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Qinghai Province Water-saving Agriculture Zoning Study

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ABSTRACT: The factors affecting the development of agriculture in Qinghai Province are geographical location, climate as well as inefficient agricultural water use and wasted water resources. In this paper, four level 1 indicators and 10 level 2 indicators are established based on the topography, climate, water resources and crop cultivation structure to determine the index system of the partition. This is to provide a basis for the development of agricultural modernization in Qinghai Province.

KEYWORDS: Qinghai province; water-saving agriculture partition; principal component analysis; cluster analysis

Qinghai Province is located in the northeastern part of the Qinghai-Tibet Plateau. Because of its unique geographical location, its topography, climate, soil and vegetation are extremely complex, and its agricultural structure has obvious topographic differences, with high and cold terrain, dry climate and ecological environment showing obvious plateau characteristics[1]. Although agricultural production is constrained by the lack of rainfall and spatial and temporal distribution, and the large vertical variation in climate, as well as soil erosion and drought, its unique natural conditions, such as abundant light and vast land areas, also facilitate the growth of crops. Water-efficient agricultural development models have obvious regional differences and consistency within regions, and water-efficient agricultural zoning needs to be considered before choosing a locally appropriate water-efficient agricultural development model[2]. Agricultural water saving zoning can group together areas with similar characteristics and tailor agricultural water saving development models to make agriculture and water resources efficient together.

1. OVERVIEW OF THE STUDY REGION

(1) Climate characteristics

Qinghai Province is deep inland, far from the sea, and located on the Qinghai-Tibet Plateau, which has a continental climate. Its climate is characterised by long sunshine hours and strong radiation; long winters and cool summers; large daily temperature differences and small annual temperature differences; low precipitation and large geographical differences, with rain in the east and dry and windy conditions in the west, lack of oxygen and cold. The annual average temperature is affected by the topography and gradually decreases from north to south, the annual average temperature is about -5.1℃ ～ 9℃; the overall distribution trend of precipitation in the province is decreasing from southeast to northwest, the annual precipitation in most areas of the territory is below 400mm, and the difference between the maximum precipitation in the southeast and the minimum precipitation in the northwest Qaidam Basin is 728mm. The distribution of water resources is uneven within and between years, with large geographical disparities. The average annual total radiation can reach 5860~7400 MJ/m^2, and the sunshine time is 2336~3341 hours, with abundant solar energy resources.

(2) Topography

The topography of Qinghai province is generally high in the west and low in the east, high in the north and south and low in the middle, with a high altitude in the west, sloping down in a trapezoidal pattern to the east, and the transition zone from the Qinghai-Tibet Plateau to the Loess Plateau in the east, with complex topography and diverse landforms. The average altitude of the province is above 3000m, covering 111000km^2,

accounting for 15.9% of the total area of the province; the area between 3000 and 5000m in altitude is 532000km^2, accounting for 76.3% of the province, and the area above 5000m in altitude is 54000km^2, accounting for 7.8% of the total area of the province. The northeast and east of Qinghai Province are in transition with the Loess Plateau and Qinling Mountains in the northeast and east of Qinghai Province, the north of the province is in transition with the Loess Plateau and the Qinling Mountains, the north of the province is separated from Gansu's Hexi Corridor, the northwest of the province is separated from the Tarim Basin through the Arjinshan Mountains, the south is connected to the northern Tibetan Plateau, and the southeast is connected to the Sichuan Basin through the mountains and plateau basin.

(3) Water resources characteristics

There are 380 rivers in Qinghai Province with a catchment area of 500km^2 or more. The total annual runoff of the province is 61.123 billion m^3, ranking 15th in the country in terms of total water resources, and the per capita possession is 5.3 times the national average. 49% of the total runoff of the Yellow River, 1.8% of the total runoff of the Yangtze River, 17% of the total runoff of the Lancang River and 45.1% of the total runoff of the Hei River flow out of Qinghai, with 59.6 billion cubic metres of water flowing out of Qinghai every year. The amount of underground water resources is 28.16 billion cubic metres; there are 242 lakes in the province with an area of more than 1 square kilometre, and the total area of lakes in the province is 13098.04km^2, ranking second in the country; Qinghai is rich in total water resources, but the conflict between supply and demand is still very prominent. The Yangtze River and Lancang River basins have a small population and a small total industrial and agricultural economy, but are rich in water resources.

