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# Dataset Development of Arid Valley Boundary Displacement and Climate Variability in the Upper Reaches of the Minjiang River

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**Abstract:** Arid valleys are unique geoecological environments within humid environments, and the displacement of the arid valley boundary is one of the response indicators of mountain natural ecosystems to climate change. Through visual interpretation of SPOT images by two individuals, the arid valley boundary in the upper reaches of the Minjiang River was obtained. The spatial distributions of climatic factors (annual average temperature, annual precipitation, annual sunshine duration, annual relative humidity, and annual evaporation) in the study area were clarified using the radial basis function method. Finally, the response of arid valley boundary displacement to regional climate change between 1999 and 2013 was studied. The results were as follows: (1) the climate in the upper reaches of the Minjiang River exhibited a warm and humid trend between 1999 and 2013. (2) The average elevation of the arid valley boundary decreased by –0.76 ± 0.26 m/a. This decrease was significantly associated with the variability of climate ($p$ = 0.010<0.05), precipitation ($p$ = 0.011<0.05), and relative humidity ($p$ = 0.020<0.05). Therefore, the downward trend of the arid valley boundary reflects the improvement in the hydrothermal balance from 1999–2013 due to climate variation. The dataset provides additional information on climate change in the upper reaches of the Minjiang River. The data accurately reflect the primary displacement trend of the arid valley boundary within the basin. This study could support further research on regional responses to global change and guide ecological construction in arid valley areas. The dataset is archived in .shp, .tif, and .xlsx data formats, with a data size of 6.34 MB (compressed into one file with a data size of 2.59 MB).

**Keywords: arid valley boundary's displacement; spatial-temporal distribution; climate variability; Hengduan Mountains**

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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.2023.11.04.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2023.11.04.V1.

## 1 Introduction

The arid valley in the Hengduan Mountains is an unique geoecological phenomenon encountered in humid and subhumid regions[1, 2]. The complex topographic and climatic conditions in the region control the formation of arid river valleys; moreover, localized anthropogenic disturbances have contributed to arid landscapes with more pronounced characteristics[3–5]. The arid valley boundary is the transition zone between the arid valley scrub landscape and upper montane forests, whose fluctuations reflect vegetation changes due to the interaction between natural and anthropogenic factors. The habitats of arid valley boundaries are highly spatially heterogeneous and dynamic and sensitive to external environmental changes. Therefore, analyses of arid valley boundaries could provide an effective way to quickly evaluate the impacts of climate change on mountainous human-land systems.

The arid valley in the upper reaches of the Minjiang River is a typical representation of the dry and warm valleys found in the northern part of the Hengduan Mountains[6, 7] (Figure 1). From 1974 to 2000, the arid valley in the region expanded in size[8], with the highest elevation increasing from 3,128 to 3,181 m at a rate of 2 m/a[9]. Moreover, under the impacts of climate change and human activities, the distribution of desert species such as *Convolvulus tragalanthoides* and *Nitraria tangutorum* has expanded, and they have become dominant communities in some areas, further indicating degradation of the ecological environment in these region[9–13]. However, there are insufficient data to support these conclusions. Since 2000, with the implementation of ecological restoration projects such as returning farmland to forests, the area of the arid valley in the upper reaches of the Minjiang River has decreased, and the effect of ecological restoration has been outstanding[14–16]. However, quantitative studies on arid valley fluctuations and climate change since 2000 have been limited. In this study, a dataset of the displacement and climate variability of the

