GUEST EDITORIAL – SPECIAL ISSUE: Land Use Changes, Degradation and Impact on Ecosystem Services in Asia and Southeast Asia

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Abstract

Several Asian countries are undergoing rapid economic development driven by diverse factors. This development is leading to continuous land use changes, including deforestation, urbanization, and agricultural conversion. Such transformations threaten essential ecosystem functions and services, like food provision, climate regulation, and cultural benefits. Land-use changes, influenced by economic activities and policies, carry extensive consequences, impacting ecosystem productivity, water resources, and climate stability. Remote sensing technology significantly aids in monitoring and quantifying these changes, offering valuable insights for land management and policy decisions. The NASA Land-Cover and Land-Use Change (LCLUC) Program within NASA's Earth Science Division program aims to establish global assessments of land changes using space-based methods (https://lcluc.umd.edu/). The South/Southeast Asia Research Initiative (SARI), funded by NASA LCLUC, focuses on advancing LCLUC science in the region and fostering collaborations between US and Asian researchers. Utilizing geospatial data from remote sensing and models, SARI employs a comprehensive approach, considering biophysical and socioeconomic aspects of land systems and their interactions. SARI has been enhancing LCLUC science through science projects, partnerships, training, workshops, and capacity building exchanges since 2015. This Special Issue, stemming from SARI meetings in the Philippines and Malaysia in 2018 and 2019, gathers articles focusing on LCLUC, degradation, and ecosystem services in Asia. Of over 90 submissions, 30 have been accepted, providing insights into these issues and their regional impacts. The articles are summarized into various sub-themes below.

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Editorial

Several Asian countries are undergoing rapid economic development driven by diverse factors. This development is leading to continuous land use changes, including deforestation, urbanization, and agricultural conversion. Such transformations threaten essential ecosystem functions and services, like food provision, climate regulation, and cultural benefits. Land-use changes, influenced by economic activities and policies, carry extensive consequences, impacting ecosystem productivity, water resources, and climate stability. Remote sensing technology significantly aids in monitoring and quantifying these changes, offering valuable insights for land management and policy decisions. The NASA Land-Cover and Land-Use Change (LCLUC) Program within NASA's Earth Science Division program aims to establish global assessments of land changes using space-based methods (https://lcluc.umd.edu/). The South/Southeast Asia Research Initiative (SARI), funded by NASA LCLUC, focuses on advancing LCLUC science in the region and fostering collaborations between US and Asian researchers. Utilizing geospatial data from remote sensing and models, SARI employs a comprehensive approach, considering biophysical and socioeconomic aspects of land systems and their interactions. SARI has been enhancing LCLUC science through science projects, partnerships, training, workshops, and capacity building exchanges since 2015. This Special Issue, stemming from SARI meetings in the Philippines and Malaysia in 2018 and 2019, gathers articles focusing on LCLUC, degradation, and ecosystem services in Asia. Of over 90 submissions, 30 have been accepted, providing insights into these issues and their regional impacts. The articles are summarized into various sub-themes below.

1.Remote Sensing and Geospatial Technologies for Land Use Cover Changes (LUCC) and Monitoring

In the literature, Multiple studies have employed remote sensing and geospatial techniques for LUCC monitoring and within this special issue, an array of articles highlights these aspects. For example, Hassan et al. (2020) employed satellite images from SENTINEL-2A, RAPIDEYE, WORLD VIEW-2, multi-date UAV, and a digital elevation model from the Shuttle Radar Topographic Mission to assess forest cover degradation in the Cox's Bazar area, Bangladesh, related to Rohingya emigration. They used a supervised classification method for multi-date land-use/cover data and dynamic modeling with the Markov chain and cellular automata technique to predict forest-cover loss, highlighting the role of various satellite data in assessing spatiotemporal changes. Gilani et al. (2020) utilized MODIS 1km data to comprehensively determine soil erosion dynamics in Pakistan. Employing a Revised Universal Soil Loss Equation (RUSLE) and MODIS data, they evaluated soil erosion patterns between 2005 and 2015, enabling the identification of soil erosion classes and transitions, and underlining the contribution of remote sensing in understanding soil erosion dynamics. Further, Tran et al. (2021) proposed a method involving spatial analysis approaches and enhanced vegetation index (EVI) data from LANDSAT via Google Earth Engine to estimate vegetation dynamics. Their study showcased the applicability of EVI data for monitoring spatiotemporal changes in vegetation coverage, highlighting the role of remote sensing in assessing ecological health. A study by Williams et al. (2021) focused on mapping smallholder forest plantations in India using multitemporal visible and near-infrared (VNIR) bands from Sentinel-2 multispectral instruments. They demonstrated the effectiveness of Sentinel-2 VNIR bands and multitemporal data for accurately distinguishing forest plantations from natural forests, showcasing the potential of these remote sensing techniques. In addition, Kumar et al. (2021) utilized very high-resolution (VHR) Indian Remote Sensing (IRS) satellite data, specifically CARTOSAT-1 panchromatic and multispectral LISS-IV datasets, to quantify Trees outside Forest (ToF) in Haryana State. Their innovative classification scheme and VHR satellite data played a pivotal role in accurately quantifying ToF, illustrating the value of remote sensing in assessing complex landscapes. These studies collectively highlight how specific satellite data, such as MODIS, SENTINEL-2A, RAPIDEYE, WORLD VIEW-2, LANDSAT, and VHR IRS data, coupled with various geospatial techniques, play a critical role in monitoring and analyzing diverse environmental aspects.

