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Livelihood sustainability assessment of coffee and cocoa producers in the Amazon region of Ecuador using household types

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Abstract

Supporting small farmer livelihoods in fragile, biodiverse regions, such as tropical forests, is a priority for many development agencies and national governments. These regions tend to be characterized by recent human settlements, increasing populations and infrastructure development, as well as competitive land use activities, which exert pressure on fragile ecosystems. Improvement in livelihood strategies often focuses on increasing yields by improving productivity, but without taking into account alternative methods, such as better agricultural practices and their dependence on agrochemical inputs, changing land use through crop substitution, or improving product commercialization. In this research, we use household types, defined according to different land use patterns, in the Northern Amazon region of Ecuador to explore the limitations of, and identify future options for, improving livelihood strategies based on small-scale coffee and cocoa production. The results of the different types are discussed in order to highlight the methods' utility and identify benefits in terms of environmental and social objectives versus economic profitability. Lessons are drawn that could be useful in applications of public policy aimed at the betterment of small coffee grower and cocoa farmer livelihood strategies, which involve thousands of families in the Amazon region of Ecuador, without compromising the environment.

Keywords

Household types, Amazon, Ecuador, livelihoods, coffee, cocoa, sustainability

JEL classification

N56, Q12, Q24, Q56, Q57

1. Introduction

The modern use of the term livelihood is linked to the human and sustainable development policy discussions of the 1980s (Solesbury, 2003; Morse and McNamara, 2013; Scoones, 2015). It was proposed by researchers of the Institute of Development Studies at the University of Sussex as a concept to operationalize development, especially in rural and poor contexts, in which agricultural activities often prevailed. The early definitions of livelihoods were focused on food and money to meet basic needs, i.e., capabilities, assets and activities required for a means of living (Chambers, 1989; Chambers and Conway, 1992; WCED, 1987), within the framework of intentional approaches to development, which emerged out of the post-Second World War international political scenario (Cowen and Shenton, 1996, 1998).

These approaches to development, on which different livelihood strategies were originally based, have been largely criticized for different reasons, e.g., the ambiguity of the definition for development and a sort of implicit colonialism (Morse and McNamara, 2013), leading to a post-development movement focused on food sovereignty, among other things (Escobar, 1995, 2010). Thus, food and money seemed to be guaranteed by the increase in agricultural productivity experienced through the use of cheap energy sources, industrial production of chemical fertilizers and pesticides, and massive mechanization of agriculture (Tilman, 1999; Smil, 2000; Tilman et al., 2002, 2011). But the relationship between agricultural production, natural resources and development was more complex than expected, and the increased production by the "green revolution" could not cope with population growth. Thus, food production remained below the necessary levels and rural poverty did not disappear, while those productive activities that did succeed generated a significant impact on nature with serious health and environmental costs (Hartemink, 2005; Gomiero et al., 2011; Turner et al., 2011; Karp et al., 2012; Koohafkan et al., 2012).

As a consequence, the text of the Agenda 21 Action Plan, approved at the 1992 United Nations Conference on Environment and Development, held in Rio de Janeiro (Brazil), stated that everyone should have the opportunity to earn a sustainable livelihood. This widely popularized the Sustainable Livelihood Approach (SLA), i.e., the capabilities, assets and activities required for a means of living in a sustainable way, in other words, without compromising the productive properties of land or the surrounding ecosystems (Chambers and Conway, 1992; Scoones, 1998; Ashley and Carney, 1999; Carney, 1998, 2003). A framework was proposed (Carney, 1998; Scoones, 1998, 2015), in which different assets (natural, social, human, physical and economic) were assessed in terms of their vulnerability to perturbations (environmental, social, economic) and within a certain institutional context. Thus, livelihoods became a key topic of agricultural sustainability debates in pursuit of agricultural systems and practices contributing to sustainable livelihoods (Koohafkan et al., 2012; Velten et al., 2015). The SLA has been roundly criticized in four main ways (Scoones, 2009, 2015): first, its lack of engagement with global processes; second, its lack of attention to power and politics; third, its failure to deal with long-term environmental challenges, such as climate change; and lastly, its failure to cope with long-term shifts in rural economies and agrarian change.

The Northern Amazon region of Ecuador has been a good example of these phenomena. This region of Ecuador presents a complex fabric due to interactions between the oil industry, biodiversity, agricultural production and recent human settlements experiencing constant growth. In this context, smallholders (here, farmers with less than 3 ha of coffee and/or cocoa in production) needed to develop livelihood strategies for coping with production in an area lacking basic infrastructure, public services and access to international markets (Rosset et al., 2011).

Despite the fact that this area is endowed with vast quantities of natural resources (oil, biodiversity and water), the Ecuadorian Amazon performs poorly in terms of socio-economic indicators. This circumstance, together with the recent increase in population, has made its inhabitants strongly dependent on public subsidies and initiatives. The constitution of Ecuador provides provinces with significant decision-making autonomy, including the design and implementation of policies for local economic development. Despite the absence of the necessary technical expertise, while developing their political competences, provincial governments were engaged in policies that often lacked evaluation within their designs, which resulted in contradictory outcomes.

Furthermore, for many years, the slow expansion of formal institutions and the state has opened up the region to cooperation agencies and NGOs, deploying different programmes and projects centred on poverty alleviation, increasing revenues from farming and engaging in conservation activities. These activities often replicated development models from elsewhere without any contextualization, resulting in a systemic lack of cooperation between farmers (Viteri Salazar and Ramos-Martin, 2017).

A myriad of public and private interventions has taken place, with many institutions working at multiple levels (national, regional, provincial, local and community) with different approaches, leaving a mosaic of different production activities, practices and therefore outcomes, often without proper evaluation and clearly positive results. Many examples of this issue can be found. Thus, the promotion of oil palm in the province of Orellana led to a steady growth in the number of plantations as an outcome of subsidies resulting from policy intervention. The payment-for-ecosystem services (PES) scheme, known as *Socio Bosque*[1], in which smallholders receive an amount of money per hectare, which they allocate for nature conservation purposes, has covered some of the opportunity costs for settlers, but lacked any proper evaluation of its impact in terms of conservation. It makes it very difficult to inform decision makers on future policies aimed at guaranteeing the attainment of development, basic services and conservation.

In the last decade, new approaches, based on complexity and system theories, have been developed to deal with these challenges. Criteria such as resilience, lifestyles, internal (socio-economic) and external (environmental) constraints, purpose, agency and quality have been used to develop a framework, which includes societal metabolism applied to farming systems (Fischer-Kowalski, 1998; Fischer-Kowalski and Hüttler, 1998; Giampietro, 2003; Niehof, 2004; Morse and McNamara, 2013; Scheidel, 2013; Sorman and Giampietro, 2013; Ifejika Speranza et al., 2014; Lisocka-Jaegermann, 2015; Scoones, 2015; Gomiero, 2017; Sousa et al., 2017; Gerber and Scheidel, 2018).

