure	[52,77]	S1R1; S2R1; S3R1; S5R1; S7R1
	R10	Natural disasters	[37]	S1R10; S3R10; S4R10; S5R10; S6R10; S7R10
	R25	Industrial pollution and agricultural wastes	[78]	S1R25; S3R25; S4R25; S5R25; S7R25
	R26	Decreased soil fertility	[79]	S4R26; S5R26; S6R26
	R36	Poor topographic condition	Interview	S1R36; S2R36
	R3	The defective functional layout of cultivated land	[80]	S1R3; S2R3; S3R3; S5R3
C2	R11	The increasing cost of cultivated land protection	[81]	S3R11; S4R11; S6R11
	R14	Low efficiency of land utilization	[82,83]	S1R14; S2R14; S3R14; S4R14; S5R14; S6R14
	R18	Inadequate and low quality of cultivated land	[84]	S1R18; S4R18; S6R18; S7R18
	R27	Improper cultivated land construction plan	[85]	S3R27
	R35	Superfluous homestead and unreasonable layout	Interview	S1R35; S2R35; S3R35; S4R35
	R2	Imperfect incentive and constraint mechanism on cultivated land protection	[41]	S1R2; S2R2; S6R2
C3	R4	Unreasonable land planning and management	[86]	S1R4; S2R4; S3R4
	R17	Imperfect land regulatory mechanism	[43]	S1R17; S2R17; S5R17
	R20	Unreasonable distribution mechanism of land revenues	[42,58]	S1R20; S2R20; S6R20
	R28	Imperfect industry standards of land use	[87]	S2R28
	R5	Lenient land law	[88]	S1R5; S2R5
C4	R22	Unavailable or lack of subsidy funds during the land acquisition	[89]	S1R22; S2R22; S4R22; S5R22; S6R22; S7R22
	R23	Difficulties in identifying land violations of the local government	[40,43]	S2R23; S4R23; S5R23; S6R23
	R24	Difficulties in identifying the illegal land use of enterprises and farmers	[90,91]	S2R24; S3R24; S4R24; S5R24
	R29	Perfunctory protection measures for grain-producing areas	[21,92]	S1R29; S2R29
	R33	Quantity and quality of unbalanced cultivated land occupation and compensation	Interview	S1R33; S2R33; S4R33
	R34	Inadequate publicity of cultivated land protection policies	Interview	S1R34; S2R34; S5R34

Table 1. Cont.

Risk Category	Risk	Risk Description	References	Risk Factor
C5	R6	Discordance of urban and rural economic development	[93,94]	S1R6; S2R6; S3R6; S4R6; S5R6; S6R6; S7R6
	R7	Increasing demand for construction land	[39]	S1R7; S2R7; S5R7; S6R7; S7R7
	R8	Unbalanced industrial structure	[94]	S1R8; S2R8; S3R8; S5R8; S7R8
	R16	The overwhelming profit-driven development approach	[38]	S1R16; S2R16; S3R16; S5R16; S6R16
	R21	Benefit transmission during the transition from cultivated land to non-cultivated land	[95]	S1R21; S2R21; S4R21; S5R21
C6	R31	The proportion of agricultural income within the total income	[96]	S2R31; S3R31; S4R31; S5R31; S6R31
	R9	Unprofessional agricultural technician	[97]	S1R9; S2R9; S3R9
	R12	The diminishing role of local government in cultivated land protection	[98]	S1R12; S2R12; S5R12; S6R12
	R13	The weak position of farmers	[99]	S6R13
	R15	Lacking awareness of cultivated land protection	[100,101]	S1R15; S2R15; S3R15; S4R15; S5R15; S6R15; S7R15
	R19	Low level of farmer comprehensive productivity	[102]	S4R19; S5R19; S6R19
	R30	Low level of education	[103]	S4R30; S5R30; S6R30
	R32	Distrust among stakeholders	[104]	S1R32; S2R32; S5R32; S6R32; S7R32

4.2. Visualization and Analysis of Social Network

4.2.1. A Network-Level Analysis

In Figure 3, each node represents specific risk factor and the relevant stakeholder. Thus, each node has two attributes; its color represents the type of stakeholders involved, and its shape represents the category of risk factors. An arrow from node SiRj to SmRn indicates that SiRj can impact SmRn. In addition, the links between nodes represent the relationships between risk factors. The thickness of the link indicated represents the level of interaction level between risks. The network has 142 nodes and 253 links. The network density is 0.013, which indicates that the network features 1.3% network connection.

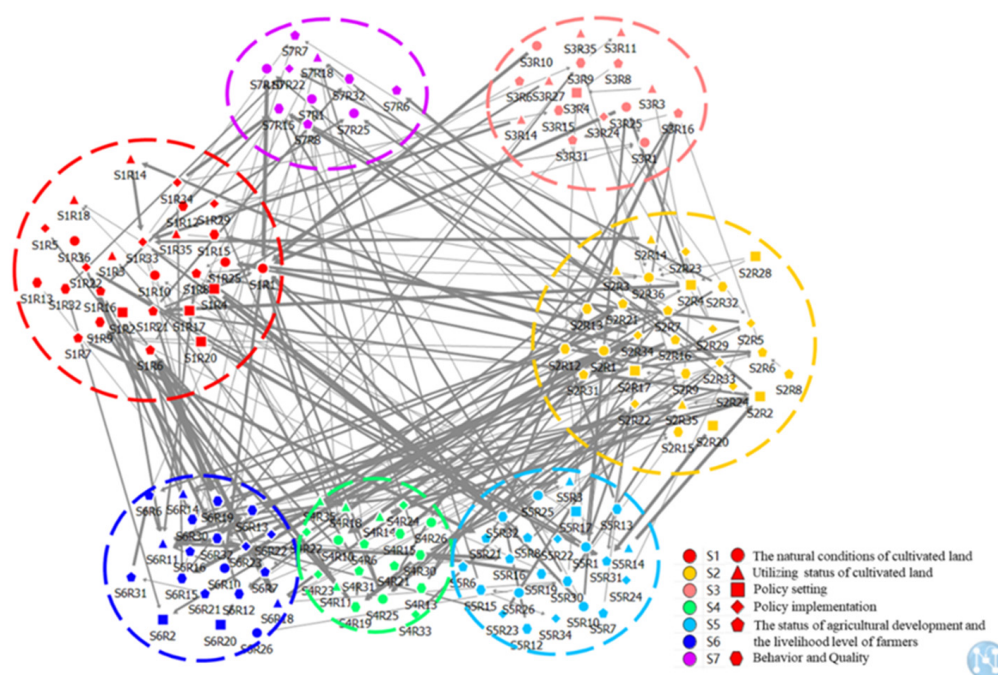


Figure 3. Network visualization graph of stakeholders. Note: S1, village committee; S2, local government; S3, land-use organization; S4, land non-flow farmers; S5, land flow-in farmers; S6, land flow-out farmers; and S7, the public.

