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Prevalence, economic contribution, and determinants of trees on farms across Sub-Saharan Africa☆

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ABSTRACT

Trees on farms are often overlooked in agricultural and natural resource research and policy in Sub-Saharan Africa. This article addresses this gap using data from the Living Standards Measurement Study-Integrated Surveys on Agriculture in five countries: Ethiopia, Malawi, Nigeria, Tanzania, and Uganda. Trees on farms are widespread. On average, almost a third of rural smallholders grow trees. They account for an average of 17% of total annual gross income for tree-growing households and 6% for all rural households. Gender, land and labor endowments, and especially forest proximity and national context are key determinants of on-farm tree adoption and management. These new, national-scale insights on the prevalence, economic contribution and determinants of trees on farms in Africa lay the basis for exploring the interaction of agriculture, on-farm tree cultivation, and forestry to gain a more complete picture of the dynamics of rural livelihoods across the continent and beyond.

1. Introduction

In Africa, as in many other parts of the world, trees on farms are often overlooked in research and policymaking. In forestry, the focus is mostly on trees in forests rather than outside them (Barton, 2002; Fay and Michon, 2005). In agriculture and livelihood studies, the focus is typically on annual crops and their effects on household income. When perennials (such as coffee trees) are considered, it is mostly from a value chain perspective. The organization of extension and other services reflects this division, with agriculture and forestry typically separated in different institutions (de Foresta et al., 2013). As a result, trees on farms are often not included in forest-related, agricultural and livelihood statistics and little remains known about their prevalence and economic contribution, particularly at the national scale.

Yet trees on farms, which may range from sporadically occurring trees to areas dominated by a single tree crop through to large forest-like stands of trees, are often an integral component of broader agriculture-forest landscapes. They perform important ecological functions, including the provision of soil nutrients, prevention of soil erosion, habitat for animals, and greater structural connectivity (Manning et al., 2006; Place and Garrity, 2015) and serve as a key basis for biodiversity conservation (Bhagwat et al., 2008; Schroth et al., 2013) and climate change adaptation and mitigation (Mbow et al., 2014a). Sub-national case studies further suggest that on-farm trees often also provide a sizeable source of income (from timber or non-timber products such as fruit) (Degrande et al., 2006; Kalaba et al., 2010; Mbow et al., 2014b). Roughly, a third of the agricultural land in Sub-Saharan Africa is estimated to have had at least 10% tree cover during 2008–2010 (Zomer et al., 2014). Trees and agricultural activities therefore often co-exist not only in larger landscape contexts but also in single landowner holdings.

The available research on trees on farms has so far largely focused on case studies within particular countries (e.g. Dewees, 1995b; Godoy, 1992; Pouliot and Treue, 2013). Region-wide aggregated approaches have also shed light on the prevalence of on-farm trees (Zomer et al., 2014), but because they are based on remotely sensed data such studies have not directly accounted for household perspectives and practices. Cross-national (e.g. Poverty and Environment Network (PEN) studies highlighted in Wunder et al., 2014) and global (Agrawal et al., 2013) syntheses of forest and broader environmental income also exist, but systematic comparative information on the prevalence and economic contribution of trees on farms remains missing. This is especially problematic given intensifying competition for land in Africa (Peters, 2013) and the challenge of simultaneously advancing human development and environmental protection goals. The lack of reliable national-scale estimates of the prevalence and contribution of trees on farms increases

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the risk that they are left out of relevant policymaking processes, which could in turn result in greater priority for competing land uses that may undermine sustainability goals.

This article addresses this gap using nationally representative, geo-referenced household survey data from five African countries collected under the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) initiative. Together, these countries (Ethiopia, Malawi, Nigeria, Tanzania, and Uganda) represent 41% of the population in Sub-Saharan Africa and cover many of its agro-ecological zones. In addition to comprehensive household level information about consumption and income sources, these surveys also collected geo-referenced plot level information on the different crops and trees grown on each farm as well as the products harvested. These features of the data are exploited here to measure the prevalence and economic contribution of trees on farms in Sub-Saharan Africa, the first objective of this study.

The long time lag between planting and harvesting, insecure property rights, small plots and landholdings, and remoteness, which often characterize smallholder farming in Africa, would all seem to play against the adoption of trees. Yet case study evidence from across Africa also shows that small farmers do plant and manage trees on their farms. So, what are the key drivers? We begin to explore this question by estimating theoretically informed models of the determinants of on-farm tree adoption, the second objective of this article.

The article proceeds as follows. The next section reviews the empirical approach. Given the multitude of possible tree-like crops, it begins with a brief typology of the different trees considered. This is followed by a description of the data and methodologies used to measure and analyze their prevalence and contribution to overall household income and welfare. An empirical model is subsequently presented to estimate the key socio-economic and agro-ecological drivers of on-farm tree adoption, drawing on key insights from the literature. Section 3 discusses the findings. Concluding remarks are offered in Section 4.

