# Mitigating the Impacts of Meteorological Disasters During the Phenological Period for Geographical Indication Agricultural Growers by Using Adaptive and Resilient Coping Strategies

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# Mitigating the impacts of meteorological disasters during the phenological period for geographical indication agricultural growers by using adaptive and resilient coping strategies

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**Abstract:** Developing geographical indication agricultural products will help to expand regional characteristic industries by taking actions that suit local circumstances. Improving the adaptability of geographical indication agricultural growers to cope with meteorological disasters is conducive to promoting the optimization of rural industrial structure and the implementation of rural revitalization strategy. Based on the field survey data of Shaanxi Province, this research uses the method of natural breaks to classify the resilience scores of meteorological disasters under the framework of Sustainable Livelihood Approach. Finally, the ordinal logistic regression model is used to quantitatively research how livelihood capital contributes to the resilience of kiwifruit growers to meteorological disasters during the phenological period. The results show that the perception of meteorological disasters by farmers does not significantly affect the resilience of farmers, and the impacts of different livelihood capitals on the resilience strategies of farmers are quite distinct: material capital, financial capital, social capital and human capital have significant positive impact on the resilience strategies of growers, while natural capital has a significant negative impact on the resilience strategies of growers. The results extend the theoretical foundation of resilience strategies for meteorological disasters in kiwifruit phenological period, and bring quantitative evidence linkage of livelihood capital and resilience strategies. Furthermore, the study emphasizes that the agricultural activities of kiwifruit growers during the phenological period should be combined with the livelihood capital guarantee measures, as well as a better financial environment should be created by government intervention. Paying attention to science popularization work of middle-aged and elderly growers, accelerating the linkages between the government and the mass, would help the government to obtain the best agricultural management methods.

**Key words:** geographical indication agricultural products; kiwifruit phenological period; Sustainable Livelihood Approach; resilience.

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# Declarations

- Ethics approval and consent to participate

Not applicable

- Consent for publication

Not applicable

- Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to the requirement of corresponding author, but are available from the corresponding author on reasonable request.

- Competing interests

The authors declare that they have no competing interests

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- Authors' contributions

XS provided relevant suggestions on conceptualization and manuscript frame structure; YQ collected manuscript data, processed and analyzed relevant results, wrote the manuscript; XL processed manuscript data; JY provided suggestions on data processing. All authors read and approved the final manuscript.

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# Mitigating the impacts of meteorological disasters during the phenological period for geographical indication agricultural growers by using adaptive and resilient coping strategies

**Abstract:** Developing geographical indication agricultural products will help to expand regional characteristic industries by taking a place-based approach. Improving the adaptability of geographical indication agricultural growers to cope with meteorological disasters is conducive to promoting the optimization of rural industrial structure and the implementation of rural revitalization strategy. Based on the field survey data in Shaanxi Province, China, this research uses the method of natural breaks to classify the resilience scores of meteorological disasters under the framework of Sustainable Livelihood Approach. Finally, the ordinal logistic regression model is used to quantitatively research whether and how much the livelihood capital contributes to the resilience of kiwifruit growers to meteorological disasters during the phenological period. The result shows that the perception of meteorological disasters by growers does not significantly affect the resilience of growers, and the impacts of different livelihood capitals on the resilience strategies of farmers are quite distinct: material capital, financial capital, social capital and human capital have significant positive impacts on the resilience strategies of growers, while natural capital has a significant negative impact on them. The result extends the theoretical foundation of resilience strategies for meteorological disasters in kiwifruit phenological period, and brings quantitative linkage of livelihood capital and resilience strategies. Furthermore, the study emphasizes that the agricultural activities of kiwifruit growers during the phenological period should be combined with the livelihood capital guarantee measures, and a better financial environment should be created by government intervention. The government should pay more attention to science popularization work of middle-aged and elderly growers, and promote the linkage between themselves and those growers, which will help them to obtain the best agricultural management method.

**Keywords:** geographical indication agricultural products; kiwifruit phenological period; Sustainable Livelihood Approach; resilience.

## 1 Introduction

Climate has vital significant influence in agricultural ecosystem. With the intensification of adverse changes in global temperature and precipitation and the frequent occurrence of various extreme weather phenomena (Eakin et al., 2012), agricultural producers are also affected by climate change, economic development and national employment (Graeub et al., 2016; Morton, 2007), when they are contributing to world food security through agricultural activities. As uncontrollable poverty is prone to appear in developing country rural areas (Keshavarz, 2018) and farmers are lack of channels to improve social, economic and financial capabilities, their livelihoods are vulnerable under the pressure of climate change. As the negative impact of climate change intensifies (Zhong et al., 2019), farmers need to take adaptation strategies to improve individual resilience ability to cope with meteorological disasters and mitigate agricultural and social economic crisis (Yin et al., 2016; Debnath and Roy, 2013). At present, researches on the adaptation and resilience of farmers are concerned. From the perspective of policy research, some studies linked the research on farmers' resilience with local agricultural policies to analyze the role of agricultural policies in building the adaptability and resilience of meteorological disasters (Tabe-Ojong et al., 2020). Some scholars also selected investigators based on whether they participate in local agricultural management projects, to analyze whether participation in agricultural policy activities affects farmers' resilience and livelihood vulnerability (Azumah et al., 2020). From the perspective of theoretical review, Shi (2016) summarized the current main research trends and discussed the future development direction according to the research on public perception of climate change and adaptation strategies; Zhao (2014) combed the relationship between farmers' perception of climate change and adaptation strategies, and constructed an analysis framework of climate change perception and adaptation, which expounded the main influencing factors that should be concerned in the process of farmers' adaptation. From the perspective of practical research, Wheeler (2013) argued that farmers should adjust to local conditions and take measures to improve resilience according to the regional characteristics of climate change. In the process of improving resilience ability, farmers' terminal decision is also affected by politic, economy and natural environment (Harvey et al., 2017). Some researchers studied the influencing factors of climate change adaptation strategies (Sun et al., 2018; Zhu and Zhou, 2011; Hou et al., 2018), such as farmers' individual basic attributes, climate change and meteorological disaster perception, and the effectiveness of adaptation strategies to climate change and meteorological disasters (Chen et al., 2014; Song and Shi, 2020).

