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Cherry growers' perceived adaption efficacy to climate change and meteorological hazards in northwest China

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A R T I C L E I N F O

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A B S T R A C T

In the context of global climate change and frequent meteorological hazards, farmers' adaptive behavior has attracted attention of many scholars. Meanwhile, the perceived adaption efficacy is related to the farmer's ability by which they can accurately and effectively cope with influences of climate change and meteorological hazards. Based on the survey data from interviews with cherry growers of 9 villages in Shaanxi Province of China, this study employs the Theory of Planned Behavior and path analysis to identify the factors affecting the degree of perceived adaption efficacy, and then utilizes the ordinal logistic regression model to explore the influence mechanism of cherry growers' attributes, perception of climate change and perception of meteorological hazards at different stages of cherry growth on the weaker perceived adaption efficacy. The results show that attitude toward the behavior, subjective norm and perceived behavioral control of cherry growers all have significant positive influences on the perceived adaption efficacy. The relatively weaker perceived adaption efficacy is mainly affected by cherry growers' age, household agricultural income, perception of local climate warming in the past 30 years and perception of frost. Finally, targeted recommendations are put forward on the basis of above conclusions.

1. Introduction

The Fifth Assessment Report (AR5) of IPCC points out that climate change and meteorological hazards pose a serious threat to agriculture, villages and farmers' livelihoods [1]. In particular, the sensitivity of developing countries are more pronounced because of their relatively weaker economy and inadequate social infrastructure, where the majority of population make a living by doing agricultural work [2].

In this context, adaptation has become the only way to deal with climate change and meteorological hazards [1]. Scholars have carried out much on the issue of farmers' adaptation to climate change, and have made rich research achievements in theoretical construction [3–6], adaptive behavior conforming local conditions [5,7–13] and other aspects. In order to have an in-depth understanding of the motivation and the orientation of farmers' adaptive behavior, it is necessary to study not only what kind of adaptive behavior they choose in the face of climate change and meteorological hazards, but also how they evaluate their choices, that is, farmers' perceived adaption efficacy, which will directly affect the motivation and the orientation of farmers' adaptive behavior [14]. Nevertheless, current studies have focused more on the specific adaptive strategies of farmers to climate change and less on the perceived adaption efficacy [15]. Therefore, this study can attract more attention to farmers' perceived adaption efficacy and help the local government deepen understanding of it so as to formulate more favorable policies to aid farmers in adapting to climate change and meteorological hazards.

Farmers are particularly susceptible to climate change [16], for highly depending on natural resources [17] which are extremely vulnerable to climate change. So farmers are reckoned as the main body of the study on adapting to climate change and meteorological hazards. According to the focus of agricultural activities, farmers are divided into different categories. Some studies were carried out on farmers who grow crops [18–20], some focused on pastoralists [21,22], and others were concerned with fishermen [8]. However, there are currently few studies on fruit farmers, especially on the fruit farmers' perceived adaption efficacy. The influence of climate change on fruit growth has been confirmed by scholars [23–27]. Global warming, abnormal precipitation and more and more meteorological hazards will not only reduce fruit production [28–32], but also affect fruit nutrition [33], taste [34] and distribution of planting areas [35,36]. These consequences are likely to

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lead to unsalable fruits and falling prices. In many countries, fruit growers earn their livings by selling fruits, so their livelihoods will be greatly affected. Therefore, it is of practical significance to study the fruit growers' perceived adaption efficacy. They should not be neglected.

In recent years, fruit planting areas and output in Shaanxi province of China have been at the forefront. Among all kinds of fruits planted in this province, cherry in Baqiao District of Xi'an has the longest planting history. Baqiao Cherry has been assessed as Geographical Indication Protection Product by Ministry of Agriculture of the P.R.C and the General Administration of Quality Supervision, Inspection and Quarantine of the P.R.C. The sweet cherry in Modern Agricultural Demonstration Park of Bailuyuan in Baqiao District is named as a famous brand product of Xi'an and passes the national certification on organic food conversion [37]. Appropriate climate for cherry growth is important, neither drought nor waterlogging. When the soil moisture is too low, the growth of new shoots will be inhibited due to lack of water. If there is too much water in soil, branches and leaves will grow crazily, which is not conducive to bear fruit. In terms of temperature, different growth stages from germination and anthesis to young fruit growth have different temperature requirements. The minimum temperature in night at anthesis should not be lower than 5 °C, and the maximum temperature during the day should be less than 23 °C. Proper temperature for fruit from the growth stage to the maturity stage is 20 °C. The sensitive nature of cherries to climate change can lead to disastrous consequences [38] seriously affecting the lives of local growers as most of them have a large area of cherry planting and only plant cherries as a source of income. Moreover, farmers in many countries around the world are planting cherries as an important source of income, and climate change and meteorological hazards have also caused great problems for farmers in these areas [39–41]. However, little research has been done on the perceived adaption efficacy of cherry growers. Therefore, it is of great significance to study the perceived adaption efficacy of cherry growers for improving their abilities to accommodate climate change and meteorological hazards, taking targeted adaptive behavior, and keeping a stable cherry yield [42].

This study aims to clarify the influencing factors of cherry growers' efficacy perception about adaptive behavior responding to climate change and meteorological hazards. Specifically it examines the influence of attitude toward the behavior (ATT), subjective norm (SN) and perceived behavioral control (PBC) to the perceived adaption efficacy of cherry growers, using the socio-psychological model——Theory of Planned Behavior (TPB). TPB has been widely favored by social behavior researchers. It has been successfully applied in many fields of behavior, and most studies have proved that it can significantly improve the explanatory power and predictive power of research on behavior [43–46]. For a thorough understanding of the growers with weaker perceived adaption efficacy, the ordinal logistic regression is also incorporated to assess the influencing factors (containing cherry growers' attributes, perception of climate change, and perception of meteorological hazards). Among these influencing factors, the perception of meteorological hazards is classified according to different growth stages of cherries instead of simply putting forward as meteorological hazards suffered in different growth stages have different degrees of damage to growers. Based on that, some useful recommendations are provided for taking the initiative to adopt effective adaptive behavior and formulating targeted adaptation policies.

