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Forest Use and Agriculture in Ucayali, Peruvian Amazon: Interactions Among Livelihood Strategies, Income and Environmental Outcomes

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ABSTRACT Findings from a survey on sources of income and land allocation outcomes of 578 households from 26 communities with diverse ethnic composition at distinct environmental settings in Ucayali (Peruvian Amazon) are used to contrast livelihood strategies featuring high forest and high agriculture dependency, examining whether agricultural intensification can be linked to lower deforestation. A typology of households based on their land use allocation profile was used to assess current and cumulative cleared land. Recently cleared areas by households oriented to perennials, semi-perennials and pastures were similar to those focusing on annual crops. Multiple class comparisons provided evidence that land use intensification is not associated to land sparing. Near 40% of the households' annual income was derived from forests, followed by agriculture (25%), wages (17%) and livestock (11%). Income structure was used to determine high dependency on forests and on agriculture, featured by respectively 24% and 17% of the households, while 10% relied mostly on wages and/or businesses and half of them had a balanced income structure. Results indicate different expressions of the criticality of forest products, highlighting livelihood strategies based on the integration of income sources. Moreover, the study shows that despite the relevance of forest products, mestizo and indigenous livelihoods heavily depend on agriculture. Policy interventions aimed at environmental conservation and economic development will only be successful when strengthening the integration between agriculture and forest use featured by different social groups in the Amazon.

Key words: household survey, Ucayali smallholders, resource allocation decisions, agricultural intensification, poverty and environment

INTRODUCTION: LIVELIHOODS, WELLBEING AND ENVIRONMENTAL OUTCOMES IN THE FOREST MARGINS

Current focus of policy and scientific communities is heavily directed to address climate change potential impacts and needed mitigating measures. Globally valued ecosystem services provisioned by forests are thus critical to renewed environmental agendas seeking conservation objectives (Corbera and Schroeder 2011). Livelihood strategies based on forest resources should be then carefully considered when designing interventions and policy options potentially

affecting social relations in the forest frontier. Enhanced understandings are still needed, for example, on the conditions associated with the engagement in extraction of forest products combined with, rather than replaced by progressive expansion of agriculture. While emphasizing the need for comprehensive accountings of multiple livelihood sources in rural communities, this article contrasts economic strategies and environmental outcomes of households featuring high dependency on forests or agriculture. With empirical evidences based on a large sample of 578 households from 26 communities with diverse ethnic composition at distinct settings in the Ucayali

region of Peru, the article explores two research questions. First, that agricultural intensification is positively associated to smaller cleared areas. Second, that households with livelihoods based on forest extraction have lower income levels. Household economic orientation is based on relative income shares of each category, while environmental outcomes are assessed in terms of the extent of land used and forest cleared.

The study builds upon and dialogs with research that links sustainable livelihoods (Ellis 2000; Scoones 1998) with scholarly debates on the interactions between rural welfare and the sustainable management of tropical forest environments (Wunder 2001). Emphasis is given to quantifying the role of forest products in smallholder livelihood strategies and wellbeing, an approach that received growing attention with the Poverty and Environment Network (PEN), a research program established in 2004 and led by CIFOR, the Center for International Forestry Research (Angelsen et al. 2011).

In the last quarter century, several scholars assessed the importance of tropical forest products for household incomes. A meta-analysis of 51 cases in developing countries has shown, for instance, that such contribution is on average 22% of total annual income (Vedeld et al. 2007). In Peru, studies indicated a limited market scope for these products and a salient product specialization at both the household and village levels (Coomes 1996). While examining the effect of increased market orientation on cultural traits of food production and exchange, Behrens (1992) observed trade-offs between forest foods and cash crops for the Shipibo, the more numerous indigenous group in Ucayali. Contrasting with the high estimates of potential extractive value of forest products (eg. Pearce 2001; Peters et al. 1989), low economic returns per unit of land area have been found in the Peruvian Amazon (Gavin and Anderson 2007; Pinedo-Vasquez et al. 1992) and elsewhere (Godoy et al. 2000). Contrasting with most Amazon studies focusing on non-timber products, Amacher et al. (2009) approached frontier farmers' livelihoods through models examining decisions regarding timber harvest and sale, while others have focused their analyses on charcoal production (Coomes and Burt 2001; Labarta et al. 2008).

Studies focusing on colonist farmers less often included forest income or accounted for subsistence income within household economic strategies. Using longitudinal data, Guedes et al. (2012) recently argued for greater accuracy of multidimensional indexes of wellbeing (as opposed to assessments based only on income) to study poverty and inequality dynamics and the links between resource allocation and wellbeing¹. Their results link viable

strategies to deforestation and negative environmental consequences, while lower poverty of recently established landowners is seen to occur at the cost of increased inequality.

The great majority of rural livelihood assessments and examinations of the relative contribution of forest products are based on household surveys. Yet, inconsistencies have been noted in the literature when comparing data on natural resource harvests obtained from survey questionnaires with that collected through direct methods (such as Godoy et al. 2000) and personal diaries (Gram 2001; Menton et al. 2010), and one needs to be cautious with policy and development outcomes derived from the interpretation of such data. Recognizing such caveats, in 2007 the Network for the Study of Livelihoods and Environment in the Amazon (RAVA) adopted a standard methodology and strived to enforce accuracy and comparability in assessing the role of forest products across smallholder communities in the Amazon. This article analyses data gathered by the RAVA team in Peru.

UCAYALI'S SOCIOECONOMIC AND ENVIRONMENTAL CONTEXTS

Two national parks (Alto Purus, Cordillera Azul), two Communal Reserves (El Sira, Purus), a Reserved Zone (Sierra del Divisor) and a Regional Conservation Area (Imiria) are protected areas partially or entirely located in Ucayali. Yet, cumulative deforestation in the region, resulting mainly from slash and burn farming, increased from 547,750 ha in 1990 to 627,064 ha in 2000 and to estimated 787,000 ha in 2010 (Sandra Rios, personal communication), reaching some 9% of the total original forested area of 8.7 million ha. Agriculture is indeed a major driver of tropical forest loss in the Peruvian Amazon (Alvarez and Naughton-Treves 2003; Fujisaka 1997; Imbernon 1999). To halt slash-and-burn agriculture, proposals compensating avoided deforestation and reduced emissions are being introduced to indigenous and smallholder communities (Capella-Vargas and Sandoval-

¹ In presenting a theory of anthropological wellbeing, Colby (1987: 880) builds on three broad dimensions of human concern and behavior: the *ecological* (material world of subsistence, technology, work and economics); the *social* (interpersonal relationships, anchored in social structures and guided by ethics and social conventions; and the *interpretive* (the world of metathought, of symbolic systems and meta-level analysis). While recognizing the need to incorporate all three dimensions, this article approaches wellbeing only through its material, subsistence dimension.

Díaz 2010; Hajek et al. 2011; Scriven 2012). Although how these projects will work on the ground is not yet clear, Ucayali is a priority region for such interventions. The region's main features are presented below.

Demography. With an area of 102,410 km² (roughly 8% of the country's total) Ucayali is the second largest of the 25 administrative regions of Peru. The region's 2012 population is estimated at 490,000 of which 75% reside in urban areas and more than 60% in its capital Pucallpa, the second most populous city of the Peruvian Amazon, and 10th in the country (INEI-UNFPA 2011). Official statistics show a considerable reduction in Ucayali's total poverty from 70.5% in 2001 to 20.3% in 2010 (INEI 2011a). Improvement in Ucayali's social conditions is also attested by a Human Development Index (HDI) that increased from 0.5251 in 1993 to 0.6022 in 2007 (PNUD 2010). It is however symptomatic that the HDI of Yurúa, a district of Ucayali's Atalaya province, markedly rural and with a significant indigenous population, is the lowest among Peru's 1833 districts². Substantial demographic discrepancies exist across Ucayali's four regional provinces, with greater population concentration along the Federico Basadre Highway that connects Pucallpa to Lima. The northern Coronel Portillo and Padre Abad provinces present a combined demographic density more than ten times greater than the southern Atalaya and Purus provinces, predominantly rural (65%), disconnected from paved roads (INEI 2009a).

