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Forest income and dependency in lowland Bolivia

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Abstract Forests contribute to livelihoods of rural people throughout the tropics. This paper adds to the emerging body of quantitative knowledge on absolute and relative economic importance, through both cash and subsistence income, of moist forests to households. Qualitative contextual information was collected in six villages in lowland Bolivia, followed by a structured survey of randomly selected households ($n = 118$) that included four quarterly income surveys. We employed a novel data collection approach that allows detailed estimation of total household accounts, including sources of forest income. We estimated the average forest income share of total annual household income (forest dependency) at 20%, ranging from 18 to 24%. Adding environmental income increased the average to 26%, being fairly constant across income quartiles at 24–28%. Absolute levels of forest income increased with total household income, while forest dependency was the highest in the best-off income quartile—the primary harvesters of forest products are better-off households. The pattern of high forest dependency among better-off households has also been reported from other countries, indicating that this pattern may be more common than advocated by conventional wisdom. Using ordinary least squares (OLS) regressions, we found significant determinants of absolute forest income to be household size, sex of household head and area of cultivated land; the significant determinants for forest dependency were level of education, whether household head was born in village and whether household was food self-sufficient. Better-off households were able to realise cash income from forests, while poorer households—in particular if headed by women—were more reliant on subsistence forest income. We argue that the differential patterns of forest income across income quartiles should be considered in future development interventions and that findings indicate a potential for forests to contribute to moving households out of poverty.

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1 Introduction

There is emerging tropics-wide evidence that forests provide an important source of subsistence and cash income to rural households. Forest dependency, here defined as relative forest income (the average household-level share of forest income in total household income), spans a wide range—from households that depend almost entirely on forest income to those that do not depend on such income at all (Vedeld et al. 2007). Most available evidence is from drier sites in southern and eastern Africa; these studies have shown that relative forest income ranges from 15 to 39% (Babulo et al. 2008; Cavendish 2000; Dovie et al. 2005; Fisher 2004; Kamanga et al. 2009; Mamo et al. 2007) even in locations with very scarce forest resources and that poorer households are generally more forest dependent even if more well-off households have higher levels of absolute forest income. Qualitative studies also indicate that moist forests are important (e.g. Becker and Leon 2000; Colchester 2006) as part of diversified livelihood strategies but quantitative evidence from moist forests is very limited. There is a huge number of forest valuation and income-related studies that do not report household-level total absolute and relative forest income estimates, for example, as other objectives are pursued (e.g. Appiah et al. 2009; Reyes-García et al. 2006). It may also be that the resources required to collect valid and reliable forest income data (Cavendish 2002) are limiting the number of such studies, for example, as just one or a few forest products are included (e.g. Tschakert et al. 2007). Lastly, the perceived challenges in collecting such data means that forest income estimates are not included in standardised living standards measurement surveys (Oksanen and Mersmann 2003); studies based on such data sets are therefore not directly useful in connection to understanding the role of forest income in rural households. The few available studies from south and central America indicate a share of forest income in household subsistence income of 15–53% and a share of 7–57% of forest products in household cash income (Godoy et al. 2000, 2002; McSweeney 2002); reported levels of relative forest income are about 18–27% (Coomes et al. 2004; Matos 2005; McSweeney 2002).

There are very few published studies that present results on total household income and distinguishing cash and subsistence income. Most studies of forest income and dependency have focused on (i) either forest cash income or forest subsistence income, (ii) just a subset of forest products (e.g. Svarrer and Olsen 2005), (iii) merely reporting total income, omitting details on what is cash and subsistence income (e.g. Kamanga et al. 2009), or (iv) reporting income in units that cannot be related to households, for example, in USD/ha/yr. But there may be differential patterns of resource use across resources generating cash and subsistence income; our understanding of such differences is limited yet may be important in designing specific, targeted policy interventions.

This paper will contribute to the emerging body of knowledge on the importance of wet forests to rural households through a study of six villages in lowland Bolivia. We employ a novel data collection approach that allows detailed estimation of total household accounts, including sources of forest income, using brief recall periods throughout a 1-year period. The emphasis is on analysing and understanding variation, by income sources and quartiles, in (i) absolute and relative household income and (ii) subsistence and cash income.

With particular attention to absolute and relative forest income, we use theory to identify possible household-level determinants (including household education, size, land owned and food self-sufficiency; household head sex, age and origin) of absolute and relative forest income, and multiple regression models to empirically investigate the determinants. We proceed to discuss how findings may inform future policies and development interventions.

2 Methods

2.1 Case study area

Field work was undertaken in the Tropics of Cochabamba, a 39,560 km^2 area making up 58% of the Department of Cochabamba in the Central Bolivian lowlands (Fig. 1). Annual rainfall is 5,573 mm, and annual average temperature is 25°C. The study area has a population of 158,000 people (INE 2002), of which 17% are found in seven urban areas, with the remaining scattered across hundreds of small villages, composed of indigenous groups (such as Yuracare, Yuqui and Mojenos) and in-migrants from the Bolivian highlands. Each indigenous village has a council, which is the main administrative body. For in-migrant villages, the lowest legally recognised administrative unit is the sindicato, usually comprising only one or a few villages that are organised in centrales, which are again organised in federaciones.

Land use in the region is dominated by natural forests (67%), followed by agriculture and pasture lands (22%). Agriculture is important to livelihood strategies; soils are generally fragile (clay loam with low acidity and moderate availability of macronutrients); main subsistence crops are rice, maize and cassava; main commercial crops are coca leaves, fruits (citrus, plantain) and cocoa. It is legal for farmers to produce coca leaves on plots of up to 1,600 m^2 per household; alternative crops, such as palm heart, pineapple, achiote (*Bixa orellana*), coffee and camu-camu (*Myrciaria dubia*), are promoted by development agencies in the study area, as is formal forest management (UMSS-PROGEO