[1] The *Socio Bosque* project has been run since 2010 by the Ministry of the Environment with several goals: conservation, CO_2 emission reduction (by land use changes and deforestation avoidance), carbon sequestration and improving smallholders' livelihoods. It establishes a maximum compensation of US$30/ha/year for untouched forest under a PES scheme (MAE, 2010).

This paper contributes to the SLA literature, as depicted above, by studying livelihood strategies developed by farmers in the Northern Amazon region of Ecuador as a case study and analysing the diversity of producers by using a typology of household farming systems according to their practices.

The main objective of this study is to contribute to the evaluation of agricultural production systems. This is done here by using a typology of four predominant production systems and comparing their performance against a set of indicators. A second objective is to inform decision makers about the differentiated outcomes these production systems have, so that tailored policy interventions can be designed based on the evaluation of past initiatives. In particular, this work focuses on: i) identifying the socio-economic and environmental restrictions implicit in different land use patterns; ii) analysing how different land use patterns improve livelihoods in terms of income; and iii) identifying how certain public policies can lead to the establishment of particular types or lifestyles, thereby generating an impact on the income of small-scale producers.

For this purpose, this paper is organized as follows. Section 2 illustrates the approach and theoretical basis on which the study is based. Section 3 describes the case study and the methods used. Section 4 presents the main results, which are discussed in Section 5, leaving the conclusions reached and the policy recommendations for the final section.

2. Case study and methods

2.1. Case study

The field work took place in the provinces of Orellana and Sucumbíos between 2011 and 2013. These two provinces represent a large fraction of the Northern Amazon region of Ecuador (Figure 1), occupying an area of 39,052 km^2 and accommodating a population of 125,922 inhabitants in rural areas, corresponding to 41% of the total population (GAPO, 2014; GADPS, 2015), and over 23,000 smallholder families (Viteri Salazar, 2013).

This region was one of the last to be opened up for colonization in the country. The 1964 Law of Agrarian Reform and Colonization (Viteri, 2007), together with severe droughts in the south of the country, and the beginning of oil exploration in the 1970s (Maldonado, 1979; Gondard and Mazurek, 2001), encouraged new settlements by colonists from different parts of Ecuador.

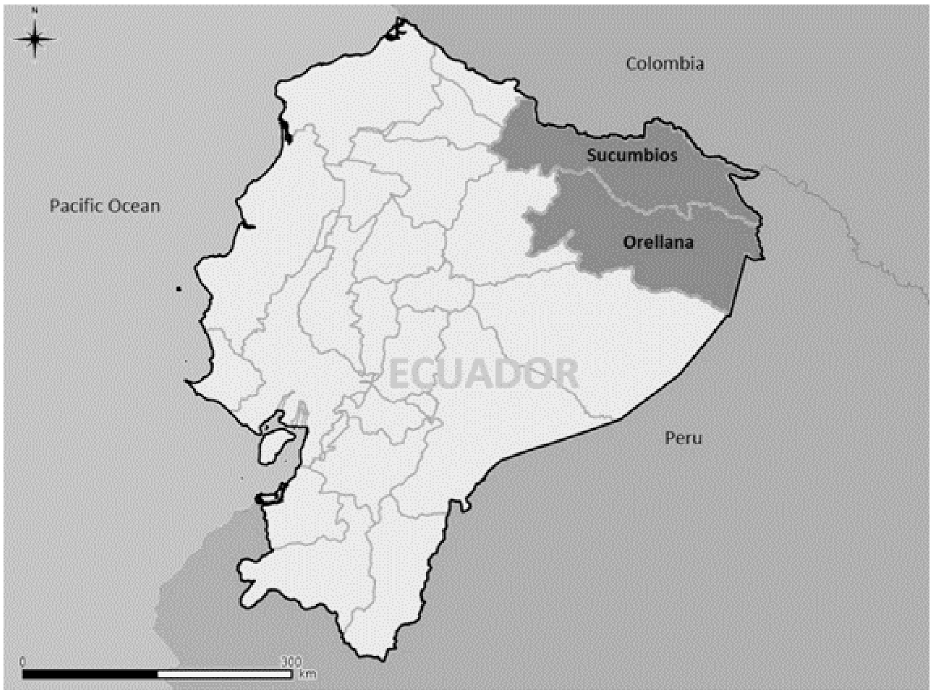

Figure 1. Study area in the Northern Amazon region of Ecuador, with Sucumbíos and Orellana provinces highlighted.

These new settlers began cultivating coffee and cocoa. Due to high prices on the markets[2], (Little, 1992; Eberhart, 1998) Robusta coffee (*Coffea canephora*) and national[3] cocoa (*Theobroma cacao*) became the predominant crops in the region, replacing primary forests. For decades, coffee and cocoa have

[2] For example, in 1977, the price of Robusta coffee was US$3.10/lb, while, in 2014, it was US$0.46/lb (ICO, 2016).

[3] Ecuador grows a unique variety of cocoa known as "national". This cocoa variety is characterized by its post-harvest processing, during which there is a short fermentation period, resulting in mild chocolate notes with rich flavour and aroma, which is known internationally as "fine aroma cocoa" (Quingaísa and Riveros, 2007).

been a source of employment and foreign currency, reaching almost 8% of non-petroleum exports of Ecuador (Proecuador, 2016).

Paradoxically, these provinces perform rather poorly in terms of socio-economic indicators: for example, the extreme poor comprised 40.8% of the total population in 2011, as opposed to the national average of 11.6% (INEC, 2012; GAPO, 2014; GADPS, 2015). The reasons are not fully understood, as the region has enormous resource endowments that benefit smallholders. Indeed, contrary to what happens in other regions of Ecuador and Latin America, where land concentration is the norm (Toledo, 2011), this region is characterized by a high distribution of land. The average size of farms is 34 ha (Table 2), compared to 50 ha 40 years ago, but higher than 20 ha, which is considered the optimal size for a household to generate income in the regional context (Viteri Salazar, 2013).

Figure 2 represents the land use share for the two provinces, based on the Agricultural Census of 2001 (unfortunately, this is the most recent one available), and secondary and primary data collected between 2002 and 2013. It can be seen that there is still a large fraction of forests, both in protected areas and on private property. The area allocated to pastures is larger than that for agricultural production. Land in production for coffee and cocoa represents less than 25% of the total land in production, but it is very important in terms of cultural and economic impacts.

