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Vegetation Health Index 1-km Grid Dataset in Yellow River–Huangshui River Valley (2000–2020)

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Abstract: Yellow River–Huangshui River valley (YHV) is the most important agricultural area and grain production base in Qinghai province. The analysis of the evolution trend of the agricultural drought in YHV is of great significance for ensuring the healthy development of agriculture in Qinghai province. The dataset is obtained using the vegetation health index (VHI) calculation model and the daily land reflectance MOD09GA and daily land temperature MOD11A1 data. VHI is the metric parameter that can couple the normalized differential vegetation index (NDVI) and land surface temperature (LST) to reflect the agricultural drought level of the region. The area covered by this dataset is YHV, and the observation duration is from March to November (Vegetation growing season) during 2000–2020. The dataset is in the GeoTiff format, has a spatial resolution of 1 km, comprises 406 files, has a data size of 20.9 MB.

Keywords: Yellow River–Huangshui River valley; agricultural drought; vegetation health index; growing season

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.08.03.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2022.08.03.V1.

1 Introduction

Agricultural drought is characterized by long duration and wide impact, which can seriously affect agricultural production, human activities, and economic development as well as the stability and security of society. It is one of the major agricultural disasters[1–3]. Intergovernmental Panel on Climate Change stated in its Sixth Assessment Report that

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[2] Sun, N. S., Chen, Q., Liu, F. G., *et al*. Grid dataset of 1-km vegetation health index in Yellow River–Huangshui River valley (2000–2020) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2022. https://doi.org/10.3974/geodb.2022.08.03.V1.https://cstr.escience.org.cn/CSTR:20146.11.2022.08.03.V1.

continued global warming will lead to enhanced evapotranspiration and an increase in the agricultural drought area in the future[4]. The accumulated agricultural drought disaster in China in 2021 damaged 3,426.2 thousand hectares of crops and caused direct economic losses of 20.09 billion Yuan[5]. Thus, studying the agricultural drought problem in China is significant for ensuring food supply and maintaining social stability.

YHV is located in the northeast of Qinghai province; it is the alluvial formation of the valley of Yellow River and its tributaries Huangshui River[6]. The total area of the YHV region is about 3.3×10^4 km^2, accounting for only about 4.5% of the total area of the province. Nearly 70% of the province's population is concentrated in this region, and more than 80% of the land is arable. Therefore, studying the agricultural drought in the YHV region is essential for promoting sustainable agricultural development in the Qinghai province. Compared to other indices, the vegetation health index (VHI) has better applicability in the field of agricultural drought monitoring[7] and is widely employed by scholars worldwide. The dataset compiled herein is based on the MODIS remote sensing data with the use of the VHI calculation model to calculate the annual VHI and seasonal VHI from 2000 to 2020 and the threshold method to determine the agricultural drought. This dataset can intuitively reflect the location of agricultural drought areas and agricultural drought area changes in YHV and provide reference for drought policy formulation and agricultural production and management in YHV.

2 Metadata of the Dataset

The metadata summary of the dataset[8] is provided in Table 1, including the dataset name, short name, authors, year, temporal resolution, spatial resolution, data format, data size, data files, publisher, and sharing policies, etc.

3 Methods

3.1 Algorithm

VHI was proposed by Kogan *et al*. and was calculated from the vegetation condition index (VCI) and temperature condition index (TCI)[10]. When crops are affected by agricultural drought, VCI and TCI beneficially reflect the crop growth status and temperature, respectively[11]. When a drought occurs, the vegetation growth will be stressed and the VCI index will decrease. Additionally, a drought is usually accompanied by an abnormal increase in temperature, and consequently, the TCI index will decrease. In this study, the weighted combination index VHI[12], which integrates the respective advantages of VCI and TCI, is adopted to study the agricultural drought in the YHV. The specific calculation methods of VCI, TCI, and VHI are as follows:

$$VCI = 100 \times \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \tag{1}$$

$$TCI = 100 \times \frac{LST_{max} - LST}{LST_{max} - LST_{min}} \tag{2}$$

Table 1 Metadata summary of the Grid dataset of 1-km vegetation health index in Yellow River-Huangshui River valley (2000–2020)