2. Study area

Bailuyuan is located at the Loess Plateau in the southeast of Xi'an, Shaanxi province. It is bordered by Qinling Mountain in the south and the Ba River in the north, with 25 km long and 6–9 km wide, covering a total area of 263 km^2 (see Fig. 1). The sloping surface is inclined from the southeast to the northwest, with an altitude of 680–780 m, and the northeast side is 240–320 m above the Ba River [47]. Climate in this area

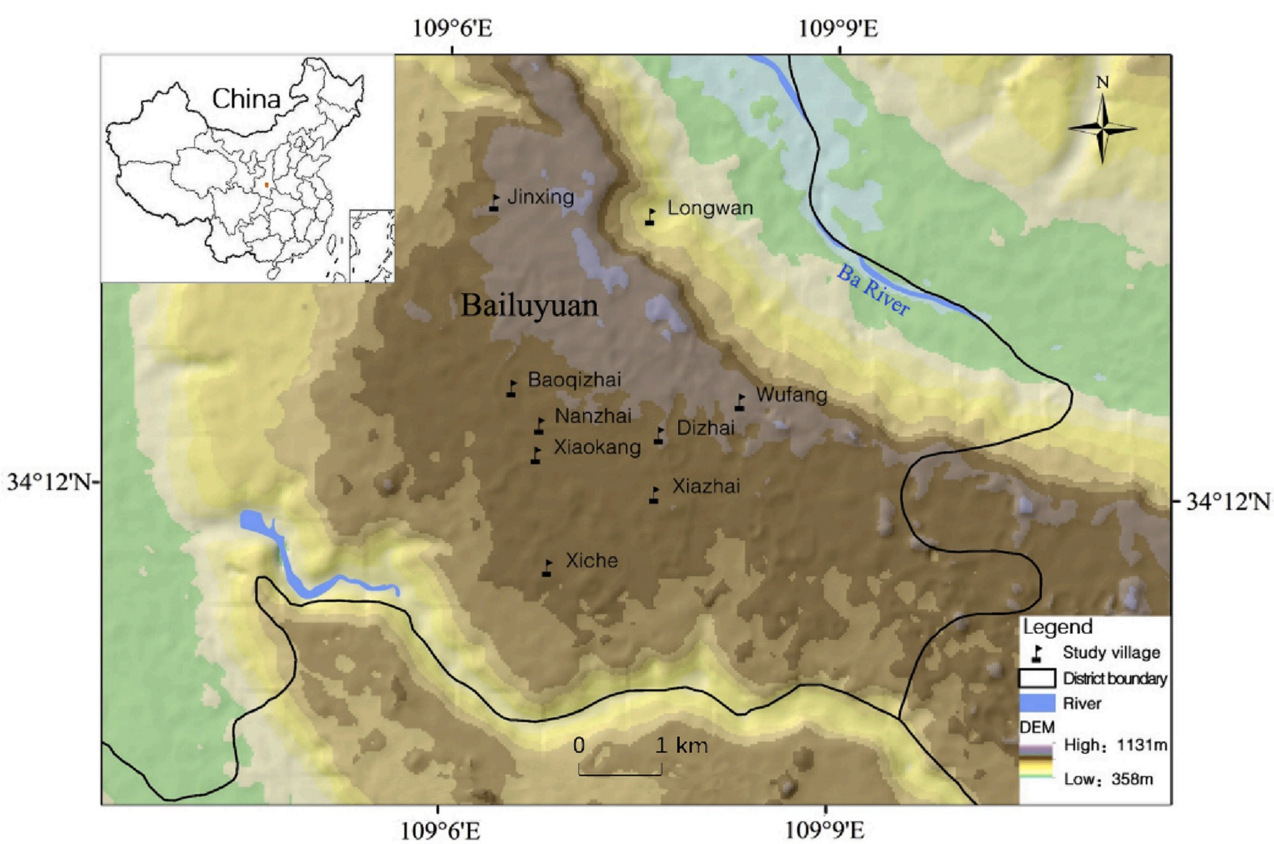

Fig. 1. Location of survey sites.

belongs to the continental monsoon climate with four distinct seasons. Annual sunshine hours range between 1725 and 2260 h. Average sunshine hours from cherry germination to maturity is 410 h, and average annual temperature is 7–14 °C. Sufficient illumination and heat resources meet the requirements of light and heat during cherry growth. Precipitation shows obvious seasonality, with the least from the end of March to April, the most in May. The annual precipitation is 600 mm, which meets the demand for water during the cherry growing period [38]. At present, cherry planting areas in Baqiao district are nearly 2667 ha including 1933 ha in Bailuyuan. The bearing fruit area can reach 2600 ha, and the total output is nearly 30,000 ton [48]. The cherry industry has become the pillar industry of the modern agricultural development project in Baqiao district of Xi'an, forming the largest cherry industry base in northwestern China [38]. Every year, cherries bring considerable benefits to local cherry growers.

In the past ten years, meteorological hazards such as low temperature and rain at anthesis, drought at the hard core of young fruit stage and continuous rainy days at the mature stage are the main hazards faced by cherry growers in Bailuyuan area. At anthesis, that rainy weather reaches more than 5 days or the average sunshine time is less than 5 h is easy to cause the damage of low temperature and frost. At the hard core of young fruit stage and summer growth stage, drought will seriously affect the fruit yield and quality, and cause fruit to drop. Continuous rainy days at the mature stage will lead to excessive soil moisture, increased humidity and increased cherry fruit cracking rates.

3. Materials and methods

3.1. Data collection

This survey was conducted in November 2017 mainly through semi-structured in-depth interviews and participatory rural assessment (PRA). Questionnaires were employed in the survey to collect information. The content of a questionnaire is divided into four parts by referring to relevant research, including: 1) perception of climate change and meteorological hazards based on TPB; 2) variables of perception of climate change and meteorological hazards; 3) variables of adopted adaptive behavior; 4) respondents' basic information.