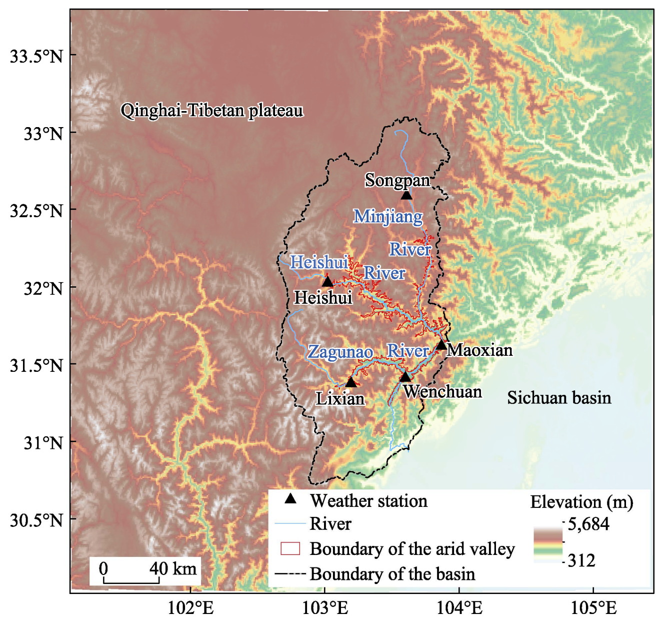


**Figure 1** Distribution of the arid valley in the upper reaches of the Minjiang River

arid valley boundary in the upper reaches of the Minjiang River was constructed based on SPOT images, field investigations, and meteorological data. This study aimed to reveal the response characteristics of the arid valley boundary to regional climate variation from 1999–2013. Tihs study could enhance the understanding of regional responses to global changes and provide data support for ecological construction in arid valleys.

## 2 Metadata of the Dataset

The metadata of the Dataset of arid valley boundary displacement and climate variability in the upper reaches of the Minjiang River (1999–2013)[17] are summarized in Table 1. It includes the dataset's full name, short name, authors, year of the dataset, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

**Table 1** Metadata summary of the Dataset of arid valley boundary displacement and climate variability in the upper reaches of the Minjiang River (1999–2013)

| Items | Description |
|---|---|
| Dataset full name | Dataset of arid valley boundary displacement and climate variability in the upper reaches of the Minjiang River (1999–2013) |
| Dataset short name | Boundary_Climate_UpperMinjiang |
| Authors | Yan, W. P. L-5250-2016, Sichuan Academy of Environmental Policy and Planning, School of Environment and Resource, Southwest University of Science and Technology, wei-po.yan@hotmail.com<br>Wang, Q. L-5245-2016, School of Environment and Resource, Southwest University of Science and Technology, qingw@imde.ac.cn<br>Guo, Y. L., L-5221-2016, School of Environment and Resource, Southwest University of Science and Technology, guoyalin_linda@163.com Hu, Q., School of Environment and Resource, Southwest University of Science and Technology, 2635542962@qq.com<br>Yang, M., School of Environment and Resource, Southwest University of Science and Technology, miro-y@swust.edu.cn<br>Zhang, Y., School of Environment and Resource, Southwest University of Science and Technology, 1653651783@qq.com<br>Han, Y. W., School of Environment and Resource, Southwest University of Science and Technology, hanyw1976@163.com |
| Geographical region | China |
| Year | 1999, 2013 |
| Temporal resolution | Year |
| Spatial resolution | 30 m |
| Data format | .shp, .tif, .xslx |
| Data size | 6.34 MB |
| Data files | (1) The arid valley boundary data in 1999 and 2013 (.shp)<br>(2) The climate variability data from 1999 to 2013 (.tif)<br>(3) Statistics of arid valley boundary displacement and climate variability (. xlsx) |
| Foundations | Ministry of Science and Technology of P. R. China (2015BAC05B05-01); National Natural Science Foundation of China (41601088, 41071115); Natural Science Foundation of Southwest University of Science and Technology (18zx7117) |
| 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 | (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[18] |
| Communication and searchable system | DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS |

## 3 Methods

### 3.1 Data Sources

**Climatic Data:** Climatic data, including the annual average temperature, annual precipitation, annual sunshine duration, annual relative humidity, and annual evaporation in the upper reaches of the Minjiang River, were obtained from the China National Meteorological Information Centre.

**Remote Sensing Data:** Due to the short study time scale, the movement of the arid valley boundary is likely relatively minor. Therefore, SPOT images were chosen as the base data. Notably, 1999 imagery was acquired in December 1999 and January 2000 at a spatial resolution of 10 m, and 2013 imagery was acquired in January 2014 and February 2014 at a spatial resolution of 1.5 m. Moreover, the concept of the arid valley is relative, and its definition is not yet uniform[6, 19, 20]. To assess the accuracy of the interpretation of the arid valley boundary, the arid valley boundary in 1974 was extracted based on Landsat MSS imagery (with a spatial resolution of 30 m) and compared with existing studies.

