






Spatial Variation of Agricultural Drought Vulnerability in Eastern Agricultural Zone of Qinghai Province, China

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Abstract. Based on the statistical indicators of 14 counties in the agricultural area of eastern Qinghai, the evaluation of exposure, sensitivity and adaptability were studied by using principal component analysis and weighted synthesis method. Then, the vulnerability of the risk-bearing body was analyzed by using GIS The barrier degree model was established to analyze the barrier degree of each indicator. The spatial distribution map of drought vulnerability in the eastern part of Qinghai and the barrier index of each indicator were obtained. The results show a trend of increasing from the central part to the north and south; drought vulnerability in the agricultural production environment shows the highest in the Naoshan area, followed by the Qianshan area, and the lowest in the Chuanshui area. According to the barrier degree index, precipitation, per capita net income of farmers and gross regional product are derived as the main causes of disaster management.

Keywords: Agricultural Zone in Eastern Qinghai Province · Agricultural Drought Vulnerability · Barrier Degree · GIS · Principal Component Analysis

1 Introduction

1.1 Research Background

Droughts are spatially widespread and long-lasting, posing a great threat to people's normal life. Droughts are caused by the interaction of external droughts faced by a region with its own internal factors [1].

Qinghai Province is located in the northeastern part of the Qinghai-Tibet Plateau and has a plateau continental climate. The eastern agricultural region of Qinghai province is the breadbasket of Qinghai [2]. In most places of the eastern agricultural region, it is spring and autumn with one harvest a year. In this region, the average annual temperature and precipitation is low, and summer is predominant. October to April is the season for farm harvesting, but with only 15% of the annual rainfall, drought is the main factor limiting spring wheat production [3–5].

1.2 Review of Chinese and International Research

The concept of vulnerability was first introduced by Burton [6] in 1960 and has played a large role in disaster research. Burton considers vulnerability as an exposure risk [6]. Cutter et al. [7] emphasize vulnerability as a social problem. Liverman [8] shows how vulnerability to natural hazards can be measured and analyzed and how drought vulnerability is linked to new agricultural technologies and land tenure in Mexico. Liverman shows how vulnerability to natural hazards can be measured and analyzed and how drought vulnerability is linked to new agricultural technologies and land tenure in Mexico. And he argues that the impact of drought on agricultural systems depends on both the technological, economic, and political characteristics of a region and the severity of meteorological events [8]. Some scholars argue that vulnerability can be measured in both temporal and spatial dimensions [9], and SÖNMEZ investigated the spatial and temporal dimensions of meteorological drought in Turkey from the concept of vulnerability [10]. Sahana et al. consider drought hazards in a multivariate framework and use reliable drought vulnerability indicators that consider exposure, sensitivity and adaptive capacity for a comprehensive, fine-grained, nationwide drought risk assessment, a three-level evaluation system widely used in drought vulnerability studies [11]. Vulnerability has been studied in a variety of ways, and in recent years there has been more research on vulnerability in conjunction with GIS. Aksoy et al. proposed a method using a standardised precipitation index to obtain empirical relationships between intensity and return periods using site-specific IDF curves [12]. Z Taheri uses percent normal precipitation index and GIS for hazard assessment of drought in Iran [13].

Domestic research on vulnerability started relatively late, but there are still many scholars who apply vulnerability to their research fields. Yanrui Shang conducted a statistical analysis of the effects of different factors on vulnerability based on rural survey subhousehold statistics separately [14]. Zhongyuan Li et al. analyzed the vulnerability of agricultural drought in Henan Province based on statistical and meteorological data of the province using several indicators and applying gray correlation analysis [15]. Yali Ma et al. conducted a vulnerability study by combining comprehensive weighting with GIS [16]. Yongqiang Dai et al. used the projection tracing model indicators to influence the weight coefficients, objectively reducing the influence of artificial weighting on the evaluation results, and analyzed and evaluated the main agricultural drought vulnerability indicators in 14 regions of Province to Gansu verify the feasibility of the method [17]. Jing Cheng et al. used principal component analysis to study the drought risk in the middle and lower reaches of the Yangtze River, and spatial variation was studied by using cluster analysis. Disaster vulnerability risk studies have also been explored for the agricultural areas in eastern Qinghai Province affected by global changes [18]. Liu Xuan et al. studied the ecological drought vulnerability in northwest China, they found that the local vulnerability in southern Qinghai was on the rise [19].