After consulting the Agricultural Bureau of Baqiao District, 9 villages where cherries were grown in large numbers were selected as the survey areas. A pre-survey of a small sample was conducted before the formal survey. According to the pre-survey results, some unreasonable and unclear items were revised to ensure the quality of the questionnaire. First, by learning the villagers' social-economic situation with village officers, economic level and household characteristics of different cherry growers were determined and divided into three grades. Then, 10–15 samples of each grade were randomly selected. Finally, a total of 370 questionnaires were issued. After deducting the uncollected and unfinished questionnaires, there were 318 valid questionnaires with an effectiveness rate of 85.95%. Each household was the unit of this study and the heads of households or their spouses were the survey respondents. The formal survey began with a short time of interpretation of the study purpose. Furthermore, interviewers also told respondents that this survey need not fill in their names, telephone numbers and detailed addresses. During the survey, interviewers asked farmers questions in plain language, and they would explain farmers' doubts if some items were hard to understand. According to the validity and completeness principle of a questionnaire, screening work was carried out on the day when investigation was completed. After the screening, members of the investigation team summarized experience based on their own actions and made a record to guide the subsequent investigation.

3.2. Methods

3.2.1. Variables description

There are 11 main kinds of adaptive behavior of cherry growers coping with climate change and meteorological hazards, such as paying attention to the weather forecast and other media information concerning climate, applying fertilizer (including chemical fertilizer and farm manure), replacing cherry varieties, using more pesticide, increasing irrigation times, spraying the trunk with antifreeze, opening fire and smoking in orchards, building greenhouses against frost, setting up a protective forest/a windproof and anti-frost barrier, timely hoeing and buying insurance. When investigating cherry growers' perceived adaption efficacy, the Likert five-level method with a scale of 1 (invalid) to 5 (most valid) was adopted for evaluation and quantification. Respondents were required to use the five points to indicate their answers to corresponding items. Scores of efficacy perception of adaptive behavior selected by each respondent were added to obtain the minimum value of 20 and the maximum value of 51. The average value of all the respondents' scores of perceived adaption efficacy was about 40. On this basis, a respondent whose score was less than or equal to 40 could be selected as the analysis object with weaker perceived adaption efficacy, defined as dependent variables. Cherry growers' attributes, perception of climate change and meteorological hazards were selected as the factors influencing the degree of weaker perceived adaption efficacy, namely independent variables. Cherry growers' attributes included gender, age, culture, cherry planting area, cherry planting time, household agricultural income and non-agricultural income per year. Perception of climate change included perception of local climate warming in the past 30 years, perception of average summer temperature, perception of average winter temperature, perception of average annual precipitation, perception of drought and perception of frost. Perception of meteorological hazards included effects of drought on the cherry yield at the hard core of young fruit stage, effects of low temperature and rain/frost on the fruit setting rate of cherry at anthesis, effects of continuous rain on the cherry yield at the mature stage and effects of hail on the cherry yield. The scale and descriptive statistics of variables are shown in Table 1.

3.2.2. Theory of Planned Behavior

TPB is an important theory in the field of social psychology which is adopted to explain the individual behavioral decision-making, developed by psychologist Ajzen on the Theory of Planned Behavior (TPB) [49] and widely used to study farmers' intentions and behavior [50]. This theory predicts the behavioral intention implementing the particular behavior based on the following three dimensions: ATT, which can be positive or negative; SN, the perception of social pressure when an individual takes particular behavior; PBC, the degree of control and management an individual expects when he takes particular behavior. According to the TPB, the willingness to act is determined by three factors: ATT, SN, and PBC. If people have positive ATT which is related to the environment and believe that they have the ability to achieve their own intentions, meantime others hope that they will adopt the behavior and give strong support to them, then they will take action that is beneficial to the environment [51–53].

TPB focuses on the motive hidden under the decision-making behavior of cherry growers, and provides a suitable theoretical basis for investigating the driving force behind selections of specific adaptive behavior. The driving force is the perceived adaption efficacy, which is the perception of the effectiveness of adaptive behavior taken to protect oneself or others from threats [54], emphasizing the perception about the efficacy of certain actions. Meanwhile, the perception is a kind of consciousness and attitude [15], and the decisive factor to adopt adaptive behavior. Behavioral intention in TPB is also the determinant of behavior. Based on the above analysis, ATT, SN and PBC will also have indirect impacts on adaptive behavior in the context of climate change through direct impacts on perceived adaption efficacy. Through the

Table 1
Scale and descriptive statistics of variables for cherry growers in Northwest China.

	Variables	Scale	Mean	Standard error (%)
	Perceived adaption efficacy (Y)		3.61	0.477
Cherry growers' attributes	Sex (X_1)	1 = female; 2 = male	1.49	0.501
	Age (year) (X_2)	1 = 0–30; 2 = 31–40; 3 = 41–50; 4 = 51–60; 5 = older than 60	4.06	1.124
	Education (X_3)	1 = Primary and below; 2 = Junior high school; 3 = High school; 4 = Secondary Vocational School; 5 = College and above	2.11	0.946
	Planting area (mu) (X_4)	1 = 0–5; 2 = 5–10; 3 = 10–15; 4 = 15–20; 5 = more than 20	1.37	0.568
	Planting time (year) (X_5)	1 = 0–5; 2 = 5–10; 3 = 10–15; 4 = 15–20; 5 = more than 20	2.56	1.088
	Household agricultural income (yuan/year) (X_6)	1 = less than 10,000; 2 = 10,000–20,000; 3 = 20,000–30,000; 4 = 30,000–40,000;	1.80	0.967
	Household non-agricultural income (yuan/year) (X_7)	5 = more than 40,000	1.54	0.928
Perception of climate change	Perception of local climate warming in the past 30 years (X_8)	1 = strongly disagree; 5 = strongly agree	3.97	1.192
	Perception of average summer temperature (X_9)	1 = drop largely; 5 = rise largely	3.87	1.187
	Perception of average winter temperature (X_{10})		3.17	0.964
	Perception of average annual precipitation (X_{11})	1 = reduce largely;	3.34	1.006
	Perception of drought (X_{12})	5 = increase largely	3.38	0.910
	Perception of frost (X_{13})		3.05	0.718
Perception of meteorological hazards	Effects of low temperature and rain/frost on the fruit setting rate of cherry at anthesis (X_{14})	1 = no influence; 5 = great influence	3.91	0.978
	Effects of drought on the cherry yield at the hard core of young fruit stage (X_{15})		3.77	0.893
	Effects of continuous rain on the cherry yield at the mature stage (X_{16})		4.27	0.788
	Effects of hail on the cherry yield (X_{17})		2.68	1.206