### 3.2 Data Processing

**Climatic data processing:** The linear tendency estimation method is commonly used to analyze climatic factor trends[21]. This method involves fitting a straight line to the data, where the slope of the line indicates the direction and rate of interannual changes in the climatic elements. The Mann–Kendall trend test (M-K test) is a nonparametric statistical method widely employed to analyze whether there is a sudden change in time series data[22]. This model was used to test the significance and reliability of the variability of the climatic factors in this study. Furthermore, the spatial distribution of climatic factor variations in the basin was analyzed using the radial basis function method on the ArcGIS platform[18].

**Remote sensing images pre-processing:** To ensure the accuracy and reliability of the subsequent data, the remote sensing data coordinate system was unified as WGS_1984_UTM_Zone_48N, with its central meridian at 105°E. Then, the remote sensing images were sequentially preprocessed via geometric correction, orthogonal correction, image fusion, image mosaicing, image cutting, etc., to ensure an accurate geometry and facilitate the extraction of precise geographic information at the subsequent stages[2].

**Interpretation of the arid valley boundary:** Firstly, representative typical sample areas were selected for field surveys to obtain information such as latitude, longitude, elevation, slope, orientation, vegetation types, ground litter, and human activities. During the field survey, sample points with relatively high coincidence of the geographic location with Google Earth online images were selected. Eighty-eight control points and 61 verification points were obtained[23], providing essential references for the subsequent data processing and geographic information extraction. Secondly, since the SPOT images contained shaded areas, Landsat images from the same period were referenced to improve the accuracy and completeness of the data. Combined with the field survey and unsupervised classification of the remote sensing images, arid valley boundary interpretation signatures were established based on vegetation types, image colors, and textural features. Finally, two individuals extracted the arid valley boundaries through visual interpretation. The consistency of the extraction results was verified using the maximum likelihood method[24]. When the consistency rate was higher than 90%, the interpretation results were considered highly reliable, and only inconsistent parts were revised through consultation. However, when the consistency rate was lower than 90%, the interpretation results were considered less consistent, and reinterpretation was necessary.

# 4 Data Results and Validation

## 4.1 Data Composition

The dataset of arid valley boundary displacement and climate variability in the upper reaches of the Minjiang River (1999–2013) consists of three parts: (1) the arid valley boundary data in 1999 and 2013; (2) the climate variability data from 1999 to 2013; and (3) the statistics of arid valley boundary displacement and climate variability.

## 4.2 Data Validation

Data validation focused on verification of the arid valley boundary. On the one hand, the average elevation of the arid valley boundary in the study increased at a rate of 1.72 ± 0.32 m/a between 1974 and 1999. These results are similar to previous research results based on the highest elevation of the arid valley boundary (2 m/a)[9]. This information serves as a valuable reference for verifying the accuracy of the displacement of the arid valley boundary. On the other hand, the research team has studied the ecology and settlement geography in the upper reaches of the Minjiang River for a long time and has accumulated valuable information. Additionally, to better understand the regional ecological characteristics, typical settlements in Li county and Wenchuan county in the basin were investigated[23], providing basic information for extraction and displacement analysis of the arid valley boundary. Therefore, this dataset can accurately reflect the trend in the displacement of the arid valley boundary in the upper reaches of the Minjiang River.

## 4.3 Data Products

**4.3.1** Climate Variability

From 1999 to 2013, the annual average temperature and precipitation in the upper reaches of the Minjiang River increased by 0.008 ℃/a and 2.25 mm/a, respectively, with an overall warm-humid climate trend (Table 2). Due to the differences in climate and regional geographic characteristics, the variations in the climatic factors exhibited obvious geographical differences. The arid valley center was drier, and the warm-humid trend was more pronounced. The annual average temperature and annual precipitation increased the fastest, at rates of 0.018 ℃/a and 3.84 mm/a, respectively. In the Heishui River basin, the average elevation was higher, and the annual average temperature was lower. The warm-humid trend was relatively weak, with slower increases in the temperature and precipitation than those in the arid valley center. In the southern part of the upper reaches of the Minjiang River, the Zagunao River basin exhibited a lower elevation and a more humid climate. However, the increases in temperature and precipitation were the slowest, and the warm-humid trend was the weakest. The dataset provides additional information on climate change in the upper reaches of the Minjiang River and could provide basic data support for regional environmental change studies and ecological construction.

