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What is the contribution of forest-related income to rural livelihood strategies in the Philippines' remaining forested landscapes?

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ABSTRACT

Forest products have become scarce for local communities in the Philippines. After decades of severe deforestation, a net gain in forest area has only been observed in recent years for the first time. This paper seeks to broaden the understanding of forest livelihood relationships at the turning point of a forest transition trajectory. Based on 993 household surveys from 10 distinct research sites, we use Hierarchical Cluster Analysis to identify six distinct livelihood strategies (LS): remittances-based, livestock-based, crop farming-based, business-oriented, natural resource-based, and wage-based strategies. The highest number of households belongs to the wage-based cluster, which also shows the highest total income. Forest-related incomes only account for small shares of total income for the vast majority of households, although most households collect limited quantities of forest products for domestic use. Nevertheless, one cluster, which includes 12.4% of the sample, generates the largest shares of their income from extractive activities like harvesting forest products and fishing. The households relying most strongly on natural resources in our study sites are also the ones with the lowest total income. Our finding implies that future reforestation policies have to put a special focus on incorporating livelihood benefits for local communities. This should go beyond short-term payments for activities such as tree planting and enable the rural households to derive long-term impacts for human well-being and poverty alleviation. Because most of the forest products reported by our surveyed households were collected for domestic use, they did not contribute much to total household income. This indicates a potential for improving rural income, if forest-product value chains at the smallholder level are improved by future policy interventions.

1. Introduction

Forests provide valuable contributions to the livelihoods of millions of people, especially in the developing world (Angelsen et al., 2014; Miller et al., 2021; Hajjar et al., 2021). For rural households, forests are a source of various products ranging from fuel, food, fodder and construction materials to medicine (Angelsen et al., 2011). In many parts of the tropics, forest products account for substantial shares of cash and subsistence incomes (Duchelle et al., 2014). For example, Angelsen et al. (2014) found in a comparative study in 24 tropical and sub-tropical countries that forest income on average accounts for 20.1–28.6% of the total household income, while Vedeld et al. (2007) reported that the average income contribution of forest environmental activities in 17 tropical and sub-tropical countries was 22%. Since forest resources keep shrinking in many places, the contribution of forest products to the livelihoods of rural communities has received increasing attention in science and development policies over the last decades (Cavendish, 2002; Pouliot and Treue, 2013; Angelsen et al., 2014; Langat et al., 2016). Particularly, quantifying the importance of forest-based income has gained scientific momentum in order to determine the welfare implications of deforestation and forest degradation, and to design effective conservation policies that take into account the resource needs of local communities (Cavendish, 2002; Pouliot et al., 2012; Angelsen et al., 2014; Langat et al., 2016). Due to the high overlap of forested areas with poverty, a substantial body of literature has explored whether poorer households are more dependent on forest income than better-off ones (Vedeld et al., 2007; Babulo et al., 2009; Pouliot and Treue, 2013; Angelsen et al., 2014; Dokken and Angelsen, 2015; Garekae et al., 2017;

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Zenteno et al., 2013). While several studies have found that poorer households have higher relative forest incomes, varying results exist for absolute forest income (Dokken and Angelsen, 2015; Langat et al., 2016). Angelsen et al. (2014) reported that the amount of harvested forest products roughly increases with household wealth. Nielsen et al. (2012) found that poor households harvest less forest products than better-off households, which have higher absolute forest and agricultural incomes, but rely less on forest products. In a recent review of evidence on the role of forests in poverty dynamics, Razafindratsima et al. (2021) conclude that even though the dependence of the poor on forests for their livelihoods and well-being is widespread, the ability and capacities of the poor to use forest resources to lift themselves out of poverty remains limited.

Furthermore, the focus of current research on forest livelihoods is geographically imbalanced (Hajjar et al., 2021), whereby almost half of the research looking at forest-poverty linkages during the last three decades comes from just five countries: Bangladesh, Brazil, China, India, and Nepal (Cheng et al., 2019). Many forest livelihood studies represent case studies from purposively selected regions (Belcher et al., 2015). In addition, a few pan-tropical studies have been undertaken in order to present global comparisons (Vedeld et al., 2007; Angelsen et al., 2014). However, as Rasmussen et al. (2017) point out, region- and nationwide studies on forest livelihood relationships are still scarce and data on forest product extractions are still very limited to develop solid policies across regions and countries. Since many forest products are consumed at home or marketed through informal channels, the official government statistics do not depict the overall economic contribution of forests, which can lead to future policies that do not take the many roles that forests play for human-wellbeing and poverty alleviation into account (Hajjar et al., 2021).

The goal of this study is to expand an understanding of the role of forests for rural livelihoods in the tropics by focusing on the Philippines, where quantitative evidence on forest-based livelihoods remains limited. The Philippines present an interesting case study as a country at the turning point of a forest transition trajectory which experienced widespread deforestation in the past. Once endowed with vast, highly valuable forests and a flourishing timber industry, massive deforestation has left the country with a fraction of its original forest cover and strong restrictions on forest use (Pulhin et al., 2006; Carandang, 2012). Following the forest cover loss of almost one million ha between 1990 and 2010 or on average 0.60% of forest lost annually, a net increase in forest area of around 350 thousand hectares has been reported between 2010 and 2020 (average of 0.51% of forest increase annually) (FAO, 2020a). The net gain in forest cover indicates that forest transition may have occurred. Thus, the context of the Philippines can serve as an example for a country at the turning point of a forest transition trajectory, which provides a good contrast to the situation in highly forested parts of the tropics and may broaden the understanding of forest livelihoods. Given the scarcity of studies that examine the role of forests for rural livelihoods in the remaining forested landscapes in the Philippines, the current study can also help inform future policies that promote forest restoration and sustainable forest management in the country.

The present study assesses the role of forest-related incomes for rural livelihood strategies in the Philippines. In order to do this, we conducted 1005 household surveys at ten research sites that are located in nine municipalities spread across five provinces. The research design aims at covering a high variability of livelihood portfolios (e.g. differences in agricultural products, focus on off-farm employment etc.), and landscape context (e.g. forest cover, physical accessibility of forest areas, land use systems). This paper aims to address the following two main research questions: 1) Which livelihood strategies do rural households pursue in different forested landscapes in the Philippines? 2) How do incomes from forest products contribute to the peoples' livelihoods?

The rest of the paper is structured as follows. The next section gives an overview of deforestation history in the Philippines and policies that have emerged over the last decades. Section 3 describes the research sites, data used for the study, and description of variables and analytical techniques. Section 4 provides the findings from the principal component analysis (PCA) and hierarchical cluster analysis, which are discussed in Section 5. Section 6 concludes.

