Appendix 1

Study Limitations

Several limitations related to the data sources and methodologies used should be noted. First, our study relied on survey data that aggregated household responses to the village-level and in some cases sampled only a subset of villages impacted by a land deal. These issues were due to feasibility constraints associated with the geography of land allocation to deals, as some were quite extensive impacting more than 10 villages and occurred across the entire country. Consequently, survey responses only provide a partial picture of socioeconomic impacts and direct and indirect land-use changes and do not capture intra-village variability in land deal impacts (Hett et al. 2020, Nanthavong et al. 2021). Thus, it was possible that no land-use change was reported in the village survey, but it was detected in areas surrounding land deals with remote sensing and not reflected in surveyed village responses. These limitations were unavoidable given the national scope of the survey effort.

We were also not able to detect or differentiate the crop type of iLUC in impacted villages. The ability to discern whether iLUC in impacted villages was driven by smallholder expansion of commodity crops or whether swidden cultivation had been displaced would have provided a more direct indication of whether a regime shift had occurred. Swidden cultivation is notoriously difficult to detect and map owing to issues with cloud cover, spectral similarity to secondary forest, and the long time series needed to detect fallow cycles (Li and Fox 2012, Hurni et al. 2013, 2017, Vongvisouk et al. 2014). We made the assumption that iLUC in the presence of income improvement was most likely related to smallholder adoption of commodity crops, while iLUC without income improvement was linked to the displacement and continuation of swidden cultivation.

Finally, the inability to find matched non-rubber (control) and rubber (treatment) land deals that eliminated the statistical differences in population densities undermined the reliability of the matching results. It is difficult to discern whether the difference in iLUC among the control and treatment villages was attributable to the differences in population densities, real processes of iLUC associated with land deals impacts, or a combination. However, additional, independent lines of evidence combined with the robust sensitivity results for matching between rubber and non-rubber deals suggest that the higher rates of observed iLUC associated with rubber producing land deals are real. The other matching analyses both produced significantly higher iLUC rates in treatment villages that support logical inference about rubber vs. non-rubber iLUC trends. Direct LUC trends were similar between foreign investor and rubber-producing land deals (Figure 5), and iLUC rates were strongly higher in villages with land deals that were greater than 25% implemented. Both trends are similar to the land-use change dynamics observed for rubber-producing land concessions regionally that tend to be implemented more rapidly leading to greater conflict and iLUC (Magliocca et al. 2019, 2020). Similarly, other studies of boom crops in the region have demonstrated multiple pathways for iLUC in areas impacted by land deals, including the reinvestment of cash crop profits into other smallholder land-use activities (Ornetsmueller et al. 2018a), displacement of swidden production into adjacent areas (Baird 2010, Hall 2011, Baird and Fox 2015, Schoenberger et al. 2017), and land speculation and immigration (Baird and Fox 2015, Fox et al. 2018, Baird et al. 2019). Based on these additional lines of evidence, we concluded that the higher rates of iLUC observed with rubber-producing land deals were likely real.