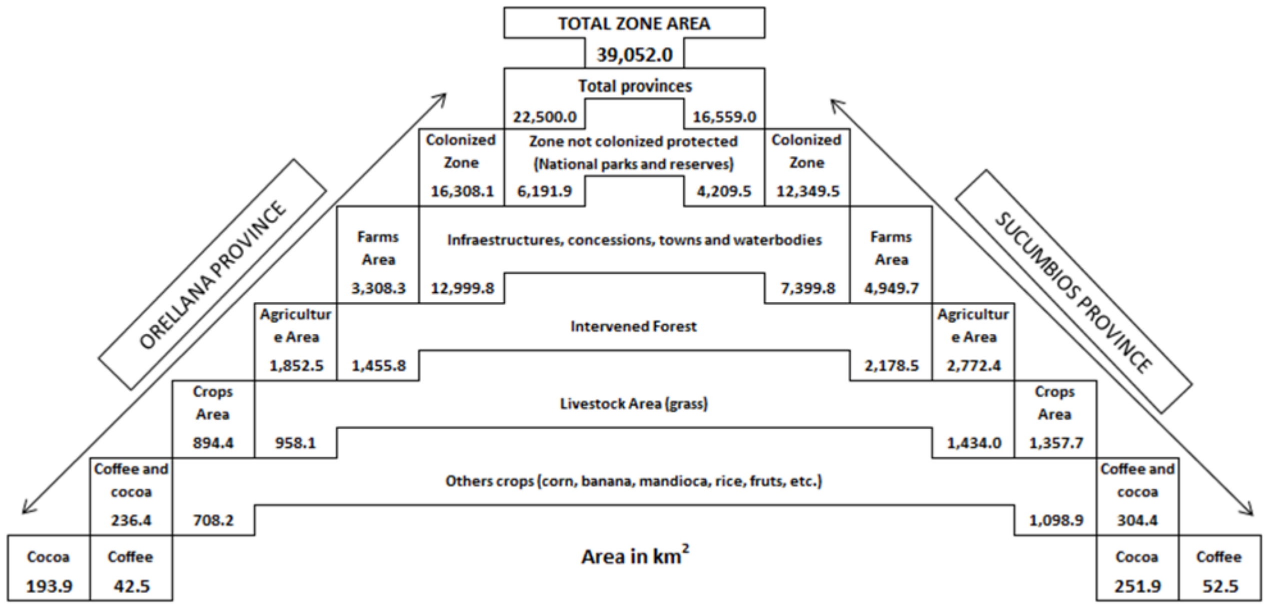

Figure 2. Land use distribution in the provinces of Orellana and Sucumbíos, Ecuador (area in km^2) for 2013. Source: Own elaboration based on data from the INCCA (2010), GAPO (2014), INEC (2015) and GADPS (2015).

Smallholders in this sector usually own around 30 ha, on which multiple land uses take place. Human activity is basically dedicated to agriculture, on their own land and as dayworkers. Land in production is just a fraction of total available land. A small area is used for production for both self-consumption and local markets (maize, cassava and fruits). However, most of the time, land *in production* is dedicated to coffee and cocoa production.

However, in recent years, large monocultures belonging to private firms (pastures, oil palm, and rubber) have been established. The short-term effect of the increasing intensification has been an expansion of the agricultural frontier, with pressure on previously non-colonized areas and a loss of biodiversity (Muchagata and Brown, 2000; Hartemink, 2005; Turner et al., 2011; Karp et al., 2012) .

2.2. Methodology

Agriculture is the main activity in the provinces of Orellana and Sucumbíos (in terms of people), involving the largest proportion of the economically active population (21.7%), out of a total population of 307,127 people (GAPO, 2014; GADPS, 2015; INEC, 2016).

In order to determine the universe of data, the database of the National Peasant Training Institute (INCCA)[4] was used (Table 1). Through a systematic probabilistic sampling (with a range of 254), 96 households were selected from a group of 24,360 households drawn from the INCCA registry of families, adjusted for the tendency towards the annual fractioning of farms. One of the difficulties faced by the study was the dispersion of families and the long distances between them, considering that each farm covers a surface of about 30 ha.

Table 1. Families' distribution in the study zone

Province	County	Families	Sample
Orellana	Francisco de Orellana	5,758	23
	Aguarico	338	1
	Joya de los Sachas	3,575	14
	Loreto	2,357	9
Sucumbíos	Cascales	1,087	4
	Cuyabeno	1,311	5
	Gonzalo Pizarro	844	3
	Lago Agrio	5,299	21
	Sucumbíos	9	0
	Putumayo	911	4
	Shushufindi	2,870	11
	Total	24,360	96

Source: Own elaboration based on the INCCA (2010) database.

The information used for the classification of households is mainly primary, i.e., the result of extensive fieldwork, which included visiting 96 households, and interviews with main smallholder leaders and government authorities (e.g., Director of the Ministry of Agriculture in the provinces,

[4] The Instituto Nacional de Capacitación Campesina (INCCA) is a public entity, which developed a programme of agricultural production reactivation in the period 2003-2011.

Director of the National Institute for Peasant Training and presidents of agricultural centres). Forty-nine households were located in the province of Sucumbíos, and 47 in the province of Orellana. Our sample was composed of 46% female and 54% male respondents, while 62% of the sample was of working age (between 15 and 65 years old). This information was combined with existing official and non-official information about productive practices, land use and sources of income.

Field work was conducted between late 2011 and early 2013. Farmers were visited on their own farms, where in-depth interviews were conducted and a broad questionnaire, to obtain social, economic, and environmental information, was issued. Considering the long distances between farms, spending between one and two days with each family was necessary. In terms of the social aspects, information about family composition, origin (native or settler), education level, health issues, basic services and other topics related to time usage was obtained, which was key to determining how much time they dedicated themselves to productive activities. The economic aspect was also important in determining the family economic structure, their income sources, and the way in which they spent this income from the farm (agricultural and livestock activities), off-farm income through renting out their labour, various enterprises that generate income, and subsidies from the government. Finally, the environmental aspect connected with land use was a fundamental variable as a criterion for the establishment of types, while information was also obtained about the amount of forest, crop area, crop rotations, crop management practices etc.

After collecting the data, a typology of households was established as a method of conceptualization and empirical analysis. Household types have been largely used as societal functional units of analysis within integrated assessments for rural systems (Pastore et al., 1999; Giampietro, 2003; Scheidel et al., 2013; Williams et al., 2015), as well as often employed to strengthen the focus of policies and interventions associated with rural livelihoods (Gomiero and Giampietro, 2001; Niehof and Price, 2001; Senthilkumar et al., 2009; Serrano-Tovar and Giampietro, 2014; Tittonell et al., 2010; Williams et al., 2015).

The characterization of types was made in terms of land use patterns and impacts upon the environment, whether through the use of synthetic inputs, the implementation of monocultures or the expansion of the agricultural frontier and the consequent reduction in the forested area. The classification of typologies was based on the technical data sheets suggested by the National Institute of Agricultural Research (Instituto Nacional de Investigaciones Agropecuarias), in terms of area, level of agrochemical use, crop combination, etc., with consideration given to these recommendations as thresholds.

One characteristic shared by the different types is the need for crops that guarantee a permanent inflow of cash. In all cases, apart from coffee and cocoa, there are "other crops" (plantain, maize, cassava, rice and fruit trees) that help in providing food security to households. The types defined include farmers who share at least one of the cash crops, as follows: Type 1 contains coffee and cocoa plantations (CC); Type 2 contains only cocoa cultivation (C); Type 3 comprises coffee, cocoa and oil palm plantations (CCP); and finally, Type 4 only has coffee farming (Cf).

Based on the expenditure on agricultural inputs (e.g., agrochemicals, tools), and following the work of Arizpe et al. (2011), thresholds for external input use were defined in the following way: low-input use (LIU) for those households with input expenditure below 10% of the average household income; medium-input use (MIU) for those with expenditure between 10 and 25% of the average income; and high-input use (HIU) for those households with more than 25% of their income allocated to inputs.