Ethnicity. The population in Ucayali is differentiated by origin and cultural group. Indigenous territories of near 300 native communities comprise some 20% of the region's land, half of this area being legally titled (IBC 2012; MINEM-GOREU 2007). Projected to 2012, the Pano (60%) and Arawak (40%) ethnolinguistic families comprise a 70,000 indigenous population (14% of Ucayali's), not including urban indigenous residents (IBC 2012; INEI 2009b; MINEM-GOREU 2007). Thousands of *mestizo* colonists, on the other hand, have settled near the Federico Basadre Highway, built in 1945, or along the banks of the Ucayali River and tributaries, where they joined long-term, non-tribal *ribereño*³ communities. Projected to 2012, some 53,000 *mestizos* inhabit 487 non-indigenous rural settlements accounted for in Ucayali, two thirds of them

located at the Coronel Portillo and Padre Abad provinces (GOREU 2008).

Economy. Despite sharp increases in construction and services related to the bustling developments of Pucallpa, the regional economy remains strongly dependent on primary sector activities. Near 20% of the regional GDP continues to be derived from agriculture, livestock and forestry, while timber and agricultural processing companies contribute with a substantial portion of industry's 13% share of the GDP⁴ (INEI 2011b). In the agricultural sector, total area of annual crops harvested in Ucayali in the last decade represented less than 2% of Peru's total (MINAG 2012a), while livestock is of limited relevance when compared to agriculture⁵. Table 1 depicts variation in harvested area, production, and productivity of Ucayali's major crops in the last decade by comparing situations in 1999/2000 and 2009/2010 (MINAG 2012b).

The last Peruvian agricultural census (1994) accounted for 21,425 landholdings in an area of 446,000 ha in Ucayali. Some 122,000 ha were considered agricultural land, respectively under annual crops (38%), pasture (15%), perennials and intercropped (12%), and fallow (35%) (INEI 1995). Official agricultural statistics do not mention, however, the production of coca, a major economic driver in Ucayali since the 1980s, mostly at the higher landscapes of the Aguaytia basin (Perz et al. 2003). Relevance of coca can be attested by the eradication of some 3,000 fields in an area covering more than 4,000 hectares in 2003 and 2004 (Salisbury and Fagan 2011). In 2009, total area under coca in Aguaytia was 2,913 ha⁶ and the basin featured the highest levels of coca expansion in the country (UNODC-DEVIDA 2010). Aside from coca, the most important crops are traditional staples (rice, maize, cassava, plantains, and beans) along with cash crops becoming more relevant in the last decade, particularly cocoa, coffee, papaya and oil palm. Although the vast majority of Ucayali's agricultural producers are smallholders, an incipient number of entrepreneurs and private companies recently engaged in large-scale commercial cultivation of maize, with areas larger than 1,000 ha (MINEM-GOREU 2007).

Logging remains a major industry due to Pucallpa's road connectivity to the country's capital. Half of the estimated 8 million hectares of Ucayali's productive forests

² At the provincial level, the 2007 HDI for the northern Coronel Portillo and Padre Abad reached respectively 0.6180 and 0.6032 while the index for southern Purus and Atalaya was considerably lower at 0.5333 and 0.5033 (PNUD 2010).

³ Most *ribereños* are descendants of detribalized natives and of immigrants who arrived in the Amazonian lowlands of Peru in generations past, many during the rubber boom of the early 1900s (Padoch and de Jong 1989, 103).

⁴ In 2006, forest and agricultural processing units accounted respectively for 41.1% and 26.7% of the 1,112 industrial units in Ucayali (MINEM-GOREU 2007).

⁵ In 2011 the production of meat in Ucayali was respectively 11,718 (poultry), 1,089 (pork) and 1,622 (beef) metric tons, while milk production totaled 5,081 metric tons (MINAG 2012a).

⁶ www.unodc.org/unodc/en/crop_monitoring/index.html

Table 1. Variation in harvested area, production, and productivity of major agricultural crops in Ucayali 1999/2000 – 2009/2010)

Crop	Harvested area (ha)		Production (ton)		Productivity (kg/ha)		% variation 2009-2010 / 1999-2000		
	1999-2000	2009-2010	1999-2000	2009-2010	1999-2000	2009-2010	area	production	productivity
rice	8,885	11,203	23,203	27,769	2,608	2,478	26%	20%	-5%
maize	8,372	10,459	19,488	25,479	2,328	2,436	25%	31%	5%
beans	4,698	3,127	7,729	5,246	1,635	1,675	-33%	-32%	-2%
cotton	1,693	208	1,255	192	676	926	-88%	-85%	37%
cassava	8,104	10,119	119,262	151,048	14,719	14,927	25%	27%	1%
plantain	23,624	17,602	237,996	252,751	10,025	14,382	-25%	6%	43%
cocoa	780	1,056	422	978	543	927	35%	132%	71%
coffee	713	1,517	565	2,185	796	1,432	113%	287%	80%
papaya	2,576	4,881	17,165	82,352	6,500	16,890	89%	390%	160%
oil-palm	1,217	4,274	15,857	55,087	12,652	12,936	251%	247%	2%