2. Deforestation history and forest policy in the Philippines

The history of deforestation in the Philippines already started with the beginning of the Spanish colonial rule in 1521. At this time, 90% of the country were covered with vast tropical rainforests (Pulhin et al., 2006). To benefit from timber exploitation the Spanish colonizers placed all forests under the control of the state and the forest area shrunk to about 70% or 21 million hectares until 1900 (Pulhin, 2002; Pulhin et al., 2008a). However, deforestation accelerated with the introduction of modern logging operations at the beginning of the 20th century under the control of the United States. Mechanized logging led to an estimated decrease in forest cover from about 21 to 17 million hectares between 1900 and 1940 and intensive commercial logging under concessions further increased after the independence of the Philippines in 1946 (Pulhin, 2002; Pulhin et al., 2006). At the peak of logging activities in the 1970's, a total of 10 million hectares of forest were placed under concessions (Lasco et al., 2001) which caused an estimated deforestation of 210,000 ha annually between 1969 and 1988 (Kummer, 1992a). Logging was followed by agricultural expansion linked to upland migration (Pulhin et al., 2006). Roads built by timber harvesters permitted the encroachment of upland areas, which led to an influx of migrants in search of farmland (Carandang et al., 2013). The massive deforestation led to a variety of negative effects. While the Philippines used to be one of the world's biggest exporters of tropical hardwoods in the 1960s, the country became a net importer of wood in the 1990's (FMB, 2009). In addition, the denudation of former forest land caused severe flooding and accelerated soil erosion in many locations (Lasco et al., 2010). While commercial logging used to form a major livelihood activity in many upland areas, the decline of logging operations left many labourers unemployed. Thus, they either had to seek employment in other sectors or had to resort to upland farming, including shifting cultivation (locally called "kaingin"), and timber poaching (Pulhin et al., 2008b). In the late 1980's the paradigm of forest governance in the Philippines changed radically from a state-run corporate mode towards a people-centred approach that regarded local communities as stewards of the forests (Pulhin et al., 2008a; Carandang, 2012). Policies started to aim at poverty alleviation in upland areas, sustainable forest management and more equitable distribution of forest resources through community-based forestry (Pulhin, 2002). In 1995, community-based forest management (CBFM) became a flagship policy for sustainable forest management and limited use rights were granted to organized communities through agreements with the government over a period of 25 years (Guiang et al., 2001). However, CBFM has been of varying success. It has been criticised that the level of control granted to communities was limited, while they were subject to strict rules and received little help with the implementation of forest management activities (Chechina et al., 2018). In addition, a series of suspensions of cutting permits adversely impacted the economic viability (Carandang, 2012). In response to a series of severe floodings, a nationwide logging ban in all natural forests was imposed in 2011 (Carandang, 2012). Hence, resource-use rights in all natural forests were banned (Guiang and Aragon, 2016) and the Department of Environment and Natural Resources (DENR) has been prohibited from issuing or renewing logging agreements or tree cutting permits in natural and residual forests (Israel, 2016). The logging moratorium has effectively ended many community-based timber enterprises (Carandang, 2012). In order to reverse the negative impact of past deforestation, strong emphasis has been put on reforestation activities in recent years. In particular the so called National Greening Program (NGP) was launched in 2011 with the aim of planting 1.5 billion seedlings in 1.5 million hectares of public lands throughout the country until 2016 (Israel, 2016). Since the early 2000s,

the trend of deforestation seems to have halted and the Philippines now show a net gain of forest area attributed to plantings and natural regeneration (Carandang, 2012) which indicates that forest transition may have occurred (Keenan et al., 2015).

3. Materials and methods

3.1. Research sites

This study was conducted within the framework of the LaForeT project (Landscape Forestry in the Tropics), which aimed to explore the impact of policy instruments on deforestation and reforestation in the forested landscapes in the Philippines, Zambia, and Ecuador (www.laforet.org). In order to understand forest use patterns at landscape level, household surveys were conducted at ten research sites with a size of approximately 10,000 ha,[1] located in three different regions of the Philippines (Fig. 1, Table 1). The research sites were selected in a two-stage process. At stage one, five provinces (i.e., Leyte, Southern Leyte, Cagayan, Quirino and Nueva Vizcaya), in two administrative regions (i.e., Cagayan Valley, Region II and Eastern Visayas, Region VIII), were chosen. The selection aimed to comprise various levels of forest/tree cover and different intensities of de- and reforestation (Mather, 1992; Grainger, 1995; Hosonuma et al., 2012). Moreover, it was intended to capture a variation of land use dynamics, agricultural practices, socio-cultural contexts, and a range of relevant drivers of deforestation and degradation. Within the selected provinces, sites from nine different municipalities were purposively selected to represent the regions' typical land use change dynamics and socio-economic conditions. Even though the original intention of the current study was to cover 10 different municipalities, the Baggao municipality was dropped due to safety reasons, and instead, two research sites were selected in the Gonzaga municipality. This selection was based on extensive research of secondary sources and prior knowledge by field teams in the focal regions, followed by scoping surveys.

The administrative region of Cagayan Valley is located in the Northern Philippines, stretching along the Sierra Madre, the country's longest mountain range. Corporate logging boomed in the Sierra Madre after the opening of the Maharlika Highway in 1965 and throughout the Marcos era (van der Ploeg et al., 2016). Nevertheless, the Sierra Madre's surroundings still represent about 40% of the country's forest cover (FFP, 2019) and comprise some of the remaining old growth, primary forests of the country (NORDECO and DENR, 1998). Hilly and plateau lands are generally dominated by smaller forest patches, shrubs and grasslands, while the floodplains are typically characterized by rice and corn farming (van den Top, 2003). Four of the eight selected landscapes in the Cagayan Valley were located in Northern Luzon (in the Municipalities of Santa Ana, Lal-lo, and Gonzaga). These landscapes represent some of the areas with higher forest cover in the local context. The remaining four landscapes within the Cagayan Valley were located in the South of the Cagayan Province and in the Provinces of Nueva Vizcaya and Quirino (in the Municipalities of Penablanca, Diadi, Diffun, and Quezon). These four landscapes represented a separate region within the larger LaForeT project, characterized by lower forest cover and the presence of reforestation projects.The second administrative region selected for this study is located on the island of Leyte, in the Eastern Visayas, which is a mountainous island of around 740,000 ha with altitudes rising up to 1346 m. Most of its remaining forest is found in upland areas and on steeper zones of the island's mountain ranges. Most of the forest in Leyte is secondary or disturbed. Primary forest is still present in some of the most remote and inaccessible areas (Mukul et al., 2016). Leyte has been affected by increasing demographic pressure after 1900 and the related expansion of upland agriculture. This has led to high levels deforestation and forest degradation (Kummer, 1992b; Dargantes and Koch, 1994). Typical drivers of deforestation include non-timber plantations (e.g. coconut and abaca), illegal harvesting of timber, conversion to swiddening farming, or conflicting land tenure (Dargantes and Koch, 1994; Carandang et al., 2013). Since the 1990's, many reforestation and restoration projects have been established in the island, mostly smallholder-based (Goeltenboth and Goeltenboth, 2000; Langenberger, 2006; Schneider et al., 2014). The municipalities of Sogod and Abuyog were chosen due to their proximity to Mount Nacolod, which refer to last continuously forested areas on Leyte.