2. Materials, methods, and theoretical underpinnings

2.1. Identifying and counting trees on farms

The nationally representative household surveys conducted under the LSMS-ISA initiative during 2010–12 from five African countries form the primary information base for this study.[1] LSMS-ISA household surveys have been stratified to be representative for rural and urban areas. The surveys gather a wide range of socio-economic information on households and the communities of which they are a part, with detailed attention to their sources of income and geo-referenced, plot-level information on their agricultural activities and crops grown.

Most importantly for this study, they also include detailed information for all cultivated plots about the type of crop (including tree crops), the harvest, and expenses incurred. For fallow or uncultivated plots, farmers were explicitly asked whether they contained trees. In countries where two seasons of agricultural data were collected (Malawi, Tanzania and Uganda), the average presence of trees across both seasons was taken. Across these countries a total of >20,000 rural households (and 47,000 plots) were surveyed and through application of survey sampling weights a representative portrait of on-farm tree prevalence and their economic contribution to rural household incomes was obtained.

In the absence of a standard classification of trees within crop data, potential trees were first identified from the LSMS-ISA agricultural crop production data, following the biological convention that to qualify as a tree a plant must be a woody perennial with a trunk or elongated stem that supports branches and leaves. With the help of several experts, the LSMS-ISA crop list was subsequently divided into five subcategories: (1) fruit trees (e.g. mango, orange, etc.); (2) tree cash crops (e.g. coffee, tea, etc.); (3) timber and fuelwood trees (e.g. Mahogany, bamboo, etc.); (4) plant/herb/grass/roots (e.g. maize, banana, etc.); and (5) a series of unidentified crops (e.g. wechino, etc.) (Table A.1 includes a detailed list of all the crops considered as trees and their further classification across these subcategories). The LSMS-ISA data included 230 crops in total, of which about 30% ($n = 68$) were classified as trees. Nearly all the remaining crops, as expected, fell in the plant/herb/grass/roots category.

Only the first three subcategories are considered here. While they contain all three perennials (with substantial lags between planting and harvesting which distinguishes them from other crops), they are nonetheless still quite distinct in their biological and economic features and support systems. Unlike fruit and timber trees, cash crops have been extensively studied in the development literature, for example, but not in forestry, and they are usually politically important and part of well-organized and integrated cooperatives and value chains. Unlike timber trees, fruit trees yield an annual return. This dramatically changes the parameters of the investment decision. For these reasons, we explore the three tree subcategories alongside each other.

The stock of trees on farms identified in our study likely represents a lower bound. First, home gardens are plausibly underreported as plots (and thus also trees in home gardens) and trees with no immediate productive function (e.g. shade trees, living fences, or those retained for their aesthetic value) may have been left out of household questionnaires. Second, respondents may not recall all trees on their lands or may be hesitant to report them where, for example, colonial legacies of state control of tree resources persist (Leach and Scoones, 2013; Ribot, 1999; Sendzimir et al., 2011). Lastly, the study was unable to classify a few species for which only the local name was available (Table A.1). Yet, such omissions would especially affect the number of trees reported, and not so much their incidence or the share of land allocated to trees (for each plot it is recorded whether trees are present or not). Consequently, this study focuses on analyzing the prevalence (i.e. presence or absence) of trees on farms and the share of land allocated to trees as opposed to the number of trees per se.

2.2. Contribution to household income and welfare

To examine the contribution of trees on farms to farmers' livelihoods, three indicators are examined: 1) how tree products are used (as a source of cash or mainly for own use or consumption); 2) their share in household crop and income portfolios (as an indication of their direct economic value) and 3) the consumption levels among farmers with and without trees on farms. Consumption levels also capture some of the more indirect contributions of trees on farms such as soil conservation, nitrogen fixing, and water regulation (Booth and Wickens, 1988; Nair, 2007; Place and Garrity, 2015) or as provider of organic fertilizer or fodder for livestock (at least to the extent that they raise and sustain agricultural income). None of these indirect aspects is typically addressed in the LSMS-ISA surveys (or household surveys more generally).

Information on the quantity of tree products harvested, their value (i.e. price per unit/kg), and their different uses (sale, auto-consumption, or other uses[2]) was directly obtained in all surveys, except in Tanzania. To assess their contribution to household income, we estimated the share of gross household income derived from trees on farms as part

[1] The LSMS-ISA initiative is a collaboration between the World Bank and national statistics offices in partner countries in Sub-Saharan Africa to design and implement multi-topic, nationally representative panel household surveys focusing on agriculture. This collaboration, funded by the Bill and Melinda Gates Foundation, seeks "to foster innovation and efficiency in statistical research on the links between agriculture and poverty reduction in the region" (World Bank, 2015). For details, see www.worldbank.org/lsms. Niger was excluded because, unlike other LSMS-ISA countries with available data for the study period, total income from trees or tree products was not recorded, only sales.

[2] "Other uses" denotes use as inputs into another production process (e.g. fodder for livestock, fruits for jam, timber for own house construction or fencing).