In the network, local government (S2) is prominent in terms of number of nodes linked to it (i.e., the number of risk factors involved is the largest). The local government also has important connections with other stakeholders. This result is consistent with the main role of local government in the current top-down mode of cultivated land protection. Among the three types of farmers, the largest number of nodes is related to land flow-in farmers (S5) (i.e., the number of risk factors involved is the largest).

4.2.2. A Node-Level Analysis

Key nodes are highly influential but not easily affected by others. To distinguish these key risk factors, further analyses were conducted to determine the status centrality, closeness centrality, degree difference.

Status centrality indicates the importance of the node [105]. In Figure 4, the higher the centrality score that a node has, the closer it is to the center, implying more critical risk factors in the network and a need for more effective mitigation strategies. The status centrality of the risk factors in the first ring reaches 1.658, and two of three are blue, which indicates that land flow-out farmers (S6) occupy a crucial role in the network. Another node in the center is red, which indicates the importance of the village committee (S1) in the network.

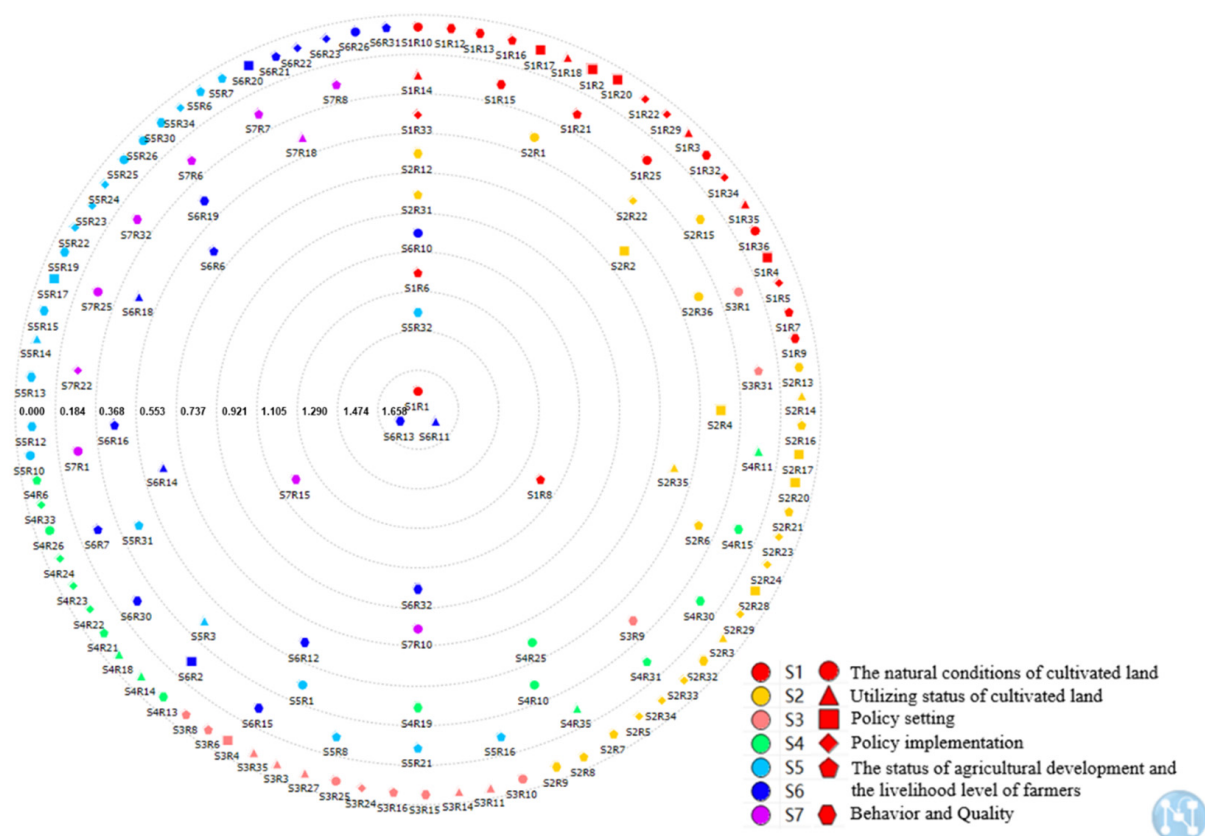


Figure 4. Distribution of risk factors in terms of the status centrality. Note: S1, village committee; S2, local government; S3, land-use organization; S4, land non-flow farmers; S5, land flow-in farmers; S6, land flow-out farmers; and S7, the public.

The shapes of the nodes in the center make it clear that the land flow-out farmers (S6) are most associated with the utilizing status of cultivated land (C2), behavior, and professional quality (C6). This result is manifested in the increasing cost of cultivated land protection (C2: R11) and the weak position of the farmers (C6: R13).

The key stakeholder village committee (S1) focuses on the natural condition of the cultivated land (C1), the status of agricultural development, and the livelihood level of farmers (C5), which is mainly manifested in the lack of irrigation and conservancy infrastructure (R1), the backward industrial structure (R8), and the discordance between urban and rural economic development (R6). The village committee (S1) is a hub in the process of cultivated land protection. More specifically, S1 both implements the government's policies but also collects farmers' opinions. The S1's behaviors shape the entire network; together with the development of agricultural industrialization, this kind of influence tends to grow. This study calculated the status centrality, closeness, and node betweenness centrality of each node. These indicators reflect the characteristics and impacts of risk nodes according to different perspectives (Table 2).

Status centrality reflects all of its connections with other nodes in the network. This is a holistic indicator that measures the overall impact of each risk factor. The level of a node's in-status centrality is affected by other nodes. For example, the maximum in-status centrality is 1.84, which represents S6R11 (i.e., the concern of land flow-out farmers for the cost of cultivated land protection). This result indicates that economic cost is the most concerning aspect in terms of cultivated land protection.