The number of barangays (villages) within the different research areas varied from one in the municipality of Lal-lo to ten at the Diadi research site. The population size ranged from 461 to 11,663 inhabitants between the sites. An overview of the features is presented in Table 1, site location is demonstrated in Fig. 1.

3.2. Data collection

In order to collect information on household characteristics, land use patterns and income sources, household surveys were conducted at the ten sites between August 2016 and April 2018. Within each study site, approximately 100 household surveys were conducted with some rounding due to the distribution of the sample households across different villages. The surveys were conducted in all present villages within a research site with a proportional distribution of the surveys based on the number of households, leading to a total of 1005 surveys. Nevertheless, some surveys were dropped from the analysis due to incomplete information. The final sample of surveys with complete information includes 993 household observations.

A structured questionnaire, which was standardized for the entire LaForeT project was used to capture agricultural production and income, forest-related income, business and wage incomes, remittances, and information on forest management. Households were selected randomly from census lists provided by village officials. All interviews were conducted face to face by local enumerators and administered in local languages based on a free prior informed consent. To minimize translation bias, questionnaires were provided in a bilingual format in English and local dialects of the respective regions (Cebuano, Tagalog, Ilocano). Interviews were generally given by the household head, the spouse or another household member that was at least 18 years old (e.g. adult children, extended family). In addition, GPS coordinates were recorded for all interviewed households in order to locate the position of the household in the respective study site.

3.3. Data analysis

3.3.1. Definition of income sources

Sources of income were classified into different categories: income from agricultural crops, livestock keeping, off-farm wages and salaries, income from businesses, fishing, forests, remittances and other incomes.

Generally, income was calculated as gross value minus the total costs of all purchased inputs including hired labour (Pouliot and Treue, 2013) while family labour is not considered. Total household income is calculated as the sum of net incomes in all income categories (see Torres et al., 2018).

Incomes from crop farming and livestock keeping were distinguished into subsistence and cash incomes. Subsistence income is defined as the value of products consumed by the household (Hogarth et al., 2013). Crop income was calculated as the product of the produced amount with the farm gate price minus all reported costs for fertilizers and pesticides, hired labour, land rental and costs for machinery and marketing. For livestock incomes, fluctuations in stocks through birth or death of animals were considered as fluctuations in assets. Incomes were calculated as the product of the farm gate price and the number of sold animals, minus reported costs for cash incomes and the value of slaughtered animals for subsistence incomes. For both, crop and livestock incomes

[1] While the targeted size of research sites was 10,000 ha, some flexibility was applied so that the sites aligned with administrative boundaries.

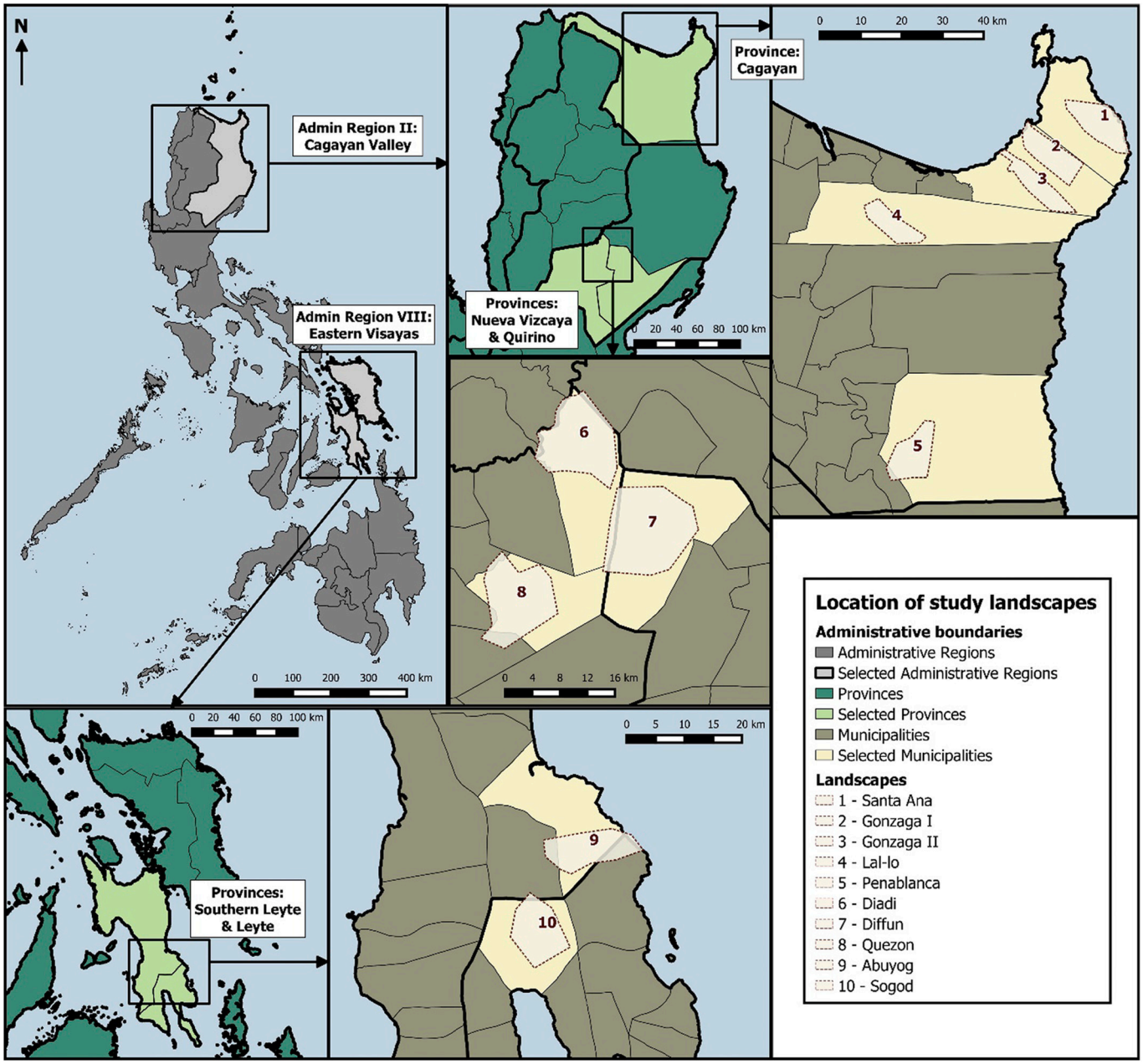

Fig. 1. The location of the ten research sites in the Cagayan Valley (Provinces Cagayan, Nueva Vizcaya and Quirino) and in Leyte Island, Eastern Visayas (Provinces of Southern Leyte and Leyte).

we generally used prices reported in the surveys for all sold items in the past 12 months at the time of the survey. Missing livestock prices were estimated through expert interviews with knowledgeable staff from local universities.

