JURNAL GEOGRAFI
Geografi dan Pengajarannya
ISSN : 1412 - 6982
e-ISSN : 2443-3977
Volume 23, Number 1, June 2025
https://journal.unesa.ac.id/index.php/jg

DOI : https://doi.org/10.26740/jggp.v23n1.p259-268

# A REMOTE SENSING-BASED ECOLOGICAL INDEX FOR WEST BANDUNG: INTEGRATING SURFACE INDICATORS AND TOPOGRAPHIC FACTORS USING A MODIFIED RSEIFE APPROACH

**Maya Indah Sari*[1], Fajrun Wahidil Muharram*[2], Putu Wirabumi*[3]**
[1]Department of Geography, Faculty of Social Science Education, Indonesia University of Education, Bandung, Indonesia
[2]Department of Geography, Faculty of Social and Historical Science, University College London, London, United Kingdom
[3]Department of Geography Education, Faculty of Social and Political Sciences, Surabaya State University, Surabaya, Indonesia

ARTICLE INFO

***Article history:***
Received 31 May 2025
Revised 03 June 2025
Accepted 09 June 2025

***Keywords*:**
Ecological Index,
Environment,
Urbanisation

ABSTRACT

This study assesses ecological conditions in West Bandung using the Remote Sensing Ecological Index Considering Full Elements (RSEIFE), which integrates NDVI, NDBSI, WET, and LST through entropy-based weighting. Landsat 9 imagery and elevation data were used to evaluate ecological quality across four elevation zones. Results show a strong positive correlation between NDVI and WET ($r = 0.728$) and a negative correlation between NDVI and LST ($r = –0.628$), indicating vegetation's role in cooling and moisture retention. The highest mean RSEIFE value (0.424) was found in areas above 1500 masl, while the lowest minimum value (0.0677) occurred below 1000 masl. Spatial analysis reveals that highland districts (e.g., Gunung Halu, Rongga) maintain better ecological integrity, while lowland urban zones (e.g., Padalarang, Batujajar) face ecological stress. These findings highlight how topographic variation influences ecological conditions, emphasizing its importance in guiding sustainable land-use planning.

## A. INTRODUCTION

West Bandung has experienced rapid development driven largely by the expansion of industrial sectors and a surge in tourism-related activities. While this economic growth has delivered substantial benefits in terms of employment and infrastructure, it has also posed significant challenges to the region's ecological balance. Urbanization, land conversion, and escalating environmental stress have raised critical concerns about sustainable land use and environmental health (Velasco-Munoz et al., 2021; Li et al., 2020). Understanding how these developments affect ecological quality over time is essential for guiding future spatial planning and conservation.

Remote sensing technologies offer valuable tools for ecological assessment, particularly through the use of ecological indices that capture environmental dynamics across spatial and temporal scales (Wu, 2024; Sun et al., 2022).

*Correspondence address: mayainds@upi.edu

Several indices have been developed—such as the Remote Sensing Ecological Index (RSEI), Modified RSEI (MRSEI), Eco-Environmental Quality Index (EQI), and Ecosystem Service Value (ESV)—each designed to reflect specific aspects of ecological health, ranging from vegetation cover and surface temperature to land use intensity and ecosystem services.

However, despite their wide application, these models have certain limitations. The original RSEI, for example, relies on Principal Component Analysis (PCA), which introduces stochastic variability and requires the exclusion of water bodies to maintain statistical consistency (Li et al., 2020; Wang et al., 2023). These exclusions can undermine the comprehensiveness of ecological evaluation, particularly in mixed or water-rich environments.

To overcome these constraints, the Remote Sensing Ecological Index Considering Full Elements (RSEIFE) was developed (Wang et al., 2023). RSEIFE replaces PCA with an entropy-based weighting method and retains all ecological elements, including water bodies. This approach produces more stable, objective, and interpretable results, especially in heterogeneous landscapes where the interactions between vegetation, built-up land, and hydrological features are complex and ecologically significant (Li et al., 2024).

In this study, RSEIFE is applied to assess the ecological quality of West Bandung, with a novel emphasis on topographic variation across four elevation zones. Elevation plays a critical role in shaping land use patterns, microclimates, and ecological resilience (Zandonai et al., 2024; Guan et al., 2024; Yang et al., 2023; Zhang et al., 2016). By integrating surface indicators such as NDVI, NDBSI, WET, and LST with elevation data, this study aims to provide a spatially nuanced understanding of ecological conditions. The findings are expected to inform targeted environmental planning, promote sustainable development, and support conservation efforts in one of West Java's most dynamically changing regions.