Table 2. Critical risk factors based on node centrality.

Rank	SR	In-Status Centrality	SR	Out-Status Centrality	SR	In-Closeness Centrality	SR	Out-Closeness Centrality	SR	Degree Difference
1	S6R11	1.84	S2R1	1.00	S1R8	0.18	S3R25	0.12	S2R33	8
2	S6R13	1.70	S2R34	0.95	S6R11	0.18	S2R33	0.11	S2R34	6
3	S1R1	1.67	S3R25	0.94	S6R13	0.16	S2R4	0.10	S2R29	5
4	S5R32	1.34	S2R33	0.93	S1R1	0.16	S3R16	0.10	S2R7	5
5	S1R8	1.28	S2R2	0.81	S2R36	0.16	S2R29	0.10	S3R16	5
6	S1R6	1.18	S3R16	0.76	S6R10	0.16	S1R29	0.10	S3R25	5
7	S7R15	1.15	S6R16	0.76	S2R31	0.16	S2R1	0.10	S1R29	4
8	S6R10	1.04	S6R11	0.70	S2R6	0.14	S1R21	0.10	S2R16	4
9	S6R32	0.99	S1R1	0.68	S4R6	0.14	S2R2	0.09	S2R17	4
10	S7R10	0.76	S4R14	0.67	S6R6	0.14	S2R24	0.09	S2R21	4
11	S2R31	0.76	S4R30	0.65	S5R32	0.13	S2R12	0.09	S2R24	4
12	S2R12	0.67	S1R21	0.64	S3R31	0.13	S5R10	0.09	S2R9	4
13	S2R35	0.65	S2R17	0.64	S7R8	0.13	S2R28	0.08	S4R30	4
14	S2R2	0.63	S2R7	0.60	S7R10	0.13	S2R17	0.08	S5R10	3
15	S6R6	0.63	S1R33	0.60	S2R12	0.13	S3R3	0.08	S1R21	3

Closeness centrality reflects the centrality of a network structure according to the geodesic distance between nodes [106]. The geodesic distance refers to the shortest path between two nodes in a network. Closeness centrality is measured by standardizing the inverse ratio of the sum of the distances from one node to all other nodes [107]. A node is central if it only takes a few steps to reach other nodes in the network (i.e., closeness centrality). Regarding out-closeness centrality, S3R25 (i.e., land-use organization discharging industrial pollution and agricultural waste) is a central risk factor in the network. In Xiliuhe, pollution from factories is not effectively controlled, which affects the quality of water and soil, reducing trust in the capacity of local government among farmers and the public.

Degree-difference refers to the difference between the out-degree and in-degree of a node [108]. Out-degree demonstrates the ability that a node affects other nodes, while in-degree reflects the extent to which a node is influenced by other nodes. A risk factor that demonstrates a large difference in degree can exert a stronger influence on its surrounding nodes than it can receive influences [74]. According to Table 2, S2R33 (i.e., quantity and quality of unbalanced cultivated land occupation and compensation), S2R34 (i.e., inadequate publicity of cultivated land protection policies), and S2R29 (i.e., perfunctory protection measures for grain-producing areas) easily influence other risk factors. These risk factors are all related to S2 (i.e., local government).

A systematic analysis of centrality indicators shows that land flow-out farmers (S6) are the main stakeholders that focus on cultivated land protection, while town governments (S2), the policy practitioners, need to be better supervised. These stakeholders are the key to coping with the risks of cultivated land protection. Risk categories that are highly correlated with S2 and S6 are C5 (i.e., status of agricultural development and livelihood level of farmers) and C6 (i.e., behavior and professional quality), which are key concerns in relation to the risks of cultivated land protection.

4.2.3. Determination and Classification of Key Risk Relationships

Node betweenness centrality is measured by how often a node appears on all other nodes' geodesic paths [109]. The more times that a node appears on geodesic paths, the higher the centrality. Node betweenness centrality and link betweenness centrality demonstrate the extent to which a risk factor or interaction can control the influencing paths that pass through it [74]. It measures the dependence of each risk effect on other risk effects, and it has mediation.

Only three risk factors have a betweenness centrality above 0.06, including S2R12 (i.e., diminishing role of local government in cultivated land protection), S6R13 (i.e., weak

position of farmers), and S2R6 (i.e., discordance of urban and rural economic development). Removing these nodes from the network can reduce the connectivity of the risk factors network.

Link betweenness centrality is measured by the degree of linkage among all nodes located on a geodesic path [109]. The more times the link appears on a path, the more central it becomes. For example, S1R8→S6R11 indicates how the imbalance of industrial structure related to the village committee increases the cost of cultivated land protection for land flow-out farmers; S4R10→S2R1 describes how natural disasters faced by land non-flow farmers destroy the irrigation and water conservancy measures of the local government. In a cultivated land risk network, links with high betweenness centrality values play a pivotal role in the underlying risk dissemination process [110]. To optimize the risk-factor network, this study focuses on mitigating the most influential risk factors and relationships in cultivated land protection (as shown in Table 3).

Table 3. Critical risk factors and relationships based on node/link centrality.

Rank	SR	Node Betweenness Centrality	Interaction ID	Link Betweenness Centrality
1	S2R12	0.08	S2R6→S2R12	1423.00
2	S6R13	0.07	S6R13→S2R6	1264.00
3	S2R6	0.07	S2R12→S2R4	1003.58
4	S6R11	0.06	S6R11→S6R13	754.17
5	S2R4	0.06	S2R4→S1R21	741.33
6	S1R1	0.05	S1R1→S4R10	677.58
7	S1R8	0.04	S4R10→S2R1	621.00
8	S1R6	0.03	S1R8→S1R1	546.67
9	S1R21	0.03	S1R21→S2R2	501.92
10	S4R10	0.03	S1R6→S6R13	496.33
11	S2R1	0.03	S2R1→S6R30	440.50
12	S2R2	0.03	S6R18→S1R6	399.00
13	S6R30	0.02	S6R32→S6R11	374.33
14	S6R18	0.02	S6R11→S1R8	330.00
15	S6R32	0.02	S1R8→S6R11	241.33

In Tables 2 and 3, the crucial risk factors and their interactions in the network are given. The SNA network indicators indicate a relationship between higher degree difference, higher betweenness centrality, and higher status centrality. On this basis, in combination with the semi-structured interviews, this study represents the risk factors and provides a detailed description of major challenges in cultivated land protection (as shown in Table 4).