Subsidies provided by the central government were also accounted for as part of household income, such as: a) fossil fuels – LPG, diesel and gasoline, subsidies associated with redistribution policies from the central government concerning oil revenues from oil extraction activities in the region;

b) electricity, through the "dignity fare"[5], and c) through the human development bond[6]. Moreover, subsidies from agricultural development programmes were also estimated, which usually included tools, inputs, seeds and saplings. In order to fully account for income, a monetized figure for production for the self-consumption of "other crops" and "grass" (a valuable source of food products for households) was included.

Off-farm work was also accounted for as a source of income available to most households. The nexus between the farm and the environment results from the pressure that crops impose on the forest and the ecosystem services they provide. By the time the fieldwork was carried out, no single farmer was involved in any PES scheme, such as *Socio Bosque*.

3. Results

3.1. General characterization of household types

Table 2 characterizes household types and shows the area for the combination of crops, the number of households involved, the level of inputs used, as well as the required number of working days per hectare and per year. The diversity of crops found in the different households contributes to improving household self-consumption and, in some cases, generates income whenever there is a surplus.

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[5] A subsidy of US$0.05/kWh (from the official price of US$0.09 to US$0.04) for a monthly consumption of 110 kWh in the sierra regions and 130 kWh in the coastal regions, the Amazon and the Galapagos, for households in Quintiles 1 and 2, according to the National Institute of Statistics and Censuses (INEC).

[6] A subsidy for low-income households attached to certain obligations. In 2013, about two million households benefited from this subsidy. More information is available at http://www.mies.gob.ec/.

Table 2. Land use by household type

Type	General variables				Land use distribution of production, ha (average farm size = 33.9 ha)						
	% of producers	**Surface (ha)**	**No. of households**	**Input use**	**Coffee**	**Cocoa**	**Palm**	**Other crops**	**Grazing**	**Forest**	**Working days required: type/year/ha**
1. CC	60	29,462	14,616	MIU	0.5	1.5	0	5.4	9	17.5	52
2. C	32.2	20,928	7,849	MIU	0	2.7	0	2.9	9.4	18.9	39
3. CCP	4.4	10,869	1,083	HIU	0.7	1.8	7.8	15.7	6.8	1.4	46
4. Cf	3.3	1,092	812	LIU	1.3	0	0	6.8	1.8	24	88

Source: Own elaboration based on a survey and technical data sheets suggested by the National Institute of Agricultural Research (2008) and the database of the INCCA (2010).

Table 2 shows the predominance of cocoa combined with coffee. This combination may respond to a strategy of income diversification by trying to minimize the negative impact of both market price and production fluctuation upon household income. The number of smallholders producing only cocoa is 10 times more than for those producing coffee. This could be related to the labour requirement of each crop. While cocoa requires only 39 working days/ha/year, coffee is more labour-intensive, requiring 88 working days/ha/year, especially during the harvesting phase, in which only red beans are picked, ensuring uniformity in the quality of the coffee harvested.

Furthermore, Tables 3 to 6 present a comprehensive economic account of income, expenditures[7] and surplus for each household type.

Table 3. Farm income per activity per month (US$)

Type	**Agricultural production**									**Livestock**	**Total**
	Coffee	**Cocoa**	**Palm**	**Cassava**	**Maize**	**Rice**	**Plantain**	**Fruits**	**Wood**	**Animals**	
1. CC	32.3	67.7	0.0	6.8	24.0	2.7	24.8	4.9	12.1	63.8	**239**
2. C	0.0	96.4	0.0	4.9	16.8	4.4	9.4	0.3	1.8	125.5	**260**
3. CCP	22.0	60.0	775.0	28.5	20.0	0.0	0.0	45.0	0.0	103.8	**1,054**
4. Cf	13.9	0.0	0.0	11.1	33.3	0.0	11.1	0.0	100.0	0.0	**170**

Source: Own elaboration based on data collected by survey.

[7] Various education expenses are covered by the state: public education is free and includes the provision of uniforms, books and school breakfast (for more information, see: https://educacion.gob.ec/gratuidad-de-la-educacion-publica/).

Table 4. Income by source per month (US$)

Type	Farm activities	Self-consumption	Off-farm activities			Subsidies	Total
			Dayworker	Business	Other		
1. CC	239.0	66.6	74.0	36.4	65.3	47.0	**528**
2. C	259.6		125.3	13.8	24.3		**537**
3. CCP	1,054.3		0.0	41.5	150.0		**1,360**
4. Cf	169.4		156.4	0.0	0.0		**440**

Source: Own elaboration based on data collected by survey and subsidies provided by the government.

Table 5. Expenditures per month (US$)

Type	Goods				Services				Other	Total
	Food	Medicines	Clothes	Agricultural inputs	Telephone	Transport	Gas	Electricity		
1. CC	250.7	28.2	22.4	80.3	11.6	29.9	4.6	11.3	16.0	**455**
2. C	214.0	27.9	16.2	82.9	7.2	25.6	3.8	8.4	32.9	**419**
3. CCP	251.6	18.5	19.3	867.5	7.5	10.5	3.9	12.5	23.5	**1,214**
4. Cf	166.6	10.0	46.7	2.0	3.7	30.3	3.2	8.3	46.7	**317**

Source: Own elaboration based on data collected by survey.

Table 6. Surplus by household type per month (US$)

Type	Income	Expenditure	Surplus
1. CC	528	455	73
2. C	537	419	118
3. CCP	1,359	1,215	144
4. Cf	439	317	122

Source: Own elaboration based on data collected by survey.

The economic activity shown in the tables above links land use with the market as a source of income through the selling of agricultural (i.e., coffee, cocoa, plantain, maize, cassava, rice) and animal (i.e., hens, milk, eggs) products.

With the goal of understanding whether income level is high or low, these values have been compared to the Cost of the Household Basic Basket (CHBB)[8], as defined by the central government (INEC, 2014). In addition, the types have been framed by indicators with intensive variables, which allows for a better discussion of the results. The performance of the four types is compared in terms of the number of households meeting the CHBB level, the surplus generated, the expenditure on inputs, the surface of forest that is conserved and the labour requirement. Table 7 presents the number of households that would be supported for every 1,000 ha across every type, with the restriction of being able to cover 100% of the CHBB.

Table 7. Indicators per 1,000 ha

Type	No. of households meeting 100% of CHBB*	Surplus (US$)	Expenditure on inputs (US$)	% of forest	Required working time (dayworker/year)
1. CC	26	1,661	2,369	51.7	2,696
2. C	25	2,618	2,447	55.9	2,655
3. CCP	68	4,266	25,590	4.1	31,456
4. Cf	20	2,535	59	70.8	2,389

[8] The Household Basic Basket refers to the products that a four-member household requires to satisfy their needs. The INEC (2014) uses this 'basket' for the calculation of inflation.

Source: Own elaboration based on survey. (** Project Cost of the Household Basic Basket.)*

In the following paragraphs, the different types are described according to these characteristics.