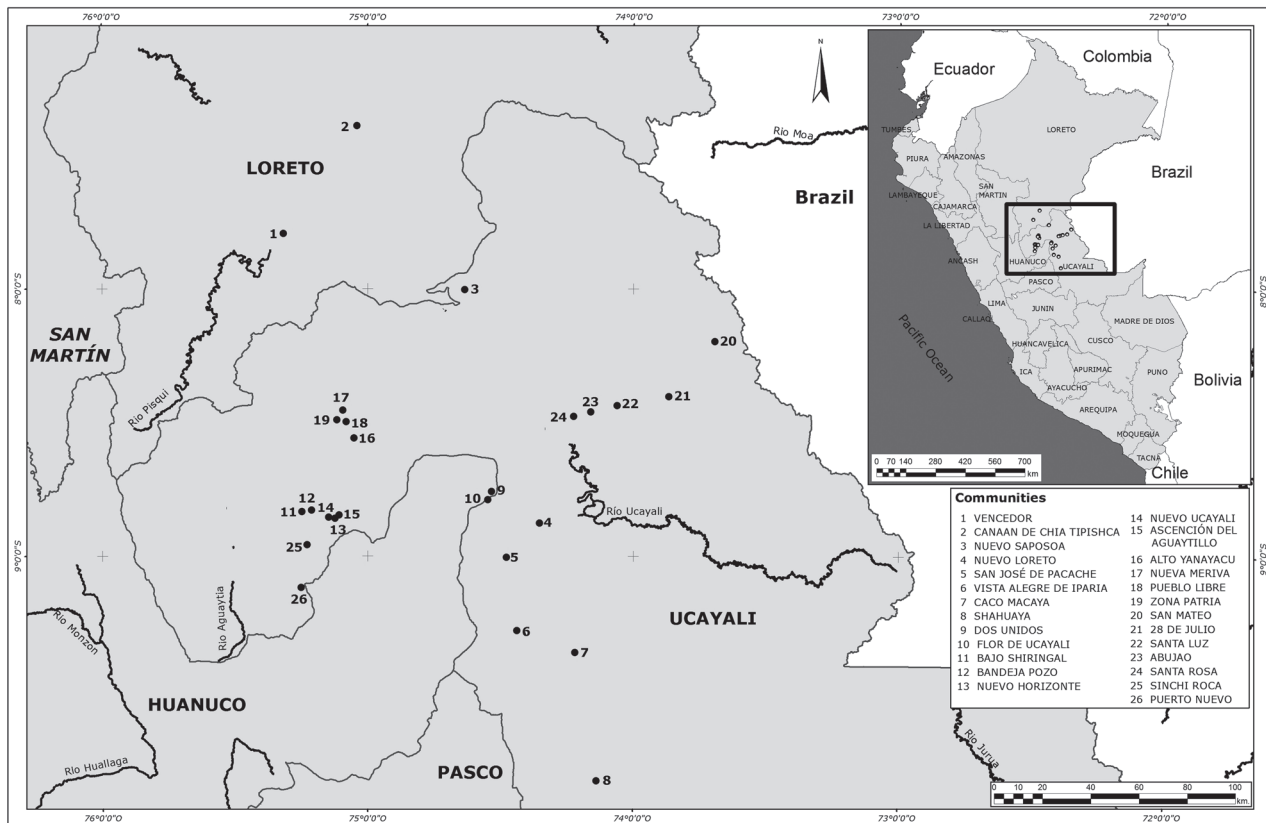


Fig. 1. Location of study communities.

have been declared as permanent production forests in 2002, being exploited through management plans and forest concessions granted by INRENA, the National Institute for Natural Resources, replaced in 2008 by the Ministry of Agriculture's *Dirección General Forestal y de Fauna Silvestre*. In the 2005-2009 period, annual averages of approximately 315,000 m³ of round wood and 193,000 m³ of lumber were produced in Ucayali (INEI 2011c).

METHODS

Data collection. This study adopted the PEN methodology (Angelsen et al. 2011) to systematically collect data for the assessment of livelihoods' dependency on environmental resources. Two annual surveys (separated by twelve months) and four quarterly questionnaires at the household level, as well as two village-level annual surveys (derived from focus groups discussions) were conducted to gather information and data on multiple livelihood sources.

Table 2. Location, size, and ethnicity of communities participating in the RAVA survey, Ucayali-Peru

Community name	Ethnicity	Basin	District	Province	Region	Households		Surveying institution
						total	sample	
1. Vencedor	Shipibo-Conibo	Ucayali	Contamana	Ucayali	Loreto*	31	12	IIAP
2. Canaan de Chia Tipishca	Shipibo-Conibo	Ucayali	Contamana	Ucayali	Loreto*	36	12	IIAP
3. Nuevo Saposoa	Shipibo-Conibo	Ucayali	Calleria	C. Portillo	Ucayali	56	12	IIAP
4. Nuevo Loreto	Shipibo-Conibo	Ucayali	Masisea	C. Portillo	Ucayali	34	12	IIAP
5. San Jose de Pacache	Shipibo-Conibo	Ucayali	Iparia	C. Portillo	Ucayali	45	11	IIAP
6. Vista Alegre de Iparia	Shipibo-Conibo	Ucayali	Iparia	C. Portillo	Ucayali	96	12	IIAP
7. Caco Macaya	Shipibo-Conibo	Ucayali	Iparia	C. Portillo	Ucayali	150	12	IIAP
8. Shahuaya	Shipibo-Conibo	Ucayali	Tahuania	Atalaya	Ucayali	82	12	IIAP
9. Dos Unidos	Shipibo-Conibo	Ucayali	Honoría	Puerto Inca	Huanuco*	54	12	IIAP
10. Flor de Ucayali	Shipibo-Conibo	Ucayali	Masisea	C. Portillo	Ucayali	45	10	IIAP
11. Santa Rosa	Shipibo-Conibo	Abujao	Calleria	C. Portillo	Ucayali	65	42	UNU
12. San Mateo	Ashaninka	Abujao	Calleria	C. Portillo	Ucayali	10	6	ACATPA
13. Sinchi Roca	Cashibo-Cacataibo	S. Alejandro	Irazola	Padre Abad	Ucayali	360	83	UNU
14. Puerto Nuevo	Cashibo-Cacataibo	S. Alejandro	Irazola	Padre Abad	Ucayali	120	51	ACATPA
15. Bajo Shiringal	Mestizo	S. Alejandro	Irazola	Padre Abad	Ucayali	90	38	INIA
16. Bandeja Pozo	Mestizo	S. Alejandro	Irazola	Padre Abad	Ucayali	30	20	INIA
17. Nuevo Horizonte	Mestizo	S. Alejandro	Irazola	Padre Abad	Ucayali	36	19	INIA
18. Nuevo Ucayali	Mestizo	S. Alejandro	Irazola	Padre Abad	Ucayali	40	40	INIA
19. Ascencion del Aguaytillo	Mestizo	S. Alejandro	Irazola	Padre Abad	Ucayali	80	20	INIA
20. Alto Yanayacu	Mestizo	S. Alejandro	Irazola	Padre Abad	Ucayali	48	19	INIA
21. Nueva Meriva	Mestizo	Aguaytia	Curimaná	Padre Abad	Ucayali	65	20	INIA
22. Pueblo Libre	Mestizo	Aguaytia	Curimaná	Padre Abad	Ucayali	40	20	INIA
23. Zona Patria	Mestizo	Aguaytia	Curimaná	Padre Abad	Ucayali	38	19	INIA
24. 28 de Julio	Mestizo	Abujao	Calleria	C. Portillo	Ucayali	18	18	UNU
25. Santa Luz	Mestizo	Abujao	Calleria	C. Portillo	Ucayali	30	23	UNU
26. Abujao	Mestizo	Abujao	Calleria	C. Portillo	Ucayali	54	26	UNU

* Although located in the Loreto and Huanuco regions, access to these three communities is more often done through Pucallpa.

To conduct the study, the RAVA network relied on partnerships with local Amazonian educational, research, extension and civil society organizations engaged in research and/or development work with the target communities. Selection of locations took into consideration PEN recommendations for intra-site variation for key features such as forest integrity, distance to markets, land tenure, and social groups (Cavendish 2000, 2003).

Site selection. Major socio-cultural, economic and environmental features of Ucayali guided the rationale used for the definition of specific sites to carry out the research. Selection of communities was based on the ethnic structure of Coronel Portillo and Padre Abad, Ucayali's two provinces with larger demographic density and greater agricultural development. Predominant landscape patterns were also considered as both upland and flooded forest environments were selected. The liaison with local institutions prioritizing and developing activities in areas that fulfilled the above criteria was indeed fundamental for

the adoption of a stratified sampling procedure. Fig. 1 is a map with the location of 26 communities selected for the study. Table 2 lists their location, size, ethnicity, and institution leading the respective surveys.