Table 4. Risk classification and description.

Risk Aspects	Challenges Description	Critical Risk Factors/Interactions	Associated Stakeholders
Economic aspect	1. Measures of local government to alleviate the discordance of urban and rural economic development (S2R6)→the diminishing role of local government in cultivated land protection (S2R12)→unreasonable land planning and management of local government (S2R4)→benefit transmission of village committee during the transition from cultivated land to non-cultivated land (S1R21)→imperfect incentive and constraint mechanism on cultivated land protection of local government (S2R2). Discordance of urban and rural economic development affects all aspects of farmland protection. The main stakeholders involved in this kind of connection are local governments (S2) and village committees (S1).	S2R6→S2R12 S2R12→S2R4 S2R4→S1R21 S1R21→S2R2 S1R21 S2R7 S2R34	The local government The local government The local government The village committee The village committee The local government The local government
	2. The unbalanced industrial structure of the village committee (S1R8) will affect the input of irrigation and conservancy facilities (S1R1) and land flow-out farmers' cost of cultivated land protection (S6R11), which in turn will harm the unbalanced industrial structure (S1R8). At the same time, the rising cost of cultivated land protection for land flow-out farmers (S6R11) aggravates their weak position (S6R13). The cost of cultivated land protection affects farmers' livelihood and social security and restricts the layout of rural industries.	S1R8→S1R1 S1R8→S6R11 S6R11→S6R13 S6R11→S1R8 S6R11	The village committee The village committee Land flow-out farmers Land flow-out farmers Land flow-out farmers
	3. The discordance of urban and rural economic development (S1R6) will aggravate the weak position of land flow-out farmers (S6R13), and further leads to discordance of urban and rural economic development (S2R6). The weak position of farmers is the bottleneck restricting agricultural modernization and rural prosperity and development.	S1R6→S6R13 S6R13→S2R6 S3R16 S6R13	The village committee Land flow-out farmers Land-use organization Land flow-out farmers
Social aspect	4. Farmers' distrust of other stakeholders and systems (S6R32) increases the cost of their cultivated land protection (S6R11), which is mainly reflected in the social relationship between land flow-out farmers (S6) and other risk factors. Such risk associations are primarily related to behavior and professional quality (C6). The local government's ability to implement and manage the cultivated land protection policy, as well as the unfair phenomenon in the management process, will affect the relationship between the government and the public.	S6R32→S6R11 S2R12 S2R29 S6R13	Land flow-out farmers The local government The local government Land flow-out farmers
Environmental aspect	5. The village committee's lack of irrigation and conservancy infrastructure (S1R1) affects the ability of land non-flow farmers to resist natural disasters (S4R10), which will affect the funding of the local government in irrigation and conservancy infrastructure (S2R1). Moreover, in the context of (S2R1), farmers who take cultivated land as the only production income have difficulties in livelihood and seek other economic production income, such as migrant workers, which means that some land flow-out farmers have a low level of education (S6R30). In addition, due to the land flow-out farmers' inadequate and low quality of cultivated land (S6R18), the discordance of urban and rural economic development of the village committee (S1R6) is aggravated. The stakeholders of environmental factors interactions are the most extensive and comprehensive.	S1R1→S4R10 S4R10→S2R1 S2R1→S6R30 S6R18→S1R6 S1R1 S3R25 S5R10	The village committee Land non-flow farmers The local government Land flow-out farmers The village committee Land-use organization land flow-in farmers

5. Discussion and Strategies

5.1. Discussion

5.1.1. Stakeholders and Risks

To address RQ1, network analysis indicates that the discordance between urban and rural economic development (R6) is the main factor affecting cultivated land protection. The most direct impact is seen in the labor shortage in agricultural production and the abandonment of cultivated land. Recent studies are mainly focused on the impact of rural labor migration on the distribution of livelihood capital and the specialization of agricultural activities against the background of the urban–rural economic disharmony [111,112]. This study indicates the interaction between the risk factors of the discordance between urban and rural economic development and other factors regarding cultivated land protection, which generally manifest in the following two aspects. First, the quality of cultivated land has declined due to the outflow of the rural population to the cities, which is an inherent part of urbanization and economic development. This labor shortage leads to the abandonment of cultivated land, which has an impact on rural land transfer [113]. Second, in China, there is a dual structure between urban and rural land, in a land system composed of state-owned urban land and collectively-owned rural land [114]. The urbanization of land is going faster than the urbanization the population, and there has been a double growth with increases in both urban land and rural construction land. These together indicate a lack of guarantee of the quality and quantity of rural cultivated land.

Land flow-out farmers (S6) are dominant stakeholders who affect the stability of a cultivated land risk network. In a field investigation, farmers' willingness to transfer cultivated land relates to income maximization. There are two types of cultivated land flow-out farmers in Xiliuhe. First, against the background of the increasing cost of using cultivated land (C2), economic benefits no longer meet livelihood needs, so many small farmers go out of their local area for work, and the elderly individuals who remain are not able to make full use of the cultivated land. The protection policy for cultivated land indicates that these small farmers transfer their cultivated land to large farmers or cooperatives. Second, compensation for land expropriation by local governments cannot meet the requirements of the farmers who participate in land transfer, which increases their distrustful relationship with local governments and village committees.

Figure 4 indicates that policy risk, such as policymaking (C3) and policy implementation (C4), are located at the edge of the network, while the impact of behavior and professional quality (C6) is closer to the center within the risk network of cultivated land protection. This situation reflects the distrust among the government, the village committee, and farmers. Fieldwork in Xiliuhe indicates that the local government has expropriated fertile cultivated land and carried out what is called a vanity project of landscape construction, which has produced a feeling of disconnection among farmers. Therefore, the governance level of local government is closely related to the implementation effects of the cultivated land protection policy. Meanwhile, the relationship between local government officials and farmers affects the efficiency of the protection of the cultivated land protection because this protection is organized by the government from top to bottom to promote local economic development [115], in opposition to that driven by farmers, going from bottom to top. The contradictions among the government, the village committee, and farmers are focused on cultivated land compensation disputes. The compensation benchmark for cultivated land is the direct economic loss of its agricultural value, which only accounts for 2–10% of the land value increment [114]: First, in addition to the economic compensation determined by the agricultural land output, social (e.g., employment) and ecological compensation for damaging the ecosystem must be included. Farmers and collectives should receive compensation for these, however indirect [116]. The existing farmland compensation system has shortcomings in this regard, and this leads to discontent among land flow-out farmers; Second, local governments purchase land at a lower price and sell it at a higher price, which leads to a value gap in land transfer [116]. This deepens the distrust between farmers and the government and increases the risk to cultivated land

protection. Alleviating the discordance of urban and rural economic development is a prominent challenge for cultivated land protection.

