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Differences in Forest Use Strategies for Cash Income between Households Living outside and inside Selectively Logged Production Forests in Myanmar

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Abstract: In many tropical regions, rural households often depend on forests for cash income, but there is still little knowledge on how forest use strategies differ among people living in different locations. This study aimed to detect differences in forest use strategies and forest cash income dependency between households living outside and inside selectively logged production forests, known as Reserved Forests (RFs), in Bago Township, Myanmar. A questionnaire survey was conducted with 146 and 48 households living outside and inside the RFs, respectively. The inside-households (encroachers) had a much higher forest cash income dependency (83%), with charcoal production as the main forest use activity, than the outside-households (32%), with bamboo cutting as the main activity. Higher forest dependency was found for outside-households that had less farmland, better accessibility to forest and more recognition of prohibited access to RFs in forest law. This study revealed evidence of substantial forest use for commercial purposes in RFs by households living both inside and outside the RFs, despite local recognition of the illegality of the use. Implementing community forestry practices for local communities may be a better option to reduce illegal dependence on selectively logged production forests.

Keywords: bamboo; charcoal; encroachment; forest dependency; production forest

1. Introduction

Global attention has focused on deforestation and forest degradation in tropics, which can reduce various ecosystem services (e.g., [1]. Designation of a permanent forest estate (PFE) within a legal framework is a commonly used practice to combat deforestation and forest degradation in natural tropical forests [2]. Under PFEs, there are different zones, such as protected areas and production forests, where the forest use activities by local people are restricted. One of the important aspects for sustainable management of PFEs is the forest dependency of local people living adjacent to PFEs; this is because 1.6 billion people around the globe substantially depend on forests for their livelihoods [3]. Understanding the dependency and conservation attitudes of local people toward the forests surrounding them is of great importance to formulate new or modify existing conservation strategies [4].

Many studies in tropics have investigated the forest dependency of local people and found that forest income makes a significant contribution to rural livelihoods [5–7]. Vedeld et al. [8] summarized

51 case studies from 17 countries covering Asia, Africa, and Latin America, revealing that forest environmental income made up 22% of the total income on average. A similar share was confirmed by Angelsen et al. [9], who used data from 7978 households in 29 tropical countries. Forest income usually includes cash income and subsistence income from products harvested in forested areas such as firewood, timber, and non-timber forest products (NTFPs) (e.g., [8,9]). Despite the growing literature on forest dependency, however, there is still a limited understanding of diversity in forest use strategies among local people. This was pointed out by Kazungu et al. [10], who classified forest use strategies into three groups: specialized charcoal sellers, forest food and charcoal sellers, and pure subsistence forest users. Additionally, previous studies on forest income dependency are often biased toward sites around protected areas, such as national parks and forest reserves (e.g., [4,11]), and fewer studies focus on income dependency around production forests. A few studies have reported impacts from selective logging in natural tropical production forests on NTFPs of livelihood importance, but most studies focus on the ecological aspects of conflicts and compatibility in species for timber and NTFPs (e.g., [12]).

Myanmar is one of the biodiversity hotspots in the Indo-Pacific region [13] and forest still covers around 42.9% of the country. The forestry sector is one of the main contributors to the national economy, while forests play a vital role in local livelihoods, because around 68% of the total population are rural people living near forests [14]. In Myanmar, all of the forest areas are state-owned, and the 73.0% of the country's forest area are managed as PFE, enforced by the Myanmar Forest Law [15]. The remainder of the forests are called unclassified forests (27.0%). The PFE is classified into production forests (59.4% of the country's forest area), which include reserved forest (RF), protected public forest (PPF), and protected area (PA) (13.6% of the country's forest area). The RF is designated for timber export from higher-value commercial species while the PPF is mainly for local use of lower commercial value species. Legal timber extraction is mainly carried out in RF and PPF, but local community access for commercial purposes is strictly prohibited [15].