The researches on the resilience strategy of climate change mostly regard farmers as subject, but farmers in different regions have large differences in planting crops and are affected by meteorological disasters. At present, geographical indication agricultural products, due to their unique quality, high visibility, as well as good reputation, play an important role in improving the potential of agricultural development, farmers' income and promoting the development of agricultural industrialization. In recent years, the planting scale of geographical indication agricultural products in Shaanxi Province has gradually expanded. Among many geographical indication agricultural products, kiwifruit industry has attracted considerable attention. Kiwifruit, originated in China, has a unique sweet and sour taste, is a fruit with high nutritional value. The Guanzhong area, where kiwifruit cultivation has a long history, has many kinds of kiwifruit. In Zhouzhi County and Mei County, a large area of kiwifruit planting base has been developed, kiwifruit fruit has become a famous geographical indication of agricultural planting area with large size, beautiful shape, unique taste and high economic value. Therefore, taking kiwifruit as the research object, this paper seeks to provide insights about the influencing factors of kiwifruit growers when choosing the strategy to enhance the resilience of kiwifruit growers and reduce the negative impact of disasters.

This paper introduces the concept of phenological period due to two reasons: firstly, the phenological period has an important influence on the agricultural production and sales process; secondly, the phenological stage has a great influence on farmers' agricultural activities. The phenological stage provides a significant climatic basis by dividing the growth stages. It helps farmers understand the growth of kiwifruit in stages, improve the planting method of kiwifruit, and take reasonable meteorological disaster resilient strategies. Kiwifruit has a clear phenological region, which can be divided into germination period, leaf expansion period, flowering period, fruit development period, fruit ripening period, leaf falling period and tree dormancy period (Fig 1). According to the metabolic rate of plants and fruit growth, the phenological stages with frequent meteorological disasters and important influence on the growth of kiwifruit were selected as the research object, including tree dormancy period, tree dormancy period, fruit development stage and fruit ripening period.

Different phenological periods have different climatic characteristics, and the meteorological disasters that had great influence on the growth and development of kiwifruit in each phenological stage were summarized. The disaster-causing factors of frost damage in overwinter period were extreme minimum temperature, which were mostly in the tree dormancy period from November to February of next year, mainly distributed in the Qinling Mountains and the northern and western regions of Guanzhong. Most of the disaster-prone orchards were orchards with initial fruit hanging and vigorous growth. The disaster-causing factors of frost damage in germination period are extremely low temperature as well, which occurs from March to April each year, and easily endangers the growth of the bud of kiwifruit, mainly distributed in Weinan City and Xianyang City. The disaster-causing factor of Summer drought is high temperature, occurs in June to July each year, when kiwifruit is in young fruit period and fruit enlargement period (Wang et al., 2013) ; The disaster-causing factor of sun scald disaster is high temperature, which mainly occurs in the fruit development period from June to July each year. Due to the acceleration of plant transpiration and soil evaporation by high temperature, the plant growth process lacks of water supply, which hinders the fruit growth. The disaster-causing factor of continuous autumn rain in autumn is the waterlogging disaster caused by rainstorm, which mostly occurs in the fruit ripening period from August to September each year. Continuous autumn rain leads to excessive accumulation of water in the orchard, which will result in death of plant roots.

Based on studies of natural disasters during the phenological period of kiwifruit, Zhang and Yan (2013) believed that kiwifruit had climatic and ecological conditions for temperature, moisture, light and wind. Frost damage in overwinter stage, frost and sun scald as three serious meteorological disasters required growers to take adaptive measures to prevent. Wang et al. (2013) constructed the risk assessment model of kiwifruit high temperature and drought disasters, and put forward suggestions on the design of high temperature and drought disaster related insurance, claims and disaster avoidance. At present, most of the studies focus on the impact of meteorological disasters. This study explores the influencing factors of meteorological disaster resilient strategies in kiwifruit phenological period from the perspective of growers.

Fig 1. Phenological period and meteorological disaster of kiwifruit

Livelihood capital is based on farmers' individual or family ability, assets and economic activities. Livelihood capital directly affects the choice of growers when taking livelihood strategies (He et al., 2019). Increasing the accumulation of livelihood capital is conducive to help farmers adapt to meteorological disasters in the phenological period then reducing the negative impact. Therefore, based on the framework of sustainable livelihood approach, this research analyzed the impact of livelihood capital on the resilience of growers to meteorological disasters. For example, farmers with sufficient natural capital have greater flexibility in taking agricultural diversification strategies (Smit and Pilifosova, 2003). Farmers with rich human capital can increase the family's non-agricultural employment opportunities by improving family members' education level. Farmers with higher cultural level are more likely to take advanced agricultural technology to improve family income (Ma and Liu, 2019). Farmers with substantial financial capital are able to purchase advanced agricultural tools, high-survival seeds and chemicals (Tucker et al., 2019); Material capital can be converted into individual income, and also improve the utilization rate of funds in new agricultural technology (Knowler and Bradshaw, 2007); Rich social capital can provide social assistance when farmers encounter difficulties. Therefore, it is of great significance to study the resilience strategy of kiwifruit phenological meteorological disasters with farmers' livelihood capital.

Data classification, as an important part of the research, is mainly used to synthesize and summarize the data under the condition that retain the maximum original characteristics of data (Xiao et al., 2020). The methods of data classification are diverse and scholars have already studied the evaluation of classification results (Koo et al., 2017; Mu and Tong, 2019; Wei and Grubesic, 2017). According to the existing research results, the Method of Natural Breaks, a classical analysis tool, is commonly used in geographical research and mostly used to present as well as identify regional spatial differentiation characteristics in geographical research (Han and Qi, 2020). The Method of Natural Breaks can identify the natural turning points and feature points between sequences according to the determined classification requirements, and properly group the similarity values to maximize the difference between classes (Zhao and Wu, 2018), so as to better research the characteristics of the same classification data. At present, the natural breakpoint method is mostly used for land consolidation and zoning in geography. Sadeghfam et al. (2018) used the natural breakpoint method to calculate the fuzzy interval and draw the groundwater potential field in the plain of Maragheh Bonab in Iran. Tan et al. (2020) used the natural breakpoint method to classify the integration degree of the inner line of the third ring in Fuzhou, and measured and studied the accessibility of the comprehensive park in Fuzhou more accurately. Chen et al. (2013) also studied the division of geographical environment units in South Asia by natural breakpoint method. Studies have shown that when dealing with data sets with obvious boundaries, the Method of Natural Breaks obtains the optimal exponential entropy, which is significantly better than other classification methods (Smit and Pilifosova, 2003). It can be applied to the data classification under certain grades, so it is scientific to apply the Method of Natural Breaks to the data classification in ordinal logistic regression.