5.1.2. Risk Relationship

Prior studies mainly focus on individual factor analysis of cultivated land protection risk, such as non-agriculturalization phenomena [4], non-grain phenomena [10], cultivated land fragmentation [117], isolation [31], and marginalization [118]. In response to RQ2, the current study quantifies the key stakeholders and associated risk factors from a network perspective. As shown in Figure 4, the direct effects of a policy's influence are peripheral within the network. However, regarding link betweenness centrality, connections to local governments occur most frequently, which demonstrates significant transmission effects within the risk-factor network. According to Table 4, the main challenges from the key risk factors and their intertwined relationships are summarized as follows:

(1) Cultivated land protection costs remain high

Cultivated land protection cost refers to the resource input in the process of cultivated land protection. For small farmers, the profit from agriculture is relatively low [10], and the cost of cultivated land protection increases, which aggravates their weak position. During the field investigation of Xiliuhe, many farmers reported choosing to maintain the function of cultivated land at a loss due to affective factors.

The price of agricultural products, especially grain products, was restrained. In the actual transaction process, the transaction price of grain products was lower than the lowest national purchase price of grain, and the agricultural income was decreasing year by year. Only out of their responsibility for cultivated land could they insist on farming. (Interview with a villager in Wakou village).

To implement the strictest cultivated land protection policy, Xiliuhe town introduced the cultivated land monitoring system, combining real-time monitoring with actual inspection, to curb the rural land abandon. In this context, to obtain food subsidies, some local farmers in Xiliuhe town, because the nonagricultural economic income is far greater than the agricultural economic income, will choose to pay a certain amount of labor remuneration and subcontract part or all of the land to the nearby villagers for farming. (Interview with a land resource management official).

This is consistent with the findings of [119]. As the cost of farming increases, the lack of standardized land transfers diminishes farmers' willingness to engage in agricultural production, hence increasing the risk of cultivated land protection.

(2) The weak position of farmers in cultivated land protection

In China, the relationship between urban and rural areas is characterized by discordance. Due to the long-term suppression of food prices and urban capital expansion, farmers are in an weak position. The cultivated land of small farmers has lost its original function of social security and has failed to support livelihood demands [64]. In addition, to promote development in Xiliuhe, the local government expropriated land from some farmers. While this land acquisition was taking place, the majority of farmers were in a relatively passive position. Land flow-out farmers (S6) were forced to change their livelihoods and go out for work. However, the expropriated land was not used in a way as to achieve economic development, which leads to a crisis of trust in the local government.

Regarding the risk-factor network, both the increase in the of protecting cultivated land and the discordance of economic development call for changing the inequality between urban and rural areas. As such, the first solution is to improve the economic benefits of agricultural production to ensure an adequately scaled labor force in rural areas [120]. Through the development of the system of market entry for rural collective land, most interests arising in the process of land transfer are guaranteed to flow to farmers, the legitimate rights and interests of the farmers are protected, and their awareness of the protections for cultivated land is strengthened [121].

(3) Unreasonable land use

Unreasonable land use has two aspects: inappropriate farming patterns and unreasonable land use structures. First, long-term reclamation around the lake has weakened flood control and drainage. The increased water level increases the drainage pressure, making Xiliuhe more vulnerable to flooding and waterlogging. This farming pattern seriously affects the vulnerability of the soil environment and destroys the ability of cultivated land to recover. Furthermore, the shrimp–rice crop model in Xiliuhe has led to long-term waterlogging of the soil, decreased soil structure and aeration permeability, and reduced land fertility. In the context of intensive grain production, unreasonable use of fertilizers, pesticides, and agricultural mulch films has led to a decline in the quality of soil and water [122].

Second, living space in Xiliuhe is dominated by scattered, rural residential areas, with a disordered distribution of homestead and cultivated land, resulting in an unreasonable structure of land use. The local government is the main stakeholder (i.e., the main planner and key decision maker) responsible for the balance of cultivated land, which is consistent with the findings of [8]. In the face of the complex risks of cultivated land protection, making reasonable and effective use of land and protecting cultivated land leads to higher requirements on the governance ability of the local government [123]. First of all, the central government and local governments need to strengthen their interactions and strictly adhere to the “red line” (i.e., main thread) on the protection of cultivated land. In particular, local governments must enhance their responsibility for policy implementation and play a bridging role, linking the central government and farmers [124]. It is necessary to strengthen supervision and control over local governments, promote the transparency of policy implementation, and improve policy feedback with the aim of achieving the sustainable development requirements for cultivated land.

(4) Distrustful relationships exist among different stakeholders

Farmers’ distrust of policy systems increases the cost of protecting cultivated land and may even trigger tension in social relations. Therefore, it is crucial to establish and maintain effective social contact and interaction, especially in the relationship between farmers and other stakeholders. This result resonates with the work of [121]. When stakeholders believe that other stakeholders are trustworthy, they can effectively work together to contain the risks of cultivated land protection. Since the implementation of a subsidy system for cultivated land protection in 2016, Xiliuhe has exposed a series of problems. Specifically, although the central government has put forward directional and principled policies, the specific measures put into practice by local government are not closely linked to local conditions. The specific measures for subsidies are general and vague. For example, farmers have expressed dissatisfaction with the local government due to the unclear criteria provided for claiming crop damage subsidies from floods, and the amounts received also do not meet their expectations. The reduced cooperation and participation of farmers will lead to increased difficulty in policy implementation.

The higher the comprehensive qualities of villagers are, the more attention they pay to external social and environmental sustainability issues, and the higher the degree of coordination with the implementation of the government’s farmland protection policy. (Interview with a staff member for the village committee).

Higher levels of education make farmers more likely to prioritize the social and environmental outcomes of their agricultural land [125]. The main source of information on cultivated land protection in the surveyed areas is local government. As the professional quality improves, farmers obtain different levels of access to information and create systematic perceptions of cultivated land protection.