theoretical framework, it is possible to clarify the intensity of cherry growers' intention to adopt adaptive behavior and investigate the decisive role of ATT, SN and PBC in the formation progress of perceived adaption efficacy. Therefore, the theory quite applies to the study on the cherry growers' perceived adaption efficacy. According to the above analysis, a model of path analysis depending on TPB is constructed (see Fig. 2).

By drawing lessons from studies of Fishbein [55], Ajzen [49], Fielding [56] and some other scholars, and combining with the uniqueness of cherry growers' perception of climate change and meteorological hazards, the measurement items of ATT, SN and PBC were designed. These items were pre-investigated for a small sample before being used for formal investigation, and some of the items were modified based on pre-survey results to improve contents of the scale. The scale shown in Table 2 was finally formed.

3.2.3. Ordinal logistic regression

The variables in this study about perceived adaption efficacy are ordered categorical variables, so the ordinal logistic regression method can be used to analyze the factors affecting the perceived adaption efficacy. The model of ordinal logistic regression is expressed as:

$$P(Y=j|X_i)=\frac{1}{1+\exp[-(\alpha+\beta X_i)]} \tag{1}$$

where X_i represents the i-th factor, and Y represents the degree of cherry growers' perceived adaption efficacy. Then an equation of cumulative logistic model can be got:

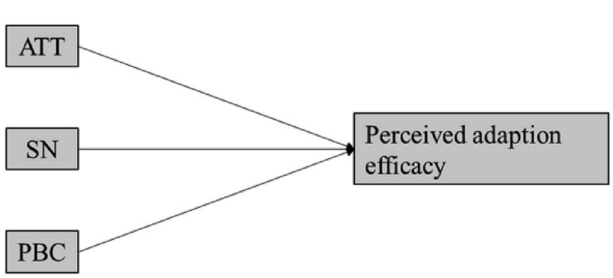

Fig. 2. Model of path analysis.

Table 2
Measurement items of each variable based on TPB.

Variables	Items
ATT	① I believe that climate change is caused by human beings' action
	② I believe that tackling climate change and meteorological hazards is not only a national issue but also an individual's issue
	③ I will take the initiative to pay attention to TV and newspaper reports on climate information
	④ I will take the initiative to pay attention to government policies to adapt to climate change and meteorological hazards
SN	① Planting cherries is good for improving local air quality and increasing farmers' agricultural income
	② Family believes that timely attention to climate information is necessary for planting cherries and preventing meteorological hazards
	③ Neighbors believe that timely attention to climate information is necessary for planting cherries and preventing meteorological hazards
	④ Meteorological administrations believe that when I pay attention to climate change information and prevent meteorological hazards, my income will increase
	⑤ My village leaders encouraged me to pay attention to climate change and prevent meteorological hazards
PBC	① For me, it is difficult to prevent or cure low temperature rainfall/frost disasters during the process of growing cherries
	② For me, it is difficult to prevent or control the drought at the hard core stage of young fruit
	③ For me, it is difficult to prevent or control the continuous rain disaster at the mature stage
	④ For me, the ability of family to cope with meteorological hazards is relatively low
	⑤ I think the expected cost of adopting climate change is relatively high

$$Logit(P_j) = ln\left[\frac{P(Y \le j)}{P(Y \ge j+1)}\right] = \alpha_j + \beta X \tag{2}$$

where $P_j = P\ (Y = j), j = 1, 2, 3, 4, 5$; X represents the factors affecting cherry growers' perceived adaption efficacy; β is a set of regression coefficients corresponding to X, α_j is the intercept of the model. After obtaining the parameter estimates of α_j and β, the occurrence probability of a particular situation (such as $Y = j$) can be obtained by:

$$P(Y \le j|X_i) = \frac{\exp[-(\alpha + \beta X_i)]}{1 + \exp[-(\alpha + \beta X_i)]} \quad (3)$$

4. Results and discussion

4.1. Respondents' profile

162 males made up 50.9% of the total 318 samples, and the rest 156 were females, accounting for 49.1%. Most of samples were over the age of 60, up to 54.7%. Nearly half of the samples had received junior high school education (48.1%), followed by primary education and below (25.8%). The area with cherry trees was mostly between 0.13 and 0.27 hm^2 (41%), and the longest planting time was 10 years (19.2%), followed by 5 years (11.9%). 46.9% households had an agricultural income less than 10,000 yuan per year, and the ones owning cumulative income of 20,000 yuan or less one year accounted for 82.7%. The percentage of household non-agricultural income less than 10,000 yuan a year was 68.6%, and the ones with cumulative income of 20,000 yuan or less took the percentage of 83.6%. By comparing the information of cherry growers in this survey with the official statistics of Baqiao District, these survey samples could better reflect the basic situation of cherry growers in the study area so that they had certain representativeness.