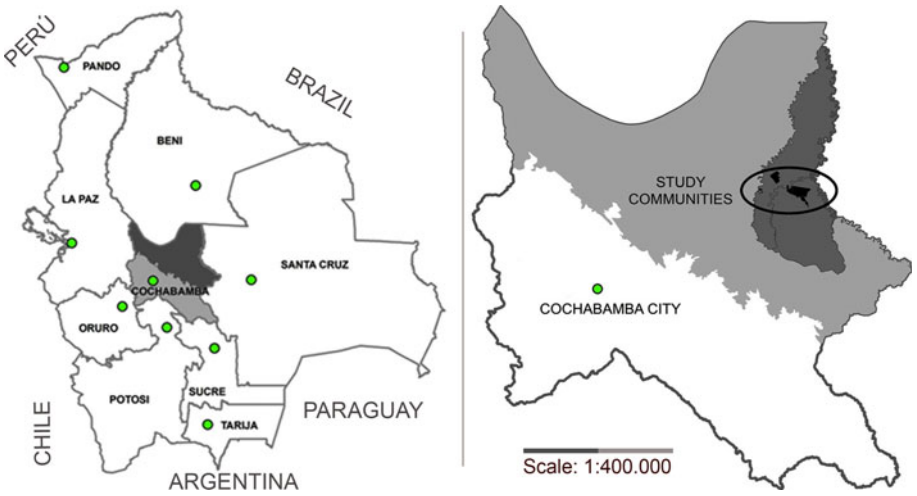

Fig. 1 Map of Bolivia showing the location of the Department of Cochabamba and the study area

2005). Following the introduction of the 1996 forest law, there has been some shift from traditional subsistence use to commercial use of forests in the region. In 2005, there were about 64 villages with formally approved forest management plans (Proyecto Jatun Sach'a 2005); commercial timber harvesting extracts about three m^3/ha/year (Malky 2005) and an estimated 150,000 ha is under formal management (UMSS-PROGEO 2005). Deforestation in the Department of Cochabamba amounts to approximately 10–15,000 ha/year due to demand for agricultural and pasture lands (Proyecto Agroforestal C-23 2003). In general, the Bolivian rural population is poor with 74.3% living below the national poverty line of 457 Bolivian bolivianos (Bs) per capita per month (about USD 1.9/cap/day; UDAPE 2009a); the human development index in the study area is 0.56 (UDAPE 2009b). Agricultural productivity is low and a significant proportion of households use forests to support their daily consumption.

Three colonist (Asaí, Aliso Colorado and Ambaibo) and three indigenous (Bejuco, Blanquillo and Bibosi) villages were included in the study (all names are fictive to provide anonymity). An overview of the six villages is presented in Table 1. Village selection criteria were as follows: (i) some degree of forest dependency; (ii) low coca production—based on previous field work experience from the area, we judged that high (i.e. illegal) coca production would result in invalid household asset and income data, as this is a very sensitive issue; (iii) legal accessibility—that it was likely that villages would grant us permission to conduct research; and (iv) physical proximity—for budgetary reasons, villages could not be located too far apart. The villages are involved in formal forest management and are members of the local forest union (that organises villages involved in such management). All six villages are located in a very humid subtropical closed-canopy natural high forest characterised by timber species such as mapajo (*Ceiba pentandra*), verdolago (*Terminalia* spp.), almendrillo (*Dipterex odorata*), trompillo (*Guarea* spp.), ambaibo (*Cecropia membranacea*), ochoó (*Hura crepitans*), charque (*Eschweilera coriaceae*), coquino (*Pouteria* spp.), jorori (*Swartzia jorori*) and negrillo (*Nectandra* spp.). All villages were established fairly recently (1970–1996, Table 1). There are differences with respect to area size, number of households and average household size, as well as average level of daily income. All villages are dependent on agriculture and five do some hunting and/or fishing. Distances to markets vary from 20 to 38 km; Bibosi is relatively isolated. Development of forest management plans was undertaken with the assistance of donor agencies.

2.2 Data collection

Before qualitative contextual data collection and household interviews could start, permission to conduct research in the six villages was negotiated with the association of municipalities as well as with the sindicatos and the indigenous councils. Negotiations, undertaken by the first author who is a Bolivian national and with extensive prior field experience from the area, took 3 months and resulted in a formal written agreement with each village, including agreement on returning preliminary findings to each village in detailed files (see Uberhuaga 2009). The purpose was to share research results as well as making these easily available as input to any future development and research projects in the villages.

Data collection and handling followed the procedures developed by the Poverty Environment Network (PEN) and specified in the prototype questionnaire (PEN 2007a) and technical guidelines (PEN 2007b). First, qualitative rural appraisal at village level was used to generate contextual information about the study area and its people; this

Table 1 Overview of the six study villages in lowland Bolivia, 2006 (based on data from household survey and forest management plans)

	Asaí	Aliso Colorado	Ambaibo	Bejuco	Blanquillo	Bibosi
Yr of establish/ legal land title	1984/1999	1982/1999	1996/2001	1970s/2003	1982/2000	Few households in 1970, more in 2003 and 2006
Area (ha)[a]	1,294	3,346	6,109	428	487	5,159
No. of households	40	119	32	26	24	81
Av. household size	5.5	4.8	5.7	4.7	7.5	5.8
No. of sampled households	18	37	8	12	12	31
Distance to market (km)	35	38	28	20	31	38
Accessibility	Road	Road	Road being constructed	Road	Road, river	Foot and cycle path, river
Main livelihood activities	Agriculture, timber, hunting, fishing	Agriculture, timber, labour in forest plantations	Own business, agriculture, fishing	Hunting, fishing, agriculture, small livestock	Timber, agriculture, hunting	Hunting, fishing, agriculture, timber
Forest mgt. plan (ha/year approved)	181/2004	195/2004	201/2003 (1,400 in prep.)	123/2004	156/1998	2000/in prep.
Per capita daily income (USD)[b]	3.7	3.0	2.4	1.9	1.7	2.1
Notes[c]	In-migrants	In-migrants	In-migrants	Yuracare	Mojenos, share infrastructure with colonist village	Yuracare, also resides in a peri-urban area

[a] Total size of village lands, including settlement and communal lands

[b] The average exchange rate in the study period was 8.01 Bs/USD (Bolivian Central Bank 2007)

[c] In-migrants have both private and communal lands; indigenous groups have communal lands only

information was then used to adopt the prototype questionnaire to the local context. Data collection was undertaken by a small team of research assistants rather than enumerators. The assistants were social science bachelors (economics or sociology) with some research experience and a lot of research interest. The team was trained in the PEN approach to research and data collection. They worked in subteams of two people: one asking the questions and the other taking notes and controlling the development of the interview. The questionnaires were pre-tested in a village in the Tropics of Cochabamba by the research team, and the experiences gained were used to fine tune approaches to asking sensitive questions and to add extra data collection techniques to the rapid appraisals at village level. Each evening in the field ended with a team meeting where the day's collected data were checked and discussed. Inconsistencies and errors were then clarified directly with relevant households the following day. Lund et al. (2008) and Angelsen et al. (2011) discuss the experiences of using the PEN approach across a range of different sites and conditions.