(4) Land resources

The total measured land area of Qinghai Province is 696600km^2 (0.6966 billion hectares). Of which, 45.105 million hectares are agricultural land, accounting for 64.75% of the province's total land area. Of the agricultural land, 585700 hectares are arable land, 40812100 hectares are pasture land, 3541500 hectares are forest land and 0.61 million hectares are garden land; 339900 hectares are construction land, accounting for 0.49% of the province's land area; and 24219900 hectares are unused land, accounting for 34.77% of the province's land area. The land types in Qinghai are diverse, with obvious vertical differentiation, roughly bounded by the Riyue Mountains and the northern edge of the Qingnan Plateau, with pastoral areas to the west and farming areas to the east. From west to east, glaciers, Gobi, deserts, grasslands, waters, woodlands and arable land are distributed in a trapezoidal pattern, and the eastern agricultural areas form three-dimensional terraces of Sichuan, shallow and cerebral, with scattered plots of land that are difficult to develop and use intensively in a row. The arable land in the east accounts for 90.8% of the total arable land area in the province, and the arable reserve resources are mainly distributed in the Qaidam Basin, Hainan Tablelands, the Qinghai Lake Rim area and the eastern region.

2. WATER RESOURCES AND AGRICULTURAL OUTPUT

Table 1 shows that there is a high mismatch between water resources and agricultural production value in Qinghai Province, with an uneven spatial distribution of water resources. Such an imbalance between water resources and agricultural production value in Qinghai is due to the geographical and climatic factors of Qinghai, and also to the inefficient use of water in agriculture and the serious waste of water resources. The uneven natural spatial distribution of water resources and the underground efficiency of water use have led to an extremely uneven distribution of water resources and arable land resources, and drought has constrained the high-quality development of Qinghai's agriculture [3]

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Table 1. Water resources, per capita water resources and agricultural output value of each city in Qinghai Province in 2020

	Water resources			Agriculture	
	Total（Billions of m^3）	Percentage（%）	Per capita（m^3）	Agricultural output（million）	Percentage（%）
Haidong	22.27	2.20	698.1	674210	36.8
Xining	17.13	1.69	818.18	419518	22.9
Tibetan Autonomous Prefecture of Haibei	64.91	6.41	21961.1	85852	4.68
Hainan	56.52	5.59	11986.8	161839	8.83
Tibetan Autonomous Prefecture of Golog	39.90	3.94	14241.7	59708	3.26
Tibetan Autonomous Prefecture of Golog	229.60	22.68	221807.9	16764	0.91
Yushu Tibetan Autonomous Prefecture	400.44	39.57	96405.8	84592	4.61
Haixi Mongolian and Tibetan Autonomous Prefecture	181.14	17.90	44855.9	331029	18.1

3. DATA SOURCES AND ANALYSIS METHODS

The data and information used in this paper were obtained from the Water Resources Bulletin of Qinghai Province and the Statistical Yearbook of Qinghai Province, and the data were reliable.

Factor analysis was used to select key indicators for water-saving agriculture zoning, and cluster analysis was used to zoning water-saving agriculture in each state and city of Qinghai Province, providing a scientific basis for the development of water-saving agriculture in Qinghai Province[4].

4. DETERMINATION OF ZONING INDICATORS

4.1 Zoning principles

Water-saving agriculture should be zoned according to the characteristics of the region in terms of natural conditions, socio-economic status and the comprehensive benefits of water-saving agriculture, i.e. following the basic principles of tailoring to local conditions, paying attention to elements of agricultural production closely related to crop layout and administrative boundaries, and the relative integrity of watershed boundaries [5].