Income assessment. Contribution of multiple sources of income was based on information obtained from surveys conducted with 578 households⁷. Income obtained from quarterly surveys was summarized in seven categories: forest products, fishing, agriculture, livestock, wage labor, businesses, and other sources. Income data combines revenues obtained from market sales and valuation of products channeled to household subsistence, the latter by

⁷ Of the 593 households initially surveyed, 15 failing to respond at least two quarterly surveys were excluded. Income of missing trimesters (for households who answered two or three surveys) was imputed using Stata's *impute* command. Using information of the household's existing surveys, *impute* runs regressions by what is known as best-subset regression to fill in the missing values for each income category. For details on the command, see Stata Press 2007).

assigning “farm-gate” prices derived from local level transactions. Production costs (except household labor) are deducted from gross values, and total income therefore refers to reported net amounts. A one-month recall period was adopted, except for agricultural, livestock and income from other sources, which refer to a three-month period. Results based on one-month recall were scaled to the three-month period, to allow computation of annual income, calculated through the integration of the seven categories, and converted from Peruvian *Nuevos Soles* to US dollar using the 2008 average exchange rate (1 USD = S./2,87). Results were adjusted to adult equivalents (ad.eq.)⁸ (Blackorby and Donaldson 1991) to control for household demographics.

Land use allocation. Annual cropping by Ucayali smallholders is based on traditional short fallow swiddens, with progressive clearing of forest or old-fallows and use of fire (Fujisaka 1997; Labarta et al. 2008). Semi-perennial crops, usually in swidden agroforestry (Hiraoka 1986; Padoch and de Jong 1989) imply longer rotations and a less frequent need for clearing, while perennial crops tend to be associated to a level of intensification that eventually stabilizes forest clearing with positive environmental outcomes (Gutiérrez-Vélez et al. 2011)⁹. Ucayali pastures, on the other hand, are often established following annual crops and managed extensively, representing low marginal cost to those who aim to extend the use of plot through grasses adapted to less fertile soils (Loker 1993).

Our objective was to assess environmental change resulting from the dynamics of land use, land cover, and land clearing. We considered categories of agricultural land use as a proxy for agricultural intensification. Survey respondents provided information on land use allocation according to six categories, and the environmental outcomes were assessed through total land used for agricultural purposes, and the area recently cleared in the last two agricultural years. We thus examined whether farmers’ choice for semi-perennials and perennials, denoting intensification, has positive environmental outcomes in terms of a smaller cropping area, and therefore on reduced deforestation¹⁰.

⁸ For greater accuracy of comparative household demographic attributes (as a replacement for simple head-counting) this study used an adult equivalent scale with the following weights, based on the age of household members: (0–1: 0.1 ad. eq.), (2–3: 0.2), (4–5: 0.3), (6–7: 0.4), (8–9: 0.5), (10–11: 0.6), (12–13: 0.7), (14–15: 0.8), (16–17: 0.9), (>17: 1).

⁹ Agricultural intensification in Ucayali has not reached a level in which chemical and mechanical inputs represent environmental concern. This dimension, however, should be considered in longer term assessments.

Detailed information was obtained on the area and crops for all agricultural parcels and on planted pastures of a household. The main crop reported for each parcel was used to cluster responses according to four “agricultural” categories: annuals, semi-perennials, perennials and pastures¹¹. Additionally, land under forest and fallow was obtained from the overall distribution of land cover categories reported in the annual survey for privately owned landholdings¹². For the 13 indigenous and two *mestizo* communities featuring common forested ownership, the forest areas assigned are averages applied to all households of the respective communities, based on ratios between total forest land and resident households informed at village-level surveys.

Statistical tests of environmental and economic outcomes. Households were classified according to two typologies to verify the statistical significance of differential land use allocation and income levels. Initially, to test whether land use allocation profile (and thus agricultural intensification) is associated to land clearing, a 9-class typology was built on the basis of possible combinations of the four agricultural categories (annuals, semi-perennials, perennials and pastures). Second, a 4-class typology was based on relative shares of household income sources (livelihood orientation). Ethnicity and geographical location were then added to this latter typology, for greater explanatory power. Analysis of variance within typological classes was conducted using oneway command and Bonferroni multiple-comparison tests¹³ with STATA software.

¹⁰ In this analysis we considered that length of residence (and thus farm state before arrival of current landholder) plays no relevant role on land use pattern. The great majority of perennials is cropped by *mestizo* farmers, and the average time of establishment of their plots is 13 years (standard deviation of 11). It is thus unlikely that land use differentials are the result of a farm life cycle pattern in which younger farms start off with annuals and then diversify over time.

¹¹ Predominant annual crops include maize, rice and cassava, followed by beans, cotton, groundnuts and a few crops with very low occurrence. Semi-perennials consisted mainly of plantain, with lower incidences of papaya and pineapple. Perennials included cocoa, and to a much lower extent oil-palm, peach-palm, and miscellaneous fruit and timber trees.

¹² Surveyed forest and fallow categories included sub-categories. Forest land cover could be reported as primary forest, managed forest, or planted forest while fallow land could be reported as recent fallow (up to five years) and old-fallow (more than five years). For the purpose of this analysis, however, we have not considered the break-down categories.

¹³ Bonferroni is a simple and widely applicable test for pairwise comparisons. Critics of the test point out, however, that it is often unnecessarily conservative, with the confidence interval α * being smaller than it needs to be (Day and Quinn 1989).

Table 3. Income sources of smallholder households in Ucayali, Peru, 2008

Income source	n	%	Income (US\$ / adult equivalent)			Income (US\$ / household)				Income share*	
			mean	median	sd	mean	median	sd	sum	hhhold. avg.	% of total
1. forest	552	96	478	116	1,387	1,857	463	5,881	1,073,201	27.2	38.8
2. fish	516	89	114	43	240	388	163	676	224,096	12.0	8.1
3. agriculture	547	95	311	130	641	1,101	465	2,111	636,568	24.5	23.0
4. livestock	489	85	135	35	362	473	145	1,047	273,642	10.8	9.9
5. wages	432	75	175	90	245	595	371	837	343,777	17.4	12.4
6. business	168	29	84	0	450	282	0	1,240	163,206	5.0	5.9
7. other	306	53	24	1.4	77	89	7	270	51,345	3.0	1.9
<i>total</i>	<i>578</i>	<i>100</i>	<i>1,320</i>	<i>873</i>	<i>1,828</i>	<i>4,785</i>	<i>3,049</i>	<i>7,180</i>	<i>2,765,836</i>	<i>100</i>	<i>100</i>

* (hhhold. avg.): average proportion of each income/asset type across households; (% of total): proportion based on total share of income/asset type Source: RAVA-Peru 2008 survey.

RESULTS

This section presents descriptive statistics relevant to the two overarching research variables addressed in this manuscript: income and land use allocations.

Income sources and economic strategies

Table 3 presents aggregated statistics scaled to a one-year period for the seven income categories assessed in this study. More detail for forest products generating greater income is provided in Table 4. Such products are comprised of round wood (17 items out of the 30), bush meat (6 species) and products derived from palms (3 items). Firewood is the more ubiquitous forest product, reported by 72% of the households, followed by two palm-derived products (palm fronds for thatch, mostly from the *Attalea* genus, and *Mauritia flexuosa* fruits), four wildlife species used for meat (*Tayassu tajacu*, *Agouti paca*, *Priodontes maximum*, and *Dasyprocta spp*) and three round wood species (*Dipteryx odorata*, *Myroxylon balsamun* and *Guazuma crinita*). Thirteen of the 15 highest ranked forest products have more than 70% of their production being sold, with firewood and palm fronds being the two exceptions (sales of 22% and 19% of their total). Considering overall quantities for all forest products combined, 85% of this production is sold.

A total of 43 fish species were reported, 25 of which by at least 20 households. Almost all of the fish is obtained from natural environments, with only 1% being provided by fish farms. The most frequently reported species was boquichico (*Prochilodus nigricans*, 72% of the households) followed by palometa (*Hypoptomus spp.*), lisa (*Mylossoma duriventris*), bagre (*Pseudoplatystoma fasciatum*) and

carachama (*Leporinus friderici*). Fish is mostly consumed, with the overall share of sales being 38% of the total catch. Relevant exceptions are paiche (*Arapaima gigas*) and doncella (*Pseudoplatystoma fasciatum*), with sales substantially greater.

