GIS-Based Risk Assessment of Meteorological Disasters During the Growth and Development Period of Tibetan Sheep (Postprint)

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Abstract

This study takes Tibetan Sheep in high-altitude fragile ecological environments as the research object, utilizing daily meteorological data from 1961—2017, vulnerability of the hazard-affected body, sensitivity of the disaster-forming environment, and socio-economic conditions as factors, combined with disaster theory models and ArcGIS spatial analysis tools, to analyze and evaluate the comprehensive meteorological disaster risk during different growth and development periods of Tibetan Sheep in this region. Results indicate that: high-altitude alpine areas exhibit higher risks during the lamb-rearing and shearing periods, while foothill or plain areas show lower risks; during the grass-cutting and breeding periods, foothill, plain, and river valley zones demonstrate higher risks, whereas alpine areas exhibit lower risks. This demonstrates that terrain factor constitutes the dominant factor influencing the growth and development periods of Tibetan Sheep in high-altitude regions.

Full Text

Preamble

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Authors and Affiliations (partial reconstruction from corrupted text)

1.3 Data Sources

The study area's grassland vegetation types include *Kobresia myosuroides*, *Kobresia capillifolia*, *Poa pratensis*, *Stipa sareptana*, *Phragmites australis*, *Achnatherum splendens*, *Orinus kokonorica*, *Nitraria sphaerocarpa*, and *Kalidium foliatum* [Figure 1: see original paper].

1.2 Assessment Model

The risk assessment model is based on the theoretical framework of natural disaster risk formation. The mathematical model is expressed as:

$$X = f(W, S)$$

where X represents meteorological disaster risk, W denotes the hazard factor, and S represents the vulnerability of the disaster-bearing body. An expanded form of the model is:

$$X = W \times C \times M$$

where C is the exposure of the hazard-affected body and M represents the sensitivity coefficient.

2.1 Data Processing and Normalization

The normalization formula used to standardize all evaluation indicators is:

$$T_i = \frac{X_i - X_{min}}{X_{max} - X_{min}}, \quad i = 1, 2, \dots, n$$

where T_i is the normalized value of indicator i, X_i is the actual value, and X_{max} and X_{min} are the maximum and minimum values of the indicator, respectively. This transformation yields normalized values in the range [0, 1], where 0 represents the lowest risk and 1 represents the highest risk.

2.1.1 GIS Spatial Analysis

All normalized indicator grids were processed using ArcGIS software. The Inverse Distance Weighted (IDW) interpolation method was employed to generate spatial distribution maps of meteorological factors. The evaluation indicators included digital elevation model (DEM), temperature, precipitation, wind speed, and other meteorological parameters [FIGURE:2a-2e]. The spatial distribution of normalized snow disaster risk during the lambing period is shown in [Figure 2f: see original paper].

2.1.2 Strong Wind Disaster Risk

The strong wind disaster risk during the lambing period was assessed based on wind speed, temperature, and topographic factors [FIGURE:2a, 2e; FIGURE:3a, 3b]. The resulting risk zoning map is presented in [Figure 3c: see original paper].

2.1.3 Meteorological Disaster Risk

The comprehensive meteorological disaster risk during the lambing period was evaluated by integrating multiple hazard factors. The risk distribution pattern shows higher risk in alpine regions and lower risk in hilly and gentle slope areas [Figure 4b: see original paper].

2.1.4 Risk Zoning

Risk zoning was performed by reclassifying the comprehensive risk assessment results into five levels: low, relatively low, moderate, relatively high, and high risk. This classification enables targeted disaster prevention and mitigation strategies.

2.2 Shearing Period Risk Assessment

During the shearing period, meteorological disaster risk is primarily influenced by temperature fluctuations and wind conditions. The risk assessment incorporated factors such as DEM, temperature, precipitation, and wind speed [FIGURE:2a, 2e; FIGURE:3a, 3b]. The spatial distribution of risk during this period shows distinct patterns between alpine and lowland areas [Figure 5b: see original paper]. The comprehensive risk zoning map for the shearing period is presented in [Figure 5c: see original paper].

2.3 Grass Harvest Period Risk Assessment

The meteorological disaster risk during the grass harvest period was evaluated using similar methodologies. The assessment considered temperature, precipitation, and wind speed as primary factors [FIGURE:2a, 2e; FIGURE:3a, 3b]. The resulting risk distribution [Figure 5b: see original paper] shows variations across different topographic zones. The comprehensive risk zoning for this period is illustrated in [Figure 5c: see original paper].

2.4 Copulation Period Risk Assessment

During the copulation period, meteorological conditions significantly affect breeding success. The risk assessment integrated temperature, precipitation, and wind data [FIGURE:2b, 2c; FIGURE:6a, 6b]. The spatial distribution of risk shows higher vulnerability in certain topographic settings [FIGURE:6c, 6d]. The comprehensive risk zoning map for the copulation period is presented in [Figure 6e: see original paper].

