Data Paper

Grazing intensity and human activity intensity data sets on the Qinghai-Tibetan Plateau during 1990–2015

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Funding information
The work was supported by the Second Scientific Expedition to the Qinghai-Tibet Plateau (No. 2019QZKK0405-05), National Key Research and Development Project (No. 2016YFC0502103) and National Natural Sciences Foundation of China (No. 41571173)

Abstract
As the ‘third pole’ of the world, the Qinghai-Tibetan Plateau (QTP) is extremely ecologically sensitive and fragile, while also facing increasing levels of human activity, especially overgrazing. In this study, livestock data from the statistical yearbook were transformed to 1 km grazing intensity raster data by integrating the net primary productivity (NPP) data for 1990, 1995, 2000, 2005, 2010 and 2015. Furthermore, the human activity intensity (HAI) data at 1 km resolution were evaluated by the entropy weight method, which applied eight types of spatial data, including grazing intensity, Night-Time Light, population density, Gross Domestic Product (GDP) density, the ratio of cultivated land, distance to road, distance to town and the slope of the Normalized Difference Vegetation Index (NDVI). Also, the five-year interval human activity intensity data on the QTP from 1990 to 2015 were evaluated. By preparing the historical spatial data sets of grazing intensity and human activity intensity, our study will help to explore the influence of human disturbance on the alpine ecosystems on the QTP, as well as provide effective support for the decision-making of the government aiming to achieve regional ecosystem management and sustainable development.

Keywords
entropy weight method, grazing intensity, human activity intensity, Qinghai-Tibet Plateau

Dataset
Identifier: https://doi.org/10.11922/sciencedb.00171
Creator: Sun Yongxiu, Liu Shiliang, Liu Yixuan, Dong Yuhong, Li Mingqi, An Yi, Shi Fangning
Title: Grazing intensity and human activity intensity datasets on the Qinghai-Tibet Plateau during 1990–2015
Publisher: Science Data Bank
Publication year: 2020
Resource type: Metadata document
Version: 1.0

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1 | INTRODUCTION

With the rapid development of social economy and the increase of global population so far during the 21st century, the intensity and scale of mankind's influence on the natural world have been steadily increasing (Li et al., 2019), which has brought great disturbance and significant pressure on ecosystems at different scales. Many researchers have shown that human demand for natural systems is rapidly accelerating (Jones et al., 2018; Motesharrei et al., 2016), which may undermine the ecosystem's stability and its ecosystem services (Ali et al., 2020; Krausmann et al., 2013; Steffen et al., 2015). Especially for grasslands, overgrazing has caused ecosystem degradation and has altered the community composition of grasslands, thus resulting in the decrease of grassland diversity (Sun et al., 2020a; Wang et al., 2015a). Therefore, it is necessary to evaluate grazing intensity and human activity intensity so that we can correctly evaluate the scale, intensity and temporal changes of these disturbances in order to prevent possible ecological threats.

The assessment method of human activity intensity evolves from statistical analysis methods to quantitative methods (Li et al., 2018a; Liu et al., 2018). The available statistical analysis methods make it difficult to gain a high-quality spatial data set of human activity intensity (Xu et al., 2015), while quantitative methods are explored based on multiple indexes of pressure change and state change (Liu et al., 2018). For pressure change, human activity intensity is evaluated through weight-based multi-index superposition systems, such as the human footprint index (Karimi & Jones, 2020), karst disturbance index (Tlhapiso & Stephens, 2020) and ecological footprint (Wu, 2020). For state change, human activity intensity is evaluated primarily considering land-use change and ecosystem service change (Rong et al., 2017). Among these, considering the spatial differences of human activity intensity, the weight-based multi-index, such as human footprint index, has been widely applied at different scales around the world (Correa Ayram et al., 2017; Johnson et al., 2017), including nature reserve management (Li et al., 2018a) and human activity influence assessment (Li et al., 2018b). Grazing intensity is mostly evaluated by the statistics of number of livestock, which is summarized according to the statistical yearbook at the county scale and lacks quantitative assessment at raster scale (Ouyang et al., 2016). Overall, spatial data of human activity assessment are still in a constant development process, while spatial data of grazing intensity are still in the exploratory stages.

As the ‘roof of the world’ and ‘third pole of the world’, the QTP provides various ecosystem services, including climate regulation (Jin et al., 2005), abundant biodiversity and genetic species (Sun et al., 2012), and abundant water resources, as it is known as the ‘Asian water tower’ (Pan et al., 2015). In recent decades, the social economy has developed rapidly and human activities have increased significantly, especially since the opening of the Qinghai-Tibet Railway. The impact of human activities on the ecological environment on the QTP has always been a research hotspot in the area of ecosystem research (Li et al., 2018b). Due to its unique and fragile ecosystem, it is significantly sensitive to climate warming and human disturbances as compared to other regions (Pan et al., 2017). It is widely acknowledged that the grassland and ecosystem services are undergoing various types of degradation, such as a decline in the water supply (Pan et al., 2015) and the loss of species and biodiversity (Li et al., 2019; Yang et al., 2018). However, only a few preliminary studies have considered the quantification of human activity intensity and graze intensity, as well as the implications for ecosystem management, on the QTP (Lu et al., 2017; Zhao et al., 2015a). Therefore, it is the need to accurately evaluate human activity intensity and grazing intensity for exploring the effect of human activity on the ecosystem, which thus provides guides for the ecological protection and restoration on the QTP.