Myanmar has practiced selective logging for timber production in natural forests since 1856 under the Myanmar Selection System (MSS), which still uses elephants for skidding. However, recent studies by remote sensing and field surveys revealed large scale forest degradation, mainly caused by over-harvesting from illegal logging [16,17]. In 2013, the Myanmar government conducted national-scale field surveys in the RF and PPF, indicating that approximately 700,000 ha within RF and PPF were encroached upon by local people. The encroachment areas were illegally used as residential, agricultural, and religious lands by a total of ca. 300,000 households in ca. 4000 villages. Dealing with encroachment in production forests is one of the most important political and administrative issues. The Myanmar forest law prohibits the commercial use of the RF and PPF without permission while the subsistence use is allowed. However, forest use strategies for cash income are still not well understood for local households living in the encroachment areas within the production forests in Myanmar or even for households adjacent to the production forests. Therefore, this study aimed to clarify the differences in forest use strategies for commercial purposes and forest cash income dependency between local people living outside and inside RFs in Myanmar, then to discuss the forest management implications.

2. Materials and Methods

2.1. Study Site

Our study site is located in Bago Township, which is part of southeastern Bago Yoma in Myanmar, between latitudes 17°14′ N and 17°50′ N and longitudes 96°24′ E and 94°41′ E (Figure 1). The average annual rainfall and temperature are approximately 3360 mm and 27 °C, respectively [18]. Bago Yoma is known as the home of the teak bearing forests with relatively abundant valuable commercial timber species in Myanmar, and it has been one of the country's major timber-producing areas [16]. Bago Township covers an area of 2905 km^2, of which around 53% is occupied by forests. The dominant forest type is a moist upper mixed deciduous forest, which is known for its abundance of teak (*Tectona*

grandis), pyinkado (*Xylia xylocarpa*), and other commercial species. The forested areas have been designated as eight RFs that are protected by Forest Law; nobody has the right to enter into these areas or to harvest any forest products for commercial purposes without permission (Figure 1). Official timber harvesting for the national economy has been practiced in all of these RFs using the Myanmar Selection System since 1856.