Households reported income from a total of 36 crops, although only seven by at least 20 households: maize, plantains, rice, cassava, cocoa, beans, and cotton. Maize is the crop providing greater income. Two perennial crops with similar revenues follow: cocoa and oil palm. However, while cocoa is reported by 92 informants of the sample, only 12 households engage in oil palm production. Plantain, fourth ranked in terms of income, is the more widespread crop, found in 62% of the households. A high proportion (72%) of agricultural production is sold: among the 13 most important crops, only two have less than two thirds of their total production channeled to the market: cassava (49%) and rice (58%).

Cattle represents the greatest income provision from livestock, while chicken are raised by the largest number of households (near 91%). Swine and ducks complete the top-four relevant livestock species¹⁴. Sale and consumption of meat (of unspecified type) is the item responsible for the largest income in this category. Our data show that cattle are mainly sold in the market; farm-raised poultry are mostly consumed, while swine present intermediate figures.

Reports of wage labor indicate 31 activity types, with seven of them listed by at least 20 households. Six of the top-ten are rural activities (small-scale agriculture, large-scale agriculture, logging, processing of forest products,

¹⁴ Income from livestock was computed by multiplying the number of animals sold and slaughtered by the unit price respectively reported by households. Livestock purchased in the period were not deducted in this calculation, being considered as stock replenishment.

Table 4. Income from forest products and share destined for sales of Smallholder households in Ucayali, Peru, 2008

Product / species popular name	Scientific name	n	Net income* (US\$)					% sold
			total	mean	median	sd	max	
1. shihuahuaco	<i>Dipteryx odorata</i>	88	84,558	961	233	3,584	33,028	94
2. bolaina	<i>Guazuma crinita</i>	69	33,494	485	150	932	5,296	96
3. estoraque	<i>Myroxylon balsamun</i>	76	22,984	302	178	358	1,551	99
4. sawn wood	NA – various species	58	22,577	389	138	784	4,756	70
5. cedro	<i>Cedrela odorata</i>	16	14,417	901	199	1,736	6,829	94
6. lupuna	<i>Chorisia sp.</i>	21	11,600	552	139	1,003	3,484	100
7. cumala	<i>Virola sp.</i>	24	10,236	427	244	505	1,951	96
8. firewood	NA - various species	417	9,954	24	14	38	424	22
9. tornillo	<i>Cedrelinga catenaeformis</i>	6	9,529	1,588	690	2,481	6,620	100
10. palm leaves	NA - various species	125	9,415	75	44	89	525	19
11. wood (general)	NA - various species	39	8,472	217	94	395	1,916	81
12. capirona	<i>Calycophyllum spruceanum</i>	28	8,335	298	64	473	1,568	88
13. copaibo	<i>Copaifera spp.</i>	7	8,310	1,187	261	2,481	6,794	97
14. aguaje	<i>Mauritia flexuosa</i>	104	6,608	64	35	69	389	75
15. charcoal	NA - various species	8	6,437	805	507	891	2,503	87
16. sajino	<i>Tayassu tajacu</i>	134	6,203	46	29	44	221	36
17. quinilla	<i>Manilkara bidentata</i>	19	5,543	292	108	426	1,437	92
18. picuro	<i>Agouti paca</i>	119	4,978	42	23	47	237	36
19. venado	<i>Mazama americana</i>	65	4,100	63	33	72	355	46
20. palomaria	<i>Calophyllum brasiliense</i>	8	3,495	437	74	833	2,439	80
21. catahua	<i>Hura crepitans</i>	11	3,407	310	136	514	1,742	100
22. poles (general)	NA - various species	35	3,401	97	31	179	907	32
23. bijao	<i>Heliconia spp.</i>	37	2,729	74	2.1	139	620	98
24. pashaco	<i>Schizolobium amazonicum</i>	11	2,307	210	74	255	749	97
25. ungurahui	<i>Oenocarpus bataua</i>	67	2,298	34	11	50	261	65
26. huangana	<i>Tayassu pecari</i>	52	2,261	43	31	37	214	31
27. panguana	<i>Brosimum spp.</i>	4	2,134	534	251	744	1,620	100
28. anuje	<i>Dasyprocta fuliginosa</i>	84	1,987	24	15	26	122	22
29. carahuasca	<i>Guatteria elata</i>	7	1,777	254	22	632	1,686	94
30. armadillo	<i>Priodontes maximum</i>	108	1,775	16	11	18	118	27
<i>Total net income from forest products</i>		559	351,657	629	148	1,989	33,938	85

* Income values based on reported quantities used/sold in the 30 days prior to quarterly surveys. Values to be multiplied by three for estimation of annual income. Imputed values for missing quarters not included. Table 4 includes information for seven households that fulfilled only one quarterly survey and were excluded from overall annual income source assessment reported in Table 3. Source: RAVA-Peru 2008 survey.

chainsaw operators, and fishing) while the other four comprise public sector jobs, transportation, construction, and wages earned at institutions in their own communities. Small-scale agriculture was the major provider of wages, comprising 45% of the number of days and 35% of the income. Commerce is the most important type of income-providing business (a 51% share of this category), as approximately one out of five households reported some sort of commercial business. Payments from government and NGOs was the most significant item reported as other source of income.

Land use allocation and land clearing

Table 5 presents land use allocations for 570 households who detailed the distribution of their area by land use class. Initially looking at absolute totals, approximately 91% of the land¹⁵ is under primary or

¹⁵ The total land area of 63,821 hectares results from the sum of all surveyed private landholdings with the proportional area of common property (for all indigenous and two *mestizo* communities) according to the ratio of households surveyed in the respective sites and total resident households.

Table 5. Land use distribution according to parcel categories informed by smallholder households in Ucayali, Peru, 2008

Land use category	n	%	Area (ha / household)				Land cover share	
			mean	median	sd	sum	hhhold avg.	% of total
1. perennials	216	38	1.0	0	1.8	545	4.3	0.8
2. semi-perennials	355	62	1.3	0.5	1.9	714	2.6	1.1
3. annuals	414	73	1.6	1.0	2.2	911	5.8	1.4
4. pastures	223	39	2.8	0	6.9	1,573	7.4	2.5
5. forest	535	94	101.0	37.0	256.0	57,748	66.0	90.5
6. fallow	482	85	4.1	2.0	5.8	2,330	13.0	3.7
<i>total</i>	<i>570</i>	<i>100</i>	<i>112.0</i>	<i>49.0</i>	<i>255.0</i>	<i>63,821</i>		<i>100</i>

Source : RAVA-Peru 2008 survey.

advanced secondary forests. Considering only agricultural land, a greater share was dedicated to annual crops (1.4%) than to semi-perennials (1.1%) and perennials (0.8%). An inverse trend is observed for their adoption, greater for annual crops and semi-perennials. If the assessment is based on average percentages of each land cover across all households, the proportion of non-forested classes substantially increases, attenuating the effect of massive forest cover at large indigenous territories.