**4.3.2** Displacement of the Arid Valley Boundary

The displacement of the arid valley boundary reflects climate change and human activities. The arid valley boundary in the upper reaches of the Minjiang River was mainly distributed between 1,601 and 3,200 m. The average elevation increased from 2,371 to 2,414 m during the 1974–1999 period, with a rate of 1.72±0.32 m/a (Figures 2 and 3). This increase rate was similar to the result based on the highest elevation of the arid valley boundary (2 m/a)[9],

**Table 2** Climate variability in regions

| Region | RT (℃/a) | RS (h/a) | RE (mm/a) | RP (mm/a) | RH (%/a) |
|---|---|---|---|---|---|
| Arid valley center | 0.018 | −5.24 | −5.40 | 3.84 | 0.08 |
| Heishui River basin | 0.006 | 8.17 | −4.18 | 2.63 | −0.29* |
| Zagunao River basin | 0.005 | −25.67* | 6.92 | 2.12 | −0.26* |
| Whole basin | 0.008 | −8.72 | 5.51 | 2.25 | −0.19* |

Notes: RT, RS, RE, RP, and RH represent the variation rates between years of annual average temperature, annual sunshine duration, annual evaporation, annual precipitation, and annual average relative humidity, respectively. * means that the variation trend is significant at the significant level (α = 0.10) based on the M-K Test.

which verifies the accuracy of arid valley boundary extraction in this study. From 1999 to 2013, the arid valley boundary moved to lower elevations with an average rate of –0.76±0.26 m/a. Additionally, the movement showed variations in different regions. The arid valley boundary in the Heishui River basin exhibited the fastest downward movement (–0.68 m/a), followed by that in the Zagunao River basin, at a rate of –0.06 m/a. However, the arid valley boundary at the arid valley center moved upward at a rate of 0.02 m/a. These patterns were consistent with the precipitation and sunshine duration distributions in the three regions. Therefore, the displacement of the arid valley boundary exhibited significant spatial and temporal heterogeneity, closely related to the climate and changes in climate characteristics during the different periods and regions, as well as human activities[2]. Between the 1970s and 1990s, the upper reaches of the Minjiang River experienced continuous increasing trends in the temperature and precipitation[21]. During the same period, there was rapid growth in the population, with significant changes in the livelihoods of residents and socioeconomic development. An increase in human activities led to more substantial interference with mountain ecosystems, expansion of arid valleys, and severe degradation in the ecological environment.

