Agriculture, Ecosystems and Environment 263 (2018) 41–52

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Retaining forests within agricultural landscapes as a pathway to sustainable intensification: Evidence from Southern Ethiopia

Jean-Yves Duriaux Chavarría[a,*], Frédéric Baudron[a], Terry Sunderland[b,c,d]

[a] CIMMYT-Zimbabwe, 12.5 km Peg Mazowe Road, Harare, Zimbabwe
[b] Centre for International Forestry Research (CIFOR), PO Box 0113, BOCBD, Bogor, 16000, Indonesia
[c] James Cook University, Cairns, Australia
[d] University of British Columbia, Vancouver, Canada

ARTICLE INFO

Keywords:
Multi-functional landscapes
Productivity
Sustainability
Resilience
Equality
Common resource pools

ABSTRACT

There are increasing calls in Africa for 'sustainable intensification' of agriculture with the aim of increasing productivity whilst minimizing the negative environmental and social impacts. This paper questions whether adopting a landscape approach—and in particular the retention of forests within agricultural landscapes—could fulfill these goals for smallholder farmers in some regions of Africa. Using a landscape in Southern Ethiopia comprised of three zones of increasing distance from a legally protected forestas a case study, the performance of a stratified sample of 27 farms was assessed through detailed surveys and empirical measurements. While livestock productivity was found to be higher closer to the forest, no difference was found for crop or total farm productivities across the three zones. Partial nutrient balances (a productivity dimension of farm sustainability), redundancy (a proxy of resilience), and equality in the distribution of livestock increased with increasing proximity to the forest. Dependency on external inputs also decreased with increasing proximity to the forest. We conclude that, under certain conditions, the retention of forests in agricultural landscapes, and the use of these forests for livestock grazing and fuelwood collection, may promote sustainability, greater resilience and equality of smallholder farming systems, without compromising on-farm productivity. Thus, landscape approaches may provide a pathway to sustainable intensification, and may represent a research and development arena that deserves increasing attention in the sustainable intensification debate.

1. Introduction

Over the last few decades, calls for agricultural intensification, particularly in developing countries, have become an accepted part of the development lexicon (Pretty and Bharucha, 2014). Many agricultural scientists and food security experts believe that intensification is necessary to feed a growing global population (FAO, 2017) while those more concerned with the broader environment claim that intensification of agricultural production is necessary to conserve current wild lands for biodiversity (Garnett et al., 2013).

Agricultural intensification has been accelerating rapidly over the last century. The conventional approach to agricultural intensification is characterized by the combined use of improved crop varieties, mineral fertilizers and irrigation (Goldman and Smith, 1995). The adoption of this approach in (parts of) the developing world, where it became known as the 'Green Revolution', transformed a number of countries (e.g., India) from large food importers and recipients of food aid into food secure countries in only few years (Larson et al., 2004). There is little doubt that this is an important part of the reason why there is a smaller percentage of people who are hungry than ever before in modern history. However, it has also resulted in a reduction of the resilience of contemporary food production systems and is also characterized by considerable environmental and social costs (FAO, 2017).

The conventional approach to intensification leads to highly simplified agroecosystems that are extremely vulnerable to shocks (Altieri, 1999). In addition, these systems are highly dependent on oil-based energy (Pfeiffer and Mulder, 2013) and other non-renewable resources, such as phosphorous, which is approaching a production peak similarly to oil (Cordell et al., 2009). Because food produced through intensive agriculture represents the vast majority of food traded globally and because intensive agriculture is highly dependent on fossil fuels, global food prices are closely tied to global oil prices (Woods et al., 2010).

Conventional intensification practices have led to erosion, compaction, acidification, salinization, or loss of soil organic matter (Oldeman, 1994), making production systems unsustainable in the long run. These systems are also characterized by high runoff and erosion

* Corresponding author at: 16.8 km Masaya Road, Managua, Nicaragua.
E-mail address: jy.duriaux@gmail.com (J.-Y. Duriaux Chavarría).

https://doi.org/10.1016/j.agee.2018.04.020
Received 30 January 2018; Received in revised form 29 April 2018; Accepted 30 April 2018
Available online 11 May 2018
0167-8809/

rates from farmland, causing siltation of streams, lakes, estuaries, and coral reefs (Gordon et al., 2008) while also transporting pesticides and nutrients (such as nitrate) into these aquatic ecosystems (Carpenter et al., 1998). Mechanical and chemical operations associated with the conventional approach to intensification significantly reduced farmland biodiversity (Carson, 2002) and the supporting and regulating ecosystem services it sustains.

In some developing countries, the Green Revolution tended to increase inequities, both between farms and between regions (Freebairn, 1995). Because of the need to purchase inputs, the Green Revolution has favored resource-rich farmers (Prahladachar, 1983) and was largely driven by market production and income, not necessarily by food production for local consumption. Thus, it favored regions with good roads and well-developed market infrastructure (Goldman and Smith, 1995). As such, its overall contribution to poverty reduction was much less pronounced in more marginal production environments (Pingali, 2012) often leaving the poorer increasingly marginalized.

In response to the negative outcomes of the conventional approach to intensification, there are increasing calls – especially in Africa, which was largely bypassed by the Green Revolution – for an alternative form of intensification, often coined 'sustainable intensification' (Garnett et al., 2013): one that increases agricultural production and productivity while minimizing the loss of resilience and other detrimental environmental and social outcomes. The large diversity of smallholders in Africa calls for a diversity of pathways to sustainable intensification, but all should be based on the principles of providing short-term benefits while being low-risk and ensuring the sustainability of the systems over time – e.g., avoiding soil nutrient mining (Vanlauwe et al., 2014).