4.2 Zoning indicator system.

The indicator setting for the sub-region must meet the requirements of comprehensiveness, generality and ease of access[6]. Taking into account the information of Qinghai Province, four level 1 indicators were selected: topography and landscape, climatic characteristics, water resources and water scarcity, and cropping structure. The level 1 indicators were further divided into level 2 indicators, with a total of 10 indicators[7]. See Table 2.

Table 2. Index system of agricultural water-saving zones

Level 1 indicators	Level 2 indicators	Units	Number
Topography	Average altitude	m	x_1
	Arable area ratio	%	x_2
Climatic characteristics	Drought index		x_3

	Multi-year average temperature	℃	x_4
	Multi-year average rainfall	mm	x_5
Water resources and extent of water scarcity	Total water	m^3	x_6
	Irrigation water consumption	m^3	x_7
	Grain crops	%	x_8
Planting structure	Cash crops	%	x_9
	Other crops	%	x_{10}

5. Zoning methods

(1) Principal component analysis

With the help of IBM SPSS Statistics data processing software, a principal component analysis was conducted on the 10 indicators of the states and cities belonging to Qinghai Province. Due to the different meanings and scales of each indicator, the individual data were first standardised[8] to reduce factor interference and make the evaluation indicators comparable, as shown in Table 3. By calculating the correlation coefficient matrix to derive the eigenvalues and contribution rates, as shown in Table 4, it can be seen that the cumulative variance contribution rate of the first three principal components is 86.198%, and the eigenvalues are all greater than 1. The selected indicators are representative.

Table 3. Standardized treatment of indicators

Serial number	Region	Z（x_1）	Z(x_2)	Z（x_3）	Z（x_4）	Z（x_5）	Z（x_6）	Z（x_7）	Z（x_8）	Z（x_9）	Z（x_{10}）
1	Xining	-1.52656	1.75130	-0.59078	0.57588	0.17472	0.71772	-1.52656	1.75130	0.04551	-0.01940
2	Haidong	-0.96581	1.46591	0.85122	1.33999	-0.95521	0.45369	-0.96581	1.46591	-0.17434	-0.23693
3	Tibetan Autonomous Prefecture of Haibei	0.15651	-0.42490	-0.94651	-1.18073	0.54892	-0.51168	0.15651	-0.42490	1.15725	-0.41107
4	Tibetan Autonomous Prefecture of Huangnan	-0.67160	-0.50332	-0.24774	0.97663	0.45354	-0.20142	-0.67160	-0.50332	-0.37765	0.65544
5	Hainan	0.63542	-0.39872	0.01270	0.22705	-0.38215	-0.77424	0.63542	-0.39872	0.04263	-0.60746

6	Tibetan Autonomous Prefecture of Golog	1.03262	-0.63770	-0.86393	-1.49178	1.44512	-0.86765	1.03262	-0.63770	-0.98711	-0.93403
7	Yushu Tibetan Autonomous Prefecture	0.00106	-0.63175	-0.25410	-0.49553	0.47334	-0.80891	0.00106	-0.63175	-1.30010	2.17259
8	HaixiHaixi Mongolian and Tibetan Autonomous Prefecture	1.33837	-0.62083	2.03913	0.04848	-1.75828	1.99250	1.33837	-0.62083	1.67906	-0.61914

Table 4. Eigenvalues and common factor contribution rate

F	Eigenvalue λ	Contribution margin（%）	Cumulative contribution rate（%）
F_1	4.738	47.383	47.383
F_2	2.417	24.174	71.556
F_3	1.464	14.641	86.198

In order to make the differences between the factors more obvious, the rotation matrix was obtained by the maximum variance method of rotation, see Table 5. from Table 5 it can be seen that the indicators with loadings of not less than 0.6 in y_1 are x_3, x_4, x_5, x_6, x_7, which shows that y_1 represents the common factor of climatic characteristics and the degree of water resources and water scarcity, the indicators with loadings of not less than 0.6 in y_2 are x_1, x_2, which is the common factor reflecting topography and landscape, and The indicators with loadings of not less than 0.6 in y_3 are x_8, x_9 and x_{10}, which are common factors reflecting the structure of cultivation [9].