4.2. Cherry growers' perception of climate change

According to the results of questionnaires, the weighted average of each variable of climate change perception was calculated as the perceptual index, which ranged from 1 to 5. Fig. 3 presents the results. Cherry growers in Bailuyuan agreed with the warming trend of local climate (perceptual index = 3.97, of which "agree" was 43.1% and "strongly agree" was 38.1%), suggesting that most people perceived the local climate had been becoming increasingly warmer over the past 30 years. Analysis of farmers' weather perception of Thailand and Vietnam also indicated increasing trend in temperature [57,58]. For the change of average summer temperature, the perceptual consistency of cherry growers was high (perceptual index = 3.87, of which "increase a little" was 45.6% and "increase a lot" was 32.4%), and many persons thought that the average summer temperature had increased recent years. It is interesting to note that the perception of the cherry growers is similar to the finding in Myanmar [59]. But the perceptual consistency of average temperature change in winter was relatively low (perceptual index = 3.17, of which "increase a little" was 41.8% and "increase a lot" was 3.8%). Two possible reasons for the different consistency indexes were: 1) the high temperature above 40 °C had always appeared in summer of Xi'an in recent years, at the same time, the high air humidity made the body difficult to dissipate heat; 2) gale, dry air and low temperature in winter. These factors left the impression that the average temperature in summer was higher than previous years and the average temperature in winter had no great variation even if the temperature rose a little for it was hard noticed with special climate distinct from that of summer. The perceived indexes of precipitation and drought change, basically reaching the same level, respectively were 3.34 (of which "no change" was 36.8% and "add a little" was 33.3%) and 3.38 (of which "no change" was 41.8% and "add a little" was 38.7%). Possible explanations for this seemingly contradictory perception were: 1) an uneven distribution and a large interannual variation of the precipitation; 2) a low utilization rate of precipitation in some areas of this region. Because of that, the frequency of drought had not changed, even increased. This observation is in close resemblance to the study of perception of farmers in India [60]. For frost, a large proportion of cherry growers thought there was no change (perceptual index = 3.05, of which "unchanged" was 67.3%).

4.3. Cherry growers' perception of meteorological hazards

Since cherries have sensitivity to climatic conditions during growth, they are likely to be affected by meteorological hazards caused by climate change at each stage of their growth (see Table 3).

According to the cherry growth stages and the susceptible hazards at different stages, meteorological hazards during cherry growth period in this study are divided into four kinds: effects of low temperature and rain/frost on the fruit setting rate of cherry at anthesis, effects of drought on the cherry yield at the hard core stage of young fruit, effects of continuous rain on the cherry yield at the maturity stage and effects of hail on the cherry yield. The calculation method of cherry growers' perceptual index of meteorological hazards is the same as before, and the results are shown in Fig. 4. The perceptual index of effects of continuous rain on the cherry yield was the highest, 4.27 (of which "great influence" was 42.1% and "greater influence" was 44.3%), the perceptual index of effects of low temperature and rain/frost on the fruit setting rate of cherry at anthesis was 3.91 (of which "great influence" was 43.7% and "greater influence" was 29.7%), and the perceptual index of effects of drought on the cherry yield at the hard core stage of young fruit was 3.77 (of which "great influence" was 51.9% and "greater influence" was 18.2%). The perceptual indexes of effects of the above three meteorological hazards on the cherry yield were relatively high, because more precipitation at the mature stage could cause mature kernels to rot and fall off, excessive precipitation at anthesis might make the temperature drop which is easy to form frost damage, and less precipitation or even drought at the hard core stage of young fruit could

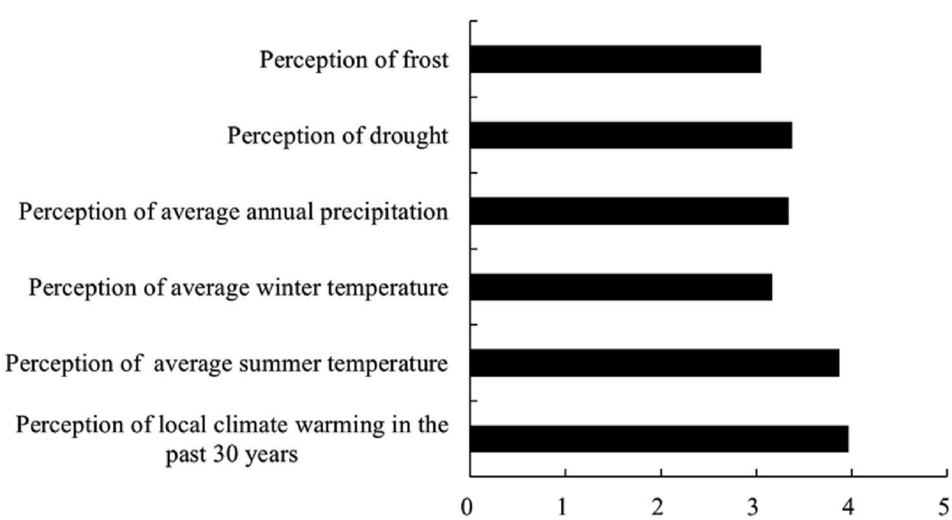

Fig. 3. Cherry growers' perceptual indexes of climate change.

Table 3
Different growth stages of cherries and key climatic factors and hazards information of each stage.

Cherry growth stages	Division basis of the growth stage	Key climatic factors	Susceptible hazards
Germination and anthesis	Budding when the average daily temperature is about 10 °C; blooming when the average daily temperature reaches about 15 °C	Temperature: The minimum temperature at night should not be lower than 5 °C and be kept at 8–10 °C; the maximum temperature during the day is less than 23 °C and should be kept at 18–22 °C	Low temperature; rain; frost
Shoot growth	5–7 d later than the flower bud sprouting stage	Water: annual precipitation is 600–800 mm	Drought
Fruit development	The first stage: from fade to hard core; the second stage: hard core and embryo development; the third stage: from hard core to fruit ripening	Illumination: The annual sunshine hours are 1200~ 2800 h	Continuous rain; hail; drought
Flower bud differentiation	About 10 days after fruit harvest	Water: suitable; Temperature: maximum temperature ≤30 °C;	High temperature; drought
Defoliation and dormancy	Around mid-November	Temperature: minimum temperature ≥ −20 °C	Low temperature; freezing