Human activity is regarded as an important factor influencing the ecological environment, but only one or more factors have been analysed, so a comprehensive analysis of the QTP is still lacking (Harris, 2010; Zhao et al., 2015a). In order to assess human activity intensity on the QTP, Zhong et al. (2008) first used only the variables of cultivation activity and highway distribution (Zhong et al., 2008). However, in recent decades, the areas of built-up land, railways and expressways on the QTP also have shown increasing trends (Lu et al., 2017). Subsequently, Zhao et al. (2015) used population density, number of villages and road length in order to evaluate the disturbance of human activity on vegetation change on the QTP (Zhao et al., 2015b). Four categories of human influencing factors, including land use/cover, population density, road distribution and grazing density, were selected in order to map human influence intensity on the QTP from 1990 to 2010, and human influence intensity (HII) was overall revealed to be low, but steadily increasing (Li et al., 2018b). Furthermore, in a study by Li et al. (2018b), combing population density, land-use intensity, road and railways and grazing intensity together, electricity infrastructure was newly introduced in order to quantify the human footprint in Tibet for 1990 and 2010 (Li et al., 2018a). However, these results were still insufficient and many other factors may also reflect human activity intensity, such as GDP density, cultivation activity and the slope of NDVI (Mrabet et al., 2017; Solen et al., 2018).

In this study, the entropy weight method was applied in order to determine the weight attribution of various human influence factors. Eight human activity factors including Night-Time Light, population density, GDP density, the ratio of cultivated land, distance to road, distance to town, grazing intensity and the slope of NDVI were considered to quantify
and map human activity intensity on the QTP. Then, six periods of human activity intensity and grazing intensity data sets from 1990, 1995, 2000, 2005, 2010 and 2015 were prepared. Through the quantitative assessment of human activity intensity and grazing intensity, the results will be conducive to providing a guidance for ecosystem service decision-making on the QTP.

2 | SITE DESCRIPTIONS

The Qinghai-Tibetan Plateau (QTP) (26°00′–39°47′N, 73°19′–104°47′E) is located in the southwest of China, covering a quarter of China’s total land area, including Tibet, Qinghai, southern Xinjiang, western Sichuan, and parts of Gansu and Yunnan provinces. It is the largest and highest plateau in the world, with an average elevation higher than 4,000 m (Yao et al., 2012) (Figure 1). The plateau is the source of important rivers in East, Southeast and South Asia, with abundant water resources totalling 546.34 billion m³, known as the ‘Asian water tower’ (Sun et al., 2020b). The typical climate type is a continental plateau climate with strong solar radiation and low temperatures (Pan et al., 2017). The average annual temperature ranges from −6°C to 20°C, and the average annual precipitation varies from 415 mm to 515 mm, primarily occurring during the period from May to September. Due to its spatial differences, the temperature and precipitation significantly differ from the northwest part to the southeast part. In recent decades, with the development of urbanization and increased population growth on the QTP, especially since the opening of the Qinghai-Tibet Railway, the economy has developed rapidly and human activities have increased significantly, including agricultural activities, grazing, mineral exploration, tourism and the construction of ecological projects (Li et al., 2018a). According to statistics, human activity intensity on the QTP increased by 28.43%–31.45% during 1990–2010 (Li et al., 2018b). The regional economy is dominated by animal husbandry, and due to the large grassland coverage, the animal husbandry economy has flourished. Tourism is another economic pillar industry, as since 2000, the average annual growth rate of tourism population on the QTP has been 25.31%.

3 | DATA SOURCES AND PROCESSING

3.1 | Grazing intensity data

3.1.1 | The NPP data

NPP refers to the total amount of organic matter accumulated by the plant community through photosynthesis per unit of time and space, which reflects the growth status of vegetation. In this study, NPP is used to take account of the spatial heterogeneity of grassland conditions, which can reflect the grazing intensity (Wang et al., 2017). In general, the larger the NPP value, the larger the grazing intensity. The NPP data were obtained from...
the monthly NPP data set covering China's terrestrial ecosystems at north of 18°N (1985–2015), published in the *Journal of Global Change Data & Discovery* (http://www.geodoi.ac.cn). The data covered the period of 1990–2015, and the spatial resolution was 1 km (Chen, 2019).

### 3.1.2 Grazing intensity

The grazing intensity data on the QTP for 2000 and 2010 were obtained from China's ecosystem assessment and ecological security database (http://www.ecosystem.csdb.cn/index.jsp) (Ouyang et al., 2016). These data were obtained by the number of sheep at county scale according to the statistical yearbook. However, the grazing intensity data for 1990, 1995 and 2015, as well as all data during 1990–2015 at raster scale, were not produced. Thus, we rasterized the county-scale data based on the NPP data and the statistical yearbook from 1990 to 2015 on the QTP.

### 3.1.3 Vegetation type map of 1:1,000,000

According to the vegetation map of 1:1,000,000 in China, the grassland area was extracted on the QTP, primarily including alpine meadow, alpine steppe and warm steppe.

### 3.2 Human activity intensity data

Considering previous studies of human activity intensity (Li et al., 2018a; Li et al., 2018b; Sun et al., 2020b), eight factors were applied to quantify and map human activity intensity on the QTP, including grazing intensity, Night-Time Light, population density, GDP density, the ratio of cultivated land, distance to road, distance to town and the slope of NDVI. Among these, positive indicators included grazing intensity, Night-Time Light, population density, GDP density and the ratio of cultivated land, which indicated that the larger the value, the higher the human activity intensity. Conversely, negative indicators were distance to road, distance to town and the slope of NDVI, indicating that the lower the value, the higher human activity intensity.