Contextual information on village history and characteristics was collected using rapid appraisal techniques, including communal maps, seasonal activity calendars, resource use flow maps, chronological village history and individual life histories. Village meetings took 3–5 h, mainly in the evening (households are busy during the day). As the interview team spent between 10 and 15 weeks in each village, it also made participatory observations of households' livelihood activities (e.g. work in agricultural fields, fishing and woodcarving). Direct observations, for example, of household assets and activities formed an important part of the research team's everyday work. These observations were used to check the structured survey responses while the interview was going on and probe as required, for example, to understand in detail the how, when and where of wild fruit collection. Lastly, the research team also recorded long informal conversations with household members.

Empirical data collection covered the 1-year period February 2006–January 2007. So-called annual household-level questionnaires (see PEN 2007a, b for details) were applied at the beginning (focusing mainly on demographics and assets) and end of the period (focusing mainly on crises in and perceptions of the past year), and in-between four quarterly surveys (focusing mainly on income) were administered. Household is here defined as "a group of people (normally family members) living under the same roof, and pooling resources (income and labour) for their livelihood" (PEN 2007b: 21). Most households consisted of family members, though some were based on ethnic kinship. The term "village" refers to a unit of households with common norms and rights, typically found in scattered settlements, under the jurisdiction of a village leader or council.

Updated and checked village-level census lists were used to randomly select households ($n = 165$) for interviews. Up to 50% of households in each village were initially selected, but some dropped out, mainly because they found the interviews too time-consuming and delving into sensitive issues, for example, the questions on savings and the detailed recording of income. The final number was $n = 118$. See Table 1 for an overview of the distribution of sampled households across villages. Generally, each quarterly interview took more than 1 h—much effort was invested in building trust, and interviewer–household relationships were very good at the time of the third and fourth quarterly surveys.

2.3 Applied income definitions

Here, we define household annual total income as the sum of all outcomes of household economic activities, measured in income per adult equivalent unit (Cavendish 2002), throughout a 1-year period. We use the value added income measure (Sjaastad et al. 2005),

that is, all reported income is gross value minus costs of intermediate inputs and capital costs (does thus not subtract labour costs). Depreciation is not taken into account as most activities have very low costs of capital consumption and intermediate outputs. Distinction is made between four income sources: *Forest income* is the sum of the values resulting from extraction of raw materials from forest, processing forest products and wages for forest-related activities such as working in forest plantations. It includes the values of mobile forest products harvested outside the forests, for example, forest animals hunted in agricultural fields. Forest product processing, including supply chains and the division of labour, in the study area is largely homogenous. *Environmental income* is value added from the consumption of non-cultivated wild products collected outside the forest, mainly from grassland/pastures and rivers. As a component of forest income is derived from returns to skilled labour, this creates some bias when comparing income across sectors. However, given the difficulties in estimating labour costs (and normal profits, required to use the rent income measure) and the relatively minor role of forest income derived from processed products and wages (Appendix), we find the use of value added the only realistic solution. We distinguish forest and environmental incomes as this allows an analysis of the relative importance of each of these sources of income. *Farm income* is the economic value from crop and livestock production: the former includes subsistence and cash annual and perennial crops, also from agroforestry and horticulture; the latter includes the sales of livestock products, also live animals and services but excludes incremental stock value changes. Agricultural and livestock wages are included in farm income. *Non-farm income* refers to income from other sources than the three above: self-owned businesses, remittances and pensions, and non-farm wages, for example, from construction work.

2.4 Data analysis

Households use a large number of forest, (non-forest) environmental, agricultural and livestock products, for both subsistence and commercial purposes—a total of 151 forest and environmental products were recorded. Analysis of basic distributional statistics for the households' own-reported values concluded that such estimates produce aggregated unit values with acceptable properties and that they can thus be used for income calculations. For details, see Uberhuaga and Olsen (2008) that also contains information on valuation techniques and calculations at the product level. Whenever possible, own-reported values were based on farm-gate prices. If these were not available—or markets were very thin—barter values, local market price of close substitute, or willingness to pay, were estimated.

When calculating income, the value of resources used as input into other production is deducted from the gross value and rebooked on the appropriate account. For instance, the value of browse and graze was estimated on the basis of annual fodder consumption per livestock unit (LU, assuming 1 LU = cow of 500 kg live weight, use of standard factors for converting livestock types to LU and an estimated daily feed requirement of 5.5 kg dry weight per LU) and the value of ordinary quality fodder grass (estimated at Bs 0.85/kg). Combined with knowledge of the relative importance of land use types as sources of fodder (available from the household questionnaire—grassland estimated to provide 67% of fodder, pasture 29% and fallows 4%), this allowed an estimate of the value of browse and graze and subsequent deduction from the livestock account and rebooking under the environmental (96%) and agricultural (4%) income accounts. When calculating net farm income, it was assumed that the value of inputs, not available at individual crop level, was proportional to the share of the crop in the value of total crop outputs.

Table 2 Overview of the expected relationships between household-level characteristics and absolute forest income (AFI) and forest dependency (relative forest income, RFI) in lowland Bolivia