Off-farm income includes all incomes generated from salaries or wages, including day labour on other peoples' farms. Business incomes contain all incomes from self-employed activities other than agriculture minus the costs for bought goods and other materials. Remittances covered all cash transfers to the interviewed household from family members working either somewhere else in the Philippines or overseas.

Forest-related income was calculated as the cash and subsistence income generated from timber, firewood, rattan, bamboo wildlife and edible plants identified as forest products by the respondents. There has been a lively debate among scholars on which products should be regarded as NTFPs, whether they are strictly sourced from forest environments and what exactly constitutes a forest in this context (Belcher, 2003). In our case it was not always clear whether products were strictly sourced from forest areas or partly originated from agroforestry, fallows or riverbanks. To address this issue, we employ the term 'forest-related income' to acknowledge that the term forest product might have been broadly applied by the respondents. Medicinal plants were excluded, because they were only collected in marginal quantities by very few households. Charcoal production was mentioned by a few households in the sample, but the production was based on agricultural residues, especially coconut shells. Fishing included the cash and subsistence incomes generated either from coastal fisheries or fresh water fishing in ponds, lakes or rivers. The category other 'cash incomes' included incomes from pension schemes and transfers from government support programs.

Valuing forest products, that are largely used for subsistence purposes, has been a common challenge and significant effort has been put in developing methodologies to quantify the contribution of forest

Table 1
Overview of the main characteristics of the research sites.

Research Sites	Province	Included barangays (villages)	No. of Brgy.	Size in hectares	Percentage of forest in the study site	Percentage of annual cropland	Percentage of perennial cropland	Distance to forest edge (Mean, Std. dev.)	Paved road access (Mean)	Total No. of HH	Interviewed HH
Sogod	Southern Leyte	Kahupian, Pancho Villa, San Francisco de Mabuhay, San Juan, San Vicente,	6	8025	27.99%	1.65%	17.36%	1013.96 ± 498.87	0.56	846	101
Abuyog	Leyte	Anibongon, Bagacay, Bulak New Taligue	4	8310	48.69%	3.14%	29.25%	1789.59 ± 1102.83	0.76	488	101
Gonzaga I	Cagayan	San Jose, Santa Maria	2	9699	76.93%	16.63%	0.89%	1669.22 ± 554.50	1	662	101
Sta. Ana	Cagayan	Patunungan, Santa Clara	2	10,887	80.30%	9.70%	0.06%	180.30 ± 161.53	0.54	570	100
Gonzaga II	Cagayan	Ipil, Magrafil	2	8113	63.47%	21.30%	5.88%	3962.69 ± 1169.90	0.9	554	100
Lal-lo	Cagayan	Dagupan	1	7357	53.06%	19.11%	1.43%	2506.73 ± 1063.30	0.93	256	100
Quezon	Nueva Vizcaya	Aurora, Baresbes, Buliwao, Caliat Darubba, Maasin	6	9895	35.94%	24.40%	3.50%	841.55 ± 513.56	0.96	2527	101
Peñablanca	Cagayan	Cabbo, Bugatay, Cabasan Manga, Minanga, San Roque, Sisim	7	10,840	11.42%	27.41%	1.80%	1706.00 ± 958.43	0.81	2740	96
Diadi	Nueva Vizcaya	Arwas, Bugnay, Escoting, Namamparan, Pinya, Poblacion, Langka, San Luis, San Pablo, Villa Aurora	10	10,571	3.95%	36.29%	4.52%	1635.80 ± 1360.95	0.91	3838	104
Diffun	Quirino	Campamento, Don Faustino Pagaduan, Dumanisi, Gabriela Silang, Liwayway, Magsaysay, Gregorio Pimentel, San Pascual	8	13,846	4.35%	55.17%	2.42%	1085.10 ± 756.21	0.83	3022	101

Sources: Analysis of survey data, Magabo (2018a, 2018b).

resources to incomes in monetary terms (Angelsen et al., 2011; Newton et al., 2016; Bakkegaard et al., 2017). We generally use self-reported prices, where sufficient information could be generated from questionnaires. Where self-reported values were unreliable or insufficient, market surveys were conducted to determine local prices (see Langat et al., 2016). In order to produce values as meaningful as possible, price information was generally obtained at the closest and lowest level point of marketing. The information is not limited to formal markets at commercial centers but includes vendors within the studied villages selling products out of their homes.

3.3.2. *Identification of livelihood strategies*

One of the main objectives of this study is to identify the livelihood strategies (LS) that are pursued by the households at our research sites. For the definition of LS we refer to concepts from the Sustainable Livelihoods Framework. The Sustainable Livelihoods Framework is an important theoretical framework in the analysis of rural livelihoods and environmental resource management (Scoones, 1998; Torres et al., 2018). Following Ellis (1999), a livelihood can be defined as "the activities, the assets, and the access that jointly determine the living gained by an individual or household". A livelihood strategy can be defined as the way of using and combining available assets to achieve a beneficial livelihood outcome (DFID, 1999). In this context, livelihood assets refer to different kinds of capitals, including natural, human, financial, physical, and social capitals (Scoones, 1998). Natural capital includes the natural resource stock such as forest resources, water and soil. Social capital refers to social resources membership in groups, trust or access to societal institutions. Human capital considers resources such as labour power and education. Physical capital includes productive assets held by the household such as land or tools. Finally, financial capital includes monetary resources such as cash savings, remittances or access to credits (De Sherbinin et al., 2008).

Which livelihood strategies people can pursue depends on the material and intangible assets they possess (Scoones, 1998). Rural households in developing countries commonly follow diverse livelihood strategies in order to maintain survival and reduce the risks of relying on a single main source of income (Ellis, 2000). Diversification of income portfolios can be a measure to reduce risks, cope with shocks or smooth consumption over the year (Ellis, 1999). Thus rural households engage in a diverse range of economic activities such as farming, fishing, off-farm employment and harvest of forest products (De Sherbinin et al., 2008; Torres et al., 2018). We draw on this knowledge in order to define the LS and determine the role of forest-related income for the livelihoods of the sampled rural households.

In order to determine livelihood strategies we use Principal Component Analysis (PCA) followed by Hierarchical Cluster Analysis (HCA) to identify which households pursue a particular LS. PCA converts possibly correlated variables into a smaller set of uncorrelated factors, the so called principal components. This helps to identify the most prominent features related to the principal components (Husson et al., 2010). PCA was conducted on the relative shares of income generated from ten different economic activities including crop farming,

livestock keeping, off-farm work, remittances, businesses, harvest of forest-related products, fishing and other incomes (pension schemes and transfers from government support programs). Cash and subsistence incomes are treated separately for crop-farming and livestock keeping. Negative incomes were set to zero.