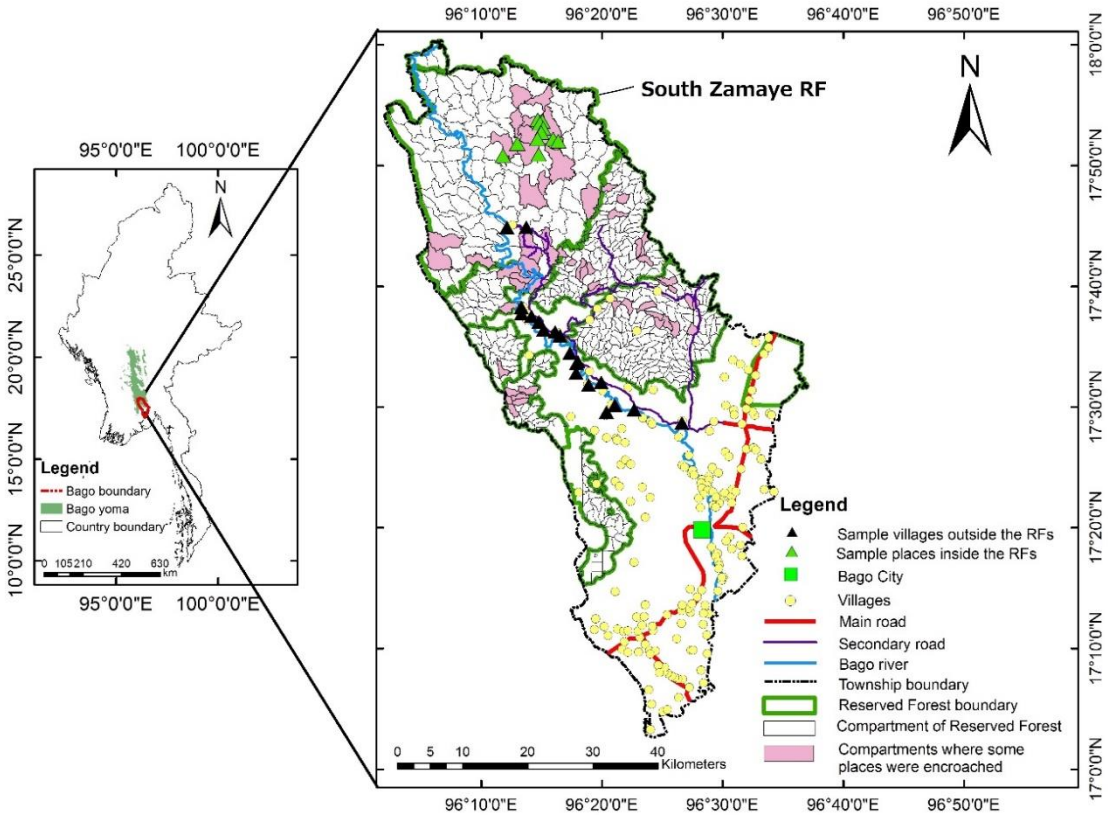

Figure 1. Study sites at Bago Township, Myanmar.

In 2013, when we conducted the field surveys, there were 491,434 people and 107,132 households in Bago Township, and 48.2% of people lived in rural areas. The overall mean household size in the Township is 4.4 members per household [11]. The Township comprises one big city called Bago and 229 villages (Figure 1). Approximately 807 households were temporarily living within the compartments of the RF areas without permission, which was regarded as encroachment (Forest Department, Bago Township, 2013). Of the total of 229 officially registered villages, two were located within the boundaries of the RFs, but because these villages were officially approved and registered, we regarded them as "outside" the RFs, rather than as part of the encroachment (Figure 1).

2.2. Data Collection

Data collection was conducted for households living outside and inside the RFs using a questionnaire survey in March and December 2013. Information was collected mainly through a meeting with the head of each household using a structured interview. The field survey team for the household interview consisted of both male and female undergraduate students with accompanying representatives from each selected village or community. Before starting an interview, the respondents were informed that the interview was only for academic research and did not concern any authority. The survey questionnaire was written in the national language to allow a clear understanding. It mainly focused on the knowledge of the household heads about the nearby RF, socio-economic conditions, resource use patterns, and livelihoods.

2.2.1. Household Surveys outside the RFs

Out of the 229 villages, a total of 19 sample villages were selected for this study along the seasonal secondary road and the river to cover different levels of accessibility to the forest (Figure 1). All the sample villages were situated on the secondary road, which was constructed mainly for use in official timber harvesting operations. This road is used for transportation by local communities in summer (February–May) and winter (October–January) seasons. In the rainy season (June–September), local communities in the sampled villages use the Bago River, which runs from north to south across Bago Township, for transportation. Therefore, most of these sampled villages had poor access to the city and markets for their products. As a consequence, most residents from these villages had relatively low education levels and poor socio-economic conditions. All the villages had been situated around the RFs for over 80 years. Local communities had legal right to the forest only for their basic needs, and commercial use without permission was prohibited by Forest Law 1992 [15]. The total population and number of households in the 19 sampled villages were 30,194 and 5679, respectively. The average land holdings per household among the 19 villages were approximately 1.60 ha.

Among the 5679 households living in the 19 sampled villages, 146 households were randomly selected with a sampling intensity of 2.6% of the total households. They mainly depended on agriculture and forest for their livelihood because of the poor accessibility to city, market and off-farm opportunities. First, a group discussion with 10 to 15 members was conducted, including the key informants from relevant villages, the head of the village, and the village elders who knew about the village to get advices on the sampling intensity, depending on the heterogeneity or homogeneity of the livelihoods of the respective villages. Next, practice household surveys were carried out to test the questions. Then, 7–14 households from each selected village were randomly chosen. Informal discussions were also carried out with the village heads, the village elders, and the respondents who voluntarily participated in the discussions, to gather more information to assist with the interpretation of the responses.