In summary, the novelty of this study lies in the following four aspects: (1) Using multidisciplinary theoretical approaches This study uses multidisciplinary theoretical approaches such as earth science, disaster science and statistics to study disaster vulnerability in the agricultural areas of eastern Qinghai Province through the theoretical basis of disaster vulnerability. (2) Constructing models and multi-methods Based on the

standardization of data, evaluation indicators are constructed from three aspects of exposure, sensitivity and adaptive capacity of the disaster-bearing system, and vulnerability is constructed to unfold the evaluation of agricultural drought vulnerability in the study area. (3) The study and analysis of spatial and temporal evolution not only assesses the natural and social vulnerability of the study area, but also further explores the temporal evolution of disaster vulnerability over the past 20 years and analyzes the spatial variability based on the county perspective. (4) The study will contribute to the construction of Qinghai and provide a practical basis for integrated disaster prevention and mitigation in the agricultural areas of eastern Qinghai and promote sustainable regional development.

1.3 Research Ideas

As shown in Fig. 1, the research ideas of the spatial differentiation of agricultural drought vulnerability and regulation measures in the eastern agricultural region of Qinghai Province are as follows: firstly, we review the information and read the literature to understand the concept of vulnerability, the current status of research and the general situation of the study area, and summarise the research significance of this study, with certain theoretical support; at the same time, we collect various relevant data and information through field surveys, internet data search and consultation with relevant departments, with certain data The study is supported by data. Afterwards, the research indicators were selected according to the specific conditions of the study area, and the research model was constructed. The weight of each indicator was determined by the principal component analysis method, which constituted the vulnerability evaluation system of the eastern agricultural area of Qinghai Province, and the indicators were divided into

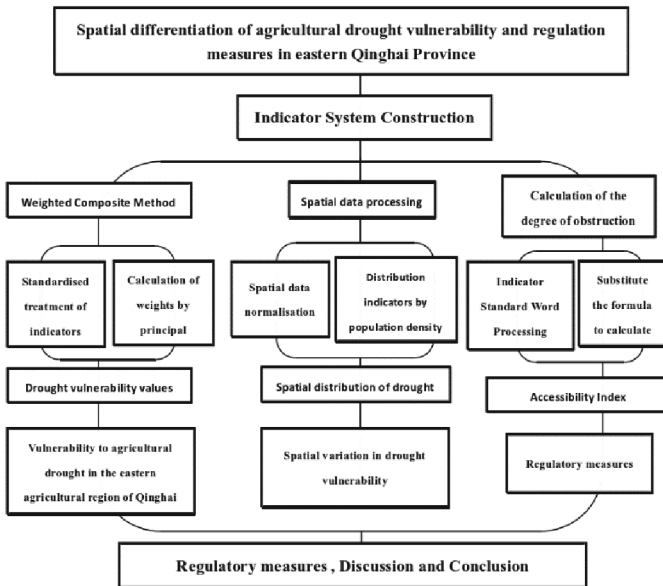


Fig. 1. Technology roadmap.

three subsystems: exposure, sensitivity and resilience. Finally, the results of vulnerability are calculated by standardising and weighting the indicators, summarising the main influencing factors of vulnerability and finally discussing and analysing the conclusions to achieve the aim of this study.

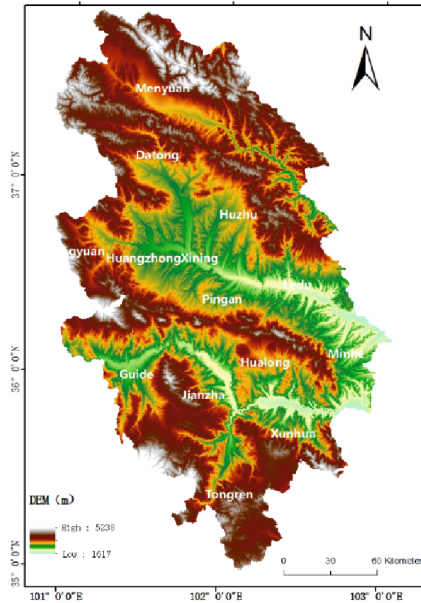


Fig. 2. Overview map of the study area.