Variables	Exp. sign, AFI	Exp. sign, RFI	Comments
Female-headed household	−	+	Female-headed (dummy = 1) households do not engage in high-return forest activities, meaning less absolute forest income (McSweeney 2003); however, they rely more on subsistence forest income, meaning higher relative forest income (Stoian 2005)
Household education	−	−	Max. no. of years of schooling attained by household members at least 18 years of age. High level means better employment opportunities, people are less engaged in low remunerative forest extraction activities (Godoy and Contreras 2001; Mamo et al. 2007; Stoian 2005)
Household size	+	+	Number of household members. The higher the more labour available to engage in labour intensive forest extraction activities (Godoy et al. 1997; Mamo et al. 2007)
Age of household head	−	−	Young households more involved in physically demanding forest extraction activities (Godoy et al. 1997; Mamo et al. 2007), while older household heads rely on less arduous activities (Cavendish 2002; Coomes et al. 2004; McElwee 2008)
Birthplace of household head	+	+	If household head is born in the village (yes = 1), this implies a close relation with the natural environment and relatively asset poverty (Stoian 2005), therefore both higher absolute and relative forest income
Land size	+	−	Cultivated land in ha. Large area means higher agricultural income and thus less relative forest income. Higher absolute forest income is, however, expected as agriculture takes place right next to the forest (spending time in fields thus leads to more forest product harvesting) and as forest clearing (leading to forest income) is frequently part of agricultural activities
Forest area under management plan	+	+	Forest area in ha under forest management plan accessible to household. The larger the area, the higher the absolute and relative forest income
Non-farm employment	−	−	No. of days of skilled non-farm employment. The higher the less need for forest income and lower relative forest income
Self-sufficient food production	−	−	Yes = 1. Self-sufficient households need not engage in forest extractive activities
Distance to market	+	+	Distance from village centre to market in km. The longer the distance, the fewer non-forest income options are available, thus increasing both absolute and relative forest income. Closeness to market often accelerates forest extraction (Godoy et al. 2002)

Income is reported by quartile, source and type (subsistence or cash). Statistical analyses are descriptive statistics and multiple regression models investigating the determinants of household-level absolute forest income and forest dependency (relative forest income). An overview of explanatory variables and expected relationships, based on published literature and knowledge of the study area, is presented in Table 2. In line with published literature, the functional forms are assumed linear. Model fits were not improved

when testing for different functional forms. Quantitative explanatory variables are continuous, whereas dummies are used for qualitative variables. The check for multicollinearity led to removal of some variables (e.g. the dropped variable 'years of residence in village' was correlated with membership of ethnic group). The Breusch–Pagan test showed that heteroscedasticity is not significant. Testing for endogeneity (Wooldridge 2006) did not produce evidence of correlation between explanatory variables and the error term.

3 Results

3.1 Overall data on household income

There are considerable differences in household and per adult equivalent unit incomes across the income quartiles, Table 3. The lowest income group accounts for 8% of total income for all households against 57% for the top quartile whose mean household income is more than seven times that of the bottom quartile. The Gini coefficient is 0.52, lower than the national figure of 0.57 (World Bank 2011). Average per adult equivalent unit daily income is USD 2.6, increasing from USD 0.8 in the lowest to USD 6.0 in the top income quartile. Per adult equivalent unit cash income shows the same pattern. Average household size declines with increasing total income.

3.2 Total annual household income

An overview of annual total mean household income by main income sources and quartiles is presented in Table 4 (additional details in the "Appendix"). *Forest income* is important to all income groups. Overall, it accounts for 20% of total income, its share increasing from 19 to 24% from the lowest to the top income group, whereas in absolute terms the contribution increases by a factor 12. Unprocessed forest products dominate in all groups; forest income is further analysed in Sect. 3.4. The share of *environmental income* is small for all income groups (3–8%); it decreases with income, while the absolute amount increases. Environmental income is mainly from fish and livestock browse and graze. *Farm income* is the most important in all income groups, on average, accounting for 54% of total household income, its share being rather equal over the groups (50–59%) but highest in the poor-income group. Agricultural income dominates in all groups, with highest share in the middle-income groups and almost the same share in the lowest and top groups. Wages (for

Table 3 Household ($n = 118$) mean income data (USD ± SD) across income quartiles, lowland Bolivia, 2006

Data	Poorest Lowest 25%	Poor 25–50%	Medium 50–75%	Less poor Top 25%	Sample mean
Total household income	302 ± 76	506 ± 79	825 ± 111	2178 ± 1212	946 ± 944
Per adult equivalent unit daily income	0.8 ± 0.2	1.4 ± 0.2	2.3 ± 0.3	6.0 ± 3.3	2.6 ± 2.6
Per adult equivalent unit cash income	0.6 ± 0.2	1.0 ± 0.2	1.9 ± 0.4	4.9 ± 3.1	2.1 ± 2.3
Average household size	6.5 ± 2.7	5.8 ± 2.3	4.9 ± 1.8	4.7 ± 2.6	5.5 ± 2.5
Quartile's share of total income (%)	8	13	22	57	100

Table 4 Total annual mean household ($n = 118$) absolute (Bs[a]) and relative (%) income per adult equivalent unit by income source and quartile, lowland Bolivia, 2006

Income source	Poorest		Poor		Medium		Less poor		Sample mean	
	Lowest 25%		25–50%		50–75%		Top 25%			
	Abs[b]	Rel[b]	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel
Forest income	466	19	827	20	1,193	18	5,533	24	1,985	20
Unprocessed forest products	374	16	667	16	983	15	4,479	18	1,610	16
Processed forest products	35	1	24	1	−11	0	893	4	231	2
Wages	57	2	136	3	222	3	161	2	144	2
Environmental income	187	8	337	8	386	6	454	3	340	6
Medicinal plants & wild fruits	2	0	0	0	10	0	0	0	3	0
Fish	81	4	270	6	235	4	345	2	232	4
Browse and graze	104	4	67	2	141	2	108	1	105	2
Farm income	1,270	53	2,389	59	3,464	53	8,309	50	3,833	54
Agriculture	995	40	1,997	49	2,835	44	7,240	42	3,244	44
Livestock	−51	−2	−1	0	−84	−1	493	3	87	0
Wages	326	15	393	10	712	10	576	5	502	10
Non-farm income	493	20	503	13	1,566	23	3,147	23	1420	20
Self-owned business	177	8	126	3	775	12	1,136	9	552	8
Remittances, pensions and other	135	5	118	3	68	1	1,335	11	409	5
Wages	182	7	259	7	722	10	676	3	460	7
Total household income	2,416	100	4,056	100	6,609	100	17,443	100	7,578	100

[a] 1 USD = 8.01 Bs, annual average (Bolivian Central Bank 2007)

[b] *Abs* absolute income, *Rel* relative income

work on other farms) are important to all income groups but most so to the lowest group (15%). Livestock is generally of little importance. *Non-farm income* has the same overall importance as forest income (20%); it is lowest (13%) in the poor-income group. To all but the top group, wages (non-farm/non-forest) are important. Self-owned business is of greatest importance to the two highest income groups. Remittances are particularly important in the highest income quartile.