Considering current deforestation trends, a total of 2,218 hectares were reported cleared along two agricultural years 2007–08 and 2008–09 by the 543 households who provided detailed land cover information and answered two annual surveys¹⁶. Average land cleared in these two years was 4.1 hectares per household. A higher proportion of households reported having cleared fallow land than primary or advanced secondary forests, and on average, areas cleared on fallows were 0.5 hectare greater than those cleared on forests. A greater number of households cleared land in the second survey, while cropping on significantly larger plots (2.3 ha as opposed to 1.8 ha)¹⁷. The average distance between house site and the area cleared was 1.4 kilometers, and for fallows, the reported time before

clearing was on average 5.6 years. Agriculture was the main purpose of land clearing for 94% of the cases, while only 5% were due to pastures. We calculated cumulative deforestation at the studied sites through the combined area of annuals, semi-perennials, perennials, pastures, and fallow. Resulting household's total agricultural land (TAL) for the 543 households reached 5,726 hectares.

ANALYSIS AND DISCUSSION

The discussion is structured in two parts. We first focus on the intensification and land use analysis, and then take up the analysis of livelihoods, incomes and wealth (including the role of ethnicity and location)

Land allocation decisions and environmental outcomes

Households were classified according to their land use allocation profile, based on possible combinations of the four agricultural categories (annuals, semi-perennials, perennials and pasture). As seen in Table 6, the 9-class typology initially comprises households with: (a) no agricultural use (3% of the cases) and (b) only annual crops (8%). Given the subsistence orientation of annual crops, the remaining categories include households that may also crop annual fields in addition to their respective primary allocation, as follows: (c) semi-perennial crops (32%); (d) pasture orientation (8%); (e) perennial crops (8%); (f) combination of parcels with semi-perennials and pasture (10%); (g) combination of perennial and semi-perennial parcels (10%); (h) combination of perennials and pasture (10%); (i) combination of parcels with perennials, semi-perennial and pastures (10%). Land use allocations based on semi-perennials (eventually combined with annuals)

¹⁶ Households were asked to report the amount of land cleared in the agricultural year previous to the initial annual survey (in late 2007/early 2008), and again after 12 months, at the second annual household survey. This analysis excluded 28 households who did not respond the second annual survey (14 of them having reported cleared land in the first period), as well as seven households who have not reported detailed land cover categories.

¹⁷ Larger clearing areas for the second year could in part reflect greater confidence of respondents after a year of interaction with the research team. Procedures of the PEN-RAVA methodology, which included multiple surveys to gather information on income and land use allocation serve to strengthen the confidence of respondents on the research team and enhance overall data reliability and accuracy.

Table 6. Multiple class comparison of total agricultural land and recent cleared area (forest and fallow) informed by smallholder households according to household typology based on land allocation in Ucayali, Peru, 2008

Household typology	Households		Total agricultural land (ha)				Recently cleared 2007-2008 (ha)			
	n	%	mean	median	sd	sum	mean	median	sd	sum
a. no agriculture	17	3	2.3	0	3.5	38	3	2	3.9	52
b. only annuals	46	8	5.0	4.3	4.0	231	5	3	5.4	229
c. semi-perennials	175	32	6.0	5.7	3.2	1,057	4.1	3	3.8	711
d. pastures	43	8	16.0	13.0	12.0	691	4.8	4	3.7	204
e. perennials	43	8	11.0	8.8	11.0	504	4.2	4	4.1	187
f. semi-perennials & pasture	57	10	13.0	11.0	7.4	761	4.5	4	2.9	257
g. semi-perennial & perennial	55	10	7.5	6.3	5.2	404	3.1	2	2.4	166
h. perennials & pasture	53	10	23.0	18.0	22.0	1,222	4.5	3	4.8	238
i. peren., semi-per. & pasture	54	10	15.0	12.0	9.7	817	3.2	3	2.4	175
<i>total</i>	<i>543</i>		<i>11.0</i>	<i>7.8</i>	<i>11.0</i>	<i>5,726</i>	<i>4.1</i>	<i>3</i>	<i>3.8</i>	<i>2,218</i>

F-test from ANOVA for groups b-i $F = 25.29$ $Prob > F = 0.000$ $F = 1.66$ $Prob > F = 0.1049$
Multiple class comparisons (Bonferroni normalization): Total agricultural land (TAL) x household land use typology:

Household land use typology	b (annuals)	d	e	f	g	h	i
d. pastures	11.0***	—	—	—	—	—	—
e. perennials	6.4*	-4.6	—	—	—	—	—
f. semi-perennials & pasture	8.3***	-2.7	1.9	—	—	—	—
g. semi-peren. & perennial	2.5	-8.6***	-4.0	-5.9*	—	—	—
h. perennials & pasture	18.0***	-7.0*	11.6***	9.7***	15.7***	—	—
i. per., semi-per. & pasture	10.1***	-0.9	3.7	1.8	7.6***	-7.9***	—
c. semi-perennials	1.0	-10.0***	-5.4*	-7.3***	-1.4	-17.0***	-9.1***

* $p < .10$, ** $p < .05$, *** $p < .01$.
Source: RAVA-Peru 2008 survey.

predominate in this typology. Apart from that, households distributed quite evenly according to the other categories. In order to verify whether land use allocation by Ucayali households supports the hypothesis of positive correlation between land use intensification and forest conservation, the typology was used to assess cumulative and recent cleared area of landholdings.

Cumulative land clearing. Variation in cumulative deforestation was operationalized through household's total agricultural land (TAL) consisting of the combined area of annuals, semi-perennials, perennials, pastures, and fallow. The upper panel in Table 6 shows that TAL variation across agricultural land use classes is statistically significant at the 99% level. The lower panel with multiple comparisons using Bonferroni normalization initially confirmed the expected role of pasture as a direct driver of land clearing. TAL for households with pasture orientation (d) is on average 11, 10 and 9 hectares greater than for households respectively focusing only on annual crops (b), semi-perennials (c), and with combinations of perennials and semi-perennials plots (g). Households combining pastures and perennials are expected to have a TAL near 12 ha greater than those focusing only on perennials, and 7 ha

greater than those focusing on pastures. Yet, when households combine semi-perennials (instead of perennials) with pastures, the increase in TAL for those adding pastures is smaller (7.5 ha) and the additional area of semi-perennials is not statistically significant, denoting that perennial crops apparently do not spare land when compared to semi-perennials.

Our assumption of land sparing associated to agricultural intensification was further tested when comparing classes with predominance of annuals, semi-perennials and perennials, considered as positioned in a continuum of land use intensification. TAL of households relying only on annuals (class b) is not statistically significant different than TAL of those focusing on semi-perennials (c) and semi-perennials combined with perennials (class g). Yet, when households with only annual crops are compared with those relying on perennials (class e), a TAL 6.5 ha greater is expected for the latter (at the 90% confidence level). An additional comparison is made between classes c (semi-perennials) and e (perennials), and TAL for the latter resulted 5.4 hectares greater. The test thus provided sufficient evidence that land use intensification for Ucayali smallholders is not associated to land sparing.

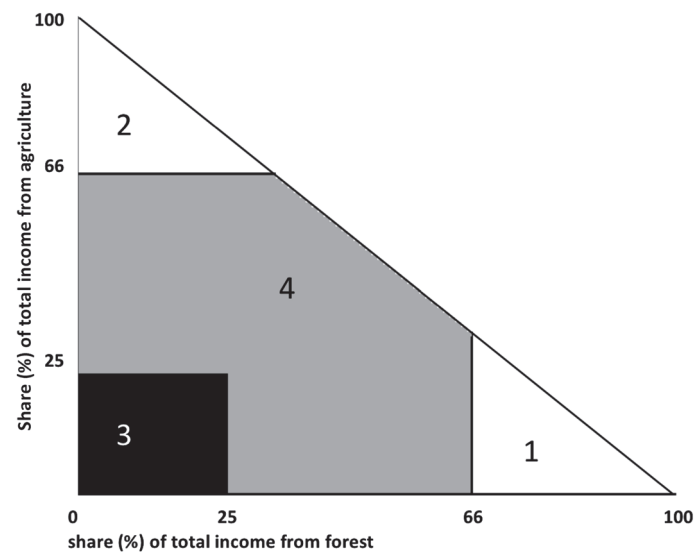


Fig. 2. Household income structure typology: (1) *high forest dependency*; (2) *high agriculture dependency*; (3) *wage-business dependency*; (4) *balanced forest-agriculture-wage income*.