In order to identify specific livelihood strategies of households, we use Hierarchical Cluster Analysis based on the Ward method. Hierarchical Cluster Analysis creates clusters of objects that have smaller distances between each other than to objects that do not belong to the respective cluster. Similar to the approach employed by Lax and Köthke (2017), the cluster analysis was performed on basis of the results of the PCA. Using the results of PCA in cluster analysis can help to obtain more stable and pronounced clusters, if only the first components are used, since this reduces "noise" in the data set. If all components from the PCA are used in cluster analysis, the distance between individuals remains the same so that the results do not change (Husson et al., 2010). We keep those principal components in the cluster analysis with an eigenvalue higher than 1.

After generating the clusters, we use a (non-parametric) Kruskal-Wallis-Test (Kruskal and Wallis, 1952) to compare the characteristics of the clusters and to check whether the difference between the clusters is statistically significant according to the selected characteristics. For the comparison, we use the absolute household income, absolute forest-related income, the amount of cropland managed by the household, age of household head and the number of household members. The Kruskal-Wallis-Test, the PCA and the HCA were performed using the JMP 13 software (JMP, 2019).

4. Results

4.1. Characteristics of the sample population

The majority of the households in our sample were male-headed, with 88% having a male household head and 12% of the households being headed by women. The mean age of the household head was 48.7 years and ranged from 19 to 90 years Fig. 2. The average number of household members was 4.5 persons. Regarding education, 37.3% of the household heads had not completed primary school. Another 32.1% had complete primary education and 22.1% possessed a high school degree, while 5.1% held a university degree and 2.9% had completed some kind of vocational training.

The mean total annual income, including cash and subsistence contributions, amounts to 124,917 Philippine Pesos (US$ 2472.16[2]) (median: 80,150 PhP (US$ 1586.2)). The mean share of off-farm income was 40.91% (median: 34.81%). The majority of interviewed households (68.28%) managed agricultural land. Those households in the sample that owned or managed agricultural land were smallholders with a mean farm size of 1.61 ha. A slight majority of 51.7% of the respondents reported that their household had experienced an income shock (e.g. crop failure or land loss) within the twelve months prior to the interview.

Connection to paved roads was used as a proxy for accessibility. However, the vast majority of the households (81.2%) could be accessed via a paved road. The mean distance from the forest edge was 1665.6 m (SD = 1229.79).

4.2. Collection and use of forest products

In total, 75.8% of the interviewed households reported the harvest of some kind of forest product, with fuelwood for domestic use being the dominant product by far. In total, 752 households reported collecting fuelwood, while edible plants from the forest were collected by 198 households. Only 94 households reported collecting timber from the forest. A variety of other non-wood forest products (NWFPs) was also reported albeit by a smaller number of households. We follow the FAO definition of NWFPs in the recent Forest Resources Assessment 2020 as "goods derived from forests that are tangible and physical objects of biological origin other than wood" (FAO, 2020b). The NWFPs reported by the surveyed households included different plants used for food, fibre, medicine and ornament, bamboo, small and large animals, ornamental leaves, and rattan.

Forest products are almost exclusively used for subsistence purposes while commercial activities are very rare.

The mean share of forest income in total household income was 13.5%. However, the median was only 4.5%, which indicates the highly skewed distribution between the households. Table 2 provides information on the share of fuelwood, timber, and NWFPs in total forest income. Overall, the contribution of timber to forest income is smallest across the three categories, contributing to 5.7% of total forest income, while the share of the fuelwood is the highest and constitutes 82.7% of total forest income.

4.3. Livelihood strategies

The PCA revealed six principal components with eigenvalues greater than 1, which were kept for further analysis (Table 3). These principal components account for 73.1% of the variability in the data set. For interpretation, we consider loading values above 0.5 and 0.3. The first component is strongly negatively correlated with off-farm income, but shows a slightly positive correlation with incomes from agricultural cropping and livestock for subsistence purposes. Overall, off-farm income is antagonistic to all other income sources. The second component is correlated with both livestock keeping for cash and subsistence purposes, but somewhat opposite to forest-related income and fishing. The third component has a high negative correlation with remittances (−0.6) and business incomes (−0.47), but a positive correlation with crop incomes, in both, cash and subsistence terms. Incomes from forest products correlate most strongly with the fourth component, while the fifth component shows a significant positive correlation with small-scale business and fishing incomes. The sixth component is most strongly correlated with incomes from pensions and government support.

The six principal components revealed by the PCA were used in hierarchical cluster analysis to identify livelihood strategies. Six clusters were identified based on the dendrogram (Fig. 3). Each cluster contains a subset of households following a particular livelihood strategy, which is defined by the level of reliance on particular sources of income (Lax and Köthke, 2017). The relative contribution of different income categories are used to name each cluster and to assign it to a particular LS (Table 4). Cluster 1 includes 10.7% (90) of the interviewed households and was called "remittances", since an average of 55.4% of the household income consists of remittances from both, domestic and international sources.

The second cluster consists of 12.4% (105) households. With 56% of the total income forest and environmental products constituted the most important source of income for this group. However, households in this cluster also generated an average of 20.9% of income from fishing. Thus, the cluster was named "natural resources".

The third cluster was called "wage-based" since households belonging to this cluster generated the largest proportion of their income from salaries and wages, which accounts for 86.3% of their incomes. With 41.1% (347) observations, Cluster 3 is the largest cluster, which points out the high importance of off-farm employment for many households in our sample. The fourth cluster contains 18.2% (154 households) of the observations. On average, the households in this group generate 62.6% of their income from cash and subsistence agriculture. Thus, the cluster can best be described as a "crop farming" LS. However, wages and salaries still accounted for 20.4% of the household income in this group. The fifth cluster contains 5.9% (50) households for

[2] Exchange rate as of July 1st 2017, at the middle point of the data collection period, is US$1 = 50.4082PhP (www.oanda.com/lang/de/currency/converter/)

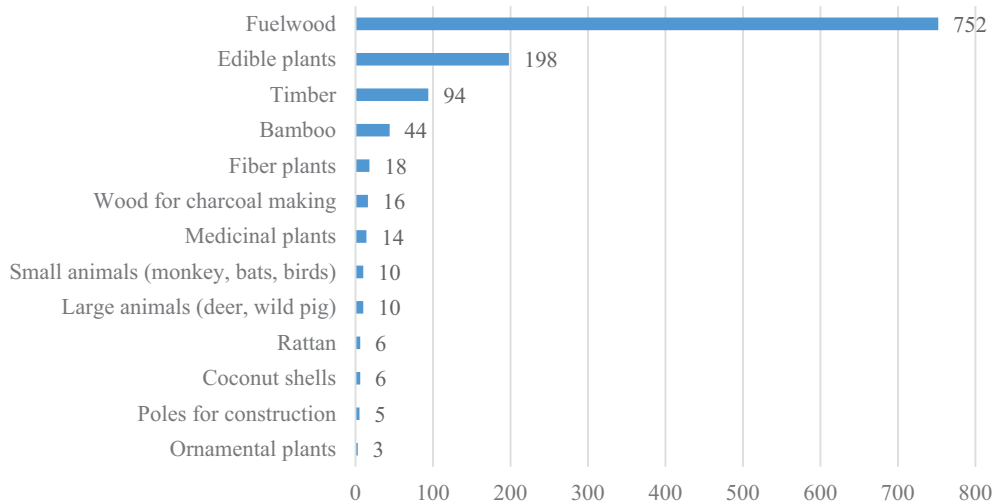

Fig. 2. Number of households collecting specific forest products in the study sites. Source: Own estimates based on the household survey data.