2.2.2. Household Surveys inside the RFs

Although the RFs are protected by Forest Law and nobody can settle in them without permission [15], around 807 households (hereafter, called encroachers) were living without permission within fifty eight compartments of the RFs in 2013 (FD Bago, 2013, Figure 1). Approximately 41% (334 encroachers) of total encroachers were living in the South Zamaye RF in 2013, where legal logging operations were being conducting. They were moving from one place to another within the forests using the logging road constructed in the legal logging operation.

The questionnaire survey was conducted in December 2013 with the encroachers living in the South Zamaye RF. Of the 119 compartments in South Zamaye RF, 20 compartments were encroached upon by local communities (Figure 1). Six out of the 20 compartments were selected subjectively considering accessibility and proximity to the current timber production site (Figure 1). Approximately 14% (48 households) of total encroacher households in South Zamaye RF were chosen randomly for the survey. Then, the survey was conducted using a pre-structured questionnaire related to encroachers' livelihoods, encroachment patterns, and dependency on forests. Unlike the survey for the outside households, group discussion with the key informants was not conducted for the inside households.

2.3. Data Analysis

We classified household cash income into forest cash income and non-forest cash income based on income sources. We defined forest cash income as cash income from activities within the RFs, such as collecting and/or producing forest products by households within the RFs, and labor, farming and small shops within the RFs. Non-forest cash income was defined as earnings from activities outside the RFs such as agriculture and small business. Some households earned only forest cash income or only non-forest cash income while others earned from the combination of forest cash income and non-forest cash income. In this study we found a total of 13 different cash income strategies, as listed in Table 1.

Table 1. Cash income sources and household cash income strategies found in this study.

Cash Income Sources + A2:G18	Household Cash Income Strategies	Households Living Outside the RFs (n = 146)		Households Living Inside the RFs (n = 48)	
		n	%	*n*	%
Only forest cash income	Only charcoal production	3	2.1	20	41.7
	Charcoal production and opening shop in RF			1	2.1
	Charcoal production and bamboo cutting	16	2.1		
	Only bamboo cutting	4	2.7		
	Only labor in RF	1	0.7	1	2.1
Only non-forest cash income	Only agriculture	28	19.2		
	Only business (opening shop in villages and small-scale animal husbandry)	13	8.9		
	Other non-forest activities (labor in villages, combination of agriculture and business or labor in villages)	30	20.5		
Combination of forest and non-forest cash income	Charcoal production and non-forest activities	5	3.4	24	50.0
	Charcoal production, bamboo cutting and non-forest activities	9	6.2	2	4.2
	Bamboo cutting and non-forest activities	31	21.2		
	Farming in RF and non-forest activities	4	2.7		
	Labor in RF and non-forest activities	2	1.4		
	Total	146	100	48	100

Non-forest activities include agriculture, small business (including livestock raising), and labor outside the reserved forests (RFs).

Forest cash income dependency was calculated as the ratio of forest cash income against the total annual household cash income [19]. The total household cash income was calculated as the sum of forest cash income and non-forest cash income. Some households earned cash income from the combination of forest cash income and non-forest cash income (Table 1). Therefore, we divided such combined household cash income into forest cash income and non-forest cash income, when we evaluated forest cash income dependency, which was calculated as forest cash income divided by total (forest and non-forest) cash income. We also classified total household income of each household into 5 forest cash income and 3 non-forest cash income sources as shown in Table 1, then we calculated the averages for the outside- and inside-households.