2 Overview of the Study Area

As shown in Fig. 2, the eastern agricultural region of Qinghai Province is located south of Daban Mountain, a branch of Qilian Mountain, north of Longyang Gorge, east of Riyue Mountain and west of Sigou Gorge [24], at latitude and longitude $98^{\circ}54' \sim 103^{\circ}04'E$, $34^{\circ}48' \sim 38^{\circ}20'N$. The eastern agricultural region includes 14 counties, while the arable land area occupies 70% of the province, which is a region with a higher percentage of grain production and rapid development of agriculture in Qinghai Province compared with other regions.

The eastern agricultural region is relatively undulating, with the Yellow River and its tributaries Huangshui and Datong River running through it. Precipitation and temperature vary markedly with the altitude and topography of the region, thus creating different types of agricultural production environments. The first type is the Chuanshui area, this type of arable land is mainly located in the river valley terraces and alluvial fans, the soil layer is relatively thick, the soil type is mainly through the irrigation of the chestnut calcium soil. The second type is shallow Qianshan area, mainly located in areas with heights between 2000 and 2600 m, with loose soil texture and very serious soil erosion due to

the influence of the topographic slope. The third type is Naoshan area, located in areas with altitudes of 2600 to 3400 m, with high soil fertility but poor thermal conditions, so that mainly cold-tolerant crops are grown.

3 Research Methodology and Data Sources

3.1 Evaluation Indicator System Construction

Taking the drought vulnerability of the eastern agricultural region of Qinghai Province as the research background, the index system is constructed in three aspects: exposure, sensitivity and recovery ability based on previous researches [14, 15, 17, 19–25]. Exposure refers to the situation of people, livelihoods, environmental services and resources, infrastructure, and economic, social or cultural assets. Vulnerability is the tendency or propensity to be adversely affected. Resilience is the ability of a system and its components to quickly anticipate, withstand, adapt or recover from the impact of a potentially hazardous event. The indicators of the exposure subsystem include three kinds of grain production, crop sown area and total agricultural output value; the indicators of the sensitivity subsystem include precipitation, agricultural production environment (Chuanshui area, Qianshan area and Naoshan area), TVDI and effective irrigation area; the indicators of the adaptability subsystem are more numerous, including per capita net income of farmers, number of village committees, gross local product, total agricultural machinery power, population density and annual fertilizer application, as shown in Table 1 below:

Table 1. Drought vulnerability indicators and weights.

System layer	Indicator layer	Weighting index
Exposure (0.198)	Grain production	0.06
	Crop sown area	0.06
	Total agricultural output	0.078
Sensitivity (0.323)	Precipitation	0.078
	Agricultural production environment	0.081
	TVDI	0.082
	Effective irrigated area	0.082
Adaptability (0.479)	Per capita net income of farmers	0.081
	Number of village committees	0.081
	Gross Local Product	0.075
	Total power of agricultural machinery	0.077
	Population density	0.08
	Annual fertilizer application	0.085

3.2 Data Sources and Processing

Grain production, average land water resources, arable land area, population, agricultural GDP, per capita net income of farmers, agricultural population, total output value of primary industry, etc. are from *Qinghai Yearbook*, *Haidong Regional Statistical Yearbook*, *Xining Statistical Yearbook*, *Menyuan Statistical Yearbook*, *Huangnan Statistical Yearbook*, and related data public. Spatial data on agricultural areas in eastern Qinghai Province, TVDI, population density, etc. are from, and soil moisture is from China Meteorological Data Network, National Earth System Science Data Centre and National Qinghai-Tibet Plateau Science Data Centre.

Product Data Processing. TVDI, population density, DEM elevation data and land use data used in this paper are all existing data products that require a range of processing using the Arcgis.

The TVDI was applied to the global 1 km resolution TVDI dataset, and as this paper is based on a study of agricultural drought vulnerability, TVDI data was downloaded for June, July and August of the growing season. The data for the study area were first extracted by mask, then resampled to obtain 300 m precision TVDI data, and finally the average TVDI for June, July and August was calculated using raster operations.