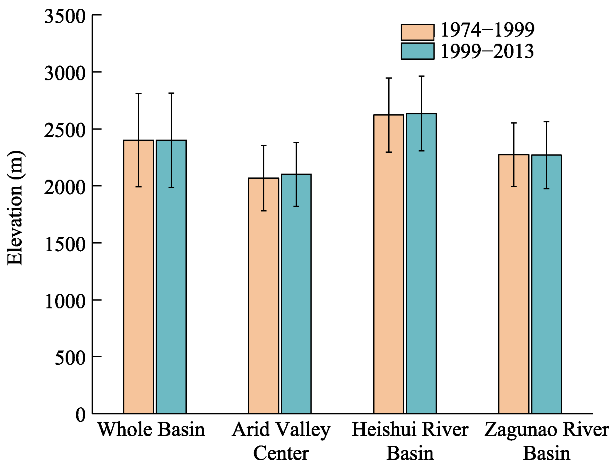


**Figure 2** Average elevation of arid valley boundary in different periods

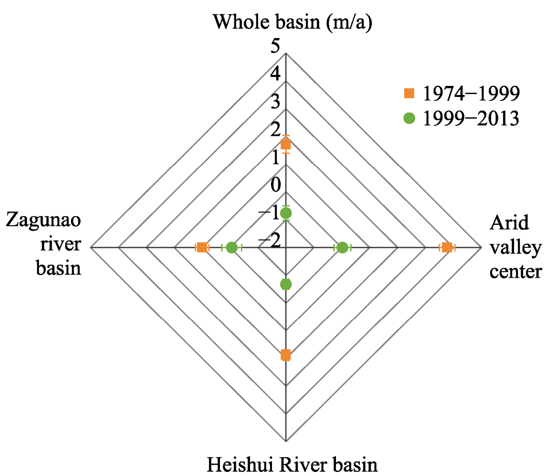


**Figure 3** Average displacement of arid valley boundary in different periods

Since 1999, the climate in the upper reaches of the Minjiang River has experienced warming and humidification. Moreover, a series of ecological projects, such as natural forest protection and return of farmland to forests and grasslands, have been successively implemented, reducing the disturbance of arid valley ecosystems by human activities. These projects successfully inhibited the expansion of arid valleys. Soil erosion in the region has been effectively controlled, and the habitat of the arid valley has been restored, impeding the rise of the arid valley boundary to a certain extent. Overall, the fluctuations in the arid valley boundary resulted from the interactions among multiple factors. This dataset is important for accurately quantifying the interaction characteristics of factors and their intrinsic correlation mechanisms. Moreover, the dataset provides fundamental support for understanding the driving forces of arid valley boundary fluctuations.

**4.3.3** Relationship between the Displacement of the Arid Valley Boundary and Climate Variability

From 1999 to 2013, the arid valley boundary displacement between 1,601 and 3,000 m in the upper reaches of the Minjiang River remained relatively stable, with an average displacement of –0.02±0.04 m/a. Principal component analysis and correlation analysis revealed that the displacement of the arid valley boundary was significantly negatively correlatedwith regional climate change (i.e., the first principal component factor) ($r$=–0.662, $p$=0.010<0.05). Moreover, the arid valley boundary displacement was negatively correlated ($p$<0.05) with variations in moisture-related factors (i.e., precipitation, relative humidity, and evaporation) and positively correlated ($r$=0.664, $p$=0.010<0.05) with variations in heat-related factors (i.e., sunshine duration) (Figure 4). These findings suggest that as the current trend of climate change intensifies, the arid valley boundary in the upper reaches of the Minjiang River will experience slower displacement toward higher elevations but increased displacement toward lower elevations. Therefore, the displacement of the arid valley boundary can effectively reflect warm and humid changes in the regional climate.

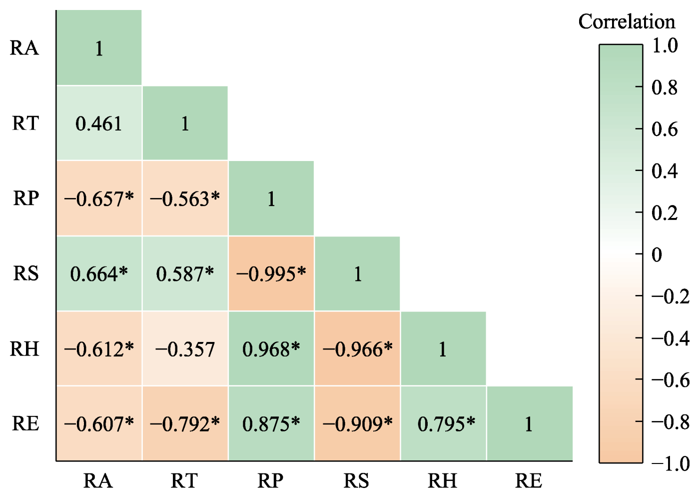


**Figure 4** Correlations analysis (*$p$<0.05. RT, RS, RE, RP, and RH represent the variation rates between years of annual average temperature, annual sunshine duration, annual evaporation, annual precipitation, and annual average relative humidity, respectively)

