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Applying MODIS Satellite Data to Identify Emerging Drought Zones in the Rural Tropical Environment

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Introduction

The tropical environment is considered the earth's regions surrounding the equator. This region can be defined in latitude from the Northern Hemisphere at 23°26′10.9″ (or 23.43636°) N to the Southern Hemisphere at 23°26′10.9″ (or 23.43636°) S. Ironically, many developing countries are in this region, and about 40% of the global population or 3.3 billion people are living there. The tropics are the most diverse region on the earth, hosting about 80% of the planet's terrestrial species and over 95% of its corals and mangroves [1]. For the healthy and sustainable life of humans and other living organisms, the rich biodiversity of the tropics provides essential elements such as food, medicine, and industrial products. With their large population, tropical countries are economically performing well and outperformed the rest of the world by about 20% in recent years [1]. However, at the local level, tropical countries have a massive population under the poverty level (add some data). The massive population and irregular precipitation patterns have created a significant risk of floods and droughts in tropical countries. Water scarcity is already a major problem for some regions in the tropics. The number of people impacted by water scarcity is projected to increase from 1.7 billion people to 5 billion people by 2025 [2]. Lack of water resources can be expected due to increased frequency of droughts, increased evaporation, and changes in rainfall patterns and run-off.

The Impact of Drought on Rural Life in Tropical Countries

Drought impact on any region of the world brings worsening consequences on human life, flora, and fauna. The effects of droughts encompass the global ecosystem vary from region to region. Within the last 5-6 years, drought hit rural farmers in Sri Lanka and India, where one of the most populated regions in tropical countries [3]. The failure of the northeast monsoon rains hit the cultivated areas in northeast Sri Lanka and southeast India. Particularly, drought occurrences in dry zones regions in Sri Lanka bring a severe environmental conflict between rural farmers and wild elephants. During the dry season, damage from wild elephants to farmers is severe, intensifying the conflict. In 2019 alone, over 400 elephant deaths and over 120 human casualties were recorded [4]. In India, about 53% of India's gross cropped area is rainfed, which shows a heavy dependence of the agricultural economy on rainfall. In a severe drought hit in 2012, one study revealed about 86% production loss in major crops [5]. The drought impact severely effects the least developed countries due to physical, social, and economic as well as knowledge and skills differences [6].

Monitoring and Predicting Drought Conditions Using Satellite Data

The AVHRR and MODIS satellite missions generate atmospherically corrected reflectance data (red, near infrared, and blue wavebands) useful in calculating vegetation indices. Among various vegetation indexes measuring environmental phenomena, several indexes are used by scientists to study drought impact. The Normalized Difference Vegetation Index (NDVI) is one of the popular indexes for assessing the greenery of the environment. The Enhanced Vegetation Index (EVI) investigates canopy-soil variations and improves sensitivity over dense vegetation conditions [7]. NASA uses the Mean Vegetation Health Index (Mean VHI) to assess the severity of the drought from the start of the growing season, examining the vegetation health and the influence of temperature on plant conditions. The Mean VHI is an average of the ten days VHI values over the crop-growing season. It considers the sensitivity of a crop to water stress over its growing season and calculates the temporal impact of moisture deficits from the start of the growing season until the current decade [8]. When dealing with drought monitoring and prediction, the Agricultural Stress Index (ASI) is a quick-look indicator that facilitates the early identification of farmlands with a high likelihood of water stress or drought [8]. According to the index calculation, the poorer the vegetation health, the more severe drought conditions prevail in the target region. Figure 1 shows one of the highly populated tropical countries, Sri Lanka, where the ASI calculation identified possible drought conditions by FAO in December 2021 and January 2022. One of the largest districts in Sri Lanka, Anuradhapura, in the central north of the island, receives only 44mm of precipitation in June in contrast to the highest monthly average of 237mm in November. The district of Vavuniya, north of Anuradhapura receives much lower average rainfall in June, which is 14mm of rain. Due to this low precipitation, dry regions of Sri Lanka suffer from frequent droughts increasing various environmental problems, including human-elephant conflict. In a situation like Sri Lanka, the application of satellite data could prove a promising potential to develop an early drought warning system with accurate and micro-level spatial information. An early drought warning system based on satellite data can be positively applied to address poverty issues in rural farmers in tropical countries. One approach is to conduct detailed studies with high-resolution satellite data to identify frequent drought affect regions and assess the crop loss and damage due to the impact of the past droughts. Another approach is to identify drought level impact on various crop types. Such experiments will help plan new irrigation facilities to severely affected regions and redesign the crop systems by introducing drought-resisting crop types.

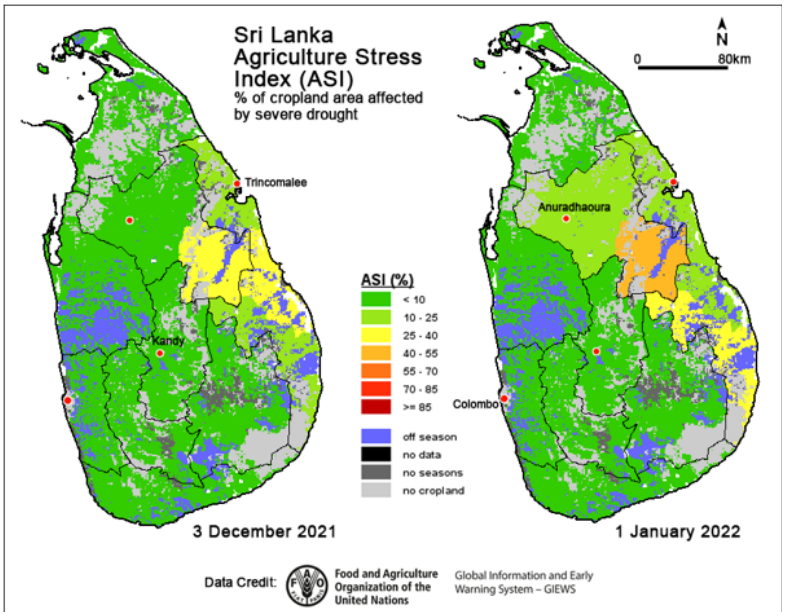

Figure 1: Satellite data provides a promising approach to predicting droughts. The above maps show Agriculture Stress calculated from satellite data after the failed northeast monsoon rains in Sri Lanka in 2021/2022.

Conclusion

Drought is one of the most critical environmental issues in most tropical countries. The drought impact is particularly grave in developing countries due to the chain of poverty and high dependency on the rural agriculture economy. Building an accurate, near-real-time and detailed spatial information-based drought forecasting system will be valuable for these countries. Satellite data products such as NDVI, EVI, VHI, and ASI can be successfully administered to produce near-real-time drought monitoring and prediction tools. Freely available, MODIS satellite data is one of the best satellite data sources that cover the entire world every 1-2 days. A sample data set acquired from FAO is presented in this report to demonstrate the successful identification of drought conditions in Sri Lanka. A deeply involved study on drought monitoring through satellite data will be a reliable source of information for

tropical countries to establish drought mitigation programs. Early identification of drought can help to change some of the cultivation practices and design irrigation facilities for frequent drought effect regions.

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