## B. METHOD

This study observed West Bandung Regency (Kabupaten Bandung Barat) that is located in the western part of Greater Bandung, West Java, Indonesia, and lies approximately between 6°41′ to 7°07′ South Latitude and 107°22′ to 107°47′ East Longitude. Covering an area of around 1,305.77 km², the region is characterized by a mix of highland and mid-elevation landscapes, with altitudes ranging from 500 to over 2,400 meters above sea level, particularly around the Lembang highlands and Mount Tangkuban Perahu (Badan Pusat Statistik Kabupaten Bandung Barat, 2023). The region has undergone rapid urban expansion and tourism-driven land conversion over the past two decades (Abriyantoro & Hasrianti, 2024), making it a suitable case for ecological quality assessment across elevation gradients.

The primary data used in this study were multispectral satellite images from Landsat 9 OLI/TIRS Level 1, acquired in April 2025 for path/row 121/65. The data provide a spatial resolution of 30 meters for most bands, a spectral resolution comprising 11 bands spanning the visible, near-infrared, shortwave-infrared, and thermal-infrared regions, and a radiometric resolution of 16 bits, allowing for the detection of subtle variations in surface reflectance and land surface temperature. Additional data included DEMNAS, which was produced through multi-source analysis by the Indonesian Geospatial Information Agency and has a spatial resolution of 8.33 meters, for the purpose of delineating elevation zones.

Four ecological indicators were derived from Landsat 9 imagery, namely:

1. Normalized Difference Vegetation Index (NDVI) – to capture greenness and vegetation health.
2. Normalized Difference Built-up and Soil Index (NDBSI) – to identify built-up areas and exposed soils.
3. Tasselled Cap Wetness (WET) – to estimate surface soil moisture.
4. Land Surface Temperature (LST) – to reflect surface heat patterns using the thermal infrared band.

All indices were normalized to values between 0 and 1 using min-max normalization.

To overcome limitations of the conventional Remote Sensing Ecological Index (RSEI), the Remote Sensing Ecological Index Considering Full Elements (RSEIFE) was employed.

Entropy values Ej were computed for each indicator j, followed by entropy-based weights Wj calculated as:

$$Wj = \frac{1-Ej}{\sum_{j=1}^{m}(1-Ej)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The final RSEIFE value at each pixel was calculated as a weighted sum:

$$\text{RSEIFE}(i,j) = W1 \cdot \text{NDVI} + W2 \cdot \text{WET} + W3 \cdot \text{NDBSI} + W4 \cdot \text{LST} \ldots\ldots\ldots\ldots(2)$$

To explore how ecological quality varies with topography, the study area was divided into four elevation zones:

1. <500 masl
2. 500–1000 masl
3. 1000–1500 masl
4. >1500 masl

Zonal statistics, including mean, minimum, maximum, and standard deviation of RSEIFE values, were calculated for each elevation class using GIS tools. All preprocessing—including atmospheric correction, radiometric calibration, and band calculations—was performed using ENVI 5.3. Entropy calculations and spatial analyses were performed using ArcGIS Pro and Python, employing libraries such as Geopandas, Rasterio, Matplotlib, and Seaborn.

## C. RESULT AND DISCUSSION

### C.1. RESULT

The ecological condition in West Bandung was assessed using four key parameters: greenness, built-up areas, soil moisture, and surface temperature. These were represented respectively by NDVI, NDBI, WET (from the Tasselled Cap Transformation), and LST. The relationships between these indices reveal both positive and negative correlations, reflecting the complexity of land cover dynamics and environmental variability in the region. Figure 1 shows the scatterplot illustrating these interrelationships.