3.2. Type 1: Coffee and cocoa producers

According to our study, 14,616 families belong to this type (Table 2), producing Robusta coffee and cocoa (National and CCN51[9]). This land use pattern generates around US$100 of income every month, while "other crops" (about 5 ha) are responsible for a fraction of production for self-consumption purposes and generate about US$64 of extra cash by selling surplus products at the market. 9 ha of pasture are mainly used for subsistence stockbreeding and, to a lesser extent, for the market, generating US$25/month. However, this type expends about US$80 on agro-inputs (falling under the MIU type). Finally, the rest of the farm contains about 18 ha of forest, which produces some wood for the household and some for the market (about US$12/month). Forests are also important because they act as savings for the household and are a valuable source of animal protein (game and fish).

This type produces coffee and cocoa in a 3:1 proportion. In order to adequately attend to this combination of crops, 104 working days/year (832 h) would be needed. However, they only allocate half that amount, generating an income flow of about US$1,200/year. Taking into account that the wage for a working day is US$13, households make 60% more in gross terms (without deducting input expenditures), or US$23.1/working day. This apparent positive cash flow is also rewarded by an increase in self-esteem implied by generating income on their own farm. The total monthly income for

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[9] In 1965, the Ecuadorian researcher Homero Castro developed a cocoa clone from the double hybridization of genetic material from the *Trinitario* and *Forastero* varieties of Amazonian origin (CCN51). This is resistant to fungal diseases and gives high yields (International Plant Nutrition Institute, 2014).

this type goes up to US$528.3, which equates to 84% of the CHBB, i.e., US$628.3 according to the INEC (2014). Off-farm activities provide for 30% of household income. Despite these characteristics, this type is the one with a lower surplus, i.e., only US$73.4.

3.3. Type 2: Cocoa-only producers

This household type includes 32% of families and covers 47% of the cocoa cultivated in the area. It has been subject to many public and private aid programmes. Every smallholder has 2.7 ha of cocoa, with only 200 kg of dry cocoa/ha/year, a yield well below the potential. The income generated is US$96.4/month, while the peak of production falls between March and July, during which more cash is available. Combining self-production and sales from other crops brings an extra US$154.8 from using 12.3 ha. In relative terms, income generated by the production of cocoa is higher than that of other crops and pastures. Off-farm income is also 30% of total income, which is higher than that reported for cocoa. Total income amounts to US$536.6, equivalent to 85% of the CHBB, almost the same as Type 1. However, the remaining surplus is higher at US$117.7, i.e., 60% above Type 1.

Families allocate 52 working days/year, equivalent to an income of US$22.2/working day. This type has more expenditure on inputs, falling under the MIU type. On the other hand, the surface occupied by forests is more than half of the farm (19 ha), providing for fish, game, wood and firewood, an alternative to LPG.

3.4. Type 3: Coffee, cocoa and palm producers

Type 3 adds oil palm to coffee and cocoa production as a cash crop. These farmers are located mainly in the province of Orellana, as the provincial government has encouraged this crop in recent years. Around 8,000 ha (30% of total oil palm cultivation) belongs to smallholders. A majority of the surface corresponds to young plantations (four to eight years), which have not reached their peak production as yet.

The average coffee and cocoa land plot is about 2.3 ha, while the oil palm average is 7.8 ha, generating a combined monthly income of US$857. This level of income is apparently high, although it involves HIU use. More than half of the farm is cultivated intensively with other crops, implying that the area left to forests is residual. Therefore, the environmental impact of this type is higher.

Off-farm income comes from renting vehicles or machinery, or from trade. This household type demands high amounts of labour. Under optimal conditions, it would demand 460 working days/year. Although the income level is high, the level of input requirements is also high. This situation may change in the near future when plantations reach their peak yield.

3.5. Type 4: Coffee-only producers

This household type shows lower levels of land use. Coffee uses a reduced surface of only 1.3 ha of average land with old or low-quality plantations, which generate only US$14/month, complementing income from other crops. There is no use of inputs, so they fall into the LIU category. Under optimal conditions, they would need 118 working days/year; however, less than a half is allocated, resulting in a very low profitability. While these smallholders would double their income if they worked off-farm instead of producing coffee, off-farm alternatives are scarce and restricted to dayworkers, with coffee being a cultural issue for them as an acculturation effect from the 1970s, resulting from colonization where the coffee crop was introduced as a generator of economic income (Little, 1992).

The low-income level makes other crops crucial in terms of self-consumption, as well as for generating some extra cash equivalent to US$55 by using an average of 6.8 ha. Total income (once production for self-consumption is monetized) amounts to US$439.5, the lowest of all types, equating to only 70% of CHBB. On the other hand, given that the land use is less intensive, forest occupies 75%

of the land, thus becoming the second source of income, after off-farm work, providing 25% of the total income.

3.6. Economic and environmental effects of agrochemicals

The expenditure on agricultural inputs (Table 5) is strongly associated with agrochemicals, which play a relevant role in both environmental and economic terms, as there seems to be an overuse that has impacts upon the environment and household budgets, as shown above.

The interviewed smallholders and leaders stated that the increase in the use of agrochemicals experienced in recent decades is related to the strong incidence of sales agents in the region, who introduce themselves as "advisers", while delivering biased analyses with a lack of control over dosages. They also state that it is due to new cultivation practices, which are increasingly aligned with monocultures practised widely in other areas of the country. These forms of cultivation are opposed to agro-ecology or to the chakra system[10], which has traditionally been practised in the area and shown to have an attribute of resilience against the attack of pests and diseases.

Agroforestry systems also present advantages in terms of erosion control, timber, food, income, medicines, fuel and soil improvement (Altieri and Nicolls, 2000; Dawson, 2014). Shade-grown agriculture, in both primary and secondary forests, represents an interesting alternative, which makes agricultural production compatible with biodiversity conservation (Purseglove, 1968; Young, 1994; Perfecto et al., 1996; Beer et al., 1997; Belsky and Siebert, 2003). However, this activity is also under pressure from markets, climate change and pests (Belsky and Siebert, 2003), in a context in which

[10] The chakra system corresponds to a combination of more than 180 species and varieties of plants, which allows growers to guarantee food availability (e.g., banana, cassava), medicinal plants, wood and cash crops, such as coffee and cocoa (Gasché, 2007; GIZ, 2013). The practice of agroforestry or chakra systems, which represents a Kichwa rural family agriculture system, constitutes an alternative that could make these productive systems more sustainable and profitable, implying alternative sources of income (Ferguson et al., 2009) and guaranteeing food security, while improving the families' nutrition (Rennie, 1991; Arzeno, Deheza, Muñecas and Zanotti, 2015).

smallholders are placed at the beginning of the value chain, resulting in more risks and less income (Díaz et al., 2009; Blackman and Naranjo, 2012).

The main agrochemicals used in the region are herbicides, followed by insecticides, fungicides and fertilizers. This has a strong relation with the prevailing climate in the area, where an average rainfall of 3,156 mm/year is recorded, distributed over 250 days/year, and with an average temperature of 26ºC (INAMHI, 2016), i.e., conditions which favour the growth of weeds and the appearance of pests and diseases.