The products consumed directly by the household or given away to friends and relatives were assumed as subsistence and the value of these products was not counted in calculating household annual cash income. The income in Myanmar Kyat (MMK) was changed to US dollars using the exchange rate (1 USD = 800 MMK) at the time of data collection. Cash income from forest-based products and agriculture was calculated based on the productivity and the price received in their sale, and the cost for all purchased inputs (such as purchased fertilizer or hired labor) was deducted to arrive at the net income. Livestock income included only income from the sale of animals within a year.

Descriptive statistics were used to explore the main characteristics of respondents concerning their socio-economic status, knowledge about the RFs, and dependency on the forests. We compared the overall mean of a continuous variable between households living outside and inside the forest using Wilcoxon rank sum t-test statistic (Table 2). We used chi-squared test for differences in categorical variables (Table 3). We also used chi-squared test to confirm differences in cash income strategies between the outside- and inside-households in term of the household number (Table 1) and of income distribution among different income strategies (USD/year).

Table 2. Continuous variables of socio-economic characteristics for the sample households.

Continuous Variables	Unit	Households Living Outside the RFs	Households Living Inside the RFs	Wilcoxon Rank Sum Test
		***n* = 146** **Mean ± SD**	***n* = 48** **Mean ± SD**	
Age of head	Years	47.1 ± 10.5	33.7 ± 9.9	$p < 0.0001$
Family size	Persons	5.4 ± 1.8	4.6 ± 1.8	$p = 0.013$
Farmland area	Hectare	2.3 ± 2.7	0.53 ± 1.2	$p < 0.0001$
Total cash income	USD/year	1701 ± 1083	1090 ± 547	$p < 0.0001$
Forest cash income dependency	%	32 ± 38	83 ± 19	$p < 0.0001$
Duration of residence	Years	38.2 ± 16.0	6.3 ± 6.2	$p < 0.0001$

Table 3. Categorical variables of socio-economic characteristics for the sample households.

Categorical Variables	Definition	Classes	Households Living Outside the RFs (*n* = 146) %	Households Living Inside the RFs (*n* = 48) %	Chi-Squared Test
Education	Education level of the household head	Primary (grade 1–4) Middle (grade 5–8) High (grade 9–)	75 17 8	81 15 4	$\chi^2 = 1.1297$ $p = 0.5684$
Accessibility to forest	The time to the RFs to collect forest products	Bad (more than 1 day) Good (within 1 day)	22 78	0 100	$\chi^2 = 11.058$ $p = 0.0009$
House possession	Household own a house for permanent settlement	Own Not own	99 1	73 27	$\chi^2 = 0.034723$ $p = 0.8522$
Knowledge about the law of RFs	Household head's knowledge about the prohibited access to RFs by Forest Law	Known Unknown	67 33	79 21	$\chi^2 = 1.9583$ $p = 0.1617$
Knowledge about the boundary of RFs	Household head's knowledge about the boundary of RFs	Known Unknown	54 46	79 21	$\chi^2 = 8.4571$ $p = 0.0036$

Moreover, linear regression models were developed to explore the factors influencing forest cash income dependency. Forest cash income dependency was used as the dependent variable. We used five continuous variables and five categorical variables, shown in Tables 2 and 3, as independent variables, based on the previous studies on forest dependency. These were related to socio-economic conditions and knowledge of the forest-dependent communities, and the hypothesized effects were shown in the Supplementary Material Table S1. Before running the model, we checked for multi-collinearity among independent variables and confirmed no collinearity using a Variance Inflation Factor (VIF) < 5 [20]. In this study, we built three regression models for (1) all the sample households living outside and inside the RFs (n = 194), (2) households living outside the RFs (n = 146) and (3) households inside the RFs (n = 48). In the model for the inside households, the variable "accessibility to forest" was not used because all the sample had the same value "Good" (Table 3), and the variable "Knowledge about the boundary of the RFs" was not used because the value for each household (known or unknown) was identical to that of the variable "Knowledge about the law of the RFs" (Table 3). All statistical analyses were conducted using the R environment [21].