Item	Description
Dataset full name	Grid dataset of 1-km vegetation health index in Yellow River-Huangshui River valley (2000–2020)
Dataset short name	YHV_VHI_2000-2020
Authors	Sun, N. S. GNW-6596-2022, School of Geographic Science, Qinghai Normal University, say0524@163.com Chen, Q. AAB-3346-2021, School of Geographic Science, Qinghai Normal University, qhchenqiong@163.com Liu, F. G. L-8795-2018, School of Geographic Science, Qinghai Normal University, lfg_918@163.com Zhou, Q. AAB-3351-2021, School of Geographic Science, Qinghai Normal University, zhouqiang729@163.com Guo, Y. Y. GOG-8661-2022, School of Geographic Science, Qinghai Normal University, 821709854@qq.com
Geographical region	Yellow River–Huangshui River valley
Year	2000–2020
Temporal resolution	Annually and seasonally
Spatial resolution	1 km
Data format	.shp, .tif
Data size	14.3M (after compression)
Data files	406 data files, including annually and quarterly vegetation health index data files
Foundations	Ministry of Science and Technology of P. R. China (2019YFA0606902)
Computing environment	Google Earth Engine (GEE), ArcGIS
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[9]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

$$VHI = aVCI + (1-a)TCI \tag{3}$$

where, the value of α is generally 0.5[13]. Kogan *et al*. proposed the agricultural drought discrimination threshold based on *VHI*[14]:

$$G(VHI) = \begin{cases} 1, VHI \leqslant 40 \\ 0, VHI > 40 \end{cases} \tag{4}$$

where *G*(*VHI*) is the drought value, with 1 representing agricultural drought and 0 representing no agricultural drought.

3.2 Data Development Process

Based on MOD09GA and MOD11A1 data of the study area from 2000 to 2020, the following steps were conducted (Figure 1):

(1) The scope of the study area was imported into GEE to obtain the MOD09GA and MOD11A1 data of the study area from 2000 to 2020.

(2) NDVI was calculated based on MOD09GA ($NDVI = \frac{NIR - R}{NIR + R}$, where NIR is the near-infrared band and R is the infrared band), and the quality. Mosaic() function in GEE was used to synthesize the maximum value of NDVI. The S-G filter was used to smooth NDVI, and the mean() function in GEE was used to synthesize the average of LST.

(3) Projection conversion and resampling of NDVI and LST were performed in ArcGIS, and the annual and seasonal VCI and TCI were calculated. Finally, the annual and seasonal VHI were calculated.

(4) The temporal variation and spatial distribution of the agricultural drought in YHV were obtained.

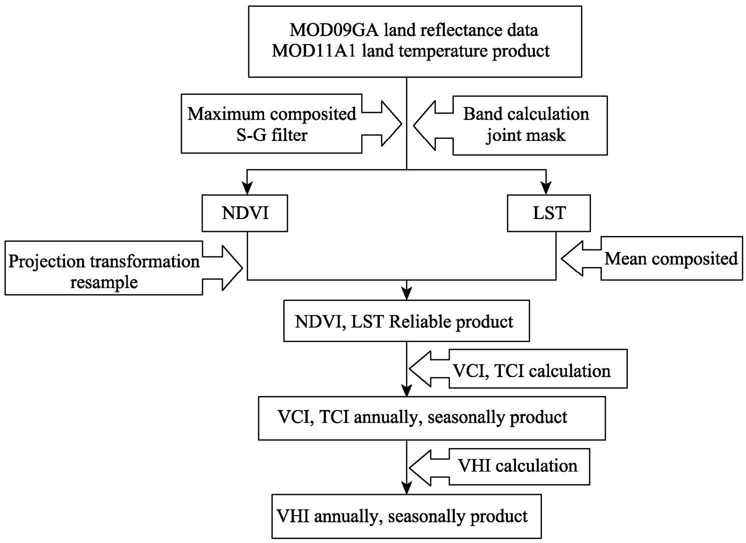

Figure 1 Flowchart of the dataset development

4 Data Results and Validation

4.1 Data Products

The 1-km grid VHI dataset in YHV was named as VHI.YYYY.1_km_season.tif and VHI.YYYY.1_km_GSeason.tif. The specific respective meanings are as follows: (1) VHI: represents the vegetation health index product; (2) YYYY: represents that the production year; (3) 1_km: represents the spatial resolution of 1 km; (4) GSeason: represents annual data. (5) season: represents seasonal data.