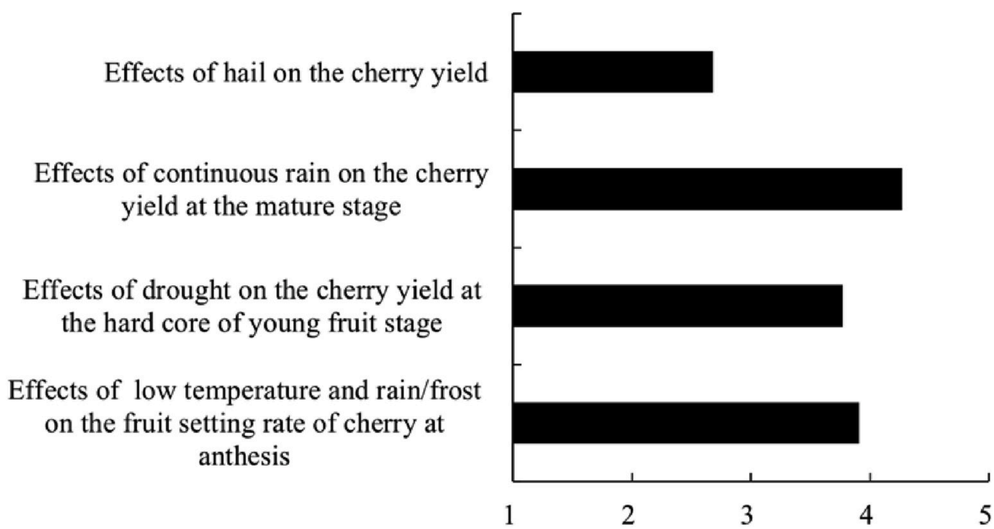

Fig. 4. Cherry growers' perception indexes of meteorological hazards.

seriously affect the yield [61]. Therefore, cherry growers were extremely sensitive to the effects of these three meteorological hazards on the cherry yield. Apple growers in Nepal were also facing the result of reduced production of low-latitude apples caused by meteorological hazards [62]. However, effects of hail on the cherry yield perceived by cherry growers were small (perceptual index = 2.68, of which "no influence" was 20.8%, "little influence" was 23.3% and "general influence" was 32.4%). According to the interview with cherry growers, hail was a rare meteorological hazard in Bailuyuan, so it had few influences on the cherry yield.

4.4. *Cherry growers' perceived adaption efficacy*

The cherry growers' perceived adaption efficacy was statistically analyzed and the results are shown in Table 4. Hoeing timely, replacing cherry varieties and building greenhouses against frost had relatively high efficacy perceived by cherry growers. On the contrary, the efficacy of buying insurance was the lowest. It reflected that cherry growers were inclined to the traditional adaptive behavior. Due to the low utilization rate and cognitive bias, some novel adaptive behavior such as buying insurance were reckoned as the behavior owning weaker efficacy. Cherry growers had few differences in perceived adaption efficacy, which indicated that the adaptive behavior in Table 4 all had certain effects on reducing the influence of climate change and meteorological hazards with less agricultural losses.

Table 4
Descriptive statistics of cherry growers' perceived adaption efficacy.

Adaptive behavior	perceived adaption efficacy			
	Minimum value	Maximum value	Mean	Standard error (%)
Paying attention to the weather forecast and other media information concerning climate	1	5	3.69	1.100
Applying fertilizer (including chemical fertilizer and farm manure)	1	5	3.55	0.984
Replacing cherry varieties	1	5	3.87	1.058
Using more pesticide	1	5	3.50	1.020
Increasing irrigation times	1	5	3.54	0.987
Spraying the trunk with antifreeze	1	5	3.47	0.987
Catching fire and smoking in orchard	1	5	3.59	1.025
Building greenhouses against frost	1	5	3.86	1.046
Setting up a protective forest/a windproof and anti-frost barrier	1	5	3.47	0.942
Timely hoeing	1	5	3.92	0.776
Buying insurance	1	5	3.24	1.007

4.5. Path analysis based on TPB

Reliability analysis, validity analysis and collinearity test were performed on the data involved in the path analysis model. Table 5 showed that the Cronbach's α and AVE of each measurement dimension were more than 0.7 and 0.36 respectively, and the VIF was less than 5, indicating that the data had good reliability and validity, and no collinearity problem existed.

The path analysis model based on TPB is shown in Table 6. Path coefficients of ATT, SN and PBC to perceived adaption efficacy were 0.107, 0.163 and 0.168 respectively, all of which were significant. It revealed that each independent variable had a significant positive influence on the dependent variable, that is to say, the more positive the individual's attitude, the greater the pressure from the surrounding when the adaptive behavior was adopted to cope with climate change and meteorological hazards, the stronger the ability to implement adaptive behavior, then the stronger the perceived adaption efficacy, namely the stronger the willingness to adapt.

ATT is an assessment of an individual's preference for a particular behavior in a given situation. The assessment of behavioral outcomes and the likelihood of occurrence together determine ATT [43]. When an individual evaluates his behavior positively, he will have a positive attitude, otherwise he will have a negative one. ATT of cherry growers was mainly influenced by reports about the climate from TV and newspapers, government policies on climate change and meteorological hazards, and perception of relationship between the individual activity and adaptive behavior to climate change and meteorological hazards (Table 2), which was the main manifestation of cherry farmers' internal motivation to adopt specific adaptive behavior. The susceptibility of cherries to climate change and meteorological hazards made cherry growers particularly concerned with climate-related information and policies, and measures to address problems induced by climate change and meteorological hazards, thereby affecting their perceived adaption efficacy. It was believed that the response to climate change and meteorological hazards was not only a national issue but also associated with an individual, which was the basis for cherry growers to take adaptive behavior initiatively. Only when an individual placed himself in the position of behavioral subject could he internalize the climate information and then the willingness and the interest of behavior be stimulated. Based on that, the sense of responsibility and ownership could be aroused so as to strengthen the perceived adaption efficacy.