For Types 1 and 2, they represent a significant share of household expenditure, at about 15%. Despite these practices, the use of agrochemicals is still low in the region, as in the case of Type 4 LIU, which also probably relates to budget restrictions; this is except for Type 3 (oil palm plantations) HIU, which presents agro-industrial characteristics.

Due to the lack of instructions in the use of agrochemicals, the practices for oil palm plantations are being replicated for other crops. This has a double-negative effect in economic terms for smallholders as it increases production costs, while, in environmental terms, it increases pollution for no reason.

4. Discussion

Income from coffee and cocoa production represents about 19% of total household income for Types 1 and 2 despite their low yield, whereas it is only 8% for Types 3 and 4. Type 3 earns more from other crops and oil palm, while Type 4 receives the most from off-farm work, although production at the farm still plays a cultural and environmental role.

Under these circumstances, Type 4 performs very well in environmental terms (LIU and 24 ha of forest) and is very close to Type 2 in economic terms. Hence, there is a need to increase income via improving some agricultural practices (e.g., pruning), selecting plants and particularly changing to commercialization, thus making it possible for smallholders to move up the value chain. Unless measures supporting productive activity of this type are implemented, a shift towards Types 1 and 2 could be expected, or even worse towards Type 3 by means of selling or renting their land.

The analysis of the surplus generated by each type helps in identifying the reasons why households have chosen different productive patterns. It can be seen how cocoa has gradually replaced the cultivation of coffee. According to the Third National Agricultural Census (2000), 49,389 ha of coffee and 7,751 ha of cocoa were present in the area, while, according to our study, there were 44,580 ha of cocoa and 9,500 ha of coffee in 2013 (Figure 2). This is consistent with our results, as Type 2 has a higher surplus than Type 1, which has the lowest surplus of all and depends largely on off-farm work for guaranteeing livelihood. Until 10 years ago, large-scale landowners dominated oil palm plantations. Only recently have smallholders engaged in oil palm production, thus giving rise to Type 3. Despite the fact that plantations are still young (four to eight years), they already show the highest surplus (US$144.63); however, from an environmental point of view, they are the least interesting of all, because they involve a HIU, with forest only covering 4% of land, and the number of families that have benefited from that is very low (4.5%). One can understand why private enterprises and even the central government are interested in this type (profits, but also greater GDP and taxes). However, this type also represents more environmental impacts and a greater degree of dependency for the households (a large fraction of their income is expended in buying agrochemicals from the very same intermediaries who are commercializing palm oil). These reasons do not make this type, in our view, an option for future development.

5. Conclusions and policy recommendations

Creating types for an analytical case study in one of the most important areas of the Ecuadorian Amazon, with highly biodiverse ecosystems and significant forest cover, allows for visualizing different land use patterns linked to economic resource generation as a means of subsistence. This behaviour is strongly linked to public policies being developed in the sector, where it is believed that oil palm monocultures could be a better alternative revenue source for farmers. However, as shown in Types 2 and 4, its utility is very similar to Type 3 (oil palm), but with a much lower dependence on intensive agrochemical use in the case of Type 2 and a practically null value in Type 4, which hardly uses agrochemical inputs. The differentiated performance of types should encourage the design of tailored interventions to address the problems encountered by each of them, promoting those types with less environmental impact, but which still provide the necessary means for livelihoods and incentives for the conversion of the types with more impact.

One example of public policy that could be informed by these results is the PES scheme *Socio Bosque*, run by the government. The current participation rate would probably benefit if it accepted applications to the programme from farmers with 'under the shadow' coffee and cocoa crops (shadow of at least 30-40%) or involved in the chakra system who have engaged in organic certification programmes. In this way, the programme would not only provide incentives for smallholders to maintain primary forests, but also increase revenues from sustainably grown coffee and cocoa, guaranteeing conservation along with improving livelihoods for smallholders.

The increased income from oil royalties (e.g., the forthcoming Organic Law of the Amazon Special Territorial Circumscription includes setting up a development fund with such royalties) could be oriented towards policies that diversify and increase household income, for instance, by encouraging associative work in cooperatives, processing coffee and cocoa to add value to production, or by engaging in new activities such as agrotourism, making households more resilient in the face of evolving international prices for coffee and cocoa and seasonality.

The intensity of land use, marked in large part by the expansion of the agricultural frontier and the reduction in forest cover on farms, is much lower in Type 4 than in the other types, making this form of production more desirable in environmental terms. However, this type shows a limitation in terms of income generation, as nearly 35% of its income comes from off-farm work performed by dayworkers. This aspect is important to consider in the development of agricultural programmes oriented toward jump-starting production, where time dedicated by farmers is an important variable, since this type would not have any time restrictions when either adopting a more labour-intensive agricultural practice or expanding the agricultural frontier. In contrast, Type 4 reflects the practical impossibility of adding crops to a farm, since agricultural use of the available land surface is found to be at 96% capacity.

Identifying the land use and economic income corresponding to types has also revealed the fact that Type 2 represents the lowest labour demand per hectare, an aspect that could be useful for pushing programmes focused on cocoa production, in which labour availability, on the one hand, and profitability per hectare for cocoa and coffee, on the other, should be analysed.

It is pertinent to analyse the amount of economic income that each type can generate, as well as how each one contributes to food provision for the family, thus reducing the risk of dependence on foods acquired from outside the farm.

There are still many aspects to investigate, especially in connection with the effects of agricultural programmes that intervene in the determination of cultivation patterns; there are such programmes that will finish in 2021 and surely modify forms of production. The use of a typology can be useful, for example, when analysing cultural factors of production. At the moment, a research project is being set up to establish two sets of types, one corresponding to the native farmers in the respective area, with chakra-style farming based on ancestral practices and quasi-organic production, and the other with colonist producers, many using typical practices of the green revolution.

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References

Altieri, M., Nicholls, C., 2000. Teoría y práctica para una agricultura sustentable. PNUMA, México.

Arizpe, N., Giampietro, M., Ramos-Martin, J., 2011. Food security and fossil energy dependence: an international comparison of the use of fossil energy in agriculture (1991-2003). Crit. Rev. Plant Sci. 30, 1–2. http://dx.doi.org/10.1080/07352689.2011.554352. 45-63.

Arzeno, M., Deheza, R. d., Muñecas, L., Zanotti, A., 2015. Discusiones en torno a las políticas públicas para la soberanía alimentaria y la agricultura familiar en Misiones (Argentina). Mundo Agrar. 16 (32).

Ashley, C., Carney, D., 1999. Sustainable Livelihoods: Lessons from Early Experience. Department for International Development, London.

Beer, J., Muschler, R., Kass, D., Somarriba, E., 1997. Shade management in coffee and cacao plantations. Agrofor. Syst. 38, 139–164. http://dx.doi.org/10.1023/A:1005956528316.

Belsky, J., Siebert, S., 2003. Cultivating cacao: implications of sun-grown cacao on local food security and environmental sustainability. Agric. Hum. Val. 20, 277–285.

Blackman, A., Naranjo, M., 2012. Does eco-certification have environmental benefits? Organic coffee in Costa Rica. Ecol. Econ. 58–66. http://dx.doi.org/10.1016/j.ecolecon.2012.08.001.

