

Downscaling the Global Land-Use Harmonization (LUH2) Dataset for Taiwan and its Application in Sustainability Development

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Land-use and land-cover (LULC) changes have significant environmental implications, particularly when forests are converted into agricultural or residential areas, leading to forest degradation and carbon emissions. The Land-Use Harmonization (LUH2) project generates global future land-use scenarios based on Shared Socio-economic Pathways (SSPs), linking historical land-use data with socio-economic patterns to predict future changes. Analyzing historical land-use data for Taiwan (Chen et al., 2019) reveals that recent land-use changes may not favor regional carbon sequestration. In response to the global climate action of achieving “Net Zero Emissions by 2050”, the Taiwan government has set several policy goals. The LUH2 database offers future land-use scenarios and data to support Taiwan's net-zero emissions goal.

The study investigates land-use spatial distribution in Taiwan under different SSPs from 2016 to 2100 using the LUH2 dataset. To strengthen the connection with regional context, the results of the national land-use survey are additionally used to assess the rationalities of regional land-use/land-cover changes. Potential Land-use Change probabilities are generated based on historical LULC maps, and then future land-use maps are created for different scenarios. Markov Chain Analysis is applied to national land-use survey data to derive land-use transition probabilities. By assessing two probabilities, regions with unreasonable land-use changes are identified as "conflict zones," representing challenges in downscaling global land-use scenarios to Taiwan using LUH2.

Under SSP2-4.5, a moderate climate adaptation scenario, carbon emissions will stabilize until 2050 but reach low levels by the century's end. The temperature is projected to increase by 2.7° by then. Comparing the 2015 LUH2 data with the corresponding satellite imagery, it was observed that the satellite imagery showed a larger forest area than LUH2 data, while the grassland area was smaller. Therefore, linear interpolation was used to correct the discrepancies between the two datasets in the first decade. After removing the correction period, it was found that from 2026 to 2100, the areas of the three land-use types experienced minimal changes. There was a slight increase in forest area, while agricultural and grassland areas, as well as built-up areas, slightly decreased. Additionally, the statistics for the land-use conflict zones in 2026 revealed that the forest conflict zone covers an area of 104.25 square kilometers, the agricultural and grassland conflict zone covers an area of 3,476.25 square kilometers, and the built-up area conflict zone covers an area of 2,064 square kilometers. In essence, achieving alignment of land use development in Taiwan with SSP2-4.5 scenarios by 2026 presents a challenge, as it currently faces a 15% deficit in reaching its desired targets.

Given the global scale of LUH2, connecting it with local data presents challenges. The study establishes spatial allocation priority principles and utilizes national land-use survey data to align the future land-use map with Taiwan's context. By implementing this methodology, the downscaling process is expected to be completed, and conflict zones are identified for different SSPs. The findings offer valuable land-use/land-cover change datasets for understanding human-induced impacts on climate change in Taiwan, providing references for environmental control through land management.

Keywords: Land-Use Harmonization(LUH2), Shared Socio-economic Pathways(SSPs), Future