Landscape approaches could be a pathway to sustainable intensification, as demonstrated by evidence from several cases of concomitant improvement in agricultural production, livelihoods, biodiversity and ecosystem services when implementing options using such approaches (e.g. DeFries and Rosenzweig, 2010; Schroth and McNeely, 2011). Landscape approaches represent a shift from viewing rural spaces solely as food providers to multi-functional mosaics providing a broad range of values and services (Sayer et al., 2013) to their inhabitants and other interested groups.

In a recent literature review focusing on the contribution of forests and trees to agricultural production and livelihoods, Reed et al. (2017) demonstrated the net positive gains that integrating trees on farms tend to have. But they also found that out of the 78 studies reviewed only 12 investigated off-farm forest and 11 of those focused exclusively on pest control and pollination services. Therefore, our study aims to fill these two gaps: 1) the lack of evidence of the contribution of off-farm forest to agriculture, and 2) the lack of studies exploring more than one dimension of the contribution of forest to agriculture.

In this paper, we hypothesize that the retention of forest areas in productive landscapes is a viable pathway for sustainable intensification and discuss this hypothesis based on empirical findings. Specifically, we test the impact of distance from the forest on (1) total farm productivity, (2) resilience, (3) sustainability, using nutrient balances as proxy and (4) equality of the distribution of land and livestock, using a landscape in Southern Ethiopia as a case study.

2. Materials and methods

2.1. Site description

The study landscape is located between 38°42.14′ and 38°49.92′ East and 7°15.05′ and 7°22.57′ North in the Arsi-Negele district (woreda) of the Oromia region, Ethiopia. The landscape borders the State-owned forest of Munesa (Baudron et al., 2017). The elevation ranges from 1970 to 2200 m above sea level. The mean annual rainfall is 1075 mm per year, and the mean annual temperature is 15 °C (Halle-Wittenberg University, 2002). There are three seasons: a short rainy season (March to May), a long rainy season (July to September), and a dry season (October to February). Cereals are the most common crops (Duriaux and Baudron, 2016) together with potato (*Solanum tuberosum* L.). Homegardens are common and are dominated by enset (*Ensete ventricosum* (Welw.) Cheesman). Various leafy vegetables can also be found in the farms of the area. Livestock in the form of cattle, sheep, goats, donkeys and chicken, is an important component of most farms. Crop residues become a communal resource after harvest unless they are harvested and brought to the homestead (Baudron et al., 2017).

Six villages were selected along a gradient of distance from the Munesa Forest (Baudron et al., 2017). Sida Malkatuka and Dikitu Shirke villages (in Ashooka kebele) border the State forest of Munesa and form a zone referred to as 'near' in the rest of the paper. Its residents have access to the Munesa Forest for extraction of fuelwood for household use and for livestock grazing. Gogorri Lako Toko (in Ashooka kebele) and Kararu Lakobsa Lama villages (in Bombaso Regi kebele) are located at about 5.5 km from Munesa Forest and form a zone referred to as 'intermediate' in the rest of the paper. Shodna and Belamu villages (in Gambelto kebele) is situated about 11 km from the forest and forms a zone referred to as 'distant'. Residents of the near zone are the only ones with legal access to Munesa Forest; residents of the intermediate zone have access to common grazing areas; and residents of the distant zone have no access to common resource pools. The near, intermediate and distant zones are located about 16, 11.5 and 6.5 km from the main market of Arsi-Negele town. For further description and maps of the zones and the general landscape see Duriaux and Baudron (2016) and Baudron et al. (2017). For further information on the experimental design and the methodological approach—which were implemented in six other tropical landscapes spread across Central America, Africa and Asia, see Sunderland et al. (2017).

2.2. Data source and sampling

From December 2014 to February 2015, 266 households, representing the totality of the households in each zone (88 in the near zone, 97 in the intermediate zone, and 81 in distant zone), were surveyed using a standardized questionnaire addressing household composition, assets, income sources, crop and livestock production, forest use, market access and trading. The head of each household was interviewed in the Oromo language by enumerators trained in the specific survey methods.

Three self-categorization exercises—one per zone—were conducted with a group of 50 to 60 community members, representative of the diversity of community members in the zone (in terms of gender, age and wealth) in September 2014. Based on the criteria from these self-categorization exercises, a farm typology was delineated, with three farm types: (1) livestock oriented farms (≥ 4 adult cattle ha^{-1}), (2) crop oriented farms (< 4 adult cattle ha^{-1} and ≥ 1 ha of farmland) and resource constrained farms (< 4 adult cattle ha^{-1} and < 1 ha of farmland). Using this typology, a stratified sample of nine farms per zone was selected for detailed characterization.

For each selected farm, the detailed characterization produced three tangible outputs: a resource flow map, resource use calendars, and a timeline (Giller et al., 2011). In addition, the area of each field was measured using a hand-held global positioning system (GPS; Garmin Etrek 10). Empirical measurements were also conducted in nine of these 27 farms (one farm per type and per zone): daily fuel consumption (once in March 2015 and once in August 2015), and milk production over a period of seven days (once in March 2015 and once in September 2015).

2.3. Calculations

2.3.1. Productivities

Crop production per farm was estimated as the sum of the energy produced by each crop, and was calculated using data reported in the farm interview, GPS measurement of each field, and dry matter content