3. Results

3.1. Socio-Economic Characteristics of Households

All the continuous variables were significantly different between households outside and inside the RFs (Table 2). The outside-households had a much higher total income (mean ± SD; 1701 ± 1083 USD/year) than the inside-households (1090 ± 547 USD/year), while forest income dependency was much higher for the inside-households (83 ± 19%) than the outside-households (32 ± 38%). The outside-households tend to have older household heads, larger family sizes and farmland area, and longer duration of residence (Table 2).

Among the categorical variables shown in Table 3, relatively large differences between the outside- and inside-households were found in relation to accessibility to forest, house possession, and knowledge about the boundary of RFs. Approximately half (47%) of the outside-households did not know the boundary of RFs while most (79%) of the inside-households knew it. In contrast, many households both outside and inside the RFs knew the law of RFs (Table 3).

3.2. Household Cash Income Strategies

Clear differences in cash income strategies were found between the outside- and inside-households (chi-squared = 16.7, df = 12, $p < 0.0001$; Figure 2, Table 1). For the outside-households, almost half (49%) of the households got cash income only from activities that were not related to forests, such as agriculture and business, whereas the other half earned some cash income from forest-related activities (charcoal production, bamboo cutting, labor, and shop in RFs) (Figure 2, Table 1). In contrast, all the inside-households got cash income from forest-related activities. Around 46% the inside-households' cash income was only from forest-related activities, whereas the income strategies for the other 54% were combinations of forest-related and non-forest activities (Figure 2, Table 1).

Forest use strategies for cash income were also quite different (Figure 2, Table 1). For the outside-households, bamboo-cutting activities were more common (41% of the sample households) than charcoal-production activities (23%). In contrast, the majority of the inside-households (98%) were engaged in charcoal production while only 4% of households carried out bamboo cutting.

Among the 12 different cash income strategies found in outside-households, the average cash income was highest for the combination of labor in RF and non-forest activities (3125 USD), followed by the combination of charcoal production, bamboo cutting and non-forest activities (2556 USD), then only business (2462 USD) (Figure 3). Among the five cash income strategies of the inside-households, the combination of the charcoal production and shop in RF was highest (2375 USD), but the other four strategies were not significantly different (ANOVA, $p > 0.05$) and the incomes of the inside-households from these four strategies were significantly lower than those of the outside-households (Figure 3).

Figure 2. Share of different cash income strategies among all the sample households (% of outside- and inside-households).