Table 2
Share of the forest product category in total forest income, %.

	NWFPs		Timber		Fuelwood	
Research site	Mean	SD	Mean	SD	Mean	SD
Abuyog	27.7	33.1	0.0	0.0	72.3	33.1
Diadi	6.3	18.7	1.4	11.1	92.3	21.3
Diffun	5.0	14.4	5.0	19.7	90.0	23.3
Gonzaga I	7.9	25.1	15.5	31.4	76.6	38.5
Gonzaga II	4.3	17.6	11.4	26.3	84.2	31.1
Lal-lo	3.2	12.3	14.6	25.8	82.2	28.7
Penablanca	1.3	11.5	7.5	22.8	91.1	25.2
Quezon	7.0	22.8	0.0	0.0	93.0	22.8
Santa Ana	9.9	21.6	5.7	13.4	84.4	28.3
Sogod	29.8	31.6	0.0	0.0	70.2	31.6
Total	11.6	24.7	5.7	18.7	82.7	29.7

Source: Own estimates based on the household survey data.

whom livestock keeping is the most important source of income. However, livestock keeping is rather conducted for subsistence while commercial livestock keeping is of less importance even within the livestock-based cluster.

The sixth cluster was named "business" since self-employment, which takes places mostly in the retail sector by operating small grocery or convenience stores, accounts for the largest share of income of the 11.7% (99) households included in this cluster.

Except for the second cluster, the contribution of forest-related income to the total income is quite low for the vast majority of the sampled households making up between 4.8% and 8.3% in the Clusters 1, 3, 4, 5 and 6.

4.4. Characteristics of the clusters

The differences between the clusters along certain socio-economic characteristics are displayed in Table 5. Comparing the characteristics of the clusters, households with remittances and high proportions of income from wages and salaries have the highest overall income. Households in the natural resources cluster have the lowest cumulative income. Households in the natural resource cluster do not only generate the highest proportion of income from forest products but also have the highest absolute values of forest-related incomes. In absolute terms households belonging to the "remittances" and "business"- clusters generate the lowest values from forest products.

With an average of only 0.58 ha, households in the natural resources cluster on average also had very little cropland. Similarly, households in the wages cluster on average only managed 0.64 ha. As could be expected, households belonging to the crop farming cluster on average had more farm land than all other clusters (1.92 ha).

With 53.9 years, the mean age of the household head was slightly higher in the remittances cluster than the average of the sample and the highest of all clusters. The household heads in the business clusters were older than the average. With 45.16 years, the household heads in the wages-based cluster were the youngest compared to all other clusters. In addition, the average number of household members in the wages cluster (4.7) is also higher than in all other clusters where the household sizes ranges between 4.21 and 4.41 persons, although the household size did show significant differences between the clusters.

Interestingly households belonging to the different clusters are distributed relatively equally across the research sites despite of different local contexts (Fig. 4) with exception of Sta. Ana where the remittances cluster is absent while the natural resource cluster is

Table 3
Results of Principal Component Analysis on the different relative incomes.

	PC1	PC2	PC3	PC4	PC5	PC6
Cash cropping share	0.37	0.184	0.457	−0.29	−0.352	0.003
Subsistence cropping share	0.264	−0.067	0.397	−0.546	0.161	−0.213
Cash livestock share	0.217	0.591	−0.045	0.343	0.292	0.137
Subsistence livestock share	0.351	0.68	0.125	0.172	0.031	0.042
Fishing share	0.243	−0.361	0.073	0.17	0.424	−0.521
Off-farm share	−0.957	0.169	0.11	−0.028	0.076	0.029
Business income share	0.27	−0.073	−0.486	−0.198	0.562	0.18
Remittances share	0.159	0.109	−0.622	0.036	−0.545	−0.488
Share of „other"incomes	0.217	−0.214	−0.265	−0.305	−0.18	0.618
Forest-related share	0.246	−0.486	0.272	0.659	−0.173	0.245

Source: Own estimates based on the household survey data.

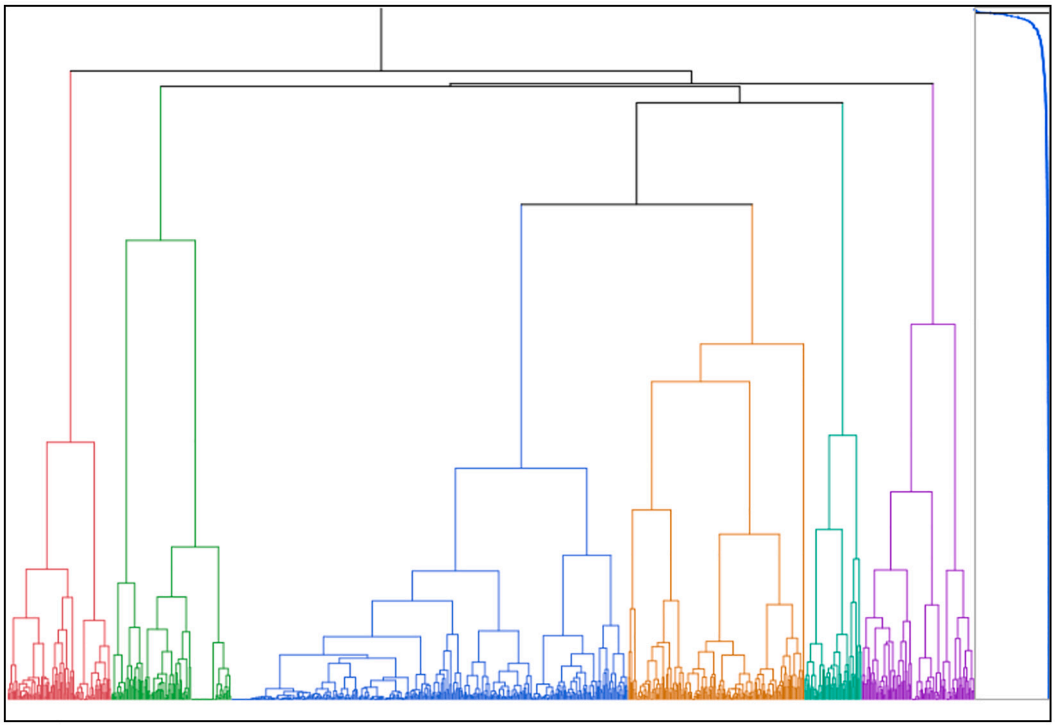

Fig. 3. Dendrogram of the results of the cluster analysis. The clusters one (1) to six (6) are displayed from left to right. Source: Own estimations.

