Supplementary Information 3 for:

Smallholder Land-Use Decisions in a Tropical Agro-Forest Frontier in Southern Mexico

Supplementary Information 3:

Description of used variables

Dependent variables

The dependent variables refer to the land-uses at the farm scale. From the semi-structured interviews and farm-visits we identified seven different land-use types: agriculture, pasture, primary forest, secondary forest, rubber, oil palm, and reforestation. These land-use types are the most representative of the MdC region in general and the study area in particular. *Ejidatarios* self-reported the number of hectares allocated to each land-use within their farms (Table 2 in main manuscript).

Independent variables

We recognize a large number of factors with possible impact on the land-use composition of the individual farms. These independent variables are organized into three categories: 1) local-level household characteristics, which are the socio-economic factors (organized in two sub-categories: endowments and economic strategies); 2) regional-level biophysical factors; and 3) national-level institutional factors (Table 2 in main manuscript).

Local-level household factors

Here, we refer to several household socio-economic characteristics that are deemed relevant for farm level smallholder decision-making and may have an impact on land-use allocation. We consider four variables: 1) age-of-head, and 2) farm size (endowment variables); and 3) off-farm income, and 4) diversity of income sources (economic strategies variables). Age-of-head is a proxy for local ecological knowledge and familiarity with local market conditions, which may influence land-use decisions (Chavez and Perz 2012; Schmook and Vance 2009). Farm size is a proxy for total quantity of land having entitlement rights per household. Household economic strategies capture different farmers' aspirations and preferences, which can be reflected in the demand placed on their farms (Roy Chowdhury and Turner 2006). Off-farm income – measured by using a dummy variable that equals one if the household receives income from other sources than the farm, and zero if not – is a proxy for income received from skilled jobs/work, small local business ownership, and/or out-migration. The diversity of income sources variable is the sum of the total number of different income sources that a farm receives (off-farm and on-farm (i.e., income from sales from agriculture, cattle, oil palm)). We did not include income from rubber cultivation in this category because the sampled plantations were too young to be productive. However, rubber plantations are likely to contribute income in the future.

Regional-level biophysical factors

According to evidence from our ethnographic research, soil quality is the most important biophysical factor for smallholders when deciding what they may do with their land. Thus, for the purpose of this study, we selected two soil quality indicators: 1) topsoil extractable phosphorous (P_{ex}), and 2) soil potential to produce food (SPP), which were measured by stratified topsoil sampling across the geopedologic land units of the MdC region (for methods see Navarrete-Segueda et al. 2017, 2018, and Lohbeck et al. 2022). Topsoil phosphorous is usually correlated with soil fertility, and hence commonly used as a proxy for soil quality (de Moraes Sá et al. 2013; Bünemann et al. 2018; Heinze et al. 2020). Building on recent research that indicates that soil quality and agricultural production depend on the inter-relationship of different factors (Calzolari et al. 2016; Muñoz-Rojas 2018), we considered the SPP variable, because it is a compound soil quality indicator that is positively related to fertility, clay content, soil organic carbon, and total nitrogen, but negatively to aluminium saturation and stoniness. The SPP is an index with values between 0 and 1.

To be able to analyze soil data at the farm scale, we first identified the multiple plots belonging to each farm on a land tenure map that contains the official land holdings (*mapa parcelario*; RAN 2010), based on the coordinates obtained during the farm visits or from land titles. The farm plots (shapes) were then mapped on top of the geopedologic land units map, and we calculated the mean soil properties for each plot. Farm-level soil properties represent the average soil properties of all the plots that comprise the farm, weighted by the relative sizes of the plots.

National-level institutional factors

Here, we refer specifically to six key agricultural and conservation institutional policies that target specific land-uses in the region: 1) PROCAMPO for agriculture; 2) PROGAN/Credit for pastures for cattle-ranching; 3) PES for forest conservation; 4) Oil palm program for oil palm cultivation; 5) Rubber program for rubber cultivation; and 6) Reforestation program for forest restoration. We derived these six policy programs from the ethnographic research and semi-structured interviews with smallholders. We measured these programs by using a dummy variable that equals one for participation and zero for non-participation. To capture the diversity of governmental subsidies, we also included a seventh variable about the number of programs in which each smallholder participates.

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