#### 3.2.1 Night-Time Light

Night-Time Light data were regarded as an effective representation of human activity, which represented electricity infrastructure intensity and energy development (Elvidge et al., 2001; Sun et al., 2020b). The Defense Meteorological Satellite Program Operational Linescan System (DMSP/OLS) data were provided by the National Oceanic and Atmospheric Administration (NOAA)'s National Centers for Environmental Information (https://ngdc.noaa.gov/eog/download.html), which covered the years of 1992, 1995, 2000, 2010 and 2013. The DMSP-OLS data from 1990 and 2015 were unavailable and thus were substituted by data from 1992 and 2013, respectively.

#### 3.2.2 Population density and GDP density

Population density and GDP density were important factors reflecting the interactions between human activity and ecosystems (Peng et al., 2020). Population data for 1990, 1995, 2000, 2005, 2010 and 2015, and GDP density for 1995, 2000, 2005, 2010 and 2015, were obtained from the Resources and Environmental Data Cloud Platform, Chinese Academy of Sciences (http://www.resdc.cn/). The GDP data from 1990 were substituted by data from 1995. Specifically, these data represent the spatial distribution grid data for population and GDP per square kilometre.

#### 3.2.3 Land use and land cover (LUCC)

Land use change is also an important indicator influencing the intensity of human activity (Liu et al., 2019). The LUCC data at a 100 m resolution for 1990, 1995, 2000, 2005 and 2010, as well as the data of 1 km resolution for 2015, were acquired by the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (http://www.resdc.cn). The 1 km land-use data in 2015 were resampled to a 100 m resolution.

#### 3.2.4 Grazing intensity

The Qinghai-Tibet Plateau has the largest alpine grassland ecosystem in the world, with a grassland area of approximately $16.538 \times 10^5 \text{ km}^2$, accounting for 41.88% of China's grassland area (Hao et al., 2020). Therefore, grazing intensity was considered to be a key factor influencing human activity intensity. The rasterized grazing intensity data above for 1990, 1995, 2000, 2005, 2010 and 2015 were used in order to evaluate human activity intensity at the 1 km scale.

#### 3.2.5 NDVI data

The NDVI data from 1986 to 1997 were derived from the NOAA Global Inventory Monitoring and Modeling System (GIMMS) (https://ecocast.arc.nasa.gov/). The temporal resolution is twice per month, and the spatial resolution is 1/12 of a degree. Then, the data during the period of 1986–1997 were resampled from 8 km resolution to
1 km resolution. The NDVI data during 1998–2015 were obtained by the vegetation instrument of SPOT-4 and SPOT-5 satellites from National Science and Technology Infrastructure (http://westdc.west-gis.ac.cn/). The source data were firstly performed according to atmospheric correction, radiation correction and geometric correction in order to generate the maximum synthetic data of 10 days. Then the formula \( \text{NDVI} = 0.004 \times \text{DN} - 0.1 \) was used to convert the original raster DN data to the NDVI data within the range of \(-1\) to \(1\).

The detailed information of the spatial data sources is shown in Table 1.

### 3.3 Data re-processing

Before processing the data, all of the original data should be preprocessed considering the differences of resolution, projection and spatial range for the different data. In this study, the spatial raster was uniformly resampled to a resolution of 1 km, and the spatial range of human activity intensity was uniformly clipped to the range of the QTP. For grazing intensity, the spatial range was uniformly clipped to the range of the grassland on the QTP, and the coordinate projection systems were uniformly transformed to Krasovsky_1940_Albers. The two standard latitudes of the projection system were 25°N and 47°N, respectively, and the central meridian was 105°E. Furthermore, according to the correction parameters from previous studies (Chang et al., 2020; Chen et al., 2019; Letu et al., 2010), the desaturation method based on the frequency distribution of the light DN value was used in order to correct the discontinuity and oversaturation of the Night-Time Light data during the period of 1992–2013. The road and town data were used to calculate the distance to road and distance to town by the Euclidean distance in ArcGIS, and the slope values of NDVI during the periods of 1986–1990, 1991–1995, 1996–2000, 2001–2005, 2006–2010 and 2011–2015 were processed by the linear regression analysis with ordinary least squares (OLS). The ratio of cultivated land for 1990, 1995, 2005, 2010 and 2015 was calculated by the land-use data based on the focal statistics in ArcGIS.

### 4 DATA PROCESSING METHOD

#### 4.1 Grazing intensity

Based on the grazing intensity data for 2000 and 2010, the variable of grazing intensity at county scale was rasterized. The unit of county-scale grazing intensity for 2000 and 2010 was the livestock unit (annual average value), and it was assumed that the NPP distribution could be applied in order to relocate the grazing intensity variability within a certain county. Thus, in this study, the uniform county-scale grazing intensity for 2000 and 2010 was rasterized based on the NPP data. The formulas were calculated as follows:

\[
Y = \frac{k \times X_1 + k \times X_2 + k \times X_3 + k \times X_4 \ldots + X_i}{i}
\]

(1)

\[
k = \frac{Y \times i}{X_1 + X_2 + X_3 + X_4 + \ldots + X_i}
\]

(2)

where \(Y\) is the county-scale grazing intensity; \(X_i\) was the NPP value at \(i\)th raster; and \(k\) was the conversion coefficient at each county.

\[
Z = \sum_{i=1}^{n} k_i \times L_i
\]

(3)