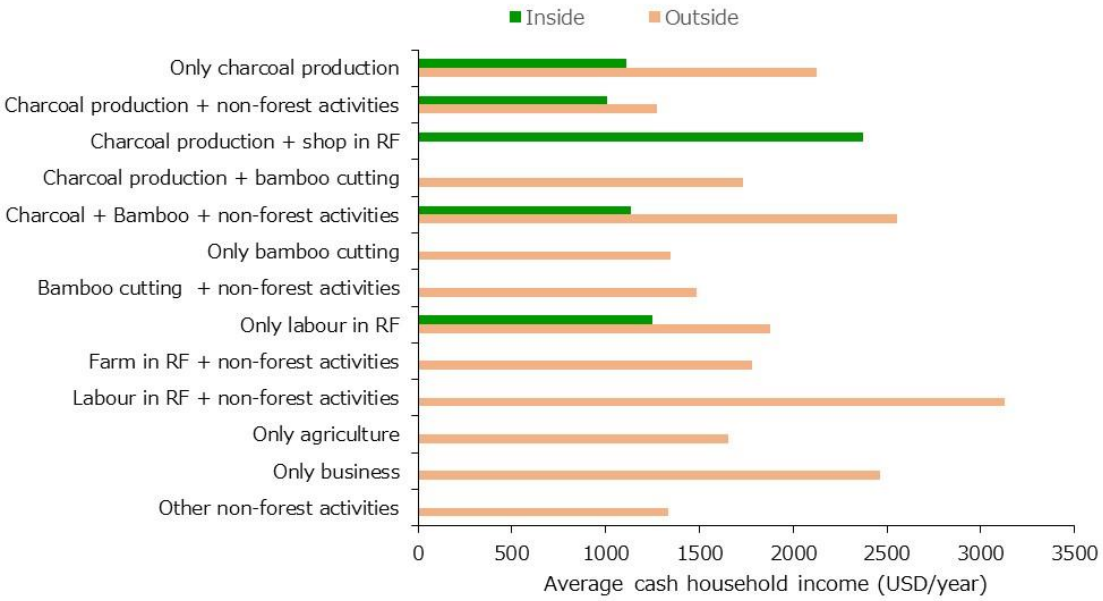

Figure 3. Average household cash income (USD/year) for each of cash income strategies.

3.3. Forest Cash Income Dependency

Average total cash income was classified into 5 forest cash income and 3 cash non-forest income sources (Figure 4). These cash income distribution patterns among eight different income sources were significantly different between the outside- and inside-households (chi-squared = 1765.4, df = 7, $p < 0.0001$; Figure 4). Of the average cash income for all the inside-households (1090 USD), 800 USD

(73%) were earned from only charcoal production, while cash income from non-forest activities was only 13% of the total cash income (Figure 4). For the outside-households, the cash income only from charcoal production was only 4% (65.5 USD) of the total average income (1701 USD), and a higher proportion of cash income was found in only bamboo cutting (10%) and the combination of charcoal production and bamboo cutting (17%) (Figure 4).

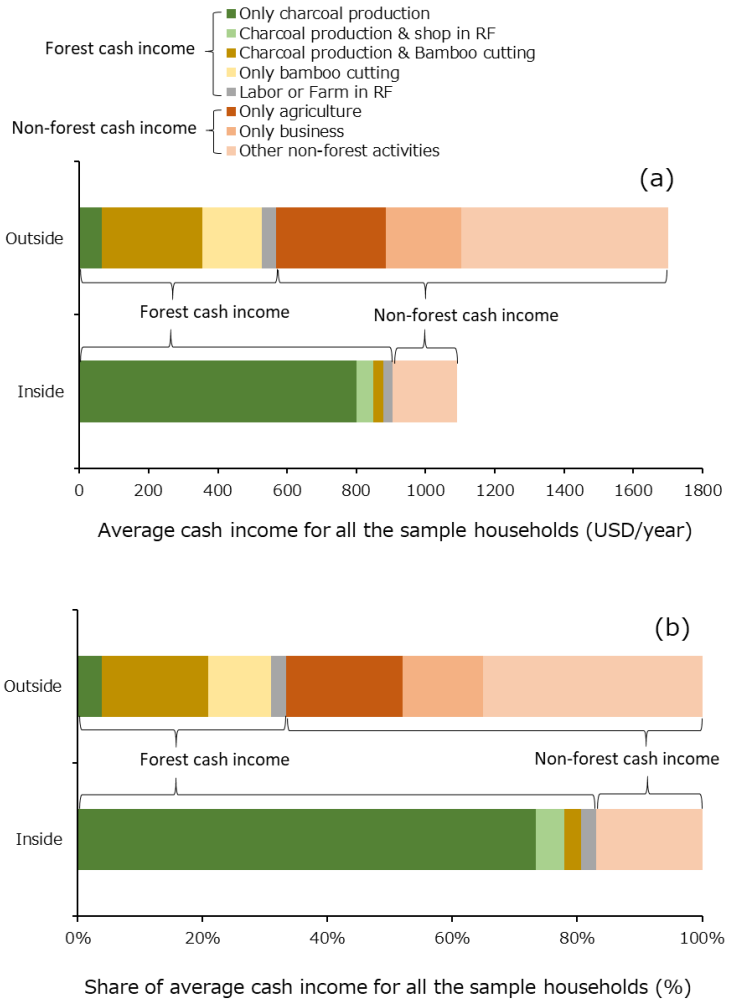

Figure 4. Average total cash income for all the sample households with being classified into 5 forest cash income and 3 non-forest cash income sources. The units are (**a**) USD/year and (**b**) share (%) of average income.