The specific objectives of this study are as follows: (1) A specific study area with geographically marked agricultural products as the main agricultural income is selected to record the resilient strategies of meteorological disasters in phenological period; (2) To explore the impact of livelihood capital of meteorological disaster resilient strategies by growers; (3) To expand the theoretical understanding of livelihood capital, meteorological disaster resilience and the relationship from the empirical perspective. With the negative impact expansion of meteorological disasters, it is of great significance to carry out the research on the resilient strategy and its influencing factors to improve the adaptability of growers, family livelihood capital and the development of regional characteristic industries.

# 2 Study area

The study was carried out in Zhouzhi county and Mei County of Shaanxi Province, involving 7 towns and 14 villages (Figure 2). In these areas, most of the growers earn their main agricultural income by planting kiwifruit. Survey areas belong to the temperate continental climate region. Zhouzhi County (N33°42'-- 34°14', E107°39'-- 108°31') covers an area of 2974km$^2$. The annual average temperature of Zhouzhi County is 13.2°C, annual average precipitation is 673.4mm, average annual sunshine duration is 1993.7h, average annual frost-free period is 225d, and its altitude is 962-1721m. Mexian county (N33°59'-- 34°19', E107°39'-- 108°00'), covers an area of

863 km$^2$. The annual average temperature of Mexian county is 12.9°C, annual average precipitation is 581.6mm, average annual sunshine duration is 1857.9 h, average annual frost-free period is 214 days, and its altitude is 442-3767 m (Wang et al., 2013; Zhang and Yan, 2013).

With unique geographical indications of agricultural product development advantages, survey areas have become the world's leading kiwi fruit producer, and form a large area of kiwi production. The planting area of Zhouzhi County kiwi fruit is 33,300 hm$^2$, and the planting area of Mei County kiwi fruit is 20,100 hm$^2$. The production and marketing of Kiwifruit is as a pillar industry of Shaanxi's agricultural economy, whose economic income can reach to 94,500 RMB hm$^{-2}$. Therefore, it is of great practical significance to carry out research on meteorological disasters and adaptation strategies of kiwi growers in this region during the phenological period, in order to cope with climate change, promote the upgrading of agricultural industry, improve growers' livelihood capital accumulation and the effectiveness of kiwi fruit disaster protection measures.

Fig 2. Geographical location of the study area

# 3 Data and methods

## 3.1 Data collection

### 3.1.1 Questionnaire design

The questionnaire was divided into four parts: climate change perception, meteorological disaster resilient strategy, livelihood capital status and personal information. The five-point Likert scale was used to measure growers' perception of climate change and meteorological disasters. The dependent variable design was based on the main phenological periods of kiwifruit: tree dormancy period, germination period, flowering period, fruit development period and fruit ripening period, then literature analysis and field research were used on resilient strategies of common meteorological disasters in each phenological period, the respondents were asked whether to adopt these strategies to reduce their vulnerability. If the answer is 'yes', the value is assigned to 1, conversely is assigned to 0. The entropy method was used to empower 23 resilient strategies (the weighting results are shown in Table 4), and the total score of resilient strategies selected by each respondent was finally obtained. Finally, the Natural Breaks Method was used to maintain the statistical characteristics of the data itself, and the similarity values in the data were grouped most appropriately (Chen et al., 2013). Four breakpoints were selected from the total score of resilient strategy, and the data were assigned to 1 — 4 according to the breakpoint as the dependent variable of the regression model.

The independent variable revolves around the Sustainable Livelihoods Approach framework, to collect five types of livelihood capital data of growers. (1) Natural capital takes the total dimension of family cultivated land (Deressa et al., 2009), the planting dimension of kiwifruit and the annual output of kiwifruit as the measurement indexes; Material capital takes the number of rooms, the total area of houses, the type of house, the main energy sources of life and the number of household durable goods (questionnaire provides 21 household durable goods including household appliances, transportation tools, electronic equipment and common agricultural tools) as the measurement indexes; financial capital is measured by farmers' type, deposit money, family annual income, kiwifruit annual income and state subsidies; Social capital is measured by the number of family members and friends working in village committees or government departments, the number of executives in enterprises, and the number of family participated in cooperative community. Families and friends are direct sources of social relations, while cooperatives can help growers avoid the risk of climate change and provide information-sharing sites for growers (Frank et al., 2011); Human capital takes family members' education level, health status and family labor ability as measurement indicators. The assignment of each measurement index under the five types of livelihood capital is shown in Table 1, and then each index is weighted according to the entropy method (the weighting results are shown in Table 3), and the total scores of the five types of livelihood capital are calculated respectively. (2) Farmers' perception of meteorological disasters during the phenological period (i.e. Frost damage in overwinter period, frost damage in germination period, summer drought, sun scald disaster and continuous autumn rain) is also assigned according to the five-point Likert scale, and then the entropy method is used to empower them. Finally the score is calculated as an independent variable input model. (3) The individual attribute characteristics of respondents are also used as independent variables in the calculation of the model, including gender, planting kiwifruit time, family production and operation mode, the distance between the planting area and the city. The definition of specific variables is shown in Table 1.

Table 1 The definition of selected variables

3.1.2 Questionnaire survey

Field research was carried out in August 2019 and multi-stage random cluster sampling method was adopted. Firstly, the research group selected seven towns (Shoushan Town, Jinqu Town, Tangyu Town, Yabai Town, Erqu Town, Sizhu Town, Louguan Town) according to the planting area and population size from all the towns that planted kiwifruit in the survey area. Secondly, two villages were randomly selected in each town. Finally, according to the population size of each village, 30-50 respondents were randomly selected. Before the questionnaire survey, the respondents were asked whether they had cultivated land and kiwifruit planting experience. The average investigation time of each interviewee was 45 minutes. A total of 400 questionnaires were distributed and 331 valid questionnaires were recovered, with the effective rate of 82.75%.

3.1.3 Sample information

In the survey samples, there are more males (55.29%). The average age of the sample is 56 years old, of which the majority is elderly growers over 61 years old (34.44%). Most of the farmers' educational level is concentrated in high school (51.36%), followed by junior high school, as for university and above, the respondents accounted for the least, only 3.63%. From the perspective of family background, farmers with annual agricultural income of 2-30000 RMB accounted for 38.97%, and farmers with annual agricultural income of more than or equal to 800000 RMB accounted for the smallest proportion, only 6.95%. From the perspective of planting time, among the growers who planted kiwifruit in the survey area, the proportion of planting time was 10 – 19 years, accounting for 41.99%, and the proportion of growers who planted kiwifruit less than four years was only 5.14 % ( Table 2 ).