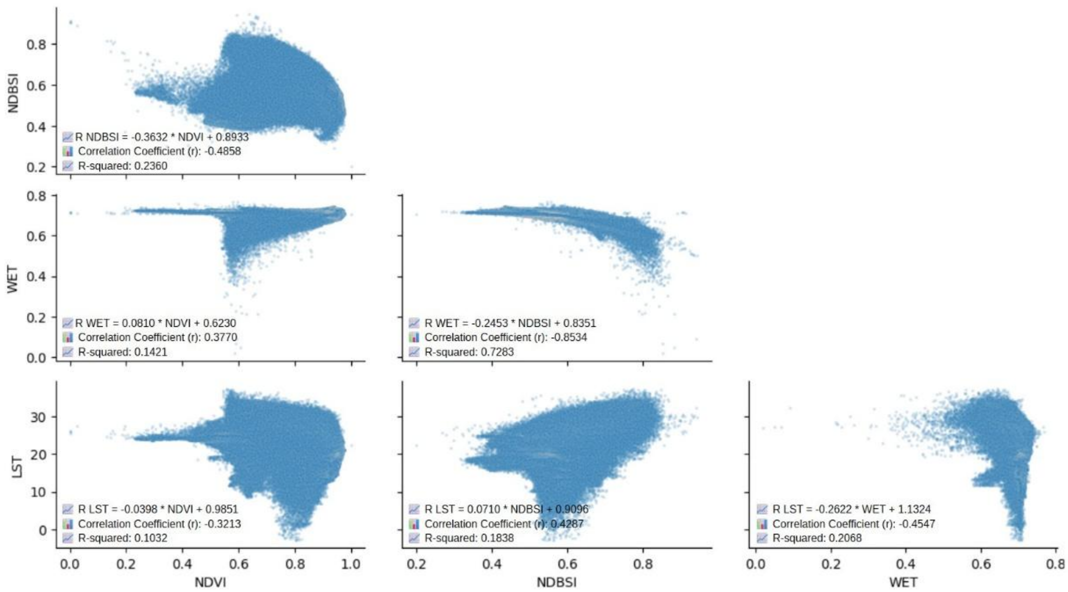


**Figure 1. Scatterplot of NDVI, NDBSI, WET, and LST in West Bandung, 2025**
(Source: Data analysis, 2025)

A strong negative correlation between NDVI and NDBSI, about -0.486, indicates that areas with higher vegetation cover tend to have less built-up or bare soil exposure. This inverse relationship is characteristic of land cover gradients transitioning from natural to anthropogenic surfaces. Similarly, NDVI exhibits a strong positive relationship with WET, with a correlation coefficient 0.728. It suggests that vegetated areas retain more surface moisture, which aligns with established findings on vegetation’s role in enhancing soil water content through evapotranspiration and canopy shading (Crist & Cicone, 1984; Gao, 1996).

Conversely, NDVI and LST show a clear negative correlation, reinforcing the “vegetation cooling effect,” whereby green cover reduces land surface temperature through energy partitioning and evaporative processes (Weng et al., 2004; Zhang et al., 2016). NDBSI and LST are positively correlated, implying that built-up or barren land contributes to increased surface temperatures, a hallmark of the Urban Heat Island (UHI) effect (Zha et al., 2003; Imhoff et al., 2010). Additionally, a negative relationship between WET and NDBSI highlights the drying influence of impervious surfaces, while WET and LST show a weak inverse association, suggesting that moisture plays a moderating role in surface heating, though other factors such as elevation and slope may also be influential.

Overall, these inter-indicator relationships underscore the ecological trade-offs between urbanization and environmental stability in West Bandung, and justify the inclusion of all four indicators in the RSEIFE model to represent the region's ecological complexity.

A further analysis was conducted based on elevation zones, using the Remote Sensing Ecological Index for Forest and Environment (RSEIFE). The data in Table 1 highlight a trend of increasing ecological quality with elevation. Areas above 1500 meters above sea level (masl) generally show higher mean RSEIFE values (up to 0.424), suggesting stronger ecological conditions likely due to reduced urban pressures and denser vegetation cover.

**Table 1. RSEIFE based on Elevation Zones in West Bandung**

| VALUE | MIN | MAX | MEAN | STD | MEDIAN | AREA |
|---|---|---|---|---|---|---|
| < 500 masl | 0,263 | 0,449 | 0,408 | 0,013 | 0,409 | 16.943 |
| <1000 masl | 0,068 | 0,453 | 0,403 | 0,019 | 0,408 | 59.028 |
| <1500 masl | 0,223 | 0,440 | 0,4108 | 0,0178 | 0,4158 | 30.424 |
| <2202 masl | 0,349 | 0,442 | 0,4248 | 0,008 | 0,4258 | 7.454 |

(Source: Data analysis, 2025)

In contrast, zones below 1000 masl recorded the lowest minimum RSEIFE value (0.0677) and the highest variability (standard deviation = 0.0195). Figure 2 illustrates the spatial distribution of the ecological index (RSEIFE) across West Bandung Regency. The values range from 0.0677 to 0.4535, representing a gradient from areas with low ecological quality (depicted in brown tones) to those with higher ecological conditions (depicted in green-blue tones). The map reveals significant spatial variation aligned with land use patterns and topographic differences.