In summary, the increasing cost of cultivated land, farmers’ weak position, unreasonable land use, and relationships of distrust among different stakeholders are the main risks and challenges. Therefore, mitigation strategies should be developed to cope with the risk factors of farmland protection.

5.2. Solution to Risk-Mitigation Strategies

According to the environmental, economic, and social-policy aspects, this study developed four strategies to meet challenges and mitigate the risks of cultivated land protection. To improve risk management, the risk factors should be handled by qualified risk-related stakeholders that show sufficient ability for risk control. The risk-mitigation strategies include facilitating agricultural economization and specialization, promoting a sustainable agriculture model, improving the compensation and mechanism of cultivated land, and establishing punishment and supervision mechanisms (as shown in Figure 5).

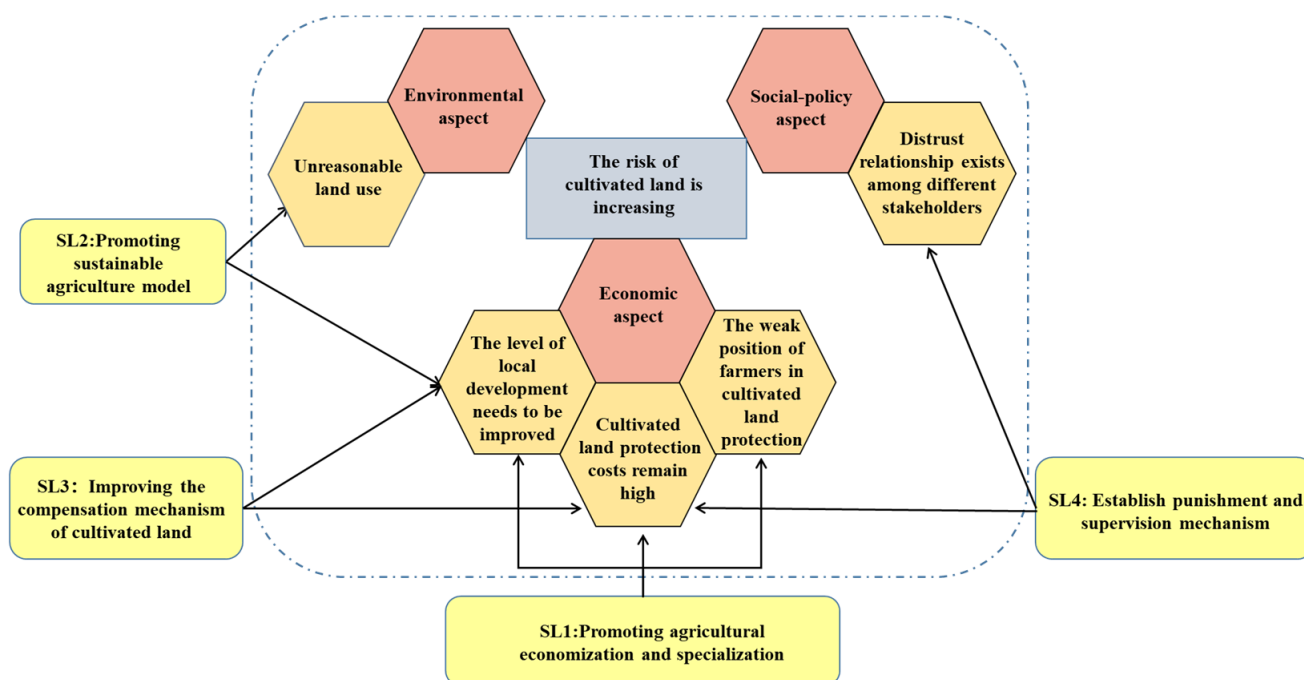


Figure 5. Framework for mitigating risk.

5.2.1. Promoting Agricultural Economization and Specialization (SL1)

When implementing land development policy, reclamation, or consolidation, as well as while promoting the ecological protection of cultivated land, governments face enormous economic challenges. Because of the considerable risk and uncertainty of agricultural operations and the lack of a social security function, improving the economic benefits of agricultural production is key aspect for cultivated land protection [8,64]. Thus, it is necessary to consider the social security plans for those farmers with low assets and incomes. Distrust among local government, village committees, and farmers makes it difficult to improve farmers' livelihoods. First, the government should further encourage investment in professional education and infrastructure projects to improve the livelihood levels of rural families [126]. Second, in response to the imbalance between the input and output of agricultural production, it is necessary to stimulate technological innovation regarding cultivated land use, provide preferential tax policies, and establish a cooperative innovation mechanism for industry, education, and research [31]. Third, the village committee should set up online learning to help farmers acquire information, adjust the direction of agricultural production, and improve agricultural productivity according to the changing, dynamic situation in agricultural production. Local governments should also use vocational training to help rural families with overpopulation enhance their competitiveness within the nonagricultural labor market [127].

5.2.2. Promoting Sustainable Agriculture Model (SL2)

Sustainable agriculture uses locally available resources and farmers' own knowledge and skills (with minimal use of chemical inputs) to improve productivity to adapt to local systems, maintain environmental quality, and improve food security [128]. Sustainable agriculture yields economic, social, and environmental benefits [128]. Sustainable agriculture can balance and improve the relationship between agricultural productivity and ecological protection, which conforms to developmental trends in environmentally friendly, cultivated-land-ecosystem thinking. In response to the local government's desire to profit from the ecological protection of cultivated land, it is necessary to strengthen cultivated land protection. Farmers should develop greater awareness of the importance of the "red line" policy for cultivated land protection and pay increasing attention to the prevention of risks. The development of sustainable agriculture needs to be tailored to local conditions. Local governments need to develop green agriculture with regional characteristics and avoid using a one-size-fits-all approach to layout planning.

Shrimp and rice technologies demonstrate a typical model of sustainable agriculture, known as "one water two uses; one field, double harvest" [129]. In Xiliuhe, the existing shrimp and rice crop technology is still immature, and it requires the support of agricultural, professional, technical, cooperation organizations and industrialization leaders. The government plays a vital role in achieving balance between increasing farmers' incomes and improving the environment. In cultivated land transfer, the local government and village committees should organize shrimp and rice crop technology learning, guide enterprises and farmers to establish an effective risk-sharing mechanism, and set a minimum transfer cost, reducing farmers' risks and protecting their interests.