Table 2 Basic information of growers

3.2 Research method

3.2.1 Index weighting

Entropy method can scientifically reflect the utility value of each measurement index information, and effectively solve the problem of information that overlap between multi-index variables (Wang et al., 2018). In this study, entropy method was used to weight the dependent variables (23 resilience strategies under five common meteorological disasters) and some independent variables (19 measurement indicators under five livelihood capitals and farmers' perception of five meteorological disasters). The specific calculation process is as follows:

(1) Data standardization: Standardization methods take extreme standardization. The specific process is as follows:

Positive indicator:

$$X'_{ij} = \frac{X_{ij} - min\{X_j\}}{max\{X_j\} - min\{X_j\}} \quad (1)$$

Negative indicators:

$$X'_{ij} = \frac{max\{X_j\} - X_{ij}}{max\{X_j\} - min\{X_j\}} \quad (2)$$

$X'_{ij}$ is a standardized data, $X_{ij}$ is the indicator j for evaluation i ; $max\{X_j\}$ and $min\{X_j\}$ are the maximum and minimum for j.

（2）Index weighting by entropy method

①For standardized data $X'_{ij}$， calculated under the j index, the proportion of the i grower’s accounted for the index $Y_{ij}$:

$$Y_{ij} = \frac{X'_{ij}}{\sum_{i=0}^{m} X'_{ij}} \quad (3)$$

$$(i = 1,2,3,\dots,n; j = 1,2,3,\dots,m)$$

N is the number of survey samples, m is the number of measurement indicators.

②Calculate the entropy of j ($e_j$):

$$e_j = -k \sum_{i=1}^{n} Y_{ij} \; ln\{Y_{ij}\} \quad (4)$$

and，$k = \frac{1}{ln\{n\}}$, $e_j \geq 0$.

③Calculate of variance factor for j ($d_j$)

$$\mathrm{d_j} = 1 - e_j \quad (5)$$

④The difference coefficient is normalized to calculate the weight of j:

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}, \quad (j = 1,2,3,\ldots,m) \quad (6)$$

Indicator weighting results are shown in table 3.

Table 3 Index weight of independent variable

Table 4 Index weight of dependent variable

3.2.2 Method of Natural Breaks and ordinal multi-classification logistic regression

In order to determine whether livelihood capital and disaster perception ability of kiwifruit growers will affect the resilience strategy of kiwifruit growers, the econometric regression model was used to analyze. Dependent variables, 23 resilience strategies, were weighted by entropy method to obtain scores. Through the C language program, the natural breaks method was used to iteratively calculate the breakpoints between classes, so that the differences in classes were minimized and the differences between classes were maximized. Thus, the similar values in the data were properly grouped according to characteristics of resilience strategy score (Chen et al., 2013). Finally, the resilience strategy score was divided into four categories according to the breakpoints and assigned to 1 ~ 4. After processing, the dependent variables were orderly multi-classification variable with a clear sequence of permutations, so the ordinal multi-classification logistic regression model was used for regression operation (Shi et al., 2014).

In the model, assuming that the score of the resilience strategy of the grower has k + 1 level, there are k formulas:

$$L_i = \ln\left(\frac{\sum_{j=1}^{i} P(Y=j|X)}{\sum_{j=i+1}^{k+1} P(Y=j|X)}\right) = \alpha_i + \beta X \qquad (7)$$

$L_i$ = L(Y = i)，i=1, 2, 3, 4. $L_i$ represents the probability of kiwifruit growers taking resilience strategy when the score belongs to level i; X represents the factors affecting kiwifruit growers' resilience strategy; β is slope variable; $\alpha_i$ is intercept parameter for the i model.

# 4 Results and analysis

4.1 Descriptive statistic

By observing the meteorological disaster resilience strategy score box line diagram (Figure 3), the average score of farmers' resilience strategy is 0.408, and there are two outliers, 0.999 and 0.970. The upper quartile is 0.521, the lower quartile is 0.253, and the median is 0.422. The median is close to the upper quartile. The distance from the upper limit to the box is far greater than that from the lower limit to the box. There are a small number of abnormal values on the side of the larger value, and the average is less than the median. The data are left skewed distribution. Finally, the natural breaks method is used to classify the data. The breakpoints are 0.048, 0.321, 0.577, and 0.999. The results show that although there are large internal differences in the resilience score of meteorological disasters during the phenological period, most growers are positively taking resilience strategies to improve their resilience of natural disasters.

For phenological period, in view of the low temperature frost damage (Frost damage in overwinter period and Frost damage in germination period) occurred in tree dormancy period and germination period, strategy which used by growers is mainly to heat preservation and antifreeze to improve the frost resistance of trees. Because the frost injury will not only affect the growth of young buds, but also endanger the root system of fruit trees, so it requires more attention in this phenological period. Planters generally take low-cost high-temperature protection measures against high-temperature disasters (summer drought and sun scald disaster) during fruit development period; In view of the continuous rain disaster in autumn at fruit ripening period, the adoption rate of resilience strategy is generally low. This is because there are fewer types of meteorological disasters in this phenological period, and the negative impact is lower than other disasters. Therefore, there are fewer farmers adopting such resilience strategy (Figure 4).

Fig 3. Boxplot of meteorological disaster resilience strategy score

Fig 4. The scale graph of the adaptation strategy

Fig 4 (a). Resilience strategy in tree dormancy period: A1. Burying soil after pruning. A2. Whitening of trunk. A3. Wrap air permeability material on trunk. A4. Clean snow coverage in time. A5. Increase branches after winter cutting. A6. Increase soil moisture by irrigation in winter. A7. Install fan; Fig 4 (b). Resilience strategy in germination period: B1. Select superior soil, air flow place to build orchard. B2. Select anti-freeze kiwifruit to plant. B3. Take high grafting technique. B4. Organic fertilizer application. B5. Spray oligose and chitosan. B6. Timely irrigation to reduce soil temperature. B7. Spray antifreeze for tree; Fig 4 (c). Resilience strategy in fruit development period: C1. Cover with grass, water conservation. C2. Irrigation in time at high temperature. C3. Fruit bagging. C4. Spray leaf fertilizer. C5. Advance fruit bagging time. C6. Standard pruning of branches. C7. Set up shading nets; Fig 4 (d). Resilience strategy in fruit ripening period: D1. Collecting fruit timely after rain. D2. Timely drainage and moisturizing.

### 4.2 Ordinal multi-classification logistic regression result

**4.2.1** Model fitting results

Farmers' family livelihood capital, planting distance from town, gender, planting time of kiwifruit, whether plant other crops, family production and management mode and the perception of meteorological disasters during the kiwifruit phenological period will affect the growers to adopt the resilience strategy of meteorological disasters. Therefore, this paper selected the above indicators as independent variables to analyze their impact on farmers to adopt the resilience strategy. In test of parallel lines, P = 0.376, indicating that the ordered multi-classification logistic model can be used for analysis (Table 5).