The population density data was adopted from China, and the data needed to go through a series of processing after downloading. The population density data for the study area was first extracted from the national data and then resampled to obtain the population density data at 300 m precision.

The extraction of agricultural production environment data required the use of DEM elevation data and land use data from Qinghai Province. The agricultural production environment in the eastern part of Qinghai is divided into Naoshan area, Qianshan area and Chuanshui area according to the altitude. The DEM elevation map was reclassified according to the altitude range of the different arable land types, assigning a value of 1 to those between 2800 and 3200 m, 2 to those between 2200 and 2800 m, 3 to those between 1565 and 2200 m, and NoData to the rest. The raster data was then extracted by mask and the reclassified cropland layer was used to extract the processed DEM elevation map to obtain the raster data by cropland type.

Statistical Data Processing. The data in this paper all need to be converted into raster data for the study, so the county statistics were integrated into an Excel sheet and the statistics were converted into raster data after the statistics were completed, the steps are as follows: (1) Download the Chinese county vector dataset, import the downloaded data into Arcgis, select the study area required to extract the 14 counties contained in the study area. (2) Rasterise the vector data. The connected map is still a vector map of each indicator, so the vector map should be rasterised, and the accuracy is also set to 500 m. (3) Calculate the density of each raster. There are many ways to classify the density, but in this paper, we use population density to classify the density of each indicator, which is considered to be dense where there are many people and vice versa. Using the raster calculator, the density is obtained by dividing the product data of the population distribution by the data rasterised by county in step three. (4) The data for each indicator distributed by population density is obtained. The rasterised data for each indicator is multiplied by the area calculated in step three to obtain the raster distribution

results for each indicator. (5) The data are normalized, which means that the required data are processed and their range of values are restricted to a uniform range. The raster calculator's formulae are used to normalize each indicator to a range between 0 and 1.

3.3 Agricultural Drought Vulnerability Evaluation Methods

Standardization of Evaluation Indexes. The agricultural drought vulnerability evaluation factors were standardized and the required data were calculated by substituting the formula:

$$X_i' = (X_i - X_i \min)(X_i \max - X_i \min) \quad (1)$$

where X denotes the standardized data of the i -th indicator; X denotes the original value of the i -th indicator; $X_i \max$, $X_i \min$ denote the maximum and minimum values of the i -th index in the data, respectively.

In this paper, both textual data and spatial data are standardized. For the textual data, the data is substituted into SPSS software for processing; the spatial data is calculated by using a raster calculator with the formula.

Determination of Evaluation Index Weights. Since the evaluation of agricultural drought vulnerability is based on the comprehensive evaluation of multiple indicators, there are obvious differences in strengths and weaknesses between each evaluation indicator and drought vulnerability.

In this paper, principal component analysis is applied to calculate the weights of each agricultural drought vulnerability evaluation index in the eastern agricultural region of Qinghai. The principal component analysis method derives the main influencing components in the space of characteristics and can use mathematical methods to reveal the correlations among the evaluation indicators in order not to bias the results in favor of a certain indicator factor. For this reason, this paper uses principal component analysis to determine the weights of each evaluation index.

The following equation was used to calculate the common factor variance H for each drought evaluation index.

$$H_j = \sum_{k=1}^m \lambda_{jk}^2 \quad (2)$$

where H_j is the common factor variance; m is the number of principal components, taking $m = 3$; j is the original total number of indicators, and λ is the eigenvalue of the indicators on the principal components. After processing the common factor variance H of each evaluation index, the weights of each index are obtained [25]:

$$W_j = H_j / \sum_{j=1}^{11} H_j \quad (3)$$

where W_j is the weight, and each evaluation index and weight coefficient are shown in Table 1 in 3.1.

Agricultural Drought Vulnerability Evaluation Model Calculation. The vulnerability index was calculated using the weighted composite method with the following formula:

$$V_i = \sum_{j=1}^m W_j \times S_{ij} \quad (4)$$

where V denotes the drought vulnerability index, W_j is the weight corresponding to the j -th indicator, and S_{ij} is the standardized value of the j -th indicator in the i -th area. The corresponding ones are calculated based on the above equations for further analysis of drought vulnerability in the study area [26].