### Table 1 Data description, resolution and periods

| Data name | Description | Format | Resolution | Time period |
|-----------|-------------|--------|------------|-------------|
| Night-Time Light (DMSP-OLS) | The level of social economy and urbanization | Raster | 1 km | 1992, 1995, 2000, 2005, 2010, 2013 |
| Population | The number of population per square kilometre | Raster | 1 km | 1990, 1995, 2000, 2005, 2010, 2015 |
| GDP | Gross Domestic Product per square kilometre (unit: \(1 \times 10^4\) yuan) | Raster | 1 km | 1995, 2000, 2005, 2010, 2015 |
| Land use and cover | Farmland, forest, grassland, wetland, settlement, desert and bare land | Raster | 100 m, 1 km | 1990, 1995, 2000, 2005, 2010, 2015 |
| Grazing intensity | Number of sheep at the county scale | Polygon | 1 km | 2000, 2010 |
| Road | Network of roads | Polygon | 1:250,000 | |
| Town | Residential distribution | Polygon | 1:250,000 | |
| NDVI | Normalized Difference Vegetation Index | Raster | 8 km, 1 km | 1986–1997, 1998–2015 |
| NPP | Net primary production | Raster | 1 km | 1990, 1995, 2000, 2005, 2010, 2015 |
where $Z$ is the raster-scale grazing intensity at the county; $L_i$ was the NPP average value at the $i$th county; and $k_i$ was the conversion coefficient of the $i$th county.

For 1990, 1995, 2005 and 2015, the number of livestock in each county of the QTP was counted according to the statistical yearbook data of each county from 1990 to 2015. The change rates of livestock stock in 1990, 1995 and 2005 relative to 2010 were calculated for each county, and the change rate of livestock stock in 2015 relative to 2010 was calculated for each county as well. Then, by multiplying the county-scale grazing intensity for 2000 and 2010 by the change rate of livestock stock relative to 2000 were calculated for each county, and the change of each county, the grazing intensity in 1990, 1995, 2005 and 2015 was obtained at the county scale. Furthermore, the raster-scale grazing intensity for 2000 and 2010 by the change rate of livestock stock in 1990, 1995, 2005 and 2015 was obtained through the NPP conversion coefficient $k$. Finally, the grazing intensity of grasslands and the grazing intensity overall on the QTP were quantified and mapped in 1990, 1995, 2000, 2005, 2010 and 2015 (Sun et al., 2020a).

### 4.2 Human activity intensity

Determining weight to factors is an important step towards evaluating the intensity of human activity. Two common methods that are applied in order to determine weights are the objective weighting approach and the subjective weighting approach. Among these, the entropy weight method belongs to the objective weighting method, which can preclude the effect of some subjective factors on the assessment results (Liu et al., 2017; Wang et al., 2015b). In this study, the entropy weight method was used to determine weight attribution, and the calculation process of the entropy weight method is as follows:

#### 4.2.1 Standardization of the indicators layer

Standardization can eliminate the influences of different dimensions. For the positive indicator and negative indicator, the range of each indicator is standardized to 0–100 using Equations 4 and 5, respectively.

**Positive indicator**

\[
X_j = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \times 100
\]  

**Negative indicator**

\[
X_j = \left(1 - \frac{x_j - x_{\min}}{x_{\max} - x_{\min}}\right) \times 100
\]

where, $X_j$ is the standardized value of the $j$th indicator, and $X_j$ is the original value; $x_{\max}$ and $x_{\min}$ are the maximum and the minimum values, respectively.

#### 4.2.2 Constructing the judgement matrix

If there are $p$ evaluation rasters $r_{ij}$, and each raster has a $q$ evaluation indicator, then the matrix $R$ was constructed as Equation 6:

\[
R = (r_{ij})_{pq} \quad (i = 1, 2, 3...p; j = 1, 2, 3...q)
\]

where $R$ is the evaluation matrix, and $r_{ij}$ is the matrix value of $i$th evaluation raster in the $j$th evaluation indicator.

#### 4.2.3 Calculation of entropy

The entropy was calculated as Equations 7 and 8:

\[
e_j = -\frac{1}{\ln p} \left(\sum_{i=1}^{p} P_{ij} \ln P_{ij}\right) \quad (i = 1, 2, 3...p; j = 1, 2, 3...q)
\]

\[
P_{ij} = r_{ij} / \sum_{i=1}^{p} r_{ij}
\]

where $e_j$ is the entropy value of indicator $j$; $P_{ij}$ is the proportion of the value of the $i$th evaluation raster in the $j$th evaluation indicator, when $P_{ij} = 0$, $P_{ij} \ln P_{ij} = 0$; and $\ln P$ is the information entropy coefficient.

#### 4.2.4 Calculation of the entropy weights

The entropy weight is calculated as Equation 9:

\[
W_j = \frac{(1 - e_j)}{\sum_{j=1}^{q} (1 - e_j)}
\]

where $W_j$ is the entropy weight of indicator $j$; $e_j$ is the entropy of indicator $j$; and $j$ is human activity indicator. The weight results are shown in Table 2.

Through the entropy weights allocation above, all human activity factor layers were overlaid to quantify the human activity intensity on the QTP for 1990, 1995, 2000, 2005, 2010 and 2015. The formula of human activity intensity is calculated as follows:

\[
HAI = \sum_{j=1}^{q} X_j \times W_j
\]

where HAI is human activity intensity; $X_j$ is the standardization of indicator $j$; $W_j$ is the entropy weight of indicator $j$; and $j$ is human activity indicator.