Carney, D., 2003. Sustainable Livelihoods Approaches: Progress and Possibilities for Change. Department for International Development, London, UK.

Carney, D., 1998. Sustainable rural livelihoods: what contribution can we make? In: Department for International Development's Natural Resources Advisers' Conference. Department for International Development (DFID).

Chambers, R., 1989. Editorial introduction: vulnerability, coping and policy. IDS Bull. 20, 1–7.

Chambers, R., Conway, G., 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st century, IDS Discussion Papers, 296. Institute of Development Studies, Brighton, UK.

Cowen, M., Shenton, R.W., 1996. Doctrines of Development. Routledge.

Cowen, M.P., Shenton, R.W., 1998. Agrarian doctrines of development: Part I. J. Peasant Stud. 25, 49–76. http://dx.doi.org/10.1080/03066159808438666.

Dawson, I., Leakey, R., Clement, C., Weber, J., Cornelius, J., Roshetko, J., Jamnadass, R., 2014. The management of tree genetic resources and the livelihoods of rural communities in the tropics: non-timber forest products, smallholder agro forestry practices and tree commodity crops. Forest Ecol. Manag. 9–21. http://dx.doi.org/10.1016/j.foreco.2014.01.021.

Díaz, R., Eakin, H., Castellanos, E., Jiménez, G., 2009. Condiciones para la adaptación de los pequeños productores de café ante presiones económicas mediante procesos de "upgrading" en la cadena productiva. Rev. Iberoam. Econ. Ecológica 10, 61–72.

Eberhart, N., 1998. Transformaciones Agrarias en el Frente de Colonización de la Amazonía Ecuatoriana. Ediciones Abya-Yala, Quito.

Escobar, A., 2010. Latin America at a crossroads. Cult. Stud. 24, 1–65. http://dx.doi.org/10.1080/09502380903424208.

Escobar, A., 1995. Imagining a post-development era. In: Crush, J. (Ed.), Power of Development. Routledge London, pp. 211–227.

Ferguson, G.G., Morales, H., González Rojas, A., Íñiguez Pérez, F., Martínez Torres, M.E., McAfee, K., Nigh, R., Perfecto, I., Philpott, S.M., Soto Pinto, L., Vandermeer, J., Vidal, R.M., Ávila Romero, L.E., Bernardino, H., Realpozo Reyes, R., 2009. La soberanía alimentaria: Cultivando nuevas alianzas entre campo, bosque y ciudad. Agroecología 4, 49–58.

Fischer-Kowalski, M., 1998. Society's metabolism. The intellectual history of materials flow analysis, Part I, 1860– 1970. J. Ind. Ecol. 2, 61–78. http://dx.doi.org/10.1162/jiec.1998.2.1.61.

Fischer-Kowalski, M., Hüttler, W., 1998. Society's metabolism. The intellectual history of materials flow analysis, Part II, 1970-1 998. J. Ind. Ecol. 2, 107–136. http://dx.doi.org/10.1162/jiec.1998.2.4.107.

GADPS, 2015. Actualización Plan de Desarrollo y Ordenamiento Territorial. Gobierno Autónomo Descentralizado de la Provincia de Sucumbíos, Nueva Loja.

GAPO, 2014. Plan de Desarrollo y Ordenamiento Territorial de la provincia de Orellana 2014-2019. Gobierno Autónomo Descentralizado de la Provincia de Orellana, Francisco de Orellana.

Gasché, J., 2006. La horticultura indígena amazónica. Ciencias V 81, 50–57.

Gerber, J.-F., Scheidel, A., 2018. In search of substantive economics: comparing Today's two major socio-metabolic approaches to the economy – MEFA and MuSIASEM. Ecol. Econ. 144, 186–194. http://dx.doi.org/10.1016/j.ecolecon.2017.08.012.

Giampietro, M., 2003. Multi-scale Integrated Analysis of Agroecosystems. CRC Press, Boca Raton, FL, USA.

GIZ, 2013. La Chakra Kichwa. Criterios para la conservación y fomento de un sistema de producción sostenible en la Asociación KALLARI y sus organizaciones socias. Deutsche Gesellschaft für Internationale Zusammenarbeit, Quito.

Gomiero, T., 2017. Agriculture and degrowth: state of the art and assessment of organic and biotech-based agriculture from a degrowth perspective. J. Clean. Prod. http://dx.doi.org/10.1016/j.jclepro.2017.03.237.

Gomiero, T., Giampietro, M., 2001. Multiple-scale integrated analysis of farming systems: the Thuong Lo Commune (Vietnamese uplands) case study. Popul. Environ. 22, 315–352. http://dx.doi.org/10.1023/A:1026624630569.

Gomiero, T., Pimentel, D., Paoletti, M.G., 2011. Is there a need for a more sustainable agriculture? CRC Crit. Rev. Plant Sci. 30, 6–23. http://dx.doi.org/10.1080/07352689.2011.553515.

Gondard, P., Mazurek, H., 2001. 30 Años de reforma Agraria y Colonización en el Ecuador (1964 -1994). Estud. Geográficos 10, 15–40.

Hartemink, A.E., 2005. Plantation agriculture in the tropics: environmental issues. Outlook Agric. http://dx.doi.org/10.5367/0000000053295150.

ICO, 2016. Historical Data on the Global Coffe Trade. International Coffee Organization [WWW Document].

Ifejika Speranza, C., Wiesmann, U., Rist, S., 2014. An indicator framework for assessing livelihood resilience in the context of social–ecological dynamics. Global Environ. Change 28, 109–119. http://dx.doi.org/10.1016/j.gloenvcha.2014.06.005.

INAMHI, 2016. Boletín meteorológico anual. Instituto Nacional de Meteorología e Hidrología. INCCA, 2010. Base de datos beneficiarios del PROERA. Quito.

INEC, 2014. IPC - Canastas 2014. Ecuador en cifras, Quito [WWW Document].

INEC, 2016. Resultados del Censo 2010 de población y vivienda. Instituto Nacional de Estadísticas y Censos, Quito.

International Plant Nutrition Institute, 2014. Manejo de sitio específico de cacao. [WWW Document].

Karp, D.S., Rominger, A.J., Zook, J., Ranganathan, J., Ehrlich, P.R., Daily, G.C., 2012. Intensive agriculture erodes β-diversity at large scales. Ecol. Lett. 15, 963–970. http://dx.doi.org/10.1111/j.1461-0248.2012.01815.x.

Koohafkan, P., Altieri, M.A., Gimenez, E.H., 2012. Green Agriculture: foundations for biodiverse, resilient and productive agricultural systems. Int. J. Agric. Sustain. 10, 61–75. http://dx.doi.org/10.1080/14735903.2011.610206.

Lisocka-Jaegermann, B., 2015. Sustainable rural development or (sustainable) rural Livelihoods? Strategies for the 21st century in peripheral regions. Barom. Reg. Anal. i prognozy 1, 13–20.

Little, P., 1992. Amazonia: Territorial Struggles on Perennial Frontiers. The Johns Hopkins University Press, Baltimore.