Table 5 Result of parallel lines test

Table 6 shows the significance test results of regression zero model and current model. The -2 Log Likelihood of the zero model is 1625.732, and the current model is 1499.561, the P value is 0.000, indicating that the linear relationship between the whole independent variable and the dependent variable is significant, and the model is statistically significant. The Pseudo R－ Square of the model are between 0 and 1.

Table 6 Model Fitting Information

Regression results show that (Table 7) among the independent variables that affecting resilience strategy score, physical capital (P = 0.000), financial capital (P = 0.007), human capital (P = 0.000), distance from town (P = 0.000), whether planting other crops (P = 0.002), and family production and management mode (P = 0.000) have significant positive effects on growers' resilience strategy. The time of planting kiwifruit (P = 0.042) had a significant negative impact on the resilience strategy of growers.

4.2.2 Regression result

According to the results of ordinal multi-classification logistic analysis (Table 7), under the control of other variables:

Physical capital and financial capital have a significant positive impact on the growers' resilience strategy of meteorological disasters at 1% and 5% significant levels, that means, more physical and financial capital in the family, the higher the grade of the growers' resilience score, and the odds ratio of physical capital is OR=$e^{1.284}$=3.611. Therefore, the possibility of increasing a grade of physical capital is 3.611 times. The odds ratio of financial capital is OR=$e^{0.963}$ = 2.620, indicating that for each additional level of financial capital, the possibility for growers to take meteorological disaster resilience strategy to increase a level is 2.620. Human capital has a significant positive impact on the growers' resilience strategy of meteorological disasters at the 1% significant level. Families with sufficient human capital do not tend to take resilience strategies to improve the resilience level of families. The odds ratio of this variable is OR =$e^{0.262}$= 1.300, indicating that the possibility of increasing the resilience score of growers by one grade is 1.300. At the significance level of 10%, social capital has a significant positive impact on the resilience strategy of growers. For every level increase in social capital, the possibility of a level increase in the resilience score of growers is 1.623. Natural capital has a significant negative impact on growers' resilience strategy at the significance level of 10%, for every reduction of one level, the probability of a level increase in the resilience score of growers is 0.559.

The distance from the town, production and management mode of the family had a significant positive impact on the resilience strategy of the growers at the 1 % significant level. The results show that the growers who are farther from the town and more diversified in the family production and management mode are more inclined to take resilience strategies to improve the adaptability of meteorological disasters during the phenological period. The odds ratio of distance from the town is OR =$e^{0.020}$= 1.020. When the distance from the town increases one grade, the possibility of increasing the resilience score of the growers is 1.020 times. Family production and management mode advantage ratio OR=$e^{0.301}$=1.351, so family production and management mode increase a level, the possibility of growers' resilience score increases by 1.351

times. Whether the growers grow other crops has a significant positive effect on the dependent variable at 5% significance level. Compared with the families without other crops, the odds ratio of families with other crops is OR $=e^{0.070}$=1.073. Planting kiwifruit time at 5% significant level has a significant negative impact on the resilience score of growers, that means the kiwifruit growers who have shorter planting experience are more inclined to take the resilience strategy, the odds ratio OR=$e^{-0.014}$=0.986, the possibility of increasing the resilience score of growers by 0.986 times for every reduction of planting time.

Table 7 Model regression results

# 5 Result and discussion

Frost damage in overwinter period (tree dormancy period), frost damage in germination period (germination period), summer drought (fruit development period), high temperature sunburn (fruit maturity period) and continuous rain disaster (fruit maturity period) are influential meteorological disasters in kiwifruit phenological period. Mutabazi et al. (2015) have shown that farmers' internal perception of local climate change often affects the adoption of resilience strategy. Different from previous studies, growers' comprehensive perception of meteorological disasters in this study does not significantly affect the adoption of resilience strategy, which is related to the frequency of disasters in phenological period and the strength of the negative impact of disasters. Although the survey results show that growers rarely adopt crop diversification strategy, but the regression results prove that whether growers plant other crops is statistically significant, indicating that land use diversification and intensive strategy have a significant positive impact on growers' resilience. This conclusion is consistent with Morton (2007), Keshavarz and Moqadas (2021) studies. Although the survey area is affected by local planting history, crop diversification is still a measure for growers to choose to improve their adaptability. The distance from town has a positive statistical significance on the recovery strategy of the growers. The result shows that the growers who are farther away from the town tend to adopt the recovery strategy. According to the rule that farther the market distance is, the greater the risk they need to bear in the transportation, the growers need to adopt the recovery strategy to ensure the quality of the fruit and reduce the transportation loss.

The household production and management mode of growers also has a positive statistical significance. The survey results show that most respondents do not participate in cooperatives or supply and marketing cooperatives, but the regression results confirm that families with high participation are more organized and planned when adopting resilience strategies. The planting time of kiwifruit has a significant negative statistical significance on resilience strategy, which indicates that farmers with longer planting time do not tend to adopt resilience strategy to improve their resilience to meteorological disasters, which is consistent with the existing research results. The results of Tucker et al. (2010) also show that farmers' rich planting experience cannot be considered to have a positive impact on resilience strategy.

There is no doubt about the significance of livelihood capital for the adaptability of farmers' families. The existing research carried by Zhao et al. (2020) shows that farmers' adaptability can be improved through the diversification of livelihood capital and the accumulation of livelihood capitals. Choosing an effective resilience strategy can also reduce the family livelihood pressure, but whether it has a significant impact for the adaptability of farmers remains in a long range or not need to be considered. The regression results show that the physical capital and financial capital have a significant positive impact on the resilience strategy of households. On the physical capital, the survey results show that the physical capital of farmers is considerable, which is mainly manifested in most growers who live in concrete houses or building. The durable goods are complete, and the popularization rate of small agricultural tools is pretty high. It provides sufficient physical guarantee for farmers to adopt resilience strategies. The regression results also prove that adequate physical capital can lay a material foundation for growers to improve the resilience of meteorological disasters, which is consistent with the results of Eakin et al. (2012) that the development of physical capital can greatly improve the adaptability of farmers, and promote the diversification of land and market in rural areas.

With regard to financial capital, the accumulation of financial capital of growers is mostly due to household deposits, annual income and subsidies. The survey shows that more than a half of the growers (54.9 %) in the region belong to part-time households. In addition to agricultural income, migrant workers and other non-agricultural income account for a larger proportion. The regression results confirm the positive role of financial capital in promoting the resilience strategy of growers. The results show that if growers only rely on agricultural income and a small amount of government subsidies to maintain their livelihoods, they will aggravate the vulnerability of growers to disasters and market fluctuations during the phenological period. Therefore, increasing financial capital has a substantial assistance to the choice of resilience strategies, which is consistent with the results of Pour et al. (2018). This study finds that financial capital has a positive impact on growers' choice of diversified resilience strategies.