3 Discussion

The assessment results demonstrate that terrain is a dominant factor affecting meteorological disaster risk for Tibetan sheep across all growth periods. In alpine zones, risk levels are higher during the lambing and shearing periods but lower during copulation and grass harvest periods. Conversely, hilly and gentle slope areas exhibit higher risk during copulation and grass harvest periods but lower risk during lambing and shearing periods.

The GIS-based approach enables spatially explicit risk assessment that accounts for local variations in topography, meteorology, and sheep vulnerability. This methodology provides a scientific basis for developing period-specific disaster prevention strategies and optimizing pastoral management practices. The integration of multi-source data and spatial analysis techniques offers a robust framework for assessing climate-related risks in fragile alpine ecosystems.

References

[1] Zhong SB, Fang ZX, Zhu M, et al. An ontology-based approach to decision-making in emergency management of meteorological disasters. *Natural Hazards*, 2017, 89(2): 531–554.

[2] Sun J, Zhao S. The impacts of multiscale weather systems on freezing rain and snowstorms over southern China. *Weather & Forecasting*, 2010, 25(2): 388–407.

[4] Dan RF, Zhang HT, Long RJ, et al. Seasonal shift of rumen bacteria quantity of grazing Tibetan sheep and forage nutrition by grazing sheep. *Acta Prataculturae Sinica*, 2009, 18(1): 100–104.

[5] Jin YC, Yan ZX, Li SS. The utilization status and prospect of Tibetan sheep resources research in China. In: *Proceedings of the Chinese Grassland Society*, 2014.

[6] Fan DQ, Zhao XS, Zheng ZT. Phenology of *Leymus chinensis* steppe in Inner Mongolia and its response to climate changes. *Geography and Geo-Information Science*, 2016, 32(6): 81–86.

[7] Namusilai. The climate review of the lamb conservation period of Ewenki Autonomous Banner of Inner Mongolia in 2016. *Animal Husbandry and Feed Science*, 2016, 37(9): 97–98.

[8] Li GY. Study on the effects of alpine-arctic pastoral zone climate and nutritional factors on fine-wool sheep body weight. *Journal of Animal Science and Veterinary Medicine*, 2012, 31(1): 27–30.

[9] Zhang LP, Gong XY, Zhang MX, et al. The production status analysis of Gansu fine-wool sheep in family ranch of Sunan pastoral area. *Grass-Feeding Livestock*, 2014(3): 1–6.

[10] Qi QQ, Li GM, Dang HS, et al. Gansu area around Qinghai lake in the mountains of fine-wool adaptation test. *Grass-Feeding Livestock*, 2008(4): 27–29.

[11] Hasitamuga, Gerile. GIS-based risk zoning of meteorological disaster in grazing period of fine-wool sheep. *Journal of Catastrophology*, 2017, 32(4): 90–93.

[12] Liu JG. Adaptive observation of the large high-yield Australian blood breeding sheep from cold areas. *Journal of Animal Science and Veterinary Medicine*, 2014, 33(5): 9–10, 14.

[13] Li FY, Li GY, Liu DH, et al. Study on economic losses of meteorological disasters in pastoral areas. *Journal of Natural Disasters*, 2011, 20(2): 90–95.

[15] Guo Q, Yin GM, Zhao HP, et al. Study on grazing behavior and feeding take of grazing sheep. *Chinese Journal of Grassland*, 2011, 33(4): 95–98.

[16] Wang K, Qiao HM, Hai JH. Analysis of the influence of meteorological disasters on sheep industry and its countermeasures. *Gansu Animal and Veterinary Sciences*, 2015, 45(4): 32–33.

[17] Han BH, Zhou BR, Wu R, et al. Grid-based estimation of snow disaster risk in Qinghai Province. *Arid Zone Research*, 2017, 34(5): 1035–1041.

[18] Zhou BR, Li F, Hu AJ, et al. Analysis and Evaluation of Climate Resources and the Division of Meteorological Disaster Risk in Qinghai Province. Beijing: Meteorological Press, 2016: 62–67.

[19] Han BH, Wu R, Zhou BR, et al. Characteristics of hydrothermal factors in soil freezing and thawing alternation over southern alpine grasslands in Qinghai Province. *Meteorological Science and Technology*, 2018, 46(2): 361–368.

[20] Hong F, Zeng ZY, Zhou WT, et al. Optimization of control system based on the subjective weighting method. *Manufacturing Automation*, 2015, 37(8): 20–22.

[21] Wang K, Qiao HM, Hai JH. The effects analysis on the sheep industry of Sunan alpine pastoral areas and its countermeasures. *Gansu Animal and Veterinary Sciences*, 2015, 45(4): 32–33.

Note: Figure translations are in progress. See original paper for figures.