A weighted composite score was developed for the three dimensions of exposure, sensitivity and resilience, named exposure index (E), sensitivity index (I) and resilience index (A), respectively, and the vulnerability of the study area was calculated with the following equation:

$$V = E \times I \div A \quad (5)$$

Agricultural Drought Vulnerability Barrier Degree Evaluation Model. Analysis of the barriers to agricultural development in the eastern agricultural region of Qinghai Province using a barrier degree model and specific values values.

$$d_{ij} = 1 - y_{ij} \quad A_{ij} = \frac{W_{ij} \cdot d_{ij}}{\sum_{i=1}^n W_{ij} \cdot d_{ij}} \times 100\% , \quad (6)$$

$$U = \sum_{i=1}^n A_{ij}$$

where A_{ij} denotes the barrier degree of single indicator in the indicator layer, and is the degree of influence of the i -th indicator on early disaster vulnerability in agriculture; W denotes the contribution of the indicator to the overall target, and is the weight value of the i -th indicator. d_{ij} is the deviation degree of the indicator, which indicates the gap between the single indicator and the maximum target, set as the gap between the standardized value of the indicator and 1; y_{ij} is the standard value of the i -th indicator; U denotes the guideline level indicator barrier degree, which is the degree of influence of the guideline level indicator on agricultural drought vulnerability [27].

4 Results and Analysis

The three sub-modules of exposure, sensitivity and adaptability were evaluated first, and then the three were combined to obtain the evaluation results of the fragility within the insured body.

4.1 Spatial Variation in Agricultural Drought Vulnerability

The distribution of agricultural drought vulnerability index in the eastern agricultural area of Qinghai province was obtained by substituting the vulnerability formula as shown in the Fig. 3. The range of the index is between 0.003 and 0.47. From the regional distribution, each county in the study area has areas with high vulnerability, and the central

areas of Datong County, Huanzhong County and Huzhu County with high vulnerability are larger, and the vulnerability index near Huangshui River Valley is higher; the vulnerability index of Tongren County increased in 2004 and 2007.

The vulnerability distribution is gradually increasing in Huzhu and Menyuan counties and decreasing in Huanzhong district between 2009 and 2019.

To analyze the spatial variation of agricultural drought vulnerability, the spatial distribution of vulnerability strengths and weaknesses could not be obtained intuitively through the vulnerability result map. Therefore, the spatial distribution of vulnerability for each year was obtained by systematically classifying the average vulnerability of each county into five levels: the lowest vulnerability, Medium low vulnerability, moderate vulnerability, high vulnerability and the highest vulnerability.

As shown in Fig. 4, through the spatial distribution diagram of vulnerability in each year, it is obvious that between 2000 and 2007, the vulnerability of Menyuan County, Tongren County and Guide County is the highest, and the vulnerability of Datong County, Huzhu County and Jianzha County is high, while the vulnerability of Xining City is the lowest. From 2011 to 2019, the spatial distribution of vulnerability strength and weaknesses has changed significantly, with the vulnerability of Menyuan County, Tongren County, Guide County and Datong County weakening, but the vulnerability of Huzhu County, Pingan County, Huanzhong County and Ledu County gradually increasing. In conclusion, the spatial distribution pattern of vulnerability has changed significantly between 2000 and 2019, from low vulnerability in the central part and high vulnerability in the north and south to high vulnerability in the north and low vulnerability in the south.

The main reason for this development of vulnerability may be that the main impact on agriculture in the early years was water resources, the central part of the agricultural region of eastern Qinghai Province is crossed by the Huangshui River, whose banks are rich in water resources while water resources are scarce at the farther ends of the basin, resulting in a deterrent to agricultural development; in recent years the main factors affecting agricultural development have been excessive economic development, insufficient market supply and demand, and increased vulnerability due to excessive pressure on land.

4.2 Temporal Variation in Agricultural Drought Vulnerability

The temporal variation of agricultural drought vulnerability in the eastern agricultural region of Qinghai Province, after averaging the vulnerability raster sub-counties, shows that the vulnerability level mainly ranges from 0 to 0.4, with most counties showing a decreasing trend over time, with some counties gradually increasing in vulnerability after falling to a low point in 2011. The highest level of vulnerability is currently in Xunhua County, while the lowest level of vulnerability has been maintained in Jianzha County.