With regard to social capital, Forke et al. (2002) and Yohe and Tol (2002) pointed out in the study that social capital can provide knowledge, skills and resource networks for farmers and is a decisive factor in improving farmers' adaptability and resilience strategy diversification. The regression results of this study also confirmed that social capital has a positive impact on growers' resilience. The results show that the higher degree of growers' own social capital , as well as the larger number of supply and marketing cooperatives participating in the agriculture production, the stronger adaptability of growers to meteorological disasters.

With regard to human capital, the survey results show that the local growers generally do not attach importance to family human capital. Most family members go out to work all year round. The respondents' cultural level is low and they are not aware of improving family education to increase family human capital. He et al. (2019) have shown that families with rich human capital are more able to choose efficient and high-return resilience strategies in a timely manner. The regression results confirm that human capital has a significant positive impact on the resilience of growers. Rich human resources can adapt to the human costs required by different disaster resilience strategies to improve the overall adaptability of families.

Natural capital has a significant negative impact on family resilience. With regard to natural capital, the survey results show that little growers' natural capital holdings, small land area, and small family cultivated land area are vital factors restricting the growers to adopt the resilience strategy. The regression results prove this conclusion, which is consistent with Pagnani et al. (2020) research results.

# 6 Conclusion and suggestion

## 6.1 Conclusion

In this study, according to the current planting situation of kiwifruit, the SLA framework was placed under the background of Zhouzhi County and Mei County in Shaanxi Province, China. As a large-scale kiwifruit production area, the meteorological disasters in the phenological period of kiwifruit threatened the fruit production and affected the family livelihood of kiwifruit growers. Through the determination of the main concept of SLA, the relationship between the livelihood capitals of farmers and the adoption of resilience strategy of meteorological disasters in this study is clarified, so as to explore how livelihood assets affect farmers' adaptation.

The first goal of the analysis is to determine the resilience strategy adopted by kiwifruit growers. The results show that the adoption rate of resilience strategies is 61%, exceeding 50%, which indicates that most resilience strategies are affirmed by growers. In view of the common disasters during the phenological period of kiwifruit (including frost damage in overwinter period, frost damage in germination period, summer drought, Sun scald disaster and continuous autumn rain), there are the maximum resilience strategies to prevent or alleviate frost damage with low temperature (including frost damage in overwinter period and frost damage in germination period), while there are the minimum number of resilience strategies to prevent or alleviate the disaster caused by excessive rainfall (autumn continuous rain) and the utilization rate is less than 25%.

Finally, this study aims to further research the relationship between livelihood capital and meteorological disaster resilience strategies of growers under SLA framework. In order to test the relationship between personal attributes, capital and resilience strategies, ordinal multi-classification logistic model is adopted. The results of this model provide quantitative data on the relationship between livelihood capital (physical, financial, natural, social and human capital), individual attribute information of growers and resilience strategies (the score is finally obtained by empowering 23 types of resilience strategies). Regression analysis shows that physical, financial, social capital and human capital have significant positive effect on resilience strategy, but natural capital has a significant negative effect on resilience strategy. The distance from town, whether plant other crops and family production are positively correlated with the adoption of resilience strategy, while the planting time of kiwifruit is negatively correlated with the adoption of resilience strategy.

## 6.2 Suggestion

First of all, the current studies have emphasized the importance of targeted solutions to improve the livelihood capital of farmers (Knowler et al., 2007), which is also of great significance to improve the livelihood of farmers and improve their resilience (Sing, 2020). In particular, the current farmers' awareness of family livelihood capital is weak, and their understanding of the role of livelihood capital is not profound. Therefore, this study suggests that the agricultural activities of kiwifruit growers should be combined with livelihood capital security measures during the phenological period. For example, the introduction of short-term insurance products for different phenological stages not only enhances growers' perception of kiwifruit phenological period, but also strengthens growers' attention to livelihood capital. At the same time, government intervention can help to create a better financial environment (Tucker et al., 2010; Knowler et al., 2007). Government work should be more inclined to create a reasonable investment and financing environment, help to improve the sales chain of local kiwifruit industry, enhance the financial capital resilience of local growers' families, and expand capital sources, which is conducive to improving the adaptability and resilience of local growers' families.

In view of the current rural communities engaged in agricultural activities are mostly middle-aged and elderly people, growers are generally older, and their attitudes towards resilience strategies are more conservative, the local government should pay attention to the science popularization work of middle-aged and elderly growers. Because of the age limit, their learning efficiency is lower than the young. The science popularization activities can be innovated according to the acceptance ability, by holding the village promotion activities, distributing the handbooks of picture explanation and so on. The communication process can also promote the communication between the government and farmers, and help the government to obtain the best agricultural management method.

The survey results show that the farmers in the region are still dependent more on non-agricultural income. Due to the limited ways to increase income, lack of other labor experience and limited communication with the outside world, the employment channels are not broad, which eventually leads to limited agricultural production income, relatively low non-agricultural income for subsidized household, and difficult accumulation of household livelihood capital. In order to attach the rural revitalization strategy in China, we should actively integrate all kinds of training resources, combine skills training courses with agricultural technology, improve farmers' personal technical level and rural employment situation, as well as increase farmers' capital accumulation.

The impact of family production and management mode on the resilience of growers cannot be ignored. Communities should improve family social capital through different activities, such as encouraging growers to participate in formal agricultural cooperative organizations. With the popularization of the concept of intelligence agriculture, agricultural cooperative organizations can act as carriers to mobilize the enthusiasm of growers to participate in activities, and provide a platform for cooperation and communication.

Secondly, different political, economic and cultural backgrounds create different regional characteristics, so the measurement standards of livelihood capitals are constantly changing according to different social and cultural backgrounds. According to the natural and human geographical characteristics of different regions, taking relevant livelihood measurement standards according to local conditions and strengthening the locality and professionalism of resilience strategies are conducive to improving the resilience of growers.

Finally, this study provides a research method for the adaptation of growers, but the factors that affect the resilience of growers are far more than family livelihood capital and personal attribute. The actual climate change and farmers' perception of climate change also affect the adaptability. Therefore, further research is needed to combine more influencing factors to explore the adaptability of households to meteorological disasters. In addition, Smit and Pilifosova (2003) have analyzed the driving factors of adaptive behavior of growers, and future studies can also improve the analysis method by incorporating the effectiveness of resilience strategies and some psychological factors into the consideration of explanatory variables to improve the accuracy of the study.