## 5 Discussion and Conclusion

The displacement of arid valley boundaries is a sensitive indicator of mountain ecosystems responses to climate change[1]. It is directly affected by habitat characteristics and climate change. Of the arid valley boundaries in the upper reaches of the Minjiang River, those located near the upper limit of the settlement niche and woodlands account for only 13% of the total length. Activities such as grazing and collecting forest products have been reduced due to the transformation of the livelihoods of ruarl residents, driven by rapid urbanization and development. Moreover, regional climatic conditions significantly impact vegetation growth. Therefore, studies based on arid valley boundary within basins can effectively reveal the relationship between the displacement of arid valley boundaries and climate change. From 1999 to 2013, the climate in the upper reaches of the Minjiang River exhibited a warm-humid trend. The arid valley boundary in the basin moved downward (0.76±0.26 m/a), and the displacement exhibited a significant negative correlation with the variability of climate, precipitation, and relative humidity. Regional climatic variation during this period contributed positively to improving arid valley habitats[20].

Ecological construction in the upper reaches of the Minjiang River requires a systematic understanding of the regional environmental characteristics and reasonable artificial regulation for effective implementation. The dataset of the displacement of the arid valley boundary and climate variability in the upper reaches of the Minjiang River can effectively reveal the spatial differentiation characteristics and displacement patterns of the arid valley boundary. This dataset can provide essential data support for studying regional responses to global climate change and offer scientific guidance for regional ecological construction. However, due to the lack of a specific definition of arid valley boundaries, the extraction of arid valley boundaries exhibits certain inaccuracies. This study provides an essential reference for automatic extraction of arid valley boundaries based on high-resolution remote sensing images. Furthermore, the arid valley in the upper reaches of the Minjiang River is an important ethnic corridor in Southwest China, and differences in the livelihood strategies of mountain residents exert different impacts on the natural environment[25–27]. The dataset can also provide helpful methods for exploring the effects of the livelihood choices of residents on changes in arid valley boundaries on long time scales.

### *Author Contributions*

Wang, Q. and Guo, Y. L. designed the algorithms of the dataset. Yan, W. P., Guo, Y. L., and Yang, M. contributed to the data processing and analysis. Hu, Q., Han, Y.W. and Zhang, Y. contributed to the data validation. Yan, W. P. wrote the data paper.

### *Conflicts of Interest*

The authors declare no conflicts of interest.

## References

[1] Zhen, D. Qinghai–Xizang Plateau and its effects on regional differentiation of physical environments in West China [J]. *Quaternary Sciences*, 2001, (6): 484–489.

[2] Guo, Y. L. Relationships between the Tibetan and Qiang settlements' habitat differentiation and climate change in the Upper Reaches of the Min River, China [D]. Mianyang: Southwest University of Science and Technology, 2018.

[3] Bao, W. K., Wang, C. M. Degradation mechanism of mountain ecosystem at the dry valley in the upper reaches of the Minjiang River [J]. *Mountain Research*, 2000, 18(1): 57–62.

[4] Chen, G. J., Tu, J. J., Fan, H., *et al*. The theory and practice of ecological construction in the upper reaches of Minjiang River [M]. Chongqing: Southwest China Normal University Press, 2006.

[5] Dong, Y. F., Xiong, D. H., Su, Z. A., *et al*. The distribution of and factors influencing the vegetation in a

gully in the Dry-hot Valley of southwest China [J]. *Catena*, 2014, 116: 60–67.

[6] Zhang, R. Z. The dry valleys of the Hengduan Mountains region [M]. Beijing: Science Press, 1992: 20–25.

[7] Fan, J. R., Yang, C., Bao, W. K., *et al*. Distribution scope and district statistical analysis of Dry Valleys in Southwest China [J]. *Mountain Research*, 2020, 38(2): 303–313.

[8] Ding, M. T., Zhou P., Zhang, Y. W., *et al*. Quantitative determination of boundary fluctuation in arid valley of the Upper Min River and its evolution feature [J]. *Mountain Research*, 2017, 35(2): 170–178.

[9] Yang, Z. P., Chang, Y., Bu, R. C., *et al*. Long–term dynamics of dry valleys in the upper reaches of Mingjiang River, China [J]. *Acta Ecologica Sinica*, 2007, 27(8): 3250–3256.

