Dissertation Abstract

論文の内容の要旨

Assessment of Asian elephant status and human-elephant conflict risk under climate change scenarios

(気候変動シナリオの下でのアジアにおける人間とゾウの軋轢の評価)

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Asian elephant (*Elephas maximus*) occurs in 13 range countries occupying heavily fragmented landscapes surrounded by human-dominated activities. Negative interactions between wild elephants and humans through crop depredation, property damages, and fatality, impact the quality of life of local communities and also hammer the species conservation outlook. As economic development and human population growth in this region are expected to continue, Human-Elephant Conflict (HEC) will likely become more frequent and emerge as the national challenge. Nevertheless, HEC management remains mostly reactive with localized assessment and lack of long-term planning. Therefore, a study on landscape-scale assessment of HEC distribution that incorporates future scenarios can benefit the species conservation, but has yet to be done. This dissertation aims to develop assessment framework for HEC that covers large spatial scale and considers climate change scenarios. Expected outputs from the proposed framework would quantify current and future HEC distribution at country-level by utilizing open-access data, spatio-temporal coverage of remotely-sensed products, ecological modeling, and climate change assessment techniques. To construct the framework and identify needed key variables for analysis, the following three sets of questions were raised: (i) What are the main priority for Asian elephant conservation in each range country? and which country is the most concern for HEC? (ii) Within the country of most concern, how did HEC distribution change over time? and what are the important variables influencing its change? Lastly, (iii) within the country of most concern, how HEC will change in the future, and which spatial locations should be given priority?

Chapter 2 categorizes range countries based on possible relationship of changes in wild elephant population to key landscape and socioeconomic factors. The long-term changes in land cover and landscape were analyzed within elephant home ranges based on remotely-sensed ESA CCI land cover product from three time periods: 1990, 2003,

and 2015. GHSL human settlement and socioeconomic factors (Human Development Index, GDP, and Control of Corruption index) were also considered as candidate variables in sustaining large wild elephant population. Based on the best model with the lowest AICc (28.77) and good pseudo-R^2 (0.68), four key drivers were identified from multiple logistic regression, namely area of the largest forest patch, land cover diversity, forest fragmentation, and average number of human population within elephant home range. Principle Component Analysis and K-means clustering were then applied on the linear trend coefficient of the elephant population and its cross-correlation coefficient to the four key selected drivers. The results indicated four possible groups with the following characteristics: (i) Cambodia, Laos, and Vietnam experienced a decrease in elephants with high forest loss and fragmentation, implying priority in halting habitat loss. (ii) Indonesia and Myanmar had a decrease in elephants even with remaining large forest patch as a possible result of illegal forest encroachment and poaching respectively, implying necessity for effective conservation law enforcement. (iii) Protection of key forest habitat was identified in Bhutan, India, and Nepal which should be further expand in other areas within the country. Lastly, (iv) a stable or increasing elephant population despite human disturbance and varying level of unfavorable conditions were identified in Bangladesh, China, Malaysia, Thailand, and Sri Lanka, implying the likelihood of overlapping resource usage and HEC. Within this group, Thailand was positioned as a potential leading country on the development pathway of forest transition theory, especially within Southeast Asia. The country showed an increasing elephant population despite highly developed landscape and deteriorating conditions of all key variables. This same situation will likely become that of many neighboring countries. Therefore, Thailand was chosen on which further analysis of HEC situation was performed.

Chapter 3 identifies governing factors of HEC by modeling its distribution in Eastern Thailand, a region with high number of reported HEC. To overcome data limitation due to the lack of official HEC records, news reports in online platform were collected from 2009 to 2018. The time-calibrated species distribution modeling (SDM) with maximum entropy (MaxEnt) was applied to model the relative probability of HEC in wet and dry seasons. The environmental dynamic over the 10-year period was represented by remotely sensed vegetation (MOD09A1), meteorological drought (KBDI), topographical (SRTM), and human-pressure data (human population, transport network, and distance to protected habitats). Results were classified into HEC zones using the proposed two-dimensional conflict matrix. The models yielded good predictive performance with AUC>0.78. The results showed that although HEC probability varied across seasons, overall HEC-prone areas expanded in all provinces from 2009 to 2018. High HEC-prone areas were estimated to cover 5,381 and 8,806 km^2 in the wet and dry season during 2018, which were double and triple that of 2009 estimation. The largest HEC areas were estimated during dry seasons with Chanthaburi, Chonburi, Nakhon Ratchasima, and Rayong provinces being the HEC hotspots. Direct human pressure caused a more gradual increase of HEC probability around protected areas, while resource suitability showed large variation across seasons. The top importance variables from direct human pressure (forest cover percent, drought level, and distance to forest) and resource suitability (distance from protected habitats, and human density) were identified. The evaluation from Eastern Thailand also highlighted climate-induced HEC impacts in which drought variations greatly alter HEC distribution.

In Chapter 4, the IPCC risk framework was adopted to assess spatial distribution of HEC risk under baseline (2000-2019) and near future (2025-2044) for Thailand. HEC risk is defined as the probability of wild elephant occurrence (hazard) in overlapping areas with human population (exposure) who possess different vulnerable levels (vulnerability). Four future scenarios were based on the combination of Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) with 12km buffer-zone (BZ) policy: A1 (RCP4.5-SSP2-BZ), A2 (RCP8.5-SSP5-BZ), B1 (RCP4.5-SSP-no BZ), and B2 (RCP8.5-SSP5-no BZ). Climatic data included ERA5 (baseline) and NEX-GDDP (5 selected future GCMs). MOD09A1, ALOS-PALSAR yearly composite, and SRTM were used for land cover supervised classification at baseline period. Future land cover were simulated from land demand projection and location suitability. Derived land cover maps together with HydroSHED, ERA-JRC surface water, transport network, and topography represented landscape conditions. Elephant occurrences were obtained from existing literature, GBIF database, and Thailand national park report. Elephant habitat suitability and dispersal probability were then modeled for hazard. Exposed rural human population were available from existing study as proxy of exposure, while vulnerability was represented by socioeconomic factors and drought probability. Composite HEC risk was then calculated using geometric means with equal weighting. The validation indicated an average AUC of 0.71 ± 0.01 for baseline HEC risk map. The findings suggested a northward shift in future HEC risk which resulted in an average of 1.7% to 7.4% increase for four forest complexes (FC) in northern region and an average reduction of -3.1% to -57.9% for other FCs in lower latitude. Climate-induced changes were estimated to prominently alter HEC risk through deteriorating habitat conditions and increasing drought probability. Although land cover changes had overall lower effect, future conversion to abandoned land holds potential for conservation. HEC buffer zones created both positive and negative effects depending on locations. Many of the FCs projected with future unfavorable habitat conditions currently host large elephant population. Hence, habitat improvement is their likely priority to buffer the effects of climate change. On the other hand, FCs with expected increase in HEC risk hold lower elephant population and is surrounded by less developed human activities. Capacity building and limited access to future habitats maybe beneficial for communities in these locations.

Lastly, Chapter 5 discusses the contribution of this research which is two-fold. First, the proposed framework improves the assessment of HEC to cover large spatial scale, multi-dimensional analysis, and climate change impacts. The approaches used in this study utilize open-access dataset which support evident-based assessment in data-poor locations and can be applied across different species. Second, the findings of the proposed framework highlighted the areas that needed management attention. Allocation of limited conservation resources, thus, can be systematically planned. Caveats and recommendations to further the applicability of the proposed framework were also discussed.