Recent land clearing trends. The upper right panel on Table 6 displays recent land clearing figures according to the typology of agricultural classes. Our results indicate that land allocation by Ucayali households does not support the hypothesis that land use intensification reduces recent land clearing. The average area recently cleared by households predominantly oriented for perennials, semi-perennials and pastures resulted as large as that observed for those focusing on annual cropping. The ANOVA F-score and multiple comparisons using Bonferroni normalization confirm that none of the differences between average recent cleared areas across land categories is statistically significant.

Livelihood options, wellbeing and intervening factors

We generated a second typology of households, this time according to prevalent livelihood strategies derived from their respective income structure, and examined whether significant variation exists in terms of income levels across the resulting classes. We then investigated whether two other variables play a determinant role in shaping these results: ethnic group and the sites' specific location.

Household typology based on relative shares of major income sources. Adopting relative income thresholds of two thirds (66.6%) of the total annual income for high dependency (Fig. 2), groups 1 and 2 are formed by households featuring respectively *high forest dependency* (HFD) and *high agriculture dependency* (HAD). In this analysis, forest income is combined with income from

fishing, and agricultural income includes livestock and livestock products. Group 3 features households to whom both forest and agriculture account for less than 25% of their income, being therefore referred as *wage & business dependent* (WBD). Group 4 comprises households presenting a *balanced forest-agriculture-wage dependency* (BFA), with at least two of these components accounting for no less than 25% of their income.

The upper panel of Table 7 summarizes (in adult equivalents) total annual income for the above-mentioned groups. HFD households present higher incomes when compared to HAD, but further examination attests that this higher income is not statistically significant, indicating possible effects of additional variables.

Typology based on ethnic group and village location. In order to study the above discrepancy, two other variables were considered: ethnic group and village location. This study was conducted with Ashaninka, Cashibo-Cacataibo, Shipibo-Conibo, and *mestizo* households. The Ashaninka¹⁸ and Cacataibo of the sample are each settled only in one location, respectively the Abujao basin (Calleria district) and the San Alejandro basin in Padre Abad. The Shipibo and *mestizos*, however, reside in villages from two distinct geographical locations in each case. Relevant differences in remoteness substantiate their separate assessment. *Mestizo* farmers from the Abujao basin are settled in more remote lands with no access to permanent roads, as opposed to

¹⁸ The Ashaninka, also located in the Abujao basin, despite showing the highest average income, comprise only six households, and given statistical limitations will not be considered in this further analysis.

Table 7. Multiple class comparison of income variation for smallholder households according to classes of income structure, ethnic group and geographical location. Ucayali, Peru. 2008

Class variable	n	%	Income (US\$ / adult equivalent)				
			mean	median	sd		
<i>a. income structure, all households</i>							
1. high forest dependency (HFD)	137	23.7	1,930	1,158	2,899		
2. high agriculture dependency (HAD)	99	17.1	1,471	933	1,618		
3. wage & business dependency (WBD)	55	9.5	1,159	871	1,397		
4. balanced forest-agriculture (BFA)	287	49.7	1,008	712	1,091		
<i>total</i>	578	100.0	1,320	873	1,828		
<i>F-test from ANOVA:</i>			<i>F = 8.58 Prob > F = 0.0000</i>				
			HFD	HAD	WBD		
multiple class comparisons	HAD		- 460				
with Bonferroni normalization:	WBD		- 772**	- 312			
	BFA		- 923***	- 463	- 151		
<hr/>							
	n	%	Income (US\$ / adult equivalent)				
			mean	median	sd		
<i>b. ethnic group and location</i>							
1. Mestizo, Irazola & Curimana district	214	37.0	1,261	898	1,250		
2. Mestizo, Callería district (Abujao)	68	11.8	2,852	1,584	3,892		
3. Shipibo, Ucayali flooded forests	114	19.7	875	624	789		
4. Shipibo, Callería district (Abujao)	42	7.3	1,892	1,349	1,942		
5. Cacataibo, San Alejandro basin	134	23.2	758	512	815		
6. Ashaninka, Callería district (Abujao)	6	1.0	3,066	2,884	1,336		
<i>F-test from ANOVA:</i>			<i>F = 17.62 Prob > F = 0.0000</i>				
			1. Me-IC	2.Me-A	3.Sh-FF	4.Sh-A	5.Cac
multiple class comparisons	2. Me-A	1,591***					
with Bonferroni normalization:	3. Sh-FF	- 386	- 1,976***				
	4. Sh-A	631	- 960*	1,017**			
	5. Cacat.	- 503	- 2,094***	- 117	- 1,134***		
	6. Asha.	1,805	214	2,191**	1,174	2,308**	

* p < .10, ** p < .05, *** p < .01.

Source: RAVA-Peru 2008 survey.

those settled in the Irazola and Curimaná districts of Padre Abad. The Shipibo of Callería, on the other hand, settled much closer to the city of Pucallpa, as opposed to the more distant communities located at the Ucayali flooded forests. We therefore aggregated ethnicity and location (or remoteness) to examine income according to six groups, presented in the lower panel of Table 7.

Our analysis shows that incomes are higher for the three ethnic groups located in the Abujao basin (statistically significant at 95% confidence level), even when compared with households from the same ethnicity located elsewhere. Looking at each of the seven income sources separately, we detect that greater income in Abujao is derived from forest products (of which timber predominates): forest-derived

income from Abujao households is greater than in other locations.

Combined typology: income structure, ethnic group and location. With the insights provided by the role of ethnicity and location, we integrate these variables in the previous typology to control for their effect and to better understand the role of livelihood strategy on welfare. Table 8 thus reports income statistics for 19 classes resulting from a typology that integrates livelihood strategy, ethnic group, and village geographical location¹⁹.

A significant contrast of livelihood orientation is noticed upfront when comparing households from Abujao with those of the same ethnic group located elsewhere. Only 2% of Padre Abad's *mestizo* households are classified

Table 8. Multiple class comparison of income variation for smallholder households according to combined classes (income structure, ethnic group and geographical location) in Ucayali, Peru, 2008