5.2.3. Improving the Compensation and Mechanism of Cultivated Land (SL3)

In response to the high cost of cultivated land protection and the imbalance between urban and rural development, the market entry system for China's rural collective land should be developed to break down land-market barriers, facilitate the redistribution of land benefits, and protect farmers' social rights and interests. In a dual urban–rural system, urban and rural residents have unequal rights to land. Thus, it is difficult for rural residents to realize the market value of their land resources and reap the benefits of land appreciation. The market entry of rural collective land has reformed the existing land acquisition system and the land appreciation benefit model, which can assist farmers in realizing property income and alleviating their resistance. The government should adopt a relatively advanced and dynamic compensation policy to make farmers enthusiastic about cultivated land protection [124] and adopt a graded set of compensation standards to maximize equity.

Due to the persistence of the urban–rural system in China, many farmers are reluctant to give up their land; they feel a natural attachment to the land and a love for rural life. As a result, social problems arise in the expropriation of cultivated land, as economic compensation is usually insufficient to meet the social security needs of land flow-out farmers [130]. Farmers' loss of land means the loss of basic employment opportunities and of stable livelihood security. Therefore, it is necessary to establish a social security system that integrates urban and rural areas according to the situation of land flow-out farmers and to improving insurance and relief policies for land flow-out farmers in a focused manner, promoting the realization of social equity.

An ecological civilization strategy has been implemented by the Chinese government, which attaches increasing importance to land protection [131,132]. In response to natural disasters and chemical pollution, it is necessary to establish ecological compensation based on the value of cultivated land ecosystem services. While designing ecological compensation policies for cultivated land, the government should consider heterogeneity among farmers. For example, those farmers whose primary livelihood is tied to cultivated land may have negative attitudes toward ecological production for cultivated land. By

contrast, nonagricultural families and part-time agricultural families may be receptive to such policies [133].

5.2.4. Establish Punishment and Supervision Mechanisms (SL4)

In response to the relationship of distrust between stakeholders and the high cost of cultivated land protection, the government should design a reasonable and flexible reward and punishment mechanism to encourage farmers to participate in cultivated land protection. Cultivated land has strong externalities. Its ecological and social benefits have made important contributions to food security and ecological civilization. In Xiliuhe, the local government is responsible for balancing the positive and negative externalities of cultivated land. Thus, the government needs to incentivize and compensate positive externalities, control and restrain negative externalities, and hence internalize externalities to mitigate the economic risks arising from cultivated land conservation. For example, subsidies for farmers who have caused severe damage to cultivated land could be canceled, and the interest rates for agricultural loans to farmers who have contributed to cultivated land protection could be reduced. Second, it is necessary to design a proper performance evaluation system. The central government can learn from the successful cases of green GDP evaluation mechanisms to design an evaluation system to assess the achievements of local governments [124]. Meanwhile, the concept of humanistic sentiment can also be incorporated into the evaluation system to assess the trust relationship between the local government and farmers. Finally, information asymmetry leads to opportunistic behaviors [134,135]; Thus, it is necessary to establish an independent regulatory agency for cultivated land protection to avoid misinterpretation of the central government's requirements [136].

5.3. Validation of Strategies' Effectiveness

To verify the effectiveness of risk-mitigation strategies, the current study simulates the status of risk-factor networks by implementing risk-mitigation solutions with reference to Yu [74]. The prerequisites of the simulation include that risk-mitigation strategies (as shown in Table 4) are effectively implemented and that corresponding nodes and links can be removed from the network [137]. Simulation methods show the effectiveness of risk-mitigation strategies and predict the potential for reducing network complexity [76].

Figure 6 presents an optimized risk-factor network. This is a simplified network, with 131 nodes and 175 links, a 30% reduction. Moreover, the network density is 0.01, a reduction of 23.08%. The node betweenness centralization is 94% reduced, which demonstrates a significant decrease in network interaction and complexity [110]. The increasing number of isolated nodes indicates that risk factors can be addressed individually without triggering a chain reaction. According to the simulation results, reduced network complexity suggests the effectiveness of the mitigation strategy.

This study separately evaluates the effectiveness of each mitigation strategy. Specifically, this study deletes the nodes and links that correspond to each strategy from the original risk-factor network. Table 5 shows the results for the validation of each strategy. Among these, it is notable that the promotion of agricultural economization and specialization (SL1) reduces the network link by 17% and the density by 15.38% by mitigating the economic risk, which is the most effective individual strategy. In Xiliuhe, economic mitigation measures are used to enhance agricultural efficiency, which in turn effectively promotes the balance between economic development and cultivated land protection. This result indicates that the promotion of economization and specialization is critical for the direction of agricultural development in developing countries such as China.

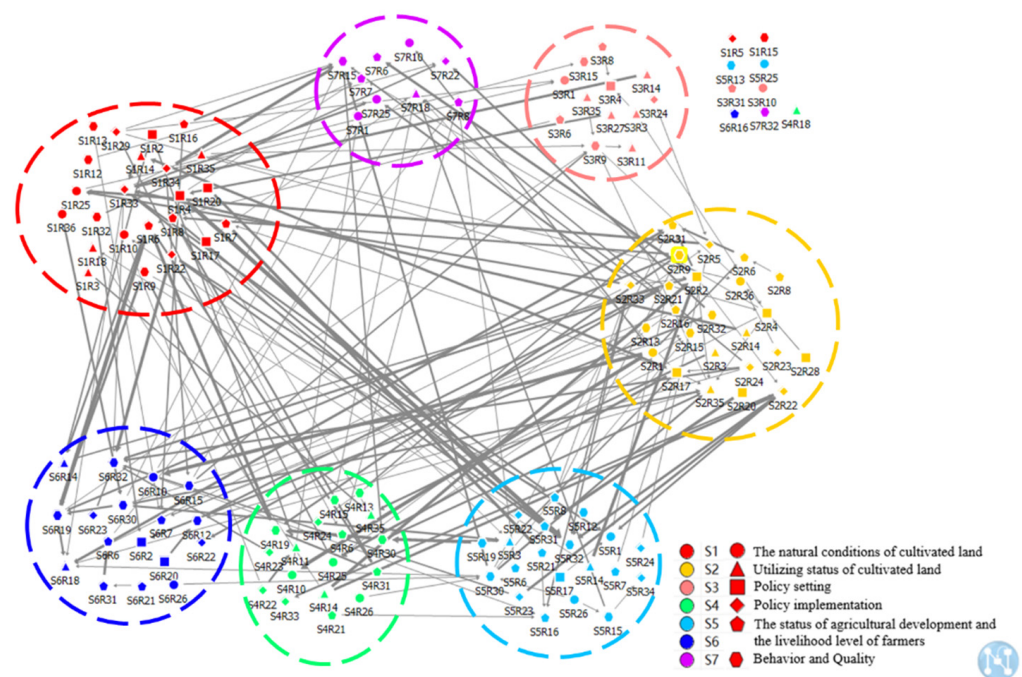


Figure 6. Risk network after mitigating critical risks and interaction. Note: S1, village committee; S2, local government; S3, land-use organization; S4, land non-flow farmers; S5, land flow-in farmers; S6, land flow-out farmers; and S7, the public.