SN is the influence and social pressure that the subject perceive from the external social environment when he implements a certain behavior. It also reflects the influence of important groups or institutions on an individual behavioral decision [63]. SN perceived by cherry growers mainly referred to the pressure from expectations of their families, neighbors, village leaders and themselves about their concerns over climate change, the actions to prevent meteorological hazards and the consequences of those actions. In the process of agricultural production, cherry growers would be affected by the external environment such as financial and technical support from families and neighbors, information exchange, policy guidance from village leaders, and so on. The influence would urge cherry growers to find appropriate adaptive behavior in the face of climate change and meteorological hazards. The pressure of selecting appropriate adaptive behavior accumulated and fermented continuously, and eventually evolved into the motivation to adopt behavior with higher efficacy, which made cherry growers generate strong perception of efficacy of adaptive behavior. In addition,

Table 5
Validity, eliability and collinearity analysis of the measurement model.

	ATT	SN	PBC
Cronbach's α	0.804	0.836	0.789
AVE	0.453	0.474	0.488
VIF	1.822	1.962	1.542

Table 6
Path analysis of influence of TPB variables on cherry growers' perceived adaption efficacy.

Path	Path coefficient	Standard error	t
ATT→Perceived adaption efficacy	0.107**	0.038	2.819
SN→Perceived adaption efficacy	0.163***	0.044	3.691
PBC→Perceived adaption efficacy	0.168***	0.042	3.986

Note: ***, **indicates $p < 0.001$ and $p < 0.01$ respectively.

the demonstration effect of other cherry growers, especially the advanced individuals and organizations in agricultural production, who took the initiative to adopt adaptive behavior, would also form a positive subjective norm that had a positive influence on the cherry growers' behavior.

PBC is the individual's perception of easiness or difficulty of completing some behavior, reflecting the individual's perception on factors that promote or hinder the implementation of behavior [64]. The stronger the ability of PBC, the more controllable factors the implementation of behavior possesses, then the greater the possibility of behavioral realization. The factors affecting the cherry growers' ability of PBC were the confidence level in their and their families' ability to act, perception of which stemmed from self-efficacy. During the growth period of cherries, various meteorological hazards would be encountered. When cherry growers thought they could prevent and control these meteorological hazards, their confidence in coping with climate change and meteorological hazards could be boosted, thus improving the degree of perceived adaption efficacy. Cherry growers need not only confidence to cope with climate change and meteorological hazards, but also the ability to accurately assess their families' resilience towards climate change and meteorological hazards. With households based agricultural production patterns, cherry growers should consider the problems their families might run into before putting the adaptive behavior into practice, such as the cost and the success rate that might not be in line with expectations, so as to avoid the failure in the process of implementation due to inadequate preparation and immature conditions. Therefore, only when cherry growers believed that they and their families could better control the processes and the results of implementing the adaptive behavior would they generate a strong sense of efficacy.

4.6. Analysis of weaker perceived adaption efficacy by ordinal logistic regression

Based on the definition of cherry growers with weaker perceived adaption efficacy, 156 samples were selected from 318 ones for a further study. Among these samples, the proportion of males and females respectively were 45.5% and 54.5%. Nearly half of the samples were over 60 years old (47.4%), and the ones between 51 and 60 years old accounted for 23.1%. The education level of these cherry growers was mostly junior high (45.5%), followed by primary and below (32.1%). 47.4% households had an agricultural income less than 10,000 yuan a year, and the ones with cumulative income of 20,000 yuan or less one year took the percentage of 83.9%. The percentage of households earning non-agricultural income less than 10,000 yuan one year was 68.6%, and the ones owning cumulative income of 20,000 yuan or less a year accounted for 83.9%. 61.5% of the respondents planted cherries within 0.3 ha, and other 33.3% ones within 0.3–0.7 ha. The time for cherry planting was mostly 5–10 years (40.4%), followed by 10–15 years (29.5%).

The perceived efficacy scores of 11 adaptive behavior selected by each of this part of cherry growers were added together and then the average was got, which represented the degree of cherry growers' perceived adaption efficacy and was reckoned as the dependent variable to be analyzed by ordinal logistic regression. The minimum average was 2 and the maximum was 4. The results of ordered logistic regression, applied to analyze the influencing factors of weaker perceived adaption efficacy, can be seen in Table 7.

(1) In terms of cherry growers' attributes, age and household agricultural income had significant positive influences on the weaker perceived adaption efficacy ($p < 0.05$). The younger the cherry growers, the less the household agricultural income, then the weaker the perceived adaption efficacy. Since farm work was done with the accumulation of practical experience, the experience would become more and more abundant as farmers' age grew, and it was more likely to implement adaptive behavior [65]. With constant agricultural practice, farmers could select adaptive behavior appropriately when the meteorological hazards were coming, so the degree of perceived adaption efficacy would be stronger. On the contrary, the degree would be weaker. Increases in agricultural income of cherry growers was due to the utilization of appropriate adaptive behavior, which could reduce the negative influence of climate change and meteorological hazards on agricultural production and minimize the economic losses. Hence, a positive attitude would be generated, followed by a strong perceived adaption efficacy. On the contrary, decreases in agricultural income might get cherry growers doubt the efficacy of adaptive behavior that had been adopted, which would weaken the degree of perceived adaption efficacy. On the other hand, cherry growers with more agricultural income had sufficient funds to bear the risk of adaptive behavior, and could also use their own income to seek more suitable adaptive behavior [57], so they would have stronger perceived adaption efficacy.
(2) In terms of perception of climate change, perception of local climate warming in the past 30 years and perception of frost had significant positive influences on the weaker perceived adaption efficacy. Cherry growers with lower perceptual degree of the local warming trend in the last 30 years and the occurrence rate of local frost had weaker perceived adaption efficacy. Perception of climate change is a key influence factor for farmers to make the decision about adaptive behavior [9]. When farmers perceived less risk associated with climate change, the likelihood of taking adaptive practices would be reduced [4]. If the climate was not thought to be warming in recent years, then adaptive behavior against the temperature change might be not essential, so cherry growers would carry out agricultural work as usual, and the perceived adaption efficacy would be weaker naturally. Similarly, when cherry growers perceived the decrease in occurrence frequency of local frost, they might feel that the local climate was becoming more and more suitable for cherry growth and pay less attention to the efficacy of adaptive behavior, and this kind of cognition could make perceived adaption efficacy become weaker.
(3) In terms of meteorological hazards perception, effects of drought on the cherry yield at the hard core of young fruit stage, effects of low temperature and rain/frost on the fruit setting rate of cherry at anthesis, effects of continuous rain on the cherry yield at the mature stage and effects of hail on the cherry yield all had no significant influence on the weaker perceived adaption efficacy. In Bailuyuan, meteorological hazards might give rise to some negative influences on the normal growth of cherries, but for some cherry growers, the economic losses caused by negative influences could be reduced through taking appropriate countermeasures, and the livelihood of their families would not be threatened. In the conversation with the local cherry growers, some people even said that they had adopted few adaptive actions to deal with meteorological hazards, and most time they "depend on the weather" to make a living. For that, even if they perceived the meteorological hazards, it would not have a lot of influences on how effective the behavior is perceived.