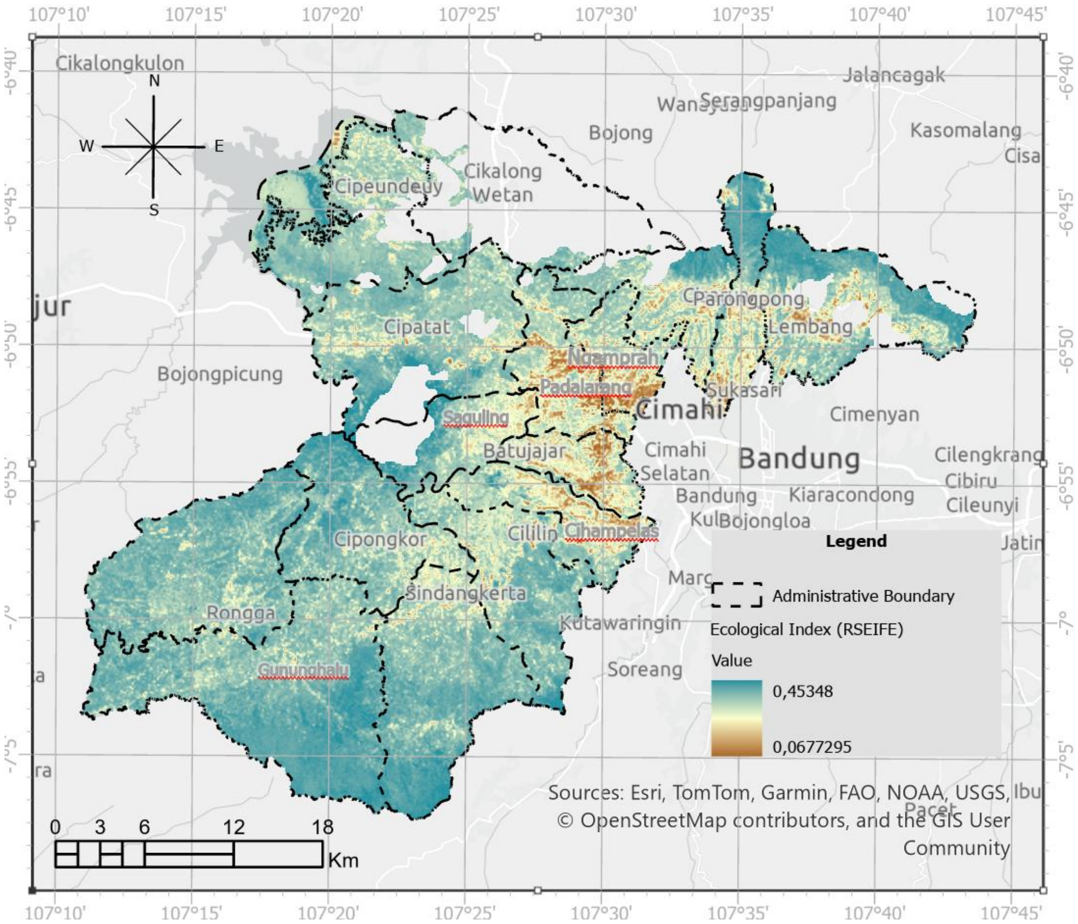


**Figure 2. Ecological Condition Map of West Bandung**
(Source: Data analysis, 2025)

Higher ecological index values are concentrated in the southern and western regions—notably in districts such as Gunung Halu, Rongga, Sindangkerta, and parts of Cipongkor—which are characterized by high elevations, dense vegetation cover, and relatively minimal urban development. These areas benefit from preserved forested landscapes, lower population densities, and cooler microclimates, contributing to better ecological performance.

In contrast, lower ecological index values are predominantly observed in the central and eastern parts, particularly in Padalarang, Batujajar, Ngamprah, and parts of Cihampelas, where rapid urbanization, industrial activity, and infrastructure expansion have intensified ecological stress. These zones display notable concentrations of built-up areas, higher land surface temperatures, and reduced vegetation cover—conditions that contribute to declining environmental quality.

The northern region, especially Lembang and Parongpong, exhibits a mixed pattern. While it maintains a relatively high ecological index in forested and agricultural pockets, areas undergoing tourism development show moderate ecological stress due to increasing land conversion pressures.These figures point to notable ecological stress, particularly in rapidly urbanizing districts such as Padalarang and Batujajar, where land development and rising surface temperatures contribute to environmental degradation.