Furthermore, the change rate of human activity intensity from 1990 to 2015 was calculated by the linear regression method is as follows:

\[
\frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \times 100
\]
analysis with ordinary least squares (OLS). The slope is calculated as follows:

$$\text{Slope} = \frac{n \times \sum_{i=1}^{n} i \times y_i - \sum_{i=1}^{n} i \sum_{j=1}^{n} y_j}{n \times \sum_{j=1}^{n} i^2 - \left( \sum_{j=1}^{n} i \right)^2}$$ \hspace{1cm} (11)

where Slope is the change trend of HAI; \( n \) is the time series; and \( y_i \) is the value of HAI at year \( i \). When \( \text{Slope} > 0 \), it indicates an increasing trend of HAI in \( n \) years; and when \( \text{Slope} < 0 \), it indicates a decreasing trend of HAI in the study period.

Figure 2 shows the working flowchart of this study.

## 5 | DATA RESULTS

### 5.1 | Data composition

The grazing intensity data sets included six periods of grazing intensity data on the grasslands of the QTP for 1990, 1995, 2000, 2005, 2010 and 2015 (Sun et al., 2020a). Each period's data were stored in TIFF format and were named by the year for 1990, 1995, 2000, 2005, 2010 and 2015, respectively. These data were saved as a compressed file titled ‘Grazing intensity datasets on the grassland of the QTP during 1990–2015.zip’, and the total data size was 17.0 MB. The grazing intensity
data sets also covered six periods of grazing intensity data on the QTP for 1990, 1995, 2000, 2005, 2010 and 2015 (Sun et al., 2020a). The data were saved as a compressed file as well ('Grazing intensity datasets on the QTP during 1990–2015.zip'). Each data period was stored in TIFF format and named by year, and the total data volume was 17.0 MB. The human activity intensity data sets also had six periods of human activity intensity on the QTP for 1990, 1995, 2000, 2005, 2010 and 2015 (Sun et al., 2020a). Each data period was named by year and saved in TIFF format. These data were saved as a compressed...
file (‘Human activity intensity datasets on the QTP during 1990–2015.zip’), and the total size was 63.6 MB. Finally, the change rate of human activity intensity was provided on the QTP from 1990 to 2015 and was titled by ‘slope1990–2015’ (Sun et al., 2020a). The data set was stored in TIFF format with a compressed file titled ‘The change rate of human activity intensity dataset on the QTP from 1990 to 2015.zip’, and the size was 10.7 MB.

**FIGURE 4** Grazing intensity data sets on the QTP for 1990, 1995, 2000, 2005, 2010 and 2015
5.2 | Data samples

5.2.1 | Grazing intensity data sets

Based on the NPP data and livestock data from the statistical yearbook, the rasterized grazing intensity data sets on the grasslands of the QTP were presented in Figure 3. Temporally, mean grazing intensity was 8.12, 7.99, 7.56, 7.86, 10.16 and 9.30, respectively for 1990, 1995, 2000, 2005, 2010 and 2015. It was shown that grazing intensity decreased first and increased from 1990 to 2015, implying that although overgrazing severely threatened biodiversity and changed the
structure of grassland plant communities, moderate grazing disturbance may actually contribute to increased grassland diversity. Therefore, we should arrange the time and patterns of grazing reasonably in order to promote the sustainable development of the grasslands. Spatially, grazing intensity showed no significant differences from 1990 to 2015 on the QTP (Figure 3a–f). The high grazing intensity areas were primarily located in the central and eastern areas of the QTP, including the middle and western areas of Tibet, southern and eastern areas of Qinghai, northern areas of Sichuan, and southern areas of Gansu. However, the low grazing intensity mostly occurred in the north and south, which covered the low grassland. Furthermore, the grazing intensity values were set as 0 in the none-grassland area of the QTP, and grazing intensity data sets on the whole area of the QTP were rasterized according to the grassland data sets, as shown in Figure 4a–f. Meanwhile, the spatio-temporal characteristics of grazing intensity on the QTP were similar to the grazing intensity data set on the grasslands of the QTP.

5.2.2 | Human activity intensity data sets

According to the weight assign results, eight human factor layers were overlaid in order to map human activity intensity on the QTP. Human activity intensity data sets were presented in Figure 5. Temporally, mean HAI for 1990, 1995, 2000, 2005, 2010 and 2015 was 26.52, 25.84, 26.02, 26.29, 25.98 and 25.33, respectively, indicating that HAI has shown a decreasing trend overall. Spatially, HAI showed no significant variations during 1990–2015 on the QTP (Figure 5a–f). The high-HAI areas were distributed among the central and eastern regions of the QTP, including the middle part of Tibet, southern and eastern areas of Qinghai, northern areas of Sichuan, and southern areas of Gansu, while the low-HAI areas were primarily located in the northwestern area, particular in the unpopulated areas of north Tibet.

In order to explore the change trends of HAI from 2000 to 2015, the change rate was calculated on the QTP (Figure 6). HAI in approximately 8% of the study area showed an increasing trend, and significant increases of HAI were primarily distributed in the north and south Tibet, south and east Qinghai and south Gansu (Figure 6). Only 2.20% of the study remained unchanged on the QTP. Meanwhile, HAI in approximately 65% of the study area showed a significant decrease ($p < 0.05$), and 24.01% of the study area experienced a non-significant decrease, indicating that the ecological environment improved greatly on the QTP during the time period 1990 to 2015. This may be due to the implementation of ecological protection projects since 2000, such as the implementation of the ‘Natural Forest Conservation Program’ and the ‘Grain for Green Program’.