3.3 Relative annual household subsistence and cash income

Cash makes up a larger share (77%) of total income than subsistence in the sample (Table 5); cash dominates across all income quartiles and is highest in the two top quartiles. Forest cash income increases with increasing income, while forest subsistence income is most important to the lower-income quartiles. Farming is by far the most important source of cash to all income groups (46–52% of total household income), followed by non-farm cash income (13–23%) and forest cash income (4–12%). Environmental income is generally dominated by subsistence income.

3.4 Annual household forest income

Subsistence forest income dominates in the two lowest income quartiles (71–76%), while cash income is higher than subsistence income in the two highest quartiles (Table 6).

Table 5 Total annual household ($n = 118$) subsistence and cash absolute (Bs[a]) and relative income (%) per adult equivalent unit by income source and quartile, lowland Bolivia, 2006

Income source	Poorest		Poor		Medium		Less poor		Sample mean	
	Lowest 25%		25–50%		50–75%		Top 25%			
	Abs[b]	Rel[b]	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel
Forest income	466	19	827	20	1,193	18	5,533	24	1,985	20
Subsistence	355	15	585	14	462	7	2,255	12	905	12
Cash	111	4	243	6	732	11	3,278	12	1,079	8
Environmental income	187	8	337	8	386	6	454	3	340	6
Subsistence	184	8	275	7	343	5	393	3	298	5
Cash	3	0	61	1	43	1	61	0	42	1
Farm income	1,270	53	2,389	59	3,464	53	8,309	50	3,833	54
Subsistence	148	7	290	7	336	5	633	4	342	6
Cash	1,123	46	2,099	52	3,128	48	7,706	46	3,490	48
Non-farm income	493	20	503	13	1,566	23	3,147	23	1,420	20
Subsistence	0	0	0	0	0	0	0	0	0	0
Cash	493	20	503	13	1,566	23	3147	23	1,420	20
Total household income	2,416	100	4,056	100	6,609	100	17,743	100	7,578	100
Subsistence	687	30	1,150	28	1,140	18	3,251	18	1,546	23
Cash	1,729	70	2,905	72	5,468	82	14,192	82	6,032	77

[a] 1 USD = 8.01 Bs, annual average (Bolivian Central Bank 2007)

[b] *Abs* absolute income, *Rel* relative income

Forest income is dominated by unprocessed products (81%), with little difference in total importance between income groups. Overall, timber is by far the most important product (59%); the importance of timber increases with increasing income. The opposite is true for all other product groups; fuel wood and game meat are particularly important in the lower-income quartiles. Forest wages are important to all groups except the highest quintile.

3.5 Determinants of household forest income and forest dependency

Basic distributional statistics for the explanatory variables in the ordinary least squares (OLS) regressions are shown in Table 7. Few households are female headed, the mean household size is 5.5, and adults have an average of 7 years of schooling. Most often, the household head belongs to the major ethnic group and is not born in the village. The mean cultivated area is 5.2 ha (of which 1.3 ha is used for staple crops). The mean area under forest management plan is 5.7 ha but with a large variation. Skilled non-farm work is widespread but varies a lot amongst households. Half of the households are self-sufficient in food production.

The results of the OLS regressions analysing forest income and forest dependency against household characteristics are presented in Table 8. There is a significant tendency for higher absolute forest income if the household head is a woman. This unexpected finding is due to high levels of subsistence forest product extraction and very limited access by such relatively poor households to other income generating options such as self-owned business or wage work. The higher the educational level of household members, the smaller is both forest income and forest dependency (the latter finding is significant)—more remunerative alternative income sources are available. Household size is significantly

Table 6 Total annual household ($n = 118$) absolute (Bs[a]) and relative (%) forest income per adult equivalent unit by quartile and source, lowland Bolivia, 2006

Forest income sources	Poorest		Poor		Medium		Less poor		Sample mean	
	Lowest 25%		25–50%		50–75%		Top 25%			
	Abs[b]	Rel[b]	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel
Unprocessed forest products	374	80	667	81	983	82	4,479	81	1,610	81
Fuel wood	152	33	198	24	208	17	322	6	219	11
Game meat	93	20	101	12	76	6	169	3	109	5
Medicinal plants	13	3	15	2	50	4	33	1	28	1
Timber	62	13	260	31	574	48	3,844	69	1,170	59
Tree leaves & branches	16	3	48	6	20	2	25	0	27	1
Wild animals & their products	2	0	10	1	32	3	2	0	11	1
Wild fruits	33	7	32	4	22	2	34	1	30	2
Other	4	1	4	1	1	0	50	1	14	1
Processed forest products	35	8	24	3	−11	−1	893	16	231	12
Construction materials	30	7	19	2	5	0	873	16	228	12
Wooden furniture & tools	0	0	0	0	−14	−1	13	0	0	0
Other	5	1	5	1	−3	0	7	0	4	0
Forest wages	57	12	136	16	222	19	161	3	144	7
Total forest income	466	100	827	100	1,193	100	5,533	100	1,985	100
Subsistence	355	76	585	71	462	39	2,255	41	905	46
Cash	111	24	243	29	731	61	3,278	59	1,079	54

[a] 1 USD = 8.01 Bs, annual average (Bolivian Central Bank 2007)

[b] *Abs* absolute income, *Rel* relative income

Table 7 Descriptive statistics for explanatory variables, ordinary least squares (OLS) regressions, lowland Bolivia, 2006

Variables	Unit	Mean	Median	SD	Min	Max
Female-headed household	Yes = 1	0.06	0	0.24	0	1
Household education	Max. years of schooling	7.0	6	3.7	0	17
Household size	No. of household members	5.5	5	2.5	1	16
Age of household head	Years	38.4	36.5	11.9	20	69
Household head born in village	Yes = 1	0.10	0	0.30	0	1
Land size	Ha	5.2	4	4.9	0	31.9
Forest area under management plan	Ha	5.7	0	21.3	0	143
Non-farm employment	Days	8.8	0	30.6	0	210
Self-sufficient food production	Yes = 1	0.51	1	0.50	0	1
Distance to market	Km	34.3	38	5.7	20	38

and negatively related to absolute forest income, contrary to what was expected—the reason may be that other income sources are available in the area and can be exploited when the number of household members increases. Both forest income and forest dependency are negatively related to age of household head as expected. If the household head is born in the village, it seems to have positive effects on both forest income and