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# Figures

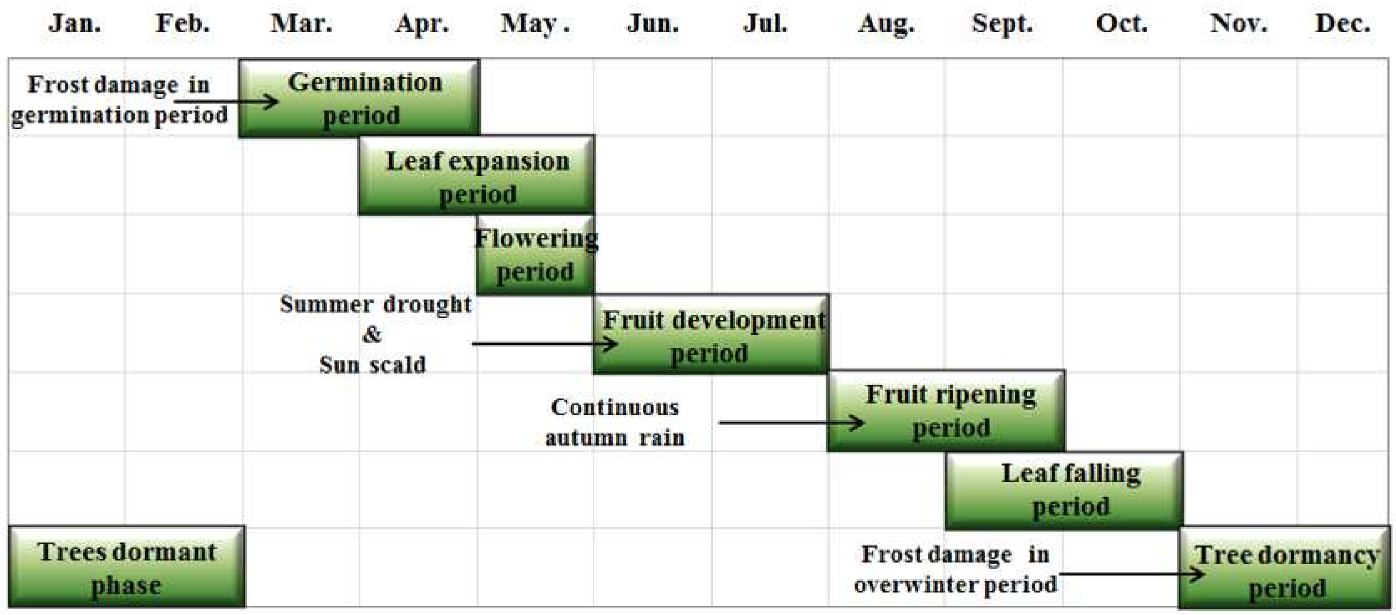
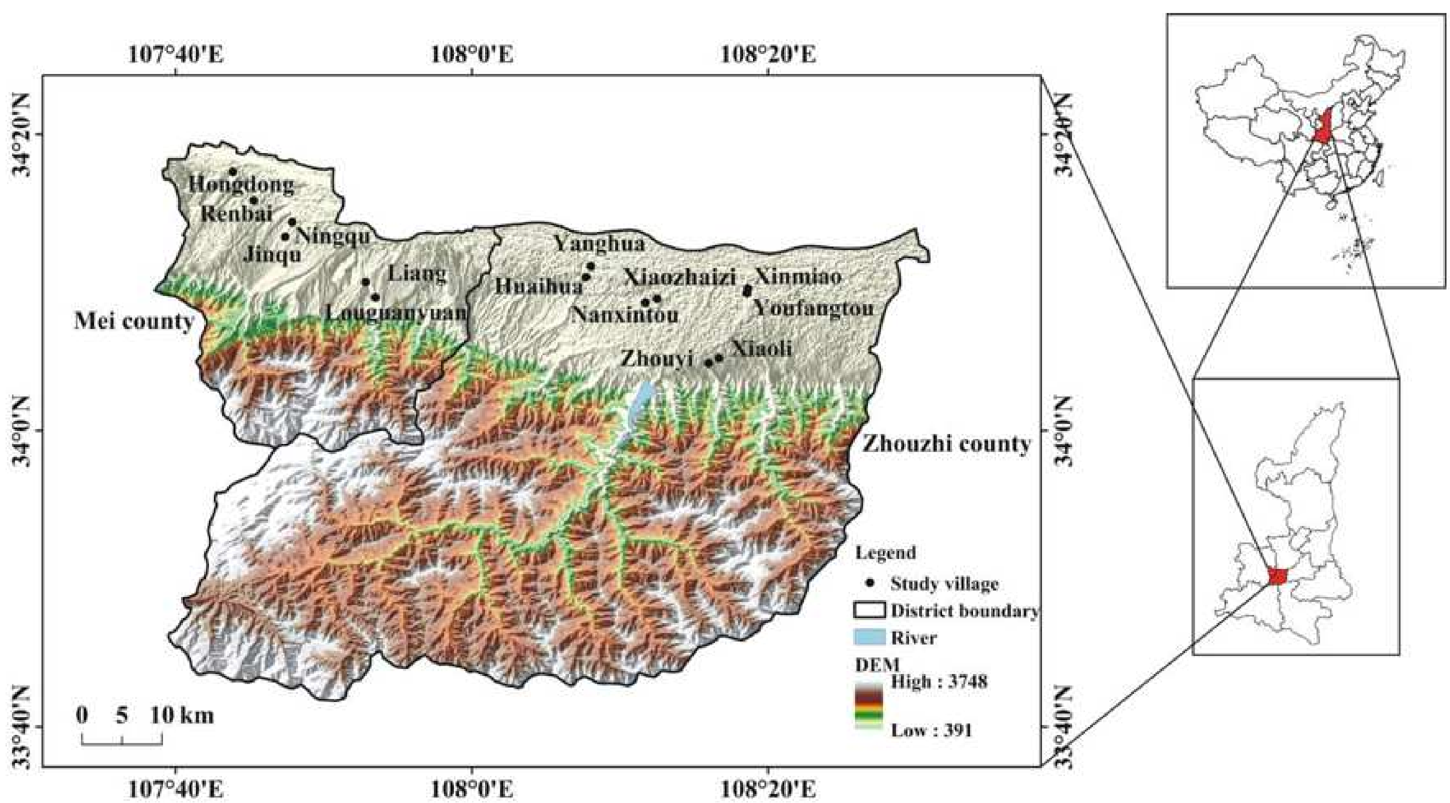