4.3 Analysis of Factors Influencing Vulnerability to Agricultural

Analysis of Meteorological Drought Factors in Agricultural Areas. The analysis was carried out from the TVDI. Due to the special local climatic conditions in Qinghai

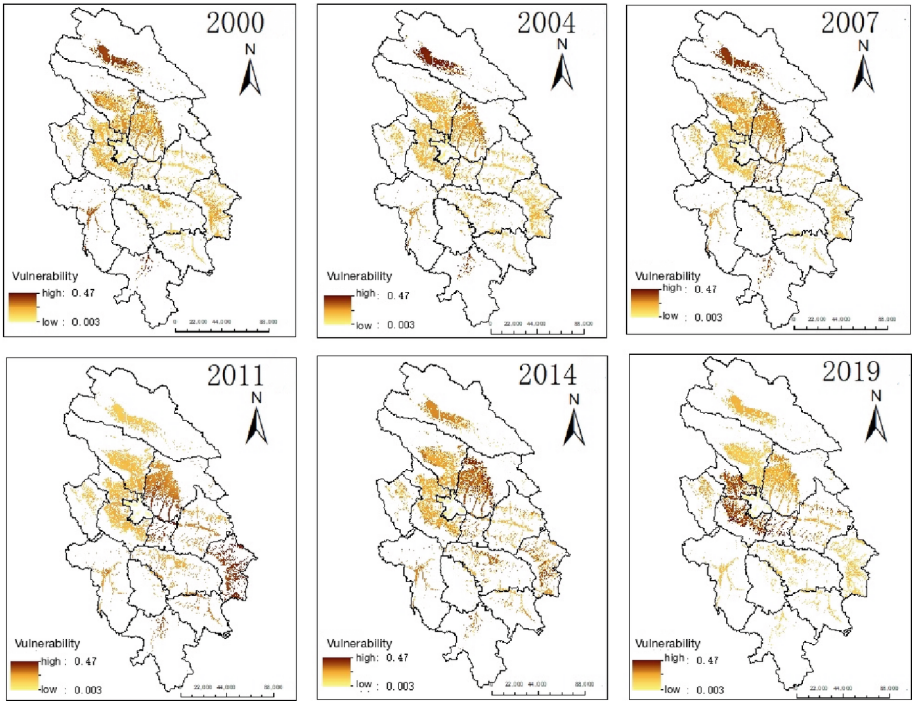


Fig. 3. Spatial distribution of drought vulnerability.

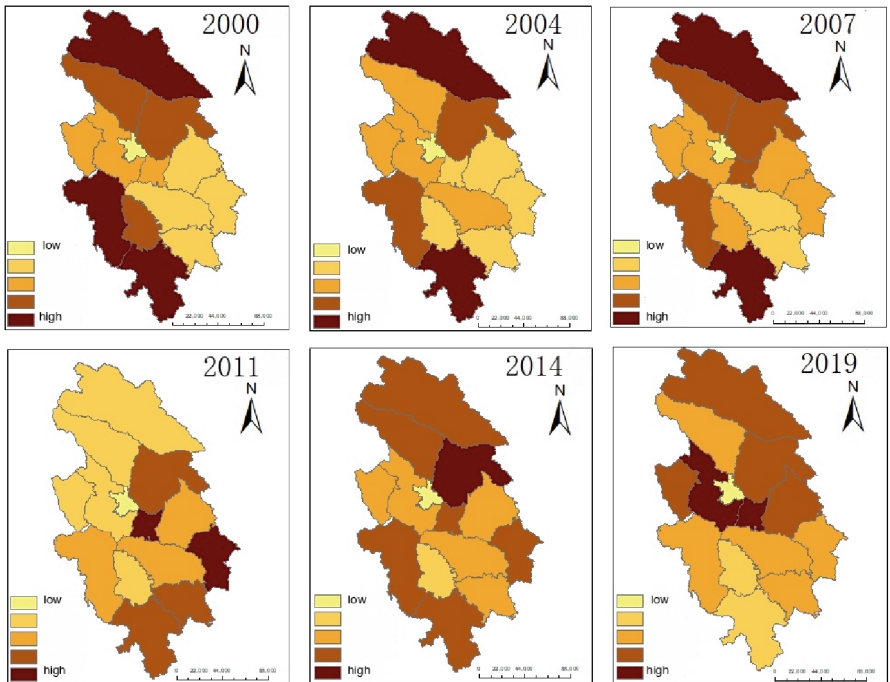


Fig. 4. County distribution of drought vulnerability.