Income structure ¹ , ethnic group and location ²	n	%	Income (US\$ / adult equivalent)			%			
			mean	median	sd	class	1. HFD_MA	10. WBD_MA	7. HAD_M
1. HFD_Mestizo_Abujao	30	5.2	4,190	2,213	5,258				
2. HFD_Mestizo	4	0.7	2,053	1,927	545				
3. HFD_Shipibo_Abujao	18	3.1	2,036	1,864	1,121	HFD_SA	-2,154***		
4. HFD_Shipibo	21	3.7	1,194	917	1,138	HFD_S	-2,996***		
5. HFD_Cacataibo	60	10.5	921	616	938	HFD_C	-3,269***	-2,911**	
6. HAD_Mestizo_Abujao	3	0.5	1,389	1,419	416				
7. HAD_Mestizo	80	14.0	1,585	949	1,694	HAD_M	-2,605***		
8. HAD_Shipibo	8	1.4	895	562	828	HAD_S	-3,295***		
9. HAD_Cacataibo	8	1.4	935	296	1,630	HAD_C	-3,255***		
10. WBD_Mestizo_Abujao	5	0.9	3,832	2,806	3,626				
11. WBD_Mestizo	23	4.0	998	1,023	545	WBD_M	-3,192***	-2,834*	
12. WBD_Shipibo_Abujao	1	0.2	531	531	.				
13. WBD_Shipibo	21	3.7	786	777	324	WBD_S	-3,404***	-3,046**	
14. WBD_Cacataibo	5	0.9	912	309	1,023	WBD_C	-3,278***		
15. BFA_Mestizo_Abujao	30	5.2	1,496	1,054	1,178	BFA_MA	-2,694***		
16. BFA_Mestizo	107	18.7	1,046	798	876	BFA_M	-3,144***	-2,786**	
17. BFA_Shipibo_Abujao	23	4.0	1,839	1,075	2,440	BFA_SA	-2,351***		
18. BFA_Shipibo	64	11.2	797	594	744	BFA_S	-3,293***	-3,035**	
19. BFA_Cacataibo	61	10.7	562	443	395	BFA_C	-3,628***	-3,270***	-1,023*
Total	572	100	1,302	864	1,824				

F-test from ANOVA: $F = 7.82$ $Prob > F = 0.0000$

* $p < .10$, ** $p < .05$, *** $p < .01$.

¹ Household classification according to income dependency: HFD, *high forest dependency*; HAD, *high agriculture dependency*; WBD, *wage and business dependent*; BFA, *balanced forest-agriculture-wage dependency*

² C, Cacataibo; M, Mestizo; MA, Mestizo-Abujao; S, Shipibo; SA, Shipibo Abujao

Source: RAVA-Peru 2008 survey.

as *high forest dependent*, compared to 44% for *mestizos* in the Abujao. A similar, although not as marked trend occurs for the Shipibo (43% of HFD in Abujao, 18% elsewhere). *High agriculture dependency* is featured by only 4% of Abujao mestizos, and for none of the Shipibo from Abujao, as opposed to proportions that elsewhere reach respectively 37% and 7%. Cacataibo households are predominantly forest dependent (45% HFD), but as in all ethnic categories, near half of the households present a more balanced income structure (BFA).

The analysis then confirms that statistically significant higher incomes are found for Abujao households predominantly relying on forests and on wages, business or other sources. Presented in Table 8 are only the 21 statistically significant (of the possible 171) multiple class comparisons using Bonferroni normalization, and 20 of these comparisons comprise Abujao *mestizo's* HFD or WBD households. A higher average income of the HFD

¹⁹ Noting that five of these classes encompass no more than five households.

Shipibo from Abujao compared to other HFD Shipibo is not statistically significant, and the same can be said for *mestizos* from Padre Abad highly dependent on agriculture, as their higher income is statistically significant only when compared to Cacataibo of the BFA class, the group presenting lower average income levels overall.

Our analysis thus provides mixed insights to understand the association between forest dependency and wellbeing, when assessed through income levels. The data show that livelihood orientation alone cannot provide sufficient evidence for income variation across households. A clear effect of geographical location is manifested through the higher incomes of residents of the Abujao basin, Callería district, as a much greater share of these households rely on forest products than in agriculture. The economic dynamic of forest resource extraction in an unconsolidated frontier is likely to explain higher incomes when compared to farmers settled in consolidated frontiers such as Irazola and Curimaná.

CONCLUSIONS

Exploring the relevance of natural tropical forest products for wellbeing, our study shows that on average, near 40% of the annual income of 578 households from 26 communities with diverse ethnic composition at distinct environmental settings in the Peruvian region of Ucayali is derived from forests and natural environments (including fisheries), followed by agriculture (25%), wages (17%) and livestock (11%). Compared to similar assessments in other tropical forest locations (Vedeld et al. 2007), these figures are a strong indicator of the criticality of multiple uses of forest products for a large share of the local population. A substantial portion of this income is obtained from the sale of timber extracted from primary forests and from the consumption and sale of bush meat, denoting potential depletion of natural capital and impact on biodiversity through rather unsustainable practices, particularly in remote *mestizo* settlements.

These results highlight the synergies and trade-offs between agriculture and forest use through livelihoods based on the integration of multiple sources of income. The study shows that livelihood orientation (either featuring high forest or high agriculture dependency), when examined in isolation, did not provide sufficient evidence to explain income variation across households.

As agriculture is the main purpose of land clearing for 94% of the households in the sample, the study in Ucayali specifically examined environmental outcomes of agricultural intensification. Outcomes were assessed in terms of both the total extent of land used for agriculture and the area recently cleared. Categories of agricultural land use were considered a proxy for agricultural intensification to assess the relationship between more intensive agricultural systems and deforestation. Empirical observation in the research sites confirmed that perennial land uses (mostly cocoa and oil palm) involved greater use of capital and labor compared to semi-perennial crops (mainly plantain), which by their turn demanded more inputs than annual fields of rice, maize and cassava. Survey results also attested negligible engagement of indigenous households in perennial crops and cattle ranching.

Land use allocation by Ucayali households did not support the hypothesis that intensification of land use reduces land clearing. After classifying households according to their predominant land use orientation, average areas recently cleared by those focusing on perennials and semi-perennials resulted as large as those observed for households focusing on annual cropping. In addition, the statistically significant variation of total land used for

agriculture across classes shows no evidence that perennial crops spare land when compared to semi-perennials or annuals. This finding is particularly relevant for policy, as it questions the argument that higher income eventually provided by cash crops would suffice to restrain farmers from further land clearing. Our results indicate that the current socioeconomic status of Ucayali smallholders combined with value chain imperfections and low yields for the main products do not allow them to preclude annual cropping for food security and greater livelihood resilience.

These enhanced understandings of the environmental consequences of resource allocation decisions in Ucayali provide insights on aspects of rural wellbeing in forested areas. Rather than associating dependency on forest use with reduced levels of wellbeing, the examination of the Abujao basin in Ucayali confirms interesting aspects of the dynamics involved in forest resource extraction in frontier areas. Higher income in more remote areas such as Abujao are explained by the fact that at sites where natural capital is abundant, earlier stages of accumulation feature comparatively higher incomes derived from natural products for local resource users, even when controlling for ethnic group.

Relevant policy implications can be derived from this study. Despite the importance of forest products for both *mestizo* and indigenous households in Ucayali, their livelihood is heavily dependent on agriculture. Policy interventions and management options aimed to the concurrent objectives of environmental conservation and economic development should thus pay attention to the modalities of integration between agriculture and forest use, and would only be successful when taking advantage of such integration to strengthen local livelihoods. This is particularly true in the current context marked by the environmental primacy of global debates on climate change mitigation. Cultural and socioeconomic implications of an emissions reduction framework heavily relying on carbon market transactions could indeed weaken efforts for greater inclusiveness and disregard the social co-benefits of rights-based environmental policy approaches. Such co-benefits are essential to prevent that a “double negative price” is paid by indigenous peoples directly impacted by adverse climate change as well as from actions taken to stop climate change from developing further (Riamit and Tauli-Corpuz 2012). The search for alternatives to the impacts resulting from drastic changes in land use in the Amazon acquires a critical dimension for vulnerable social groups whose livelihood is strictly dependent on forest products. Facing restrictions posed by ever decreasing entitlements to land and resources, they need support to assist in the adjustment

of their traditional production systems to the environmental and social challenges of the 21st century. If provided with suitable information and incentives, they are capable of implementing sustainable land use practices that will add environmental benefits to enhanced livelihoods.

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