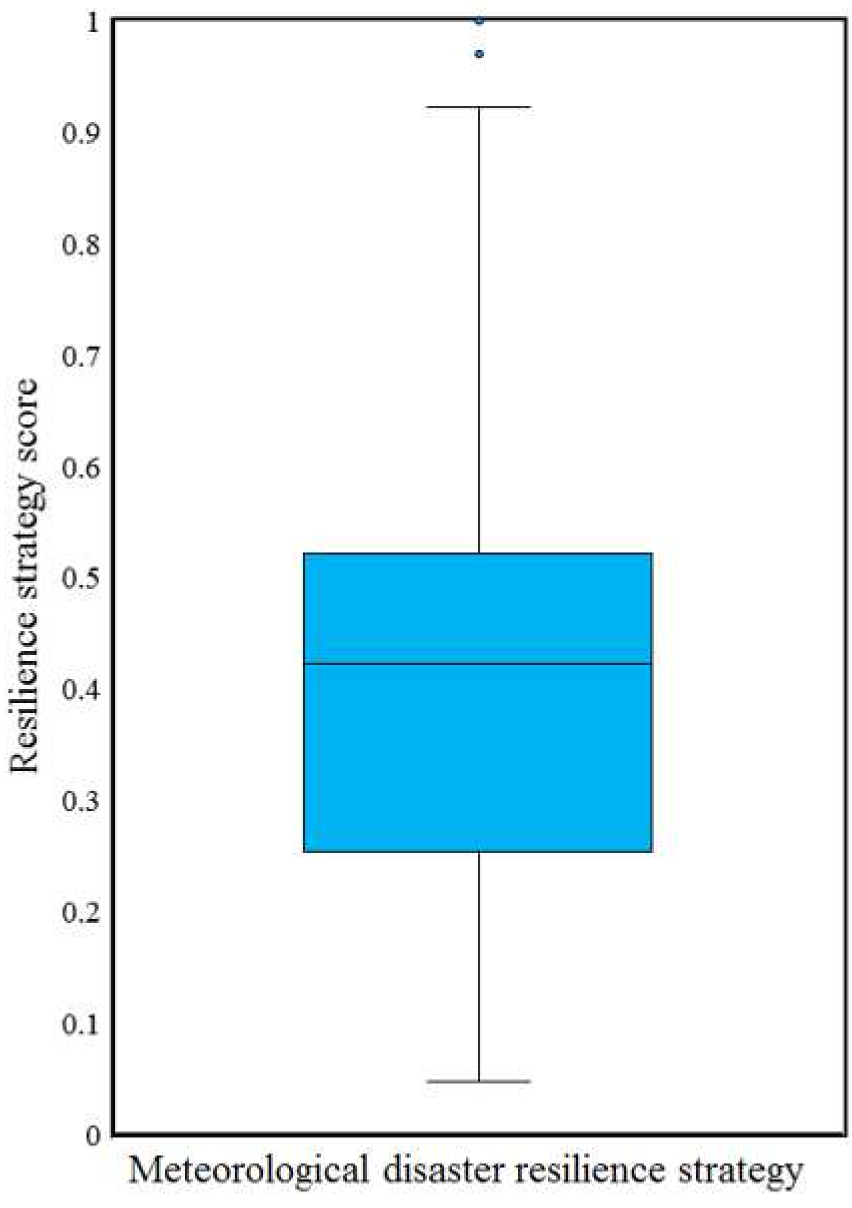

**Figure 1**

Phenological period and meteorological disaster of kiwifruit



## Figure 2

Geographical location of the study area. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.




## Figure 3

Boxplot of meteorological disaster resilience strategy score

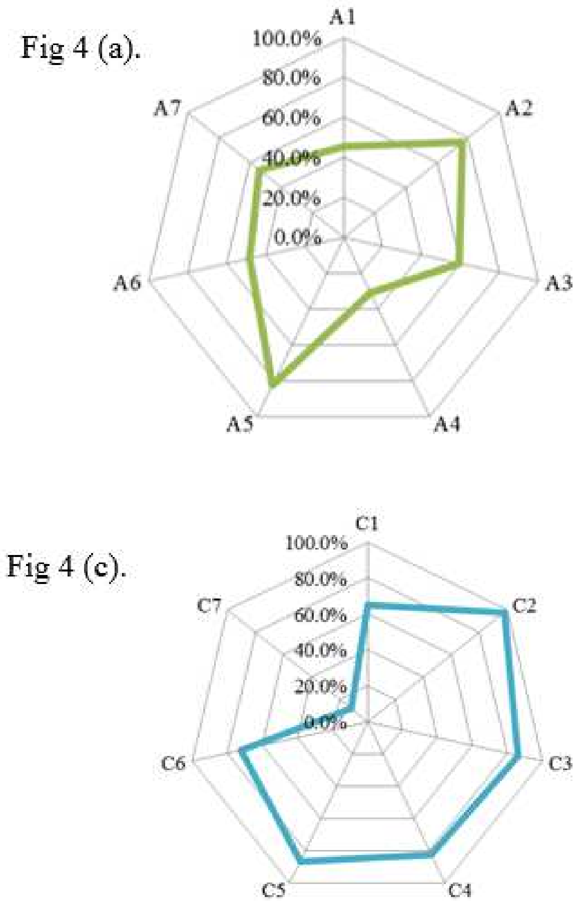



**Figure 4**

The scale graph of the adaptation strategy Fig 4 (a). Resilience strategy in tree dormancy period: A1. Burying soil after pruning. A2. Whitening of trunk. A3. Wrap air permeability material on trunk. A4. Clean snow coverage in time. A5. Increase branches after winter cutting. A6. Increase soil moisture by irrigation in winter. A7. Install fan; Fig 4 (b). Resilience strategy in germination period: B1. Select superior soil, air flow place to build orchard. B2. Select anti-freeze kiwifruit to plant. B3. Take high grafting technique. B4. Organic fertilizer application. B5. Spray oligose and chitosan. B6. Timely irrigation to reduce soil temperature. B7. Spray antifreeze for tree; Fig 4 (c). Resilience strategy in fruit development period: C1. Cover with grass, water conservation. C2. Irrigation in time at high temperature. C3. Fruit bagging. C4. Spray leaf fertilizer. C5. Advance fruit bagging time. C6. Standard pruning of branches. C7. Set up shading nets; Fig 4 (d). Resilience strategy in fruit ripening period: D1. Collecting fruit timely after rain. D2. Timely drainage and moisturizing.