

Land-use changes caused by livelihood transitions and their impact on tropical lower montane forest in Shan State, Myanmar

(ミャンマーシャン州の生業転換にともなう土地利用変化と下部山地林に対するその影響)

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Introduction: In areas where shifting cultivation was once practiced, the residents have transformed some areas for use as permanent cropland, while fallow forests have developed naturally in other areas. The main objective of this study was to observe the pattern and the extent of the conversion from a shifting cultivation landscape to permanent cropland in the upland areas of Shan State, Myanmar to obtain fundamental information for developing a land management plan to ensure the sustainability of montane forest ecosystems and the security of the livelihoods of residents. First, the land-use/land-cover changes during the past three decades were determined. Then, the transitions in livelihoods in relation to the major land-use change from shifting cultivation to permanent tea orchards were explored. Finally, the species composition and stand structure of tropical lower montane forests under various human impacts were examined.

Land-use/land-cover change: This study first analyzed the land-use/land-cover change from the initial state in 1988 to the final state in 2016 using remote sensing methods. The supervised classification method maximum likelihood classifier was used to classify Landsat images. The major land-use/land-cover change over the 28 years was the disappearance of forested areas and increase in cropland. A binary logistic regression model was used to investigate which spatial attributes governed the likelihood of cropland expansion by converting forests. Topographical factors (slope inclination and aspect) and location of an area (distance to a road) were important spatial attributes that explained the probability of

converting forest into cropland. The main underlying causes triggering major land-use changes were increasing market demand for processed tea leaves in Myanmar and government policy that discouraged shifting cultivation. In the undulating hilly region, the complete conversion from shifting cultivation to permanent cropland resulted in the disappearance of fallow forests.

Livelihood transitions: This study examined the transition in land-use change from shifting cultivation to permanent cropland in relation to the changes in livelihood of the residents. In-depth interviews were conducted with 150 respondents to explore their current livelihood patterns and the transitions in their livelihoods and land-use changes that occurred over the previous three decades. Permanent cropland in the form of tea orchards was the predominant livelihood and a major income source for the local residents; this implied that shifting cultivation had been the main livelihood option before the cultivation of tea trees became widespread. As land-use transition, 81% of hill orchard owners transformed their shifting cultivation sites to hill orchards, cultivating mainly tea trees (*Camellia sinensis*). The farmers' preference for tea orchards reflected many political, socio-economic, and topographic factors. Increasing market demand for tea leaf products, the scarcity of land as a result of population increase, and government regulation of shifting cultivation collectively resulted in the permanent disappearance of a shifting cultivation landscape, which was replaced by tea orchards.

Species composition and stand structure of tropical lower montane forest: From a forest survey of 58 sample plots ($30 \times 30 \text{ m}^2$), four stand types were categorized using nonmetric multi-dimensional scaling (NMS) ordination. The four stand types showed significant contributions from various anthropogenic impacts, reflecting differences in the local livelihoods within different varying landscapes. Anthropogenic disturbances, especially the

extraction of firewood, can significantly affect the stand structure of forests and, in turn, the species composition and tree diversity. Some early successional species such as *Phyllanthus albizzioides* and *Albizia odoratissima* were indicator species of highly disturbed forests. As firewood is mainly extracted from privately owned forests, rather than communal forests, land tenure was also an important factor governing the intensity of anthropogenic disturbances. Species richness and diversity decreased in stand types exposed to more severe anthropogenic disturbances. Stem density was significantly higher in highly disturbed forests. This was a result of greater numbers of multi-stemmed individuals, which revealed the effect of cutting larger stems for firewood extraction. In old secondary forests, the lack of young trees under the canopy may threaten future forest regeneration. Depending on varying forest conditions and the local population's input, different forest management activities should be applied to forests to optimize production and protection for the local community.

Conclusion: In the hilly region studied, tea orchards were the main income source for local communities. The established tea orchards had been transformed from areas of shifting cultivation, which is usually characterized by actively cultivated fields and fallow forests of different ages. Accordingly, the dominant livelihood transition from shifting cultivation to permanent cropping of tea orchards was the proximate cause of the disappearance of forest in this region. In undulating hilly areas where tea orchards were the dominant land-use and the main local livelihood, firewood extraction for processing tea leaves was a severe anthropogenic disturbance that impaired the species composition and stand structure of tropical lower montane forest. These major findings suggest that the transition from subsistent agriculture to commercial agriculture resulted in deforestation and forest degradation. This is the major threat to the montane forest ecosystem and the security of livelihoods for local communities.