6 | DISCUSSIONS

With the continued development of social economy and technology, the influence of human activities on the natural environment has been constantly deepening, thus resulting in a series of ecological environmental problems. As an important indicator with which measure the degree of human impact on the natural environment, human activity intensity and its impact on the ecological environment were analysed here. In this study, the spatial data sets of grazing intensity and human activity intensity were mapped and quantified from 1990 to 2015 on the QTP, which may help to explore the spatial characteristics and laws of grazing activity and human activity distribution. Among them, the quantitative evaluation of grazing intensity can provide a support for grassland degradation and play a guiding role in grassland ecosystem management on the QTP. Meanwhile, the evaluation of human activity intensity reflected the relationship changes between human activity and the ecological environment, and it also helped to explore the interactive effects of human–natural factors on the ecosystem, which in turn provided a scientific basis for the formulation of land-use policy and ecological environment construction in future studies. The high-quality spatial data of grazing intensity and human activity intensity would also contribute to distinguishing the effect of human activity and climate change on the earth’s ecosystem as a whole, further promoting an integrated understanding of the impact of human activity on the ecosystem. This could provide effective guidance and policy support for regulating human activity and promoting the sustainable development of the world.

In our study, the spatio-temporal characteristics of grazing intensity and HAI were explored in-depth. Compared with previous studies (Duan & Luo, 2019; Li et al., 2018a; Li et al., 2018b; Zhao et al., 2015a), the similarities were
as follows. Spatially, the southern and eastern areas of the QTP were the gathering regions of human activity, and climate and topography were the main driving forces resulting in the distribution of human activity intensity. These areas have abundant precipitation, favourable temperatures and low altitude, which contributed to the growth of many crops and the survival of humans (Sun et al., 2020b). In this study, higher HAI regions were primarily distributed in the south and east of the QTP, while lower HAI regions were located in the northwest. At previous studies, Zhao et al. (2015) found that the southern and eastern regions of the QTP were deeply disturbed by human activity, including central Tibet, the east of the Qinghai Province, and part of each of the Yunnan and Sichuan Provinces (Zhao et al., 2015a). Li et al. (2018) also concluded that higher HII areas were concentrated in central Tibet, as well as the east and southeast of the QTP (Li et al., 2018b). Furthermore, higher grazing intensity regions were primarily located in the middle of the QTP, while lower value regions were distributed in the south and the north, indicating that the grasslands were the most susceptible regions by grazing disturbance on the QTP. Temporally, the change rate of HAI represented the variation trends from 1990 to 2015 at different regions of the QTP, and 7.91% of HAI increased and 89.50% of HAI decreased, in accordance with previous studies (Duan & Luo, 2019; Li et al., 2018a; Li et al., 2018b). Li et al. (2018) demonstrated that 28.43% of raster-scale HII and 31.45% of county-scale HII on the QTP showed increasing trends from 1990 to 2010 (Li et al., 2018b), indicating that the ecosystem was effectively influenced by human activity. In addition, the selection of human activity factors referred to and included various human factors that have been applied in previous studies (Duan & Luo, 2019; Li et al., 2018b). The differences between these previously mentioned were that the assessment methods and the selection of the human influence factors differed. In this study, we applied the entropy weight method in order to evaluate human activity intensity, and we comprehensively considered the impacts of eight types of human factors on the ecosystem of the QTP. Grazing intensity was also rasterized based on the NPP data and livestock data from the statistical yearbook. The prior analysis indicates the reliability and validity of our methodology and data sets, and taking regional characteristics into consideration, the data sets can also be applied in many other studies and regions as well.

However, some uncertainties and limitations may still exist in this study. In the selection of human activity factors, many other factors may also influence human activity, such as tourism, mineral resources exploitation and ecological project construction. These potential factors may threaten the ecosystems on the QTP, and this may underestimate the actual human activity intensity on the QTP for lack of consideration of all possible human factors. Thus, we should pay comprehensive attention to considering the influences of other factors with regards to human activity on the QTP. Due to the adverse climate and topographical conditions, some areas of the QTP were inaccessible, and thus some remote sensing and socio-economic data are not available from these areas. For example, road and town data at 1:250,000 in 2015 were used in order to obtain the data of distance to road and distance to town, which did not demonstrate any dynamic changes. The night-time light data in 1990 and 2015 were replaced by the same data from 1990 and 2013, respectively, and these circumstances may weaken the credibility and accuracy of the human activity assessment results. Therefore, we should carry out long-term data monitoring in future studies, especially in the remote areas of the QTP.

DATA AVAILABILITY

The grazing intensity and human activity intensity data sets from the QTP during the period of 1990–2015 are all decompressed in TIFF format. All data sets presented in this paper were released on September 23, 2020, and are available at the Science Data Bank (http://www.dx.doi.org/10.11922/sciencedb.00171, Sun et al., 2020) with the file protection period until September 23, 2021 (one year after initial access). The private link for downloading the data is here: http://www.scidb.cn/api/sdb-personal-service/dataset/surl_YaYMVj. These maps that have been produced from data sets help to provide an intuitive description of the availability of each data set and to facilitate the selection of data concerning human–natural interactions and the driving mechanism of the ecosystem. These data can be opened and manipulated by ArcGIS, QGIS, ENVI and ERDAS.