5. Conclusions and recommendations

5.1. Conclusions

This study explored the factors influencing cherry growers' perceived adaption efficacy from a new perspective which is TPB belonging to social psychology. It showed that ATT, SN and PBC of cherry growers all had significant positive influences on the perceived adaption efficacy. That is to say, cherry growers' perceived adaption efficacy was largely influenced by their attitude toward the adaptive behavior, the social pressures felt by them, and the ability to control self-behavior. The more positive the attitude, the greater the external pressure felt, the stronger the self-behavior control ability, then the stronger the cherry growers' perceived adaption efficacy.

Table 7
Ordinal logistic regression results of weaker perceived adaption efficacy, cherry growers' attributes, perception of climate change and meteorological hazards.

Variables		Estimation	Standard error	Significance	EXP(β)	95% confidence intervals	
						Lower	Upper
Intercept	Weaker perceived adaption efficacy (Y) = 2	6.763	1.992	0.001	–	2.859	10.666
	Weaker perceived adaption efficacy (Y) = 3	11.807	2.315	0.000	–	7.269	16.345
Cherry growers' attributes	X_1	−0.549	0.399	0.169	0.578	−1.332	0.234
	X_2	0.459	0.169	0.007	1.582	0.128	0.790
	X_3	0.379	0.250	0.129	1.461	−0.110	0.869
	X_4	−0.033	0.084	0.690	0.968	−0.198	0.131
	X_5	0.004	0.041	0.919	1.004	−0.077	0.085
	X_6	0.494	0.247	0.045	1.639	0.010	0.978
	X_7	0.021	0.211	0.920	1.021	−0.393	0.436
Perception of climate change	X_8	1.027	0.271	0.000	2.793	0.497	1.557
	X_9	−0.059	0.256	0.818	0.943	−0.560	0.442
	X_{10}	0.268	0.221	0.225	1.307	−0.165	0.700
	X_{11}	−0.018	0.211	0.933	0.982	−0.431	0.395
	X_{12}	0.121	0.238	0.612	1.129	−0.346	0.588
	X_{13}	0.678	0.267	0.011	1.970	0.155	1.202
Perception of meteorological hazards	X_{14}	0.427	0.224	0.057	1.533	−0.013	0.866
	X_{15}	−0.042	0.256	0.870	0.959	−0.543	0.460
	X_{16}	0.026	0.252	0.919	1.026	−0.467	0.519
	X_{17}	0.032	0.173	0.851	1.033	−0.306	0.371
Parallel line test		$p = 0.682 > 0.05$					
Cox and Snell		0.455					
Fitting goodness chi-square		94.746					
Probability value of chi-square test		0.000					

In addition, many cherry growers were found that they had weaker perceived adaption efficacy. In this study, the ordinal logistic regression was used to analyze influencing factors to the weaker ones. The results indicated that age, household agricultural income, perception of local climate warming in the past 30 years and local frost had significant positive influences on the weaker perceived adaption efficacy. The younger the age, the less the household agricultural income, the lower the awareness of local climate warming, and the stronger the cognition on occurrence frequency of local frost, then the weaker the perceived adaption efficacy.

5.2. Recommendations

(1) The local government should actively innovate publicity measures about coping with climate change and meteorological hazards. Establishment of social norms and creation of public opinion should be in synchronization with publicity in order to cultivate a positive attitude of cherry growers to implement adaptive behavior. With the positive attitude, cherry growers can be motivated to take active actions to overcome negative influences of climate change and reduce economic losses caused by meteorological hazards.

(2) Encouraging cherry growers to establish cooperative economic organizations. With development and reform of society and economy, modern agriculture increasingly requires professional management and effective communication. Cooperative economic organizations can bring cherry growers together to face climate change and discuss adaptive behavior in the agricultural production process. Organization managers ought to pay attention to the "human factors" of members, guide them to participate in management with more vigor. It is also important to promote communication between members of the organization for they can acquire more effective adaptation strategies, production skills and accurate climate information. Through these methods, cherry growers will truly feel that they are the main bodies of cooperative economic organizations and their enthusiasm of investment and participation can be improved.

(3) More targeted training about adaptive behavior is necessary. Cherry growers with weaker perceived adaption efficacy tend to be younger, have not been planting cherries for a long time, lack relevant experience, and rarely communicate with other local farmers about information of cherry growing, which eventually lead to poorer agricultural production, less household agricultural income and more difficult livelihoods. So the training about adaptive behavior should be directed to the farmers mentioned above to enhance their degree of perceived adaption efficacy. Furthermore, demonstration of excellent farmers can keep them abreast of more adaptive strategies which are the latest ones so that they can more accurately perceive the effectiveness of adaptive behavior.

(4) Research institutions, business, media, non-governmental organizations (NGOs) and the local government should strengthen cooperation and share relevant information regarding adaptive behavior. Researchers can also invite the local leaders to develop research projects together to gain a different perspective in the adaptive behavior field.

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Appendix A. Supplementary data

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