4.2 Data Results

4.2.1 Interannual Spatial and Temporal Variation of Agricultural Drought in Growing Season

VHI in the growing season of YHV from 2000 to 2020 is shown in Figure 2. The figure shows that the agricultural arid area in the annual growing season of YHV in the recent 20 years exhibits a decreasing trend, from more than 1.0 × 10^4 km^2 in 2000 to less than 0.7 × 10^4 km^2 in 2020, with an average annual decrease of 142.85 km^2. Thus, the agricultural drought area greatly decreased. The agricultural arid areas of YHV are mainly located in the central and southern regions of YHV, i.e., the low-heat valley zone of the Yellow River and Huangshui River.

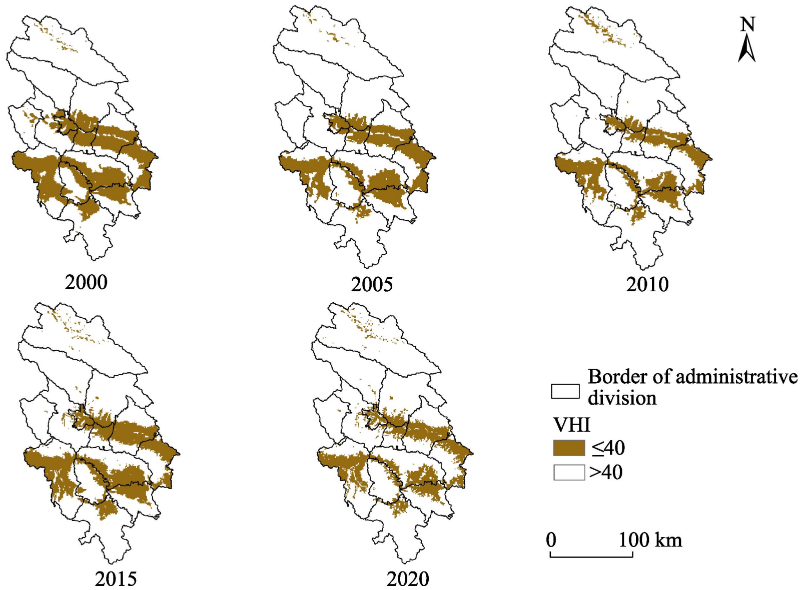

Figure 2 Maps of VHI in growing season during 2000–2020

4.2.2 Temporal and Spatial Variations of the Agricultural Drought in the Growing Season

The VHI of the YHV region in the spring, summer, and autumn from 2000 to 2020 (Figure 3, 4 and 5) intuitively shows that (1) the agricultural dry areas in spring are mainly located in the northern, central, and southern regions of YHV, (2) the annual agricultural drought areas in summer and autumn are mainly located in the central and southern parts of YHV, and (3)