Table 4
Relative contribution of different income sources to the total household income per livelihood strategy cluster.

		Cluster 1 Remittances ($N = 90$)	Cluster 2 Natural resources ($N = 105$)	Cluster 3 Wage-based ($N = 347$)	Cluster 4 Crop farming ($N = 154$)	Cluster 5 Livestock ($N = 50$)	Cluster 6 Business ($N = 99$)
Cash cropping	Mean	**0.086**	**0.068**	**0.052**	**0.472**	**0.107**	**0.065**
	SD	0.171	0.151	0.096	0.653	0.140	0.115
Subsistence cropping	Mean	**0.009**	**0.011**	**0.025**	**0.154**	**0.024**	**0.042**
	SD	0.027	0.037	0.055	0.228	0.048	0.103
Cash livestock	Mean	**0.002**	**0.001**	**0.002**	**0.002**	**0.097**	**0.001**
	SD	0.010	0.004	0.012	0.008	0.138	0.005
Subsistence livestock	Mean	**0.020**	**0.011**	**0.010**	**0.024**	**0.435**	**0.009**
	SD	0.056	0.057	0.032	0.071	0.269	0.029
Fishing	Mean	**0.023**	**0.209**	**0.020**	**0.023**	**0.018**	**0.021**
	SD	0.074	0.309	0.066	0.072	0.049	0.059
Off-farm	Mean	**0.215**	**0.074**	**0.770**	**0.204**	**0.169**	**0.117**
	SD	0.252	0.108	0.199	0.215	0.177	0.168
Businesses	Mean	**0.012**	**0.027**	**0.008**	**0.008**	**0.049**	**0.393**
	SD	0.049	0.075	0.032	0.030	0.141	0.345
Remittances	Mean	**0.554**	**0.009**	**0.010**	**0.016**	**0.038**	**0.023**
	SD	0.249	0.035	0.031	0.047	0.078	0.068
"Other" incomes	Mean	**0.029**	**0.021**	**0.010**	**0.067**	**0.014**	**0.248**
	SD	0.065	0.054	0.028	0.099	0.040	0.305
Forest-related income	Mean	**0.048**	**0.560**	**0.083**	**0.076**	**0.050**	**0.080**
	SD	0.086	0.341	0.108	0.083	0.069	0.131

Source: Own estimates based on the household survey data.

overrepresented and Gonzaga I where only 4% of households belong to the natural resource cluster. The distribution of the clusters reflects again the prevalence of the wage-based cluster across all research sites (Fig. 4).

5. Discussion

The first goal of this paper was to identify the livelihood strategies that are pursued by rural households in different regions of the Philippines. The conducted cluster analysis revealed six distinct LS. Though each livelihood strategy is driven by a specific income activity, this was typically supplemented by other livelihood sources, confirming the previous findings that diversification is a norm for rural households in developing countries (Davis et al., 2010; Walelign and Jiao, 2017; Ojeda Luna et al., 2020; Jiao et al., 2017).

The majority of the respondents followed a strategy that was primarily based either on off-farm incomes or on crop farming supplemented with off-farm activities. This points to a high importance of wage incomes in our sample and contradicts the traditional notion of rural smallholders as primarily being farmers that cultivate crops and keep livestock (Wunder et al., 2014). However, a variety of studies has shown that off-farm incomes have become increasingly important for many smallholders and often outweigh incomes from farming (Ellis, 2000; Davis et al., 2010). Ellis (1999) already points out that non-farm

Table 5
Differences in the characteristics of the livelihood strategies clusters.

		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	X^2
		Remittances	Natural resources	Wage-based	Crop farming	Livestock	Business	
Total household income (PhP)	Mean	150,730	52,466	152,734	108,844	142,772	109,447	101.99***
	SD	166,341	84,196	172,875	135,256	144,111	142,354	
Total household income (US$)	Mean	2990.2	1040.8	3029.9	2159.3	2832.3	2171.2	
	SD	3299.9	1670.3	3429.5	2683.2	2858.9	2824.0	
Forest-related income (PhP)	Mean	3143.3	17,781.7	8124.4	6284.3	5414.4	3780.2	70.09***
	SD	5491.6	27,178.7	13,633.7	9177.9	10,960.5	6405.6	
Forest-related income (US$)	Mean	62.4	352.8	161.2	124.7	107.4	75.0	
	SD	108.9	539.2	270.5	182.1	217.4	127.1	
Cropland (in ha)	Mean	0.98	0.58	0.64	1.92	1.26	0.97	130.34***
	SD	1.89	0.87	1.11	2.21	1.5	1.61	
Age of the hh head	Mean	53.9	47.88	45.16	48.31	52	53.61	38.25***
	SD	14.76	14.46	13.32	14.56	16.69	16.14	
Number of household members	Mean	4.21	4.32	4.7	4.41	4.32	4.26	7.39 n.s.
	SD	1.92	1.78	1.92	1.84	1.74	1.98	

*** significant at 0.01, ** significant at 0.05, and * significant at 0.1 levels. The Kruskal-Wallis-Test was conducted to check whether at least two clusters are significantly different from each other. Source: Own estimates based on the data from household survey.