[10] Liu, W. B. Flora of semi–arid valley shrubs at the upper reaches of Minjiang River [J]. *Mountain Research*, 1992, 10(2): 83–88.

[11] Fang, S., Zhao, Y. H., Han, L., *et a*l. Boundaries and characteristics of arid regions in mountain valleys in Southwestern China [J]. *Mountain Research and Developmen*t, 2018, 38(1): 73–84.

[12] Nan, X., Yan, D., Li, A. N., *et al*. Mountain hazards risk zoning in the upper reaches of Minjiang River [J]. *Journal of Catastrophology*, 2015, 30: 113–120.

[13] Sun, L., Cai, Y., Yang, W., *et a*l. Climatic variations within the dry valleys in southwestern China and the influences of artificial reservoirs [J]. *Climatic Change*, 2019, 155: 111–125.

[14] Wang, H. J., Guo, Y. L., Wang, Q. Boundary displacement characteristics of the dry valley in the upper reaches of the Minjiang River during the period from 1999 to 2009 [J]. *Journal of Lanzhou University*: *Natural Science*s, 2017, 53 (3): 316–321.

[15] Zhou, Y. Z., Wei, J. L., Shao, H. Y. Monitoring the scope changes of dry valleys in Maoxian area based on RS and GIS [J]. *Geomatics & Spatial Information Technology*, 2016, 39 (1): 38–40.

[16] Fan, M., Li, F. C., Guo, Y. L., *et al*. Effects of Grain for Green Project on changes in ecosystems service values of alpine settlement area in the upper reaches of the Minjiang River [J]. *Mountain Research*, 2016, 34: 356–365.

[17] Yan, W. P., Wang, Q., Guo, Y. L., *et al*. Dataset of arid valley boundary's displacement and climate variability in the upper reaches of Minjiang River (1999–2013) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2023. https://doi.org/10.3974/geodb.2023.11.04.V1.

[18] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. https://doi.org/10.3974/dp.policy. 2014.05 (Updated 2017).

[19] Gao, Y. Y., Liu, Q., Wang, H. R., *et al*. Definition dry valleys scope by RS and GIS [J]. *Journal of Beijing Normal University* (*Natural Science*), 2012, 48(1): 92–96.

[20] Yuan, H., Li, X. W., Lin, Y. Arid river valley division research in Sichuan Province based on remote sensing [J]. *Journal of Sichuan Agriculture University*, 2013, 31(2): 182–187.

[21] Li, Z. X., He, Y. Q., Xin, H. J., *et al*. Spatio–temporal variations of temperature and precipitation in Mts. Hengduan Region during 1960–2008 [J]. *Acta Geographica Sinica*, 2010, 65(5): 563–579.

[22] Gocić, M., Trajković, S. Analysis of changes in meteorological variables using Mann-Kendall and Sen's slope estimator statistical tests in Serbia [J]. *Global and Planetary Change*, 2013, 100: 172–182.

[23] Wang, Q., Zhai, Z. The Lower Timberline Dataset in the Upper Reaches of Minjiang River, China (1999–2009) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2016. https://doi.org/10.3974/geodb.2016.04.18.V1.

[24] Guo, Y. L., Wang, Q., Fan, M. Exploring the relationship between the arid valley boundary's displacement and climate change during 1999–2013 in the upper reaches of the Min River, China [J]. *ISPRS International Journal of Geo-Information*, 2017, 6(5): 146.

[25] Yang, J., Dai, J. H, Yao, H. R., *et al*. Vegetation distribution and vegetation activity changes in the Hengduan Mountains from 1992 to 2020 [J]. *Acta Geographica Sinica*, 2022, 77(11): 2787–2802.

[26] Zhou, W., Guo, S., Deng, X., *et al*. Livelihood resilience and strategies of rural residents of earthquake-threatened areas in Sichuan Province, China [J]. *Nature Hazards*, 2021, 106: 255–275.

[27] Fang, Y. P., Fan, J., Shen, M. Y., *et al*. Sensitivity of livelihood strategy to livelihood capital in mountain areas: Empirical analysis based on different settlements in the upper reaches of the Minjiang River, China [J]. *Ecological Indicators*, 2014, 38: 225–235.