Province, the growing season of crops in the eastern agricultural zone is from June to August, and the average TVDI data for crops from June to August for each county in the eastern agricultural zone of Qinghai Province from 2000 to 2019 were derived as shown in Table 2 below:

Table 2. TVDI for each county in the study area.

County Name	2000	2004	2007	2011	2014	2019
Xining	0.6654	0.6474	0.6328	0.6617	0.6273	0.6172
Datong	0.5402	0.5471	0.5323	0.5487	0.5101	0.5108
Huangzhong	0.5914	0.5683	0.5532	0.5813	0.5484	0.5397
Huangyuan	0.5892	0.5584	0.5373	0.5599	0.5367	0.5153
Ledu	0.6305	0.6238	0.6145	0.6445	0.5896	0.5695
Pingan	0.6407	0.6291	0.6047	0.6452	0.5938	0.5741
Minhe	0.6524	0.6458	0.6359	0.6734	0.6076	0.5772
Huzhu	0.5761	0.5672	0.5559	0.5832	0.5375	0.5273
Hualong	0.6587	0.6138	0.5885	0.6444	0.5934	0.5706
Xunhua	0.6303	0.5981	0.586	0.6253	0.5871	0.5619
Menyuan	0.5406	0.5422	0.5207	0.54	0.5093	0.4906
Tongren	0.6223	0.5792	0.5638	0.5838	0.5674	0.5598
Jianzha	0.6488	0.6022	0.5736	0.6099	0.5848	0.562
Guide	0.6566	0.6085	0.5769	0.6257	0.6056	0.5601

Table 3. Drought vulnerability data for the Kwarau, Shallow and Cerebral Mountains.

Year	Chuanshui area	Qianshan area	Naoshan area
2000	0.1359	0.1841	0.2255
2004	0.1163	0.1501	0.2089
2007	0.1036	0.1327	0.1772
2011	0.1243	0.0943	0.0789
2014	0.1217	0.1389	0.1544
2019	0.0941	0.1265	0.1292

It can be seen that the TVDI mostly lies between 0.5 and 0.7, and this data is in the range of 0 to 1.1 for the total TVDI taken globally, so it can be seen that the meteorological environment in the eastern agricultural zone is in a relatively dry state. The overall TVDI in the eastern agricultural zone shows a decreasing trend, but in the middle years there is a phenomenon of first decreasing and then increasing. by the nature of the TVDI, the

larger the TVDI, the lower the soil moisture, and the smaller the TVDI, the higher the soil moisture. From 2004 to 2007 the TVDI first decreases, the soil moisture increases, and from 2007 to 2011 it increases again, the soil moisture decreases, the precipitation, the changes in precipitation, grain production and total agricultural output also produced opposite fluctuations from 2004 to 2011. Thus, a decrease in the TVDI leads to a decrease in drought and a gradual weakening of the meteorological causes of drought (Table 3).

Analysis from the agricultural production environment. The agricultural production environment in Qinghai Province is divided into three types of agricultural production environment according to the special climatic environment and topography of Qinghai Province is Naoshan area, Qianshan area and Chuanshui area. The resulting vulnerability distribution data were extracted according to the three types of production environments to derive their respective vulnerability indices:

It can be seen that the vulnerability index is the lowest in the Chuanshui area, Qianshan area in the middle and Naoshan area is the highest vulnerable, with a general trend of weakening vulnerability between 2000 and 2019, with a sudden rise in 2014, but then a decline.

Analysis of Factors Influencing Drought Vulnerability. Reducing agricultural drought vulnerability in the eastern agricultural region is an important prerequisite for promoting agricultural development in the region. In order to further explore the main factors affecting agricultural development in the eastern agricultural region of Qinghai Province, the results of the barrier index calculation for each indicator are shown in Table 4 below:

Table 4. Barrier degree values for each indicator.