Table 5. Common factor load matrix

Original variable	Public factor		
	1	2	3
Average altitude x_1	-0.061	-0.960	-0.008
Arable area ratio x_2	0.334	0.783	0.406
Drought index x_3	0.864	-0.222	-0.090
Multi-year average temperature x_4	0.669	0.589	-0.004
Average multi-year rainfall x_5	-0.929	0.088	0.047
Total water quantity x_6	0.934	-0.037	0.060
Irrigation water consumption x_7	0.959	0.052	0.074
Grain crops x_8	-0.550	0.077	0.729
Cash crops x_9	0.088	-0.445	0.721
Other crops x_{10}	-0.226	0.414	-0.860

(2) Cluster analysis

Using the cluster analysis method in SPSS software, the similarities between the cities and towns under Qinghai Province were analysed and calculated by means of Euclidean distance. Based on the results of the cluster analysis, combined with the zoning principles and factors such as natural environmental conditions and water resources conditions, Qinghai Province was divided into four major regions, as shown in Table 6.

Table 6. Water-saving agricultural zones in Qinghai Province

Zones	Name	Zoning units
I	Semi-arid highland continental climate zone	Xining， Haidong
II	Highland continental climate zone	Tibetan Autonomous Prefecture of Haibei, Tibetan Autonomous Prefecture of Huangnan, Hainan and Tibetan Autonomous Prefecture of Golog
III	Alpine dry continental climate zone	Haixi Mongolian and Tibetan Autonomous Prefecture
IV	Alpine climate zone	Yushu Tibetan Autonomous Prefecture

Semi-arid plateau continental climate zone I: the region is in the Huangshui River valley basin, surrounded by mountains. The average annual rainfall in this region is 319-531 ㎜, the average annual evaporation is about 1612.3mm, the rainfall time and space distribution is uneven, among which the grain crop planting ratio accounts for more than 53.6%, the total planting area of this region accounts for 1/2 of the total planting area of Qinghai Province, but the water resources only accounts for 15% of the total water resources of the province, water resources and arable land area This region is one of the main agricultural development areas in Qinghai Province, and should promote efficient water-saving irrigation for facility agriculture, vigorously promote under-membrane drip and sprinkler irrigation technology to gradually modernise farmland water conservancy, thereby accelerating the modern development of the region.

Highland Continental Climate Zone II: This zone is characterised by hailstones, which often accompany high winds and other types of hail, causing damage to crops in the middle and late stages of growth and development. Barley is the main crop grown in this region. The region is rich in water resources, the arable land is not contiguous, the terrain is obviously undulating and soil erosion is serious.

Alpine Arid Continental Climate Zone III: This region is characterised by the high frequency of spring droughts, the intensity of wind and sand, and frosts that occur mostly at the germination stage of crops, which have a greater impact on crops. Water-saving and efficient farming systems should be actively promoted, combining drip and sprinkler irrigation. While achieving water conservation, the planting structure should be appropriately improved and crop varieties with high drought resistance should be selected.

Alpine Climate Zone IV: This region is extremely well-developed in terms of ice-edge terrain, with an average altitude of over 4,200m above sea level, high terrain and a harsh environment. The total water resources are abundant, with 96,000 m3 per capita, but the arable land area only accounts for 0.065% of the total arable land area in the province, and is rich in mineral resources, which can reduce the water pressure of other industries through agricultural water conservation.

6. CONCLUSION

By combining the principles of agricultural zoning and the actual situation of Qinghai Province to establish an agricultural zoning index system, four level 1 indicators (topography and landscape, climatic characteristics, water resources and crop cultivation structure) and ten level 2 indicators were selected, and by determining the principal components, selecting key

indicators and combining cluster analysis, a cluster analysis was carried out for each state and city in Qinghai Province, dividing Qinghai Province into four regions: semi-arid plateau continental climate region, plateau continental climate zone, alpine arid continental climate zone and alpine cold climate zone.

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