# Land Suitability Analysis for Rice Production in the Northern Regions of Bangladesh: Introducing Geo-Spatial Insurance Premiums

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# ABSTRACT

Farmers are in risk with their production due to climate changes in the developing countries. Bangladesh is one of that requires a policy to combat against vulnerability of climate change. There are two major risks of the farmers in Bangladesh concerning to the agricultural sector: first, price risk triggered by potential volatility in market and second, production risk resultant from uncertainty of climate change. One of the measures against risks is protection of crops through subsidized insurance policy based on land suitability classification, harvest index and predicted yield.

Thus, the purpose of this research is to identify the suitable lands for rice production and based on the suitability classes. Furthermore, a crop insurance premium model was aimed to develop to secure farmers revenue and increase land use intensification for ensuring food security in the northern regions of Bangladesh.

Land Suitability Analysis (LSA) was carried out using several criteria: slope, elevation, topsoil texture, soil pH, land types, flood-prone and land use. A geospatial model was developed in the ArcGIS® environment. Furthermore, a multi-criteria analysis was performed to prioritize the criteria for land suitability evaluation of rice production. In the multi-criteria analysis, analytical hierarchy process (AHP) was done using experts' opinions for identifying as highly suitable (S1), moderately suitable (S2), marginally suitable (S3), presently not suitable (N1), and restricted or permanently not suitable (N2) in three districts: Rangpur, Lalmonirhat and Kurigram. The criteria were prioritized using weights from experts' opinions. The insurance premiums were designed coverage for total revenue of production costs for Aus, Aman and Boro rice varieties. The yield prediction was incorporated for insurance premiums with considering harvest index and subsidy dependence factors. Landsat OLI datasets were used for yield prediction and Landsat 8 TIRS imageries were used for calculating the surface temperature during vegetation, reproductive and flowering stages of paddy. First, the rice production and climate risk perspectives were reported at the vulnerable areas for sustainable intensification of agricultural lands. Second, the author reported multi-criteria decision support systems to prioritize the criteria and remote sensing datasets extraction procedures from thermal imagery. Thermal imagery was used to find land surface temperature to estimate losses due to temperature variations in the growing seasons. Third, Weighted Linear Combinations (WLC) was applied to find suitable areas for rice production with the integration of AHP and GIS. The results showed that 22.74% of the area was highly suitable for rice production, 14.86% marginally suitable, 28.54% moderately suitable for rice production and proposed for sustainable intensification. On the other hand, 32.67% area was found permanently not suitable, occupied by settlements, forests, water bodies and rivers and 1.19% was presently not suitable for rice production. Fourth, developed the crop insurance premium

model was developed based on the land suitability classes. The new crop insurance premium model recommended three coverage: highly coverage (90%), moderately coverage (80%), and marginally coverage (70%) based on the annual of revenue from three varieties of rice crops. The insurance premiums were calculated from 2-6% interest rate on farmer's willingness to pay. The expected outcome was reported according to land suitability class and coverage in the range of 238.98 - 301.66 $/ha/month from marginal, to highly coverage. However, socio-economic reality requires coverage with lower insurance premium, which could be estimate using yield losses. Finally, another new crop insurance approach was developed based on the losses or yield gaps. The coverages were designed based on the losses estimated from differences between expected and observed yields. The GIS-based model was developed using regional mean optimum temperature of 23°C, 24°C and 25°C for vegetation, reproductive and flowering stages, respectively. The premiums were determined based on the predicted yield loss with corresponding insurance coverage. The calculated premiums were 14.11, 16.12 and 18.15 $/ha for marginal, moderate and highly coverage based on cumulative losses estimated from vegetation, reproductive and flowering stages.

The developed LSA was used for determining the suitability of lands for sustainable intensification of rice production and proposed the production intensification could be extended upto marginally suitable lands. To secure farmers production revenue and estimating yield losses, two new geo-spatial insurance premiums were developed with three categories coverage's as highly, moderately and marginal coverage for rice production. Satellite remote sensing, GIS could be incorporated for prediction of expected yield and observation of land surface temperature to estimate losses of yield in the different stages of crop growth.