Table 8 Ordinary least squares (OLS) regressions of absolute and relative forest income against household ($n = 118$) characteristics, lowland Bolivia, 2006

Explanatory variables	Absolute forest income				Relative forest income			
	Coefficient estimate	SE	t ratio	Prob $> \|t\|$	Coefficient estimate	SE	t ratio	Prob $> \|t\|$
Female-headed household	4,384	1,821	2.41	0.018	0.194	0.081	0.24	0.812
Household education	−17	115	−0.15	0.881	−0.011	0.005	−2.15	0.033
Household size	−567	178	−3.19	0.002	0.0051	0.079	0.66	0.512
Age of the household head	−18	36	−0.50	0.616	−0.013	−0.0016	−0.80	0.424
Household head born in village	385	1,379	0.28	0.780	0.139	0.062	2.27	0.025
Land size	244	89	2.73	0.007	−0.0025	0.040	−0.64	0.522
Forest area under management plan	29	20	1.47	0.145	0.002	0.0009	1.76	0.082
Non-farm employment	−23	15	−1.55	0.123	−0.0008	0.0007	−1.21	0.230
Self-sufficient food production	−1,430	830	−1.72	0.088	−0.105	0.037	−2.83	0.006
Distance to market	110	73	1.51	0.134	0.005	0.003	1.54	0.127
Constant	−1,339	2,975	0.45	0.654	0.178	0.133	1.34	0.183
	$R^2 = 0.197$; R^2_{adj}=0.122; $F = 2.63$; Prob $> F$=0.0067				$R^2 = 0.197$; R^2_{adj}=0.1225; $F = 2.63$; Prob $> F$=0.0066			

forest dependency—with the latter finding being significant. Household heads born in their village are also likely to belong to indigenous groups and thus have better knowledge of forest income generating opportunities. The more land is cultivated, the higher is forest income and the lower is forest dependency as expected. There is no significant positive effect of area under forest management plan—such plans may not increase the use of forest resources, at least in the short run, due to access limitations caused by administrative procedures related to harvesting (taxes, authorisations, certificates, etc.). The more skilled non-farm work and self-sufficiency in food production, the less forest income and dependency; none of these relations are surprising. Both forest income and forest dependency seem to be positively related to distance to nearest market.

4 Discussion

4.1 Household forest income and dependency

The average forest income share of total annual household income was 20%, ranging from 18 to 24%. This underlines that future income and livelihood studies from the region should explicitly include forest income. Interestingly, the highest level of forest dependency was found in the highest income quartile, with the absolute level of forest income increasing with increasing total household income. The primary harvesters of forest products are thus better-off households, not the poorer. Forest products may, even if harvested in lower quantities, still be of key importance to poorer households.

The level of the share of forest income is similar to that reported by Coomes et al. (2004) in Peru and Matos (2005) in Bolivia. The share of forest income in household subsistence income averages 52%; the share in cash income averages 10%. This is at the upper and lower boundaries, respectively, of the ranges reported by Godoy et al. (2000, 2002) from Bolivia and Honduras; the cash income share is in the span reported by McSweeney (2002) from Honduras. The average share of forest and environmental income in total household income was 26%, being fairly constant across quartiles at 24–28%. This is at the lower boundary of dependency ranges reported from Malawi (21–41%, Fisher 2004), Ethiopia (23–35%, Babulo et al. 2008), Zimbabwe (29–40%, Cavendish 2000), Bolivia and Honduras (17–45%, Godoy et al. 2002). The low range of 7–19% reported from Malawi by Kamanga et al. (2009) reflects the low forest cover and high population density in their chosen study area. In general, differences in the above studies in applied definitions, methodological approaches and contextual factors (e.g. market access and levels of education) make them difficult to compare.

Forest dependency is highest in the highest income quartile; these better-off households have assets, including physical capital like chain saws and social capital that facilitates forest access, that allow them to cut timber which is their dominant source of forest income. Similar patterns of high dependency among more well-off households have been reported from India (Jodha 1986), Nepal (Adhikari 2005) and Vietnam (McElwee 2008), indicating that this pattern may be more common that ordinarily believed—the prevailing assumption appears to be that forest product extraction is mainly undertaken by asset poor households, to prevent further impoverishment, with no other options (Angelsen and Wunder 2003). Decreasing forest dependency with rising total household income has been documented in Zimbabwe (Cavendish 2000), Malawi (Fisher 2004), Ethiopia (Mamo et al. 2007) and India (Narain et al. 2008).

All households rely on income from a large number of sources. The finding that absolute forest income increases with total household income is consistent with published results, for example, Cavendish (2000), Escobal and Aldana (2003), Babulo et al. (2008). Agricultural crop income is the main income source in all quartiles; agricultural wages are also important except for the upper quartile. Forest and non-farm income is, on average, equally important, while environmental income is of lesser importance and mainly so for poorer households. Even though environmental income dependence is low, some product groups, such as medicinal plants, may still be important for local welfare. There appears to be some scope for forest income to contribute to move households out of poverty: timber constitutes the third most important source of income in the best-off quartile. The causal explanations outlined in Table 2, the factors determining absolute and relative forest incomes, were generally supported by the empirical analyses that thus largely confirm relationships identified in the published literature. Significant determinants ($p < 0.05$) of absolute forest income were sex of household head, household size and area of cultivated land; ditto for forest dependency were level of education, whether household head was born in village and whether households were self-sufficient in food production. Noteworthy is particularly: (i) the finding that household size is negatively related to absolute forest income, contrary to what was expected—the likely explanation is that remunerative non-forest income sources are available and can be exploited. This may be facilitated by the relatively high level of education in the study area, and (ii) the unexpected positive relationship between absolute forest incomes and sex of the household head, probably caused by the lack of non-forest income generating options for female-headed households. While the modest adjusted R^2 values indicate that developing robust models of absolute and

relative forest incomes is difficult, results indicate the variables significantly linked to absolute and relative forest income and warranting further research.

4.2 Subsistence and cash income

Most cash is generated through agriculture, with production of fruits, coca leaves and cereals being the most important (Appendix). The importance of farm income, whether subsistence or cash, and non-farm income is rather constant across quartiles. Environmental cash income is not important to any group, while environmental subsistence income is important to the poorer households, but not the less poor.