CONCLUSIONS

Increasing human activities, especially overgrazing, have resulted in the degradation of the ecological environment and the ongoing loss of biodiversity. The grazing intensity and human activity intensity data are scarce but invaluable at high mountainous regions, especially on the QTP. Long-term, high spatial resolution and high-quality grazing and human activity data at raster scale on the QTP are vital for developing a deeper understanding of human disturbance on the ecosystem. In this study, a rasterized grazing intensity data set from 1990 to 2015 was presented combining the NPP data and livestock data obtained from the statistical yearbook. Furthermore, eight types of spatial data were applied in order to evaluate the intensity of human activity and HAI data sets of the QTP at 1 km raster scale were derived for 1990, 1995, 2000, 2005, 2010 and 2015. Compared with previous data sets regarding the QTP, the
data sets in this study provide more comprehensive and high-quality information. Therefore, the high-resolution data sets will contribute to promoting a greater scientific understanding of the interactions between humans and the ecosystem on the QTP, and even the earth as a whole, thus facilitating ecosystem management and sustainable development in alpine regions.

ACKNOWLEDGEMENTS
We would like to acknowledge all the teachers and students who participated in the data downloading and processing, prepared the data set maps, wrote and revised the original draft.

CONFLICT OF INTERESTS
The authors declare that they have no conflict of interests.

AUTHOR CONTRIBUTIONS
Yongxiu Sun involved in conceptualization, writing the original draft preparation, methodology and software. Shiliang Liu involved in writing, reviewing and editing, validation and funding acquisition; Yixuan Liu involved in data curation and supervision; Yuhong Dong involved in data curation and visualization; Mingqi Li involved in investigation and software; Yi An involved in software; Fangning Shi involved in investigation and resources.

DATA AVAILABILITY STATEMENT
All data generated or analysed during this study are included in this article.

OPEN RESEARCH BADGES
This article has earned an Open Data badge for making publicly available the digitally shareable data necessary to reproduce the reported results. The data are available at https://doi.org/10.11922/sciencedb.00171.

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REFERENCES
Ali, M.A.S., Khan, S.U., Khan, A., Khan, A.A. & Zhao, M. (2020) Ranking of ecosystem services on the basis of willingness to pay: monetary assessment of a subset of ecosystem services in the Heihe River basin. *Science of the Total Environment*, 734, 139447. https://doi.org/10.1016/j.scitotenv.2020.139447

Chang, S., Wang, J., Zhang, F., Niu, L. & Wang, Y. (2020) A study of the impacts of urban expansion on vegetation primary productivity levels in the Jing-Jin-Ji region, based on nighttime light data. *Journal of Cleaner Production*, 263, 121490. https://doi.org/10.1016/j.jclepro.2020.121490

Chen, P.F. (2019) Monthly NPP dataset covering China’s terrestrial ecosystems at North of 18°N (1985–2015). *Journal of Global Change Data & Discovery*, 3, 34–41. https://doi.org/10.3974/geoedp.2019.01.05

Chen, Y., Zheng, Z., Wu, Z. & Qian, Q. (2019) Review and prospect of application of nighttime light remote sensing data. *Progress in Geography*, 38, 205–223. https://doi.org/10.18306/dlkxzj.2019.02.005

Correa Ayram, C.A., Mendoza, M.E., Eiter, A. & Perez Salicrup, D.R. (2017) Anthropogenic impact on habitat connectivity: a multidimensional human footprint index evaluated in a highly biodiverse landscape of Mexico. *Ecological Indicators*, 72, 895–909. https://doi.org/10.1016/j.ecolind.2016.09.007

Duan, Q. & Luo, L. (2019) Human footprints dataset of the Qinghai-Tibetan Plateau during 1990–2015. *Science Data Bank*, V1. https://doi.org/10.11922/sciencedb.933

Elvidge, C.D., Imhoff, M.L., Baugh, K.E., Hobson, V.R., Nelson, I., Safran, J. et al. (2001) Night-time lights of the world: 1994–1995. *ISPRS Journal of Photogrammetry and Remote Sensing*, 56, 81–99. https://doi.org/10.1016/s0924-2716(01)00040-5

Hao, A., Xue, X., Peng, F., You, Q., Liao, J., Duan, H. et al. (2020) Different vegetation and soil degradation characteristics of a typical grassland in the Qinghai-Tibetan Plateau. *Acta Ecologica Sinica*, 40, 964–975. https://doi.org/10.5846/stxb201809162019

Harris, R.B. (2010) Rangeland degradation on the Qinghai-Tibetan plateau: a review of the evidence of its magnitude and causes. *Journal of Arid Environments*, 74, 1–12. https://doi.org/10.1016/j.jaridenv.2009.06.014

Jin, L.Y., Ganopoulos, A., Chen, F.H., Claussen, M. & Wang, H.J. (2005) Impacts of snow and glaciers over Tibetan Plateau on Holocene climate change: sensitivity experiments with a coupled model of intermediate complexity. *Geophysical Research Letters*, 32, 1709. https://doi.org/10.1029/2005gl023202

Johnson, C.N., Balmford, A., Brook, B.W., Buettel, J.C., Galetti, M., Lei, G. et al. (2017) Biodiversity losses and conservation responses in the Anthropocene. *Science*, 356, 270–274. https://doi.org/10.1126/science.aam9317

Jones, K.R., Venter, O., Fuller, R.A., Allan, J.R., Maxwell, S.L., Negret, P.J. et al. (2018) One-third of global protected land is under intense human pressure. *Science*, 360, 788–791. https://doi.org/10.1126/science.aar9565

Karimi, A. & Jones, K. (2020) Assessing national human footprint and implications for biodiversity conservation in Iran. *Ambio*, 49, 1506–1518. https://doi.org/10.1007/s13280-019-01305-8