Overall, the RSEIFE map reflects the trade-offs between development and ecological sustainability in West Bandung. The spatial distribution of ecological conditions reinforces the importance of topography, vegetation retention, and urban planning in shaping regional environmental health. These insights are critical for informing land-use regulation, conservation strategies, and sustainable development initiatives across different elevation zones.

Higher elevation zones—especially those above 1500 masl—exhibited more stable and higher ecological index values. The lowest standard deviation (0.0078) was recorded in the <2202 masl group, indicating more consistent ecological conditions. This could be attributed to conservation practices, stricter land use controls, or natural limitations on development due to terrain.

## C.2. DISCUSSION

Vegetation plays a central role in maintaining ecological balance, particularly by regulating the hydrological cycle. Green open spaces and healthy soil moisture levels are crucial indicators of environmental stability. The strong positive correlation between NDVI and WET observed in this study supports existing findings (Crist & Cicone, 1984; Gao, 1996), reinforcing that vegetated areas retain more surface moisture. This contributes to improved soil fertility, enhances evapotranspiration, and helps buffer the impact of climate fluctuations (Yao et al., 2024; Zeng et al., 2023; Zhang et al., 2016).

Moreover, vegetation also plays a significant role in moderating land surface temperature. Through evapotranspiration and shading, plants absorb heat and reduce local temperatures—a phenomenon known as the “vegetation cooling effect” (Li et al., 2020). In West Bandung, this effect is particularly important in forested and agricultural zones, where vegetation helps regulate microclimates and enhances environmental resilience amidst ongoing urban development (Yang et al., 2023).

On the other hand, built-up areas are closely associated with ecological degradation. Unlike vegetation, built environments and bare soil tend to retain and reflect heat, contributing to elevated surface temperatures. The positive correlation between NDBSI and LST in this study confirms the impact of urbanization on local climate, reflecting the well-known Urban Heat Island (UHI) effect (Akram et al., 2024; Rashid et al., 2022; Imhoff et al., 2010; Zha et al., 2003). Increased surface albedo, the dominance of impervious surfaces, and the reduction in vegetation all contribute to this trend.

The highland topography of West Bandung plays an essential role in buffering environmental changes. Forested and elevated regions support microclimate regulation, runoff control, and ecological sustainability. However, the study also notes that not all high-elevation zones remain ecologically intact. Tourism-driven land conversion has begun to disrupt some of these fragile ecosystems, emphasizing the need for more effective conservation and sustainable development planning

## D. CONCLUSION

The ecological condition of West Bandung is shaped by land cover and elevation. Greener areas tend to have more soil moisture and lower surface temperatures, while built-up zones show signs of ecological stress. Higher elevations generally support better ecological quality due to dense vegetation and less development, though some highland areas are now affected by tourism-driven land use changes. These patterns highlight the need for green planning in urban areas and stronger conservation efforts in upland regions.

## ACKNOWLEDGE

The authors would like to express their sincere gratitude to the reviewers and the editorial team (mitra bestari) of the JURNAL GEOGRAFI Geografi dan Pengajarannya (JGGP) for the valuable time, constructive comments, and insightful suggestions. Their dedication and expertise have significantly contributed to the improvement and clarity of this manuscript. We deeply appreciate their efforts in ensuring the quality and integrity of the publication process.

## BIBLIOGRAPHY

Abriyantoro, D., & Hasrianti, H. (2024). Factors of land use change in Bandung Regency, West Java for 2 decades. *Jurnal Indonesia Sosial Sains*, 5(06), 1462–1467. https://doi.org/10.59141/jiss.v5i06.1153

Akram, W., Amzad, & Khan, D. (2024). Urban expansion and its influence on land surface temperature: A case study of Patna City, India. Journal of Landscape Ecology, 18(1), Article e2025-0001. https://doi.org/10.2478/jlecol-2025-0001

Badan Pusat Statistik Kabupaten Bandung Barat. (2023). Kabupaten Bandung Barat dalam Angka 2023. https://bandungbaratkab.bps.go.id

Crist, E. P., & Cicone, R. C. (1984). A physically-based transformation of thematic mapper data—The TM Tasselled cap. IEEE Transactions on Geoscience and Remote Sensing, (3), 256–263. https://doi.org/10.1109/TGRS.1984.350619

Gao, B. C. (1996). NDWI—A normalized

difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment, 58(3), 257–266. https://doi.org/10.1016/S0034-4257(96)00067-3