A different pattern is observed for forest income, making it useful to distinguish between cash and subsistence incomes as there is differential access to these across households. As noted above, better-off households are able to realise cash income from forest products due to their access to assets that allow their involvement in commercial timber harvesting. This confirms existing studies noting that investments are necessary to realise high returns from forest products (e.g. Angelsen and Wunder 2003). Forest products with the potential to generate large amounts of cash cannot be accessed by poorer households; rather, these are limited to harvesting low-value commercial products and subsistence products. This is particularly true for female-headed households: these are significantly more likely to have higher absolute forest income, generated by the harvest of subsistence forest products.

4.3 Validity and reliability

Some households (47) left the study, especially after the first quarterly interview, because they found it too time-consuming and delving into sensitive issues, for example, questions about savings. Most of the attrition was due to one entire village leaving the study—thus households did not leave the study across all villages throughout the study period. We have not found any indications that attrition has biased the remaining household sample. The general interviewee attitude in the sample was positive and trust was continuously built in the interviewer–household relationship during the long field work period.

Households use a huge array of forest, non-forest environmental, agricultural and livestock products that are both traded and consumed locally. Much attention was paid to high-quality data collection, for example, checking data in the field and using the same enumerators throughout (see Lund et al. 2008 for details), and aggregated unit values were found to have satisfactory properties (Uberhuaga and Olsen 2008). Future collection of own-reported data can be further improved for key products by: (i) explicitly specifying product quality differences, for example, by distinguishing between main types of fuel wood—the better defined a product is the less variation in value estimates due to not recorded quality differences, and (ii) collecting information on local volume units at product level—this would allow more thorough cross-check of the ratio of reported unit values to the ratio of quantities.

4.4 Recommendations

The findings have a number of implications for future policies and development interventions aimed at improving the welfare of poor rural households. First, it is evident that future income and livelihood studies, including those conducted by the government, should explicitly be redesigned to include forest income. Second, the documented differential

income pattern should be taken into account, including (i) the scope to use forest resources to move households out of poverty through better access to low cost, legal timber harvesting and sale, (ii) the importance of maintaining access for poorer households to the subsistence forest products that make up a substantial part of their total household income, for example, in connection to land titling or when introducing new forms of forest governance. Even if absolute forest income levels are low for poorer households, the relative importance can make access to forest products crucial for such households. Third, while the study generally confirmed previous findings on the determinants of absolute and relative forest incomes, for example, that these are both negatively associated with level of education, a new and interesting finding is that female-headed households are more likely to have higher forest subsistence income. Specific attention should be paid to such particularly forest-dependent households when considering forest-related policies and interventions.

5 Conclusions

This study aims at contributing to the emerging body of knowledge on the levels of absolute and relative importance of forest income (forest dependency) to rural households in wet sites in developing countries. Data were generated by conducting qualitative contextual analysis of six villages in Central lowland Bolivia, followed by detailed estimation of total household accounts using brief recall periods in 118 randomly selected households in the villages. Forest income was important in all villages. The average forest income share of total annual household income was 20%, ranging from 18 to 24%. Adding environmental income increased the average to 26%, being fairly constant across income quartiles at 24–28%. These estimates appear comparable to published findings from other locations and countries. As expected, absolute levels of forest income increased with total household income. However, we also found that forest dependency was the highest in the best-off income quartile—the primary harvesters of forest products are thus better-off households, indicating that forests may have potential for contributing to moving households out of poverty. Timber is an important component in forest income for better-off households, while the poorest households gain most forest income from fuel wood and game meat. The pattern of high forest dependency among better-off households has also been reported from other countries, indicating that this pattern may be more common than advocated by conventional wisdom. Using OLS regressions, we found significant determinants of levels of absolute forest income to be sex of household head, household size and area of cultivated land; the significant determinants for forest dependency were level of education, whether household head was born in village and whether households were self-sufficient in food production. The distinction between cash and subsistence forest income proved important: Better-off households were able to realise cash income from forests, while poorer households—in particular if headed by women—were more reliant on subsistence forest income.

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Appendix

See Table 9.

Table 9 Average annual per adult equivalent unit absolute (Bs) and relative (%) net income by income source and quartile, lowland Bolivia, 2006

Income source	Poorest		Poor		Medium		Less poor		Sample mean	
	Lowest 25%		25–50%		50–75%		Top 25%			
	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel
1. Forest income	466	19.5	827	19.8	1,193	18.3	5,533	23.6	1,985	20.3
Unprocessed products (UP)	374	16.2	667	15.7	983	15.3	4,479	18.1	1,610	16.3
UP subsistence income	320	14.2	561	13.2	463	7.2	1,362	7.2	671	10.5
UP cash income	54	2.0	107	2.5	520	8.0	3,117	10.9	938	5.8
Fuel wood/firewood	152	6.5	198	4.8	208	3.3	322	2.1	219	4.2
Game meat—birds & bats	3	0.1	7	0.2	9	0.1	12	0.1	7	0.1
Game meat—reptiles	2	0.1	0	0.0	0	0.0	0	0.0	1	0.0
Game meat—mammals	88	4.0	94	2.3	68	1.0	157	1.1	101	2.1
Medicinal plants	13	0.5	15	0.4	50	0.7	33	0.2	28	0.5
Timber	62	2.2	260	6.1	574	8.9	3,844	13.8	1,170	7.7
Wild honey	1	0.0	0	0.0	1	0.0	1	0.0	0	0.0
Seeds, spices, roots & tubers	0	0.1	3	0.1	0	0.0	2	0.0	1	0.0
Reeds, lianas & vines	0	0.0	1	0.0	0	0.0	0	0.0	0	0.0
Thatching grass	3	0.1	0	0.0	0	0.0	48	0.4	13	0.1
Tree leaves & branches	16	0.8	48	1.0	20	0.3	25	0.2	27	0.6
Wild animals & their products	2	0.1	10	0.2	32	0.5	2	0.0	11	0.2
Wild fruits	33	1.6	32	0.7	22	0.3	34	0.2	30	0.7
Processed products (PP)	35	1.4	24	0.7	−11	−0.2	893	4.3	231	1.5
PP subsistence income	35	1.4	24	0.7	−1	−0.1	893	4.3	234	1.6
PP cash income	0	0.0	0	0.0	−10	−0.2	0	0.0	−3	0.0
Construction materials	30	1.1	19	0.6	5	0.1	873	4.1	228	1.4
Juice, oils & alcoholic beverages	5	0.3	1	0.0	0	0.0	8	0.1	3	0.1
Sawn wood	0	0.0	0	0.0	−6	−0.1	−1	0.0	−2	0.0
Wood crafting	0	0.0	4	0.1	4	0.1	0	0.0	2	0.0
Wooden furniture & other wooden tools	0	0.0	0	0.0	−14	−0.3	13	0.1	0	0.0
Forestry wages (cash)	57	1.9	136	3.4	222	3.3	161	1.3	144	2.5
2. Environmental income	187	8.0	337	8.3	386	6.1	454	2.9	340	6.4
EI cash income	184	7.9	275	6.7	343	5.5	393	2.6	298	5.7
EI subsistence income	3	0.1	61	1.6	43	0.7	61	0.4	42	0.7
Medicinal plants	0	0.0	0	0.0	2	0.0	0	0.0	1	0.0
Wild fruits	2	0.1	0	0.0	8	0.1	0	0.0	3	0.1
Fish	81	3.8	270	6.6	235	3.6	345	2.2	232	4.0
Grassland & pasture	104	4.0	67	1.7	141	2.4	108	0.8	105	2.3
3. Farm income	1,270	52.8	2,389	58.9	3,464	52.9	8,309	50.2	3,833	53.7
Agricultural products (AP)	995	39.7	1,997	49.1	2,835	44.2	7,240	42.0	3,244	43.7
AP subsistence income	269	11.0	330	8.3	451	7.0	573	3.6	405	7.5
AP cash income	726	28.7	1,667	40.8	2,384	37.2	6,667	38.3	2,839	36.2
Beverages & spices	6	0.2	3	0.1	9	0.2	16	0.2	9	0.1