2. Land Use/Cover Changes, Degradation and Environmental Implications

This special issue includes articles that highlight the critical issue of land degradation and its far-reaching environmental implications. The research encompasses diverse regions and landscapes. For example, a study in Iran by Mazloum et al. (2020) highlights the tension between urbanization, population growth, and

the finite availability of land resources. Converting rangelands for residential, industrial, and agricultural purposes jeopardizes ecosystems and biodiversity, reflecting a common struggle in regions pursuing economic growth without compromising ecological equilibrium. Additionally, the study in northern China's Hexi Corridor by Zhu et al. (2021) brings out the susceptibility of arid regions to climatic fluctuations through the movement of aeolian materials and changing dune formations. This study indicates that even remote areas remain susceptible to the consequences of land degradation, potentially resulting in habitat depletion, diminished soil quality, and altered ecosystems. Feng et al. (2021) introduce novel indicators to assess vegetation landscape stability in their study. These indicators are applied in a semiarid grassland coal mine area, where they successfully capture landscape dynamics across various types. In the Andaman Islands, India, Velmurugan et al. (2021) reveal the fragility of island ecosystems. The worsening of forest-cover loss due to land degradation in these islands endangers biodiversity and heightens the vulnerability of these regions to further ecological disturbances. Furthermore, a study on the Dong River upstream basin in China (Li et al., 2021) exemplifies the complex interplay between ecological restoration efforts and rapid urban expansion. While restoration initiatives aim to improve vegetation cover, urbanization's unchecked growth accelerates land degradation and weakens the ecosystem's capacity to provide essential services. Further, Li et al. (2021) explore the intricate relationship between restoration efforts and urban expansion's impact on China's land-use changes. The study reveals shifts in land-use types and their impacts on landscape patterns, including the drivers and consequences of land-use changes in this region. Lastly, in a study of the Betwa River Basin in India, Palmate et al., (2021) emphasize the relationship between climatic variables and land dynamics. It stresses that unplanned urban expansion, industrialization, and unsustainable land use practices intensify soil erosion and disrupt the balance of ecosystems. This degradation affects soil health and vegetation cover and has cascading impacts on water quality, hydrological patterns, and biodiversity. These studies emphasize the urgent need for proactive and holistic land management strategies to curb land degradation in various landscapes.

3. Land Systems, Ecosystem Services and Management

A number of the articles focused on Land Systems, Ecosystem Services, and Management, delving into the intricate relationships between land-use patterns, the benefits derived from ecosystems, and the strategies for sustainable management. Six distinct studies in the special issue highlight these aspects. For instance, Azimi et al. (2020) examine rangeland degradation's impact on water conservation in Iran's Atrak River Basin, revealing a strong link between rangeland condition and water conservation. Shrestha and Acharya (2020) focus on Nepal's Kathmandu Valley, exploring how historical and projected land-use changes affect ecosystem service values. In a different study, Meena et al. (2020) analyze the interplay between land use, topography, and carbon dynamics in the Indian Himalayas, suggesting diversified systems enhance carbon and soil sustainability. In China, Cao et al. (2020) discuss ecological restoration's intersection with poverty alleviation, indicating its potential for sustainable outcomes. Tian et al. (2020) investigate anthropogenic activities' repercussions on ecosystem services in Tibet, stressing the need for context-aware ecological management. Shi et al. (2021) explore the complex relationship between rapid urbanization and ecosystem services in Northwestern China, advocating for balanced urban planning models. Further, Dar et al. (2021) study water quality degradation from land use changes around India's Khushalsar Wetland, underlining the importance of steering land-use modifications. Additionally, Rajbanshi and Das (2021) assess land-use impacts on soil carbon dynamics, estimating the economic consequences. As a collection, these studies highlight the urgency of comprehensive methodologies encompassing ecological, social, and economic elements. Such approaches are critical in fostering sustainable land utilization, safeguarding ecosystem services, and mitigating the detrimental impacts of land degradation on the environment.

4. Agricultural Land use, Soils and Resource Management

In this special issue, various research articles address crucial aspects of agricultural land use, sustainable soil management, and its implications. For instance, Swe et al. (2020) investigates the repercussions of agricultural land use changes caused by the construction of the Paunglaung Hydropower Dam in Myanmar. The study unveils shifts in agricultural practices and income strategies among different income groups through

satellite imagery and household surveys. The research highlights the impact of dam-induced land changes on local livelihoods and food security. Singh et al. (2020) looked at how changing the way farmers grow crops affects the soil quality in India. They found that crop rotations involving vegetables or pulses can make the soil healthier and improve crop growth. Hu et al. (2020) studied how planting certain legume plants can help restore grasslands in China's Loess Plateau. They found that one particular legume, Caragana korshinskii, is better at improving the land than others. Behera et al. (2020) focus on soil management zones to combat nutrient deficiencies, proposing strategies for sustainable crop growth in the Narmada River Basin, India. Also in India, Tripathi and Tiwari (2021) investigated how too much salt in the soil affects crops. They used satellite data to predict where soil salinity might be a problem for growing wheat. Yao et al. (2020) explored how adding different amounts of nitrogen fertilizer to soil affects the bacteria that live in coastal areas. They discovered that adding more nitrogen can change the types of bacteria in the soil. Ray et al. (2021) looked at a traditional farming practice in India's northeastern hills called "jhuming" (the practice of cutting down and burning the vegetation from an area of forest in order to create farmable land) and reported significant soil degradation in these lands. They also suggested alternative practices to prevent soil degradation. Focusing on soil potassium content in China's Yangtze River Basin, Zhu et al. (2021) use experimental and statistical data to evaluate changes caused by K-fertilizer application and straw return. They find that balanced K fertilization and increased straw residues return contribute to improved soil K status, providing insights for sustainable soil management.

In summary, the articles in this special issue provide a comprehensive understanding of various issues on land use, degradation, ecosystem services, and agricultural soil management, contributing to enhanced and sustainable decision-making considering the changing LCLUC dynamics across diverse Asian countries.