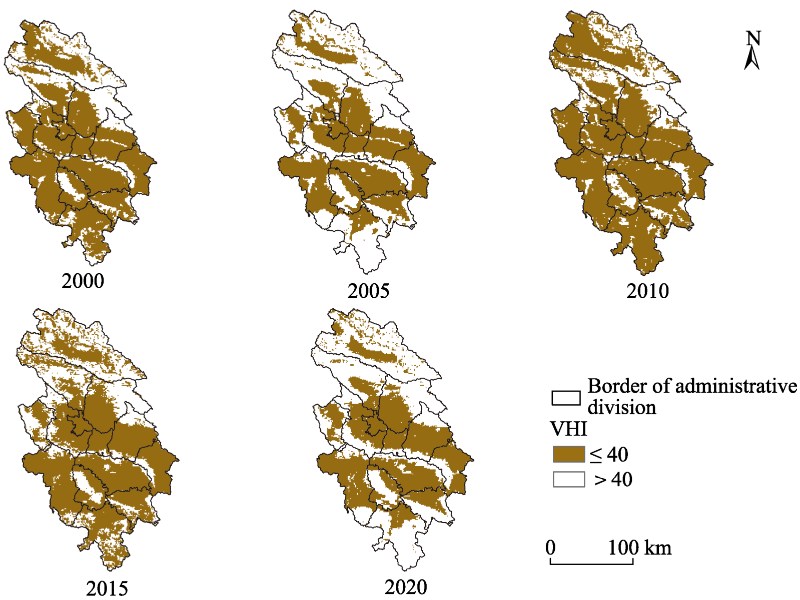

Figure 3 Maps of VHI in spring during 2000–2020

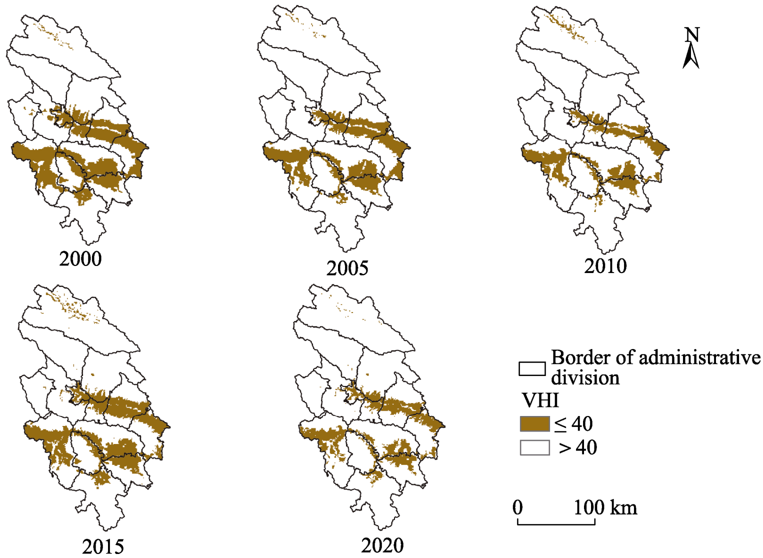

Figure 4 Maps of VHI in summer during 2000–2020

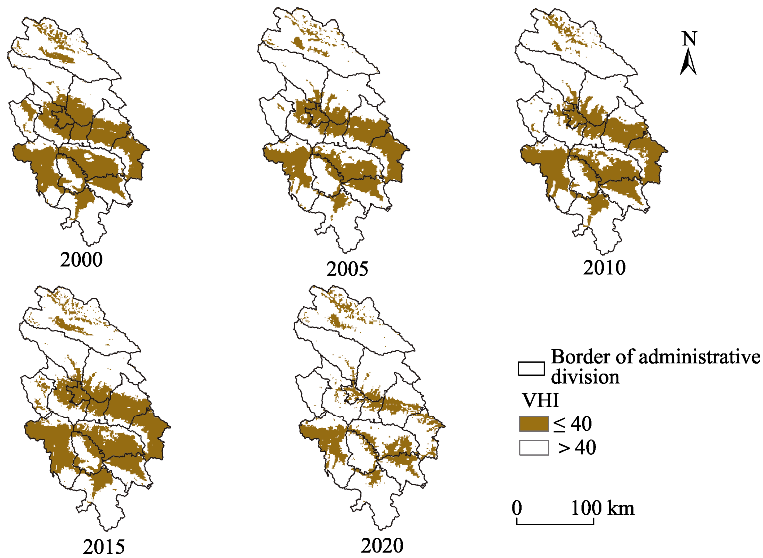

Figure 5 Maps of VHI in autumn during 2000–2020

the agricultural dry areas in each season are basically located in the low-heat valley area with large evapotranspiration. The changes of the agricultural arid area in the YHV region in the spring, summer, and autumn from 2000 to 2020 are shown in Figure 6, respectively. In the YHV region, the agricultural arid area in the spring exhibits almost no change in the past 20 years and is always above 1.4×10^4 km^2, while that in the summer and autumn exhibits a very obvious downward trend. The decrease is significantly greater in the summer than in the autumn. In the 20 years, agricultural drought area annually decreased by an average of 187.09 km^2, the summer and autumn agricultural drought area annually decreased by average of 369.64 km^2, but the whole spring of YHV agricultural drought area biggest, next autumn, summer minimum of YHV agricultural drought is given priority to with spring drought. The severity of autumn and summer drought is less severe than that of the spring drought.