MAE, 2010. Programa Socio Bosque: Ministerio del Ambiente.

Maldonado, G., 1979. La reforma Agraria en el Ecuador, una lucha por la justicia. Nueva Sociedad 14–29.

Morse, S., McNamara, N., 2013. Sustainable Livelihood Approach: a Critique of Theory and Practice. Springer, Dordrecht, The Netherlands.

Muchagata, M., Brown, K., 2000. Colonist farmers' perceptions of fertility and the frontier environment in eastern Amazonia. Agric. Hum. Val. 17, 371–384. http://dx.doi.org/10.1023/A:1026531913099.

Niehof, A., 2004. The significance of diversification for rural livelihood systems. Food Pol. 29, 321–338. http://dx.doi.org/10.1016/j.foodpol.2004.07.009.

Niehof, A., Price, L., 2001. Rural Livelihood Systems: a Conceptual Framework. (No. UPWARD Working Paper, 5). Wu-UPWARD, Wageningen, The Netherlands.

Pastore, G., Giampietro, M., Ji, L., 1999. Conventional and Land-time budget analysis of rural villages in Hubei Province, China. Crit. Rev. Plant Sci. 18, 331–357.

Perfecto, I., Rice, R.A., Greenberg, R., van der Voort, M.E., 1996. Shade coffee: a disappearing refuge for biodiversity. Bioscience 46, 598–608. http://dx.doi.org/10.2307/1312989.

Proecuador, 2016. Boletines mensuales de comercio exterior. ISSN 1390–812X.

Purseglove, J., 1968. Tropical Crops: Dicotyledons. Longman, Harlow.

Quingaísa, E., Riveros, H., 2007. Estudio de Caso: Denominación de Orígen "Cacao Arriba." Quito.

Rennie, S., 1991. Subsistence agriculture versus cash cropping- the social repercussions. J. Rural Stud. 5–9.

Rosset, P.M., Machín Sosa, B., Roque Jaime, A.M., Ávila Lozano, D.R., 2011. The Campesino -to- Campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty. J. Peasant Stud. 38, 161–191. http://dx.doi.org/10.1080/03066150.2010.538584.

Scheidel, A., 2013. New Challenges in Rural Development: a Multi-scale Inquiry into Emerging Issues, Posed by the Global Land rush. Universitat Autònoma de Barcelona (UAB), Cerdanyola del Vallès, Barcelona, Spain.

Scheidel, A., Giampietro, M., Ramos-Martin, J., 2013. Self-sufficiency or surplus: conflicting local and national rural development goals in Cambodia. Land Use Pol. 34, 342–352.

Scoones, I., 2015. Sustainable Livelihoods and Rural Development. Practical Action Publishing, UK.

Scoones, I., 2009. Livelihoods perspectives and rural development. J. Peasant Stud. 36, 171–196.

Scoones, I., 1998. Sustainable Rural Livelihoods: a Framework for Analysis, IDS Working Paper, 72. Institute of Development Studies, Brighton, UK.

Senthilkumar, K., Bindraban, P.S., de Boer, W., de Ridder, N., Thiyagarajan, T.M., Giller, K.E., 2009. Characterising rice-based farming systems to identify opportunities for adopting water efficient cultivation methods in Tamil Nadu, India. Agric. Water Manag. 96, 1851–1860. http://dx.doi.org/10.1016/j.agwat.2009.08.007.

Serrano-Tovar, T., Giampietro, M., 2014. Multi-scale integrated analysis of rural Laos: studying metabolic patterns of land uses across different levels and scales. Land Use Pol. 36, 155–170.

Smil, V., 2000. Feeding the World : a challenge for the Twenty-first century. MIT Press.

Solesbury, W., 2003. Sustainable Livelihoods: a Case Study of the Evolution of DFID Policy. Overseas Development Institute London, London, UK.

Sorman, A.H., Giampietro, M., 2013. The energetic metabolism of societies and the degrowth paradigm: analyzing biophysical constraints and realities. J. Clean. Prod. 38, 80–93.

Sousa, T., Brockway, P.E., Cullen, J.M., Henriques, S.T., Miller, J., Serrenho, A.C., Domingos, T., 2017. The need for robust, consistent methods in societal exergy accounting. Ecol. Econ. 141, 11–21. http://dx.doi.org/10.1016/j.ecolecon.2017.05.020.

Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011. Global food demand and the sustainable intensification of agriculture. Proc. Natl. Acad. Sci. Unit. States Am. 108, 20260–20264. http://dx.doi.org/10.1073/pnas.1116437108.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418, 671–677. http://dx.doi.org/10.1038/nature01014.

Tilman, D.D., 1999. Global environmental impacts of agricultural expansion: the need for sustainable and efficient practices. Proc. Natl. Acad. Sci. Unit. States Am. 96, 5995.

Tittonell, P., Muriuki, A., Shepherd, K.D., Mugendi, D., Kaizzi, K.C., Okeyo, J., Verchot, L., Coe, R., Vanlauwe, B., 2010. The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa – a typology of smallholder farms. Agric. Syst. 103, 83–97. http://dx.doi.org/10.1016/j.agsy.2009.10.001.

Toledo, V., 2011. La agroecología en Latinoamérica: tres revoluciones, una misma transformación. Agroecologí 6, 37–46.

Turner, E.C., Snaddon, J.L., Ewers, R.M., Fayle, T.M., Foster, W.a., 2011. The impact of oil palm expansion on environmental Change: putting conservation research in context. Environ. Impact. Biofuels 19–40. http://dx.doi.org/10.5772/960.

Velten, S., Leventon, J., Jager, N., Newig, J., 2015. What is sustainable Agriculture? A systematic review. Sustainability 7, 7833–7865. http://dx.doi.org/10.3390/su7067833.

Viteri, G., 2007. Reforma Agraria en el Ecuador. EUMED, Quito.

Viteri Salazar, O., 2013. Evaluación de la sostenibilidad de los cultivos de café y cacao en las provincias de Orellana y Sucumbíos - Ecuador. Universitat Autònoma de Barcelona.

Viteri Salazar, O., Ramos-Martin, J., 2017. Organizational Structure and Commercialization of Coffee and cocoa in the Northern Amazon Region of Ecuador. Rev. NERA. Núcleo Estud. Pesqui. e Proj. Reforma Agrária, pp. 266–287.

WCED, 1987. Food 2000 ;: Global Policies for Sustainable Agriculture. Zed Books, London, UK.

Williams, L.J., Afroz, S., Brown, P.R., Chialue, L., Grünbühel, C.M., Jakimow, T., Khan, I., Minea, M., Reddy, V.R., Sacklokham, S., Santoyo Rio, E., Soeun, M., Tallapragada, C., Tom, S., Roth, C.H., 2015. Household types as a tool to understand adaptive capacity: case studies from Cambodia, Lao PDR, Bangladesh and India. Clim. Dev. 1–12. http://dx.doi.org/10.1080/17565529.2015.1085362.

Young, A., 1994. The Chocolate Tree. Smithsonian Institution Press, Washington DC.