Guan, Y., Liu, J., Cui, W., Chen, D., Zhang, J., Lu, H., Maeda, E. E., Zeng, Z., & Beck, H. E. (2024). Elevation regulates the response of climate heterogeneity to climate change. Geophysical Research Letters, 51(12), e2024GL109483. https://doi.org/10.1029/2024GL109483

Imhoff, M. L., Zhang, P., Wolfe, R. E., & Bounoua, L. (2010). Remote sensing of the urban heat island effect across biomes in the continental USA. Remote Sensing of Environment, 114(3), 504–513. https://doi.org/10.1016/j.rse.2009.10.008

Li, X., Zhang, Y., & Wang, L. (2024). Study on spatial and temporal changes in landscape ecological risks and indicator weights: A case study of the Bailong River Basin. *Sustainability*, 16(5), 1915. https://doi.org/10.3390/su16051915

Li, X., Zhou, Y., Asrar, G. R., Imhoff, M., & Li, X. (2020). The surface urban heat island response to urban expansion: A panel analysis for the conterminous United States. Science of The Total Environment, 712, 136487. https://doi.org/10.1016/j.scitotenv.2019.136487

Rashid, N., Mostahidul Alam, J. A. M., Chowdhury, M. A., & Ul Islam, S. L. (2022). Impact of landuse change and urbanization on urban heat island effect in Narayanganj city, Bangladesh: A remote sensing-based estimation. Environmental Challenges, 8, 100571. https://doi.org/10.1016/j.envc.2022.100571

Sun, Y., Li, J., Yu, Y., & Zeng, W. (2022). Ecological assessment based on remote sensing ecological index: A case study of the “Three-Lake” Basin in Yuxi City, Yunnan Province, China. Sustainability, 14(18), 11554. https://doi.org/10.3390/su141811554

Velasco-Muñoz, J. F., Aznar-Sánchez, J. A., López-Felices, B., & García-Arca, D. (2021). Sustainable land use and management. In Sustainable Resource Management: Modern Approaches and Contexts (pp. 179–197). Elsevier. https://doi.org/10.1016/B978-0-12-824342-8.00015-8

Wang, Z., Chen, T., Zhu, D., Jia, K., & Plaza, A. (2023). RSEIFE: A new remote sensing ecological index for simulating the land surface eco-environment. Journal of Environmental Management, 326(Part A), 116851. https://doi.org/10.1016/j.jenvman.2022.116851

Weng, Q., Lu, D., & Schubring, J. (2004). Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. Remote Sensing of Environment, 89(4), 467–483. https://doi.org/10.1016/j.rse.2003.11.005

Wu, Y. (2024). Research progress of urban ecological evaluation methods based on remote sensing indexes. In Proceedings of the 4th International Conference on Environment Science and Advanced Energy Technologies (ESAET 2024) (Vol. 108). Highlights in Science, Engineering and Technology. https://doi.org/10.54097/rm8c6t44

Yang, X., Shi, X., Zhang, Y., Tian, F., & Ortega-Farias, S. (2023). Response of evapotranspiration (ET) to climate factors and crop planting structures in the Shiyang River Basin, Northwestern China. Remote Sensing, 15(16), 3923. https://doi.org/10.3390/rs15163923

Yao, L., Wu, R., Wang, Z., Xue, T., Liu, Y., Hu, E., Wen, Z., Shi, H., Yang, J., Han, P., Zhao, Y., & Hu, J. (2024). Climate change and vegetation greening jointly promote the increase in evapotranspiration in the Jing River Basin. Agronomy, 14(9), 1910. https://doi.org/10.3390/agronomy14091910

Zandonai, A., Fontana, V., Klotz, J. et al. Six years of high-resolution climatic data collected along an elevation gradient in the Italian Alps. Sci Data 11, 751 (2024). https://doi.org/10.1038/s41597-024-03580-x

Zeng, J., Zhang, Q., Zhang, Y., Yue, P., Yang, Z., Wang, S., Zhang, L., & Li, H. (2023). Enhanced impact of vegetation on evapotranspiration in the northern drought-prone belt of China. Remote Sensing, 15(1), 221. https://doi.org/10.3390/rs15010221

Zha, Y., Gao, J., & Ni, S. (2003). Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. International Journal of Remote Sensing, 24(3), 583–594. https://doi.org/10.1080/01431160304987

Zhang, L., Weng, Q., & Shao, Z. (2016). Investigating the relationship between land surface temperature and vegetation abundance for urban heat island mitigation in the mountainous areas of China. Urban Forestry & Urban Greening, 20, 308–317. https://doi.org/10.1016/j.ufug.2016.09.004