Table 9 continued

Income source	Poorest		Poor		Medium		Less poor		Sample mean	
	Lowest 25%		25–50%		50–75%		Top 25%			
	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel
Cereals	225	8.6	504	12.1	551	8.6	928	5.5	549	8.7
Coca leaves	419	15.8	632	15.0	857	13.2	2,303	14.3	1,046	14.6
Fruits	283	12.4	672	17.0	1,182	18.5	3,772	20.5	1,465	17.1
Non-food crops	5	0.2	92	2.6	55	0.9	114	0.6	66	1.1
Other food crops	0	0.0	22	0.6	0	0.0	2	0.0	6	0.1
Roots & tubers	44	1.9	50	1.3	169	2.6	94	0.8	89	1.7
Vegetables & legumes	8	0.4	20	0.5	6	0.1	7	0.1	10	0.3
Fallow	4	0.2	3	0.1	6	0.1	5	0.0	4	0.1
Livestock products & services (LP)	−51	−1.7	−1	0.0	−84	−1.6	493	3.4	87	0.0
LP subsistence income	−121	−4.6	−40	−1.0	−115	−2.1	30	0.3	−63	−1.9
LP cash income	71	2.9	39	1.0	32	0.4	463	3.0	149	1.9
Eggs	−7	−0.3	5	0.1	12	0.2	79	0.6	22	0.1
Hides, skin & other	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0
Milk & cheese	−2	−0.1	0	0.0	0	0.0	38	0.3	9	0.1
Honey	11	0.4	8	0.2	14	0.2	21	0.1	13	0.2
Meat	53	2.3	56	1.5	37	0.5	469	3.2	152	1.9
Browse & wild grass	−108	−4.2	−70	−1.8	−147	−2.5	−113	−0.8	−110	−2.3
Off-farm wages (cash)	326	14.8	393	9.7	712	10.3	576	4.8	502	10.0
4. Non-farm income (cash)	493	19.7	503	13.0	1,566	22.7	3,147	23.3	1,420	19.7
Self-owned businesses	177	7.7	126	3.0	775	11.8	1,136	9.0	552	7.9
Agricultural processing	2	0.1	0	0.0	1	0.0	0	0.0	1	0.0
Handicraft	27	1.0	0	0.0	0	0.0	0	0.0	7	0.2
Lodging/restaurant	22	0.8	0	0.0	0	0.0	145	0.9	41	0.4
Shop/trade	75	3.1	85	2.0	364	5.1	190	1.4	179	2.9
Skilled labour & other	34	1.9	41	1.0	141	2.4	245	2.7	115	2.0
Transport (car, boat)	16	0.9	0	0.0	269	4.2	556	3.9	209	2.3
Remittances, pensions and other	135	5.2	118	3.1	68	1.0	1,335	10.8	409	5.0
Educational fund	24	1.1	23	0.6	22	0.3	19	0.2	22	0.6
House rental & other source	4	0.2	10	0.3	10	0.2	106	0.4	32	0.3
Land sales & agricultural payments	44	1.4	45	1.1	18	0.2	744	7.4	210	2.5
Pension & other compensation	43	1.7	0	0.0	0	0.0	67	0.5	28	0.6
Remittances & gifts/support friends	11	0.4	28	0.8	15	0.2	313	1.8	90	0.8
Support government, NGO[a], other	8	0.3	12	0.3	3	0.1	86	0.5	27	0.3
Non-farm wages	182	6.7	259	6.9	722	9.9	676	3.5	460	6.8
Carpentry	21	0.7	97	2.6	0	0.0	0	0.0	29	0.8
Construction, manufacturing & service industry	61	2.1	156	4.1	402	5.4	74	0.6	174	3.1
Domestic work & other	37	1.2	7	0.2	18	0.3	14	0.1	19	0.4

Table 9 continued

Income source	Poorest		Poor		Medium		Less poor		Sample mean	
	Lowest 25%		25–50%		50–75%		Top 25%			
	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel	Abs	Rel
Government, NGO or village work	30	1.1	0	0.0	238	3.3	519	2.4	195	1.7
Transport	34	1.6	0	0.0	65	0.9	69	0.4	42	0.7
Total net income	2,416	100	4,056	100	6,609	100	17,443	100	7,578	100
Total subsistence income	687	29.8	1,150	28.0	1,140	17.6	3,251	18.0	1,546	23.4
Total cash income	1,729	70.2	2,905	72.0	5,468	82.4	14,192	82.0	6,032	76.6

[a] Non-governmental organisation

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