Krausmann, F., Erb, K.-H., Gingrich, S., Haberl, H., Bondeau, A., Gaube, V. et al. (2013) Global human appropriation of net primary production doubled in the 20th century. *Proceedings of the National Academy of Sciences of the United States of America*, 110, 10324–10329. https://doi.org/10.1073/pnas.1211349110

Letu, H., Hara, M., Yagi, H., Naoki, K., Tana, G., Nishio, F. & et al. (2010) Estimating energy consumption from night-time DMPS/OLS imagery after correcting for saturation effects. *International Journal of Remote Sensing*, 31, 4443–4458. https://doi.org/10.1080/01431160903277464

Li, C., de Jong, R., Schmid, B., Wulf, H. & Schaepman, M.E. (2019) Spatial variation of human influences on grassland biomass on the Qinghai-Tibetan plateau. *Science of the Total Environment*, 665, 678–689. https://doi.org/10.1016/j.scitotenv.2019.01.321

Li, S., Wu, J., Gong, J. & Li, S. (2018a) Human footprint in Tibet: assessing the spatial layout and effectiveness of nature reserves. *Science of the Total Environment*, 621, 18–29. https://doi.org/10.1016/j.scitotenv.2017.11.216

Li, S., Zhang, Y., Wang, Z. & Li, L. (2018b) Mapping human influence intensity in the Tibetan Plateau for conservation of ecological
service functions. *Ecosystem Services*, 30, 276–286. https://doi.org/10.1016/j.ecoser.2017.10.003
Liu, S., Liu, L., Wu, X., Hou, X., Zhao, S. & Liu, G. (2018) Quantitative evaluation of human activity intensity on the regional ecological impact studies. *Acta Ecologica Sinica*, 38, 6797–6809. https://doi.org/10.5846/stxb20171172048
Liu, T., Kong, Y., Wu, Y., Zhu, L. & Zhang, D. (2017) Provincial forest ecological security evaluation in China based on the entropy weight of the fuzzy matter-element model. *Acta Ecologica Sinica*, 37, 4946–4955. https://doi.org/10.5846/stxb201604280805
Liu, W., Zhan, J., Zhao, F., Yan, H., Zhang, F. & Wei, X. (2019) Impacts of urbanization-induced land-use changes on ecosystem services: a case study of the Pearl River Delta Metropolitan Region, China. *Ecological Indicators*, 98, 228–238. https://doi.org/10.1016/j.ecolind.2018.10.054
Lu, X., Kelsey, K.C., Yan, Y., Sun, J., Wang, X., Cheng, G. et al. (2017) Effects of grazing on ecosystem structure and function of alpine grasslands in Qinghai-Tibet Plateau: a synthesis. *Ecosphere*, 8, e01656. https://doi.org/10.1002/ecs2.1656
Motesharrehi, S., Rivas, J., Kalnay, E., Asrar, G.R., Busalacchi, A.J., Cahalan, R.F. et al. (2016) Modeling sustainability: population, inequality, consumption, and bidirectional coupling of the earth and human systems. *National Science Review*, 3, 470–494. https://doi.org/10.1093/nsr/nww081
Mrabet, Z., AlSamara, M. & Jarallah, S.H. (2017) The impact of economic development on environmental degradation in Qatar. *Environmental and Ecological Statistics*, 24, 7–38. https://doi.org/10.1007/s10651-016-0359-6
Ouyang, Z., Zheng, H., Xiao, Y., Polasky, S., Liu, J., Xu, W. et al. (2016) Improvements in ecosystem services from investments in natural capital. *Science*, 352, 1455–1459. https://doi.org/10.1126/science.aaf2295
Pan, T., Wu, S. & Liu, Y. (2015) Relative contributions of land use and climate change to water supply variations over Yellow River Source Area in Tibetan Plateau during the past three decades. *PLoS One*, 10, e0123793. https://doi.org/10.1371/journal.pone.0123793
Pan, T., Zou, X., Liu, Y., Wu, S. & He, G. (2017) Contributions of climatic and non-climatic drivers to grassland variations on the Tibetan Plateau. *Ecological Engineering*, 108, 307–317. https://doi.org/10.1016/j.ecoleng.2017.07.039
Peng, K., Zhang, Y.F., Gao, W.F. & Lu, Z. (2020) Evaluation of human activity intensity in ecological environment problems of Jinan City. *European Journal of Remote Sensing*, 5, 117–121. https://doi.org/10.1080/22797254.2020.1771214
Rong, Y., Li, C., Xu, C. & Yan, Y. (2017) Ecosystem service values and spatial differentiation changes during urbanization: a case study of Huanghua City. *Chinese Journal of Ecology*, 36, 1374–1381. https://doi.org/10.13292/j.1000-4890.201705.001
Solten, L.C., Nicolas, J., de Sarrte Xavier, A., Thibaud, D., Simon, D., Michel, G. et al. (2018) Impacts of agricultural practices and individual life characteristics on ecosystem services: a case study on family farmers in the context of an amazonian pioneer front. *Environmental Management*, 61, 772–785. https://doi.org/10.1007/s00267-018-1004-y
Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O. & Ludwig, C. (2015) The trajectory of the Anthropocene: the great acceleration. *Anthropocene Review*, 2, 81–98. https://doi.org/10.1177/2053019614564785
Sun, H., Zheng, D., Yao, T. & Zhang, Y. (2012) Protection and construction of the national ecological security shelter zone on Tibetan Plateau. *Acta Geographica Sinica*, 67, 3–12.