A Study on Geospatial Approaches to Develop Maize Production in Sri Lanka: A Case Study in Hulannuge GND, Ampara District

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Abstract

Today, self-sufficient agriculture crop production is a challenge for any country. Sri Lanka has an agriculture-based economy and is not self-sufficient in some agriculture crops, especially other field crops. Maize is one of the main agriculture crops among other field crops. Sri Lanka fulfills around 50% of its annual maize requirement through imports from other countries. This is a huge drain on the country's foreign exchange, while a huge potential exists to produce maize locally. The public and private institutions in the agriculture sector of the country are continuously working toward self-sufficiency in agriculture crop production. For example, the Government of Sri Lanka initiated the Food Production National Program 2016–2018 with the cooperation of public and private institutions in the agriculture sector to identify problems in the agriculture sector and move toward self-sufficiency. However, the program was unable to achieve its objectives fully. Therefore, this study aimed at examining effective and efficient ways to improve the maize production of the country to achieve self-sustainable maize production, which will eventually help in developing the maize industry in Sri Lanka. Specifically, this study targeted a set of geospatial approaches to improve maize production by evaluating farmers' attributes related to maize cultivation, by identifying suitable lands for maize cultivation, monitoring crop growth and yield potentials of maize cultivation, and developing a platform to upload, archive, and share data related to maize cultivations for decision support to improve maize production in the country. The Hulannuge Grama Niladari Division (GND) of Ampara District, Sri Lanka was selected as the study area for the case study. A sample questionnaire survey was used to evaluate the farmers' attributes related to maize farming. Multi-Criteria Decision Making (MCDM) with the Analytical Hierarchical Process (AHP) was applied to assess land suitability for maize cultivation by considering physical and environmental factors, such as soil, land use, elevation, slope, temperature, and rainfall in the study area. Multi-temporal UAV (Unmanned Aerial Vehicle) images taken at different growing stages of the selected maize fields of the study area were used to monitor growth development and biomass estimation of maize by evaluating plant height calculated based on crop surface models and different RGB-based vegetation

indices. Finally, free and open-source based Web GIS was developed to upload, archive, and share the data on maize cultivations.

The results of the study reveal that the socioeconomic status of farmers from maize farming is at an acceptable level, and they would happy to grow maize and use modern technology for growth monitoring, which are positive signs for increasing maize production. In addition, the study has highlighted the necessity of scientific ways to identify land suitability for maize cultivation and crop growth monitoring of maize cultivations to improve maize production. The land suitability analysis for maize cultivation shows that 14% of the total land area of the study area is highly suitable for maize farming and 60% of the current maize cultivation lands are in highly suitable areas for maize cultivation. Agriculture Instructors can use this information in the decision-making process required for the extension programs to expand maize cultivation on highly suitable lands. UAV-based crop growth monitoring enables the estimation of plant height, using crop surface models generated from UAV images, with an accuracy of 85%. The study observed a significant and strong relationship between plant heights calculated based on crop surface models and biomass, with an accuracy of 70%. Among the six vegetation indices used to model the vegetation fraction, the Excess Green minus Excess Red (ExG) vegetation index was significant in modeling the vegetation fraction in the middle of vegetative development stages and selected for biomass modeling. The correlation between ExG vegetation index and biomass has a significant and moderately strong relationship with an accuracy of 50% at the leaf development stage. Biomass predicting ability using plant height, calculated based on crop surface models, and ExG vegetation index is better than individual relationships and the most significant prediction was at the leaf development stage with an accuracy of 71%. The results reveal massive potential for the application of UAV images in monitoring crop growth development and biomass estimation of maize cultivation for efficient planning and decision making in a non-destructive manner. The Web GIS was enabled to access maize cultivation data from anywhere and at any time with mobile responsiveness. It is a cost-effective and valuable data source for decision-makers.

Finally, I have conducted this study from a scientific perspective to find possible avenues to increase maize production in Sri Lanka using geospatial techniques. The case study results revealed three significant approaches, as follows: (i) finding most suitable lands for maize cultivation using spatial MCDM and AHP; (ii) UAV-based crop growth monitoring of maize using photogrammetry and remote sensing methods; and (iii) providing access to previous growth development data of maize using Web GIS techniques. All these approaches will help to improve the productivity of maize and achieve self-sufficient maize production, one of the goals of the United Nations 2030 Agenda for Sustainable Development. The models were recommended to the Government of Sri Lank to develop the maize industry. Regulatory bodies of the Agriculture sector in Sri Lanka can apply this model by enforcing policies and providing other support to stakeholders in the industry. This model can apply not only to maize but also to other similar crops.

Keywords: AHP, crop growth monitoring, Hulannuge GND, land suitability, MCDM, UAV, Web GIS