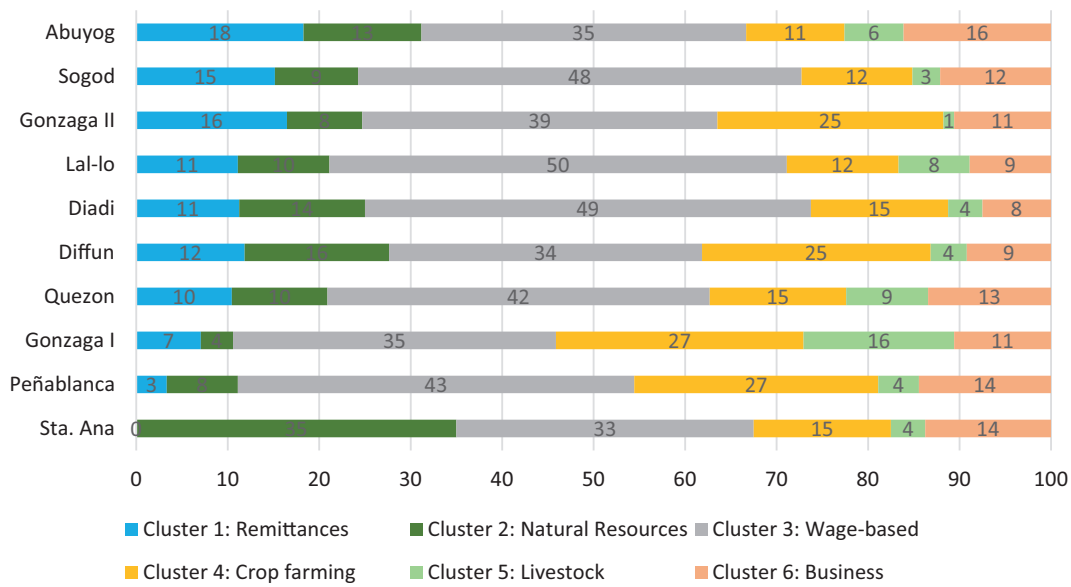

Fig. 4. The share of households in different livelihood clusters with respect to the total number of households in each site (%). Source: Own estimates based on the data from household survey.

income accounted for 30–50% of household income in sub-Saharan Africa and for approximately 60% in south Asia. The proportion of income from non-farm activities is often positively correlated with the total income (Ellis, 1999), which is also found in our case where the wage-based cluster also showed the highest total household income. In addition, our analysis revealed two smaller clusters of households primarily relying on small-scale businesses and remittances. Both, domestic and overseas migration of workers are a widespread phenomenon in the Philippines (Yang, 2011). Thus, it is unsurprising that remittances play an important role for some households, especially since remittances from migrated family members can contribute significantly to the livelihoods of rural households and reduce their reliance on farming incomes (Wunder et al., 2014).

Livestock keeping only constitutes an important livelihood activity for a rather small number of households with an emphasis on subsistence. This coincides with the fact that livestock keeping is mostly a backyard activity for smallholders in the Philippines (Mugera and Featherstone, 2008; Come and Zamora, 2014; Calub et al., 2016).

Overall, forest-related incomes play a relatively small role for the livelihoods of most households in the sample. This coincides with the limited availability of forest products and the strong resource use restrictions in the Philippines. Similarly, in their study in the Northern Sierra Madre region, van der Ploeg et al. (2016) state that indigenous peoples form only small minorities today and that most farmers have migrated to the upland areas during the 1970s. These communities no longer rely on forest products but produce cash crops that are sold in urban markets. Studies on forest livelihoods have strongly pointed out the high importance of forest products for the incomes of many rural people in developing countries (Angelsen et al., 2014). However, regarding our results this notion has to be treated with caution since the contribution of forest-related incomes may only account for marginal proportions of household income, if resource availability is low and access rights are restrictive. Similarly, Pouliot et al. (2012) find in their study on Ghana and Burkina Faso that rural households also generate relatively small proportions of 8–13% percent of their income from forest products while cropping and non-forest environmental income played a very important role. Similar to the present case, the authors conclude that this is at least partly attributed to very limited use rights and strong restrictions on forest use.

The cluster analysis also revealed a group of households that seem to

strongly rely on the extraction of forest-related products. Within this cluster, both the relative and absolute forest-related incomes are higher than for all other groups, yet the total household income reported by this group is significantly lower compared to other clusters. This group also has the smallest size of cropland among the six clusters of households. Thus, it may be assumed that extractive activities are of particular importance for a few households with limited economic alternatives (Babulo et al., 2008). The poorest households in our sample relied the most on forest-related income. This coincides with the finding of various studies that the poor commonly have a high reliance on forest environmental resources (Vedeld et al., 2007; Nielsen et al., 2012; Langat et al., 2016; Wei et al., 2017; Kazungu et al., 2020).

In addition, despite the low contribution to the household income, the collection of some kind of forest product was surprisingly widespread across all research sites with different forest cover and different biophysical and socioeconomic characteristics. Especially fuelwood collection was a popular activity that was conducted by more than two thirds of interviewed households in the sample. This is similar to a REDD+ baseline study conducted by GIZ in Southern Leyte, which found that more than 93% of the interviewed households used firewood as cooking fuel (GIZ, 2012). The overwhelming importance of fuelwood has also been reported in a number of other studies (Yemiru et al., 2010; Angelsen et al., 2014; Belcher et al., 2015). This may be explained by the fact that forest-related products commonly have low exchange values, meaning their sale does not generate much money per unit, but tend to have high use values (Sunderlin et al., 2005). Thus, fuelwood in large areas of the Philippines constitutes a highly useful good since it permits cooking.

6. Conclusions

The goal of this study was to examine the contribution of forests to rural livelihoods in the forested landscapes in the Philippines, a country at the turning point of the forest transition trajectory, which went through massive deforestation in the past and has recently observed net forest gain. Having an improved understanding of forest livelihoods at the minimum point of a forest transition curve could be very useful for designing future reforestation policies that are adjusted to local needs in order to make them both economically and socially sustainable.

Our findings show that in terms of contribution to total income, forests play only a limited role, while the largest number of households follow a livelihood strategy based on wage income or crop farming. Households belonging to wage-based and remittances clusters also reported highest total household incomes, while the cluster relying on natural resources (forest-related income) reported the lowest total household income. Our findings also show that, despite being located at the minimum point of a forest transition curve, households in the Philippines' forested landscapes continue to collect a variety of forest products, with fuelwood being the most important one. This shows that there is still a considerable demand for these products in rural areas, which underpins the need for effective reforestation measures in order to divert pressure from remaining natural forest areas (DENR - FMB, 2016).

Since government sector and large-scale private reforestation initiatives have been of limited success, smallholder tree-farming is advocated by some authors (Chokkalingam et al., 2006; Santos Martín et al., 2012). However, while this approach is appealing, it has to be taken into account that the households relying most strongly on natural resources in our sample owned particularly little land, which may lead to competition with other land use activities (Lazos-Chavero et al., 2016) and disproportionately affect the rural poor (Miller et al., 2021). Moreover, the households relying most strongly on natural resources in our study sites are also the ones with the lowest total income. This implies that future reforestation policies have to put a special focus on incorporating livelihood benefits for local communities, which go beyond short-term payments for activities such as tree planting, but enable the rural households to derive long-term impacts for human well-being and poverty alleviation. Because most of the forest products reported by our surveyed households were collected for domestic use and did not contribute much to total household income, there is still a considerable potential for improving rural income, if forest-product value chains at the smallholder level can be improved by future policy interventions.

The fact that income from forest products generate smaller proportions of total income compared to other income sources could at least partly be attributed to very limited use rights and strong restrictions on forest use in the Philippines. Future studies could focus on providing statistical evidence on the impacts of forest restrictions on the livelihoods of local communities so that future forest management and rural policies can better integrate the role of forests for poverty alleviation.

Declaration of Competing Interest

None – The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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