Indicators	Barrier degree index	Indicators	Barrier degree index
TVDI	5.671	Total power of agricultural machinery	-2.825
Precipitation	4.191	Gross Agricultural Product	0.447
Village Council Number	-0.445	Annual fertilizer application	1.353
Grain production	-1.093	Agricultural production environment	-0.667
Crop sown area	-0.926	Gross Regional Product	3.985
Population density	1.039	Effective irrigated area	-1.307
Per capita net income of farmers	4.578		

From the Table 4, it can be concluded that the variation of the barrier degree of each indicator on the vulnerability to drought in the eastern counties of Qinghai Province varies. The top four indicators in the barrier degree in the indicator layer are the TVDI, precipitation, net per capita income of farmers and gross regional product, which belong to the sensitivity and adaptive capacity subsystems respectively, indicating that these indicators have a greater impact on vulnerability and are the main influencing factors of agricultural drought in the region.

5 Discussion and Conclusion

This paper constructs an indicator system for drought risk analysis in the eastern agricultural region of Qinghai Province from the perspectives of geographical location and geomorphology, climatic conditions and water resources, geographical characteristics of agriculture, government management capacity and forecasting and mitigation capacity of disasters occurring in the eastern agricultural region of Qinghai Province. It is suggested that this index system is suitable for regional scales such as the eastern agricultural region of Qinghai Province. The system was established by applying standardization methods to normalize the relevant indicators and applying principal component analysis to determine the weights of each factor and indicator. In addition, the indicators were divided into three subsystems: exposure, sensitivity and resilience, according to the geographical characteristics of agriculture in the study area. Finally, by standardizing and weighting the indicators, the results of vulnerability were calculated and the key constraints to agricultural development were identified through a barrier model.

Existing studies on drought in the eastern agricultural region have mostly focused on natural factors such as meteorology and geography, and most of the measures for disaster mitigation and prevention are in the area of post-drought recovery. This paper presents an empirical analysis of drought vulnerability in the eastern agricultural region of Qinghai Province based on data obtained on the basis of the principles of scientific, representativeness and accessibility, which has certain feasibility and application value, but there is some subjectivity in the selection of indicators. Therefore, in order to make the evaluation results more reasonable and better used by government departments as reference for disaster prevention and mitigation policies, the indicator system and evaluation model of agricultural drought vulnerability in the eastern agricultural region of Qinghai Province still need continuous improvement. At the same time, a more precise scale and objective analysis of agricultural drought vulnerability in the eastern agricultural region of Qinghai Province are the directions to be considered in this paper. Based on the comprehensive study in this paper, the vulnerability of the eastern agricultural region of Qinghai Province was measured from 2000 to 2019, and the main conclusions are as follows:

(1) Agricultural drought vulnerability from the spatial distribution layout: from 2011 to 2019, the spatial distribution of vulnerability strengths and weaknesses has changed significantly. In summary, the spatial distribution pattern of vulnerability has changed significantly from 2000 to 2019, from low vulnerability in the central part and high in the north and south to high vulnerability in the north and low vulnerability in the south. (2) The layout of agricultural drought vulnerability in terms of temporal distribution: most

counties show a decreasing trend in vulnerability over time, with some counties showing a gradual increase in vulnerability after falling to the lowest point in 2011. At present, the highest vulnerability is in Xunhua County, while the vulnerability in Jianzha County has remained the lowest. (3) Agricultural drought vulnerability from the agricultural production environment, it can be seen that the vulnerability index is the largest in the Chuanshui area, with shallow mountainous areas in the middle and brain mountainous areas being the most vulnerable areas. Between 2000 and 2019, there was a general trend of weakening vulnerability, with a sudden rise in 2014, but then a decline. (4) Agricultural drought vulnerability in terms of influencing factors: the top 4 indicators in the indicator layer in terms of barrier degree are the TVDI, precipitation, net per capita income of farmers, and gross regional product, which belong to the sensitivity and adaptive capacity subsystems respectively, indicating that these indicators have a greater impact on vulnerability and are the main influencing factors of agricultural drought in the region.

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