Figures 7 shows that in the YHV in the recent 20 years, the average of spring VHI is basically less than 40, the average of summer VHI is between 50 and 60, and the average of autumn VHI is between 40 and 50. In the YHV region, the average of summer VHI is the largest, followed by that of the autumn VHI and spring VHI. In the YHV region, the severity of the agricultural drought is the highest in spring, followed by autumn and summer. Moreover, the trend fitting of the average VHI of the three seasons shows that the average VHI of each season increases to different degrees. Among them, the average VHI of autumn exhibits the largest increase, followed by summer and spring. Therefore, during the period from 2000 to 2020, the severity of agricultural drought in each season in YHV alleviated, but spring was the drought prone season in the YHV region.

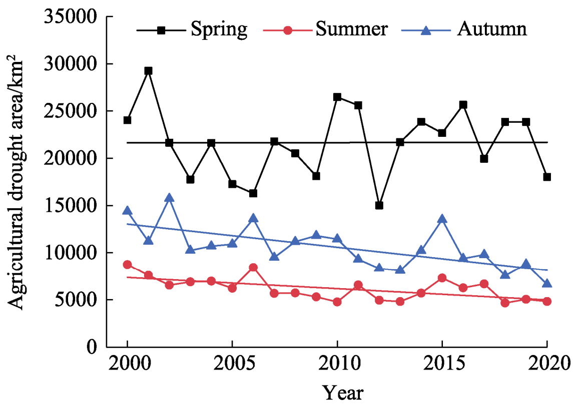

Figure 6 Agricultural drought area in spring, summer and autumn during 2000–2020

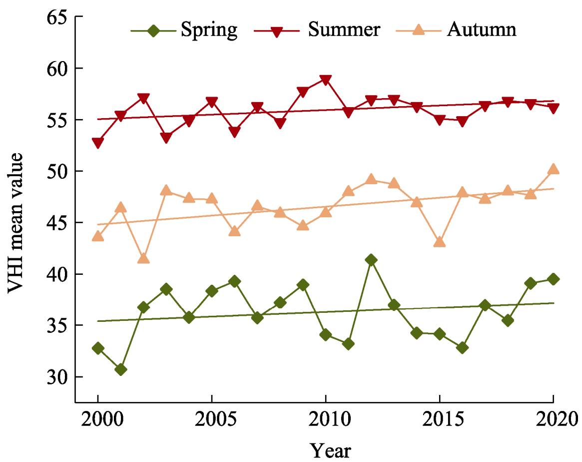

Figure 7 The averaged VHI in spring, summer and autumn during 2000–2020

5 Discussion and Conclusion

The study of agricultural drought in the YHV region is of great practical significance for the healthy agricultural development in the Qinghai province. In this study, the VHI in the growing season of YHV from 2000 to 2020 were calculated based on remote sensing data, and the agricultural drought characteristics in this period were annually and seasonally obtained.

Based on the research results, the agricultural drought in the entire YHV region is continuously alleviated, reflecting the continuous improvement of the natural conditions in this region, which is consistent with the conclusion that the natural environment of the Qinghai–Tibet Plateau is warming and wetting[15]. Furthermore, from the interannual and seasonal perspectives, the agricultural arid areas in the YHV region are all located in the valley region formed by the Datong River, Huangshui River, and Yellow River, which is the most concentrated agricultural area in the YHV region. The study results denote that using VHI to identify agricultural arid areas in the YHV region is reasonable. In the future, VHI can be used as an indicator to monitor agricultural drought in the YHV region as well as the Qinghai province.

Author Contributions

Chen, Q. proposed the idea; Liu, F. G. and Zhou, Q. designed the framework; Sun, N. S. and Guo, Y. Y. collected and processed the data; and Sun, N. S. wrote the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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