Table 5. Effectiveness verification of individual strategy.

Solution	Deleted			Result
	Nodes	Links	Link Percent	
SL1: Promoting agricultural economization and specialization	S1R21 S2R7 S2R34 S3R16 S6R11 S6R13	S1R6→S6R13	↓17.00%	↓15.38%
		S1R8→S1R1		
		S1R8→S6R11		
		S1R21→S2R2		
		S2R4→S1R21		
		S2R6→S2R12		
		S2R12→S2R4		
		S6R11→S1R8		
		S6R11→S6R13		
		S6R13→S2R6		
SL2: Promoting a sustainable agriculture model	S1R1 S1R21 S2R7 S2R34 S3R25 S5R10	S1R1→S4R10	↓15.81%	↓7.7%
		S1R21→S2R2		
		S2R1→S6R30		
		S2R4→S1R21		
		S2R6→S2R12		
		S2R12→S2R4		
		S4R10→S2R1		
		S6R18→S1R6		
		S1R8→S1R1		
		S1R8→S6R11		
SL3: Improving the compensation and mechanism of cultivated land	S1R21 S2R7 S2R34 S6R11	S1R21→S2R2	↓11.86%	↓7.7%
		S2R4→S1R21		
		S2R6→S2R12		
		S2R12→S2R4		
		S6R11→S1R8		
		S6R11→S6R13		
SL4: Establish punishment and supervision mechanisms	S2R12 S2R29 S6R11 S6R13	S1R8→S1R1	↓14.62%	↓15.38%
		S1R8→S6R11		
		S6R11→S1R8		
		S6R11→S6R13		
		S6R32→S6R11		

Finally, it is noteworthy that the village committee (S1) and land flow-in farmers (S5) have prominent embeddedness, especially in terms of the connections between these two types of stakeholders. The village committee (S1) is a hub through which the government contacts farmers in the process of cultivated land protection. The optimized network alleviates conflict between the local government and farmers and draws together the interactions between the village committee and other stakeholders close. After network optimization, the economic and social risks associated with land flow-out farmers (S6) were mitigated, whereas the role of farmland inflow farmers (S5) in risk bearing was accentuated because land flow-in farmers (S5) are an important stakeholder in subsequent risk control and take responsibility for the large-scale operation of cultivated land. The village committee (S1) and land flow-in farmers (S5) promote the involvement of land-use organizations (S3), such as farmers' cooperatives and agricultural, socialized, service organizations, in agricultural production and construction and promote economic specialization in agriculture (SL1).

5.4. Limitations and Future Research Directions

This study established a social network model to investigate interactions among risk factors and associated stakeholders in cultivated land protection. However, limitations exist that should be met with future research. First, this study adopted a simulation approach rather than empirical methods to verify the effectiveness of different risk-mitigation strategies in cultivated land protection. A natural extension would therefore be to further examine the effectiveness of risk-mitigation strategies using structural equation modeling. Second, the case selected was located in the Xiliuhe town, central China. Future studies should compare how risk-factor networks manifest themselves within different institutional environments and analyze the effectiveness of different risk-mitigation strategies in different contexts. Third, the design of this study is cross-sectional. Future studies could conduct a longitudinal analysis on the evolution of risk factors over time.

6. Conclusions

In response to the challenges of cultivated land protection, a framework was developed to identify, measure, and analyze risk factors and their interactions in a network perspective to support the formulation of targeted strategies and evaluate their effectiveness in coping with risk. A typical town located in central China, in a major grain-producing area, was selected for the systematic case study.

Through literature analysis and interviews with key stakeholders, this study identified a list of 36 risk factors (Table 1). The risk-factor network for cultivated land in Xiliuhe is composed of 142 risk nodes and 253 risk links. Using network analysis, this study identified key risks in the network and evaluated their interactions with other risks.

The conclusions were as follows. First, over the entire network, the main stakeholders most likely to affect others were the local government and village committee, and the stakeholder most likely to be affected by others was the land flow-out farmers. Therefore, measures to mitigate risks in cultivated land protection should be tailored to farmers' behaviors through the active involvement of the local government and the village committee. Second, the high cost of cultivated land protection, the weak position of farmers, unreasonable land use, and the relationship of distrust among the stakeholders are the primary risk factors for cultivated land protection. The local government and village committee focus on these risks when making decisions. Third, facilitating agricultural economization and specialization, promoting a sustainable agriculture model, improving compensation and the mechanism of cultivated land, and establishing punishment and supervision mechanisms are important strategies for mitigating the risk factors in cultivated land protection. With reference to a simulation approach, this study optimized the risk-factor network, and the complexity of the network was greatly reduced through the adoption of a series of strategies. In summary, this study provides an innovative and systematic framework for coping with the complex, intertwined risk factors in cultivated land protection.

Author Contributions: Conceptualization, Z.G. and G.W.; methodology, G.W.; validation, Q.G. and Y.C.; formal analysis, Q.G. and Y.C.; data curation, Q.G. and Y.C.; writing—original draft preparation, Z.G., Q.G. and Y.C.; writing—review and editing, G.W.; supervision, G.W.; funding acquisition, Z.G. and G.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Humanities and Social Sciences Foundation of the Ministry of Education of China (Project Number: 17YJC790044), the National Natural Science Foundation of China (Project Number: 71901101), the Fellowship of China Postdoctoral Science Foundation (Project Number: 2020M671134), and the Fundamental Research Funds for the Central Universities, China (Program Numbers: 2021JC002).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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