3.4. Factors Affecting Forest Income Dependency

There were similar regression results using all the outside- and inside-households (n = 194) and only the outside-households (n = 146), while these results were different from those using only the inside-households (n = 48). For the outside-households, farmland area and duration of residence negatively affected forest dependency, while accessibility to forest and knowledge on forest law positively affected it (Table 4). This indicates that more farmland and longer duration of residence lowered the dependency level, and the dependency was higher for households with better access to forest and the household head's recognition of the prohibition relating to RFs under Forest Law. For the inside-households, the regression model cannot significantly explain the variation of forest dependency (p = 0.4859) even though family size may negatively influence the dependency (Table 4).

Table 4. Parameter estimates of the linear regression models explaining forest cash income dependency (%).

Coefficients	Households Living Outside and Inside the RFs (n = 194)				Households Living Outside the RFs (n = 146)				Households Living Inside the RFs (n = 48)			
	Estimate	**Std. Error**	***t* Value**	**Pr (>|t|)**	**Estimate**	**Std. Error**	***t* Value**	**Pr (>|t|)**	**Estimate**	**Std. Error**	***t* Value**	**Pr (>|t|)**
(Constant)	6.093×10^{-1}	1.623×10^{-1}	3.753	<0.001	3.553×10^{-1}	3.245×10^{-1}	1.0950	0.2756	8.319×10^{-1}	2.047×10^{-1}	4.064	<0.001
Age of head (Years)	-1.594×10^{-3}	2.659×10^{-3}	−0.599	0.550	-1.358×10^{-3}	3.346×10^{-3}	−0.4060	0.6855	-8.762×10^{-5}	3.402×10^{-3}	−0.026	0.980
Family size (Persons)	-1.464×10^{-2}	1.407×10^{-2}	−1.040	0.300	-5.103×10^{-3}	1.780×10^{-2}	−0.2870	0.7747	-4.481×10^{-2}	1.760×10^{-2}	−2.547	0.015
Farmland area (hectare)	-3.619×10^{-2}	1.081×10^{-2}	−3.349	0.001	-3.907×10^{-2}	1.219×10^{-2}	−3.2050	0.0017	2.617×10^{-2}	2.645×10^{-2}	0.990	0.329
Total cash income (USD/year)	1.873×10^{-5}	2.407×10^{-5}	0.778	0.438	2.963×10^{-5}	2.715×10^{-5}	1.0910	0.2770	-4.879×10^{-6}	5.893×10^{-5}	−0.083	0.934
Duration of residence (Years)	-7.222×10^{-3}	1.599×10^{-3}	−4.517	<0.001	-4.336×10^{-3}	2.074×10^{-3}	−2.0910	0.0384	2.152×10^{-4}	5.672×10^{-3}	0.038	0.970
Education (Middle)	1.081×10^{-1}	1.062×10^{-1}	1.017	0.310	1.061×10^{-1}	1.250×10^{-1}	0.8490	0.3973	3.374×10^{-2}	1.599×10^{-1}	0.211	0.834
Education (Primary)	1.697×10^{-1}	9.660×10^{-2}	1.757	0.081	1.462×10^{-1}	1.140×10^{-1}	1.2830	0.2019	1.254×10^{-1}	1.482×10^{-1}	0.846	0.403
Accessibility to forest (Good)	1.604×10^{-1}	6.439×10^{-2}	2.491	0.014	1.323×10^{-1}	6.989×10^{-2}	1.8930	0.0606	NA	NA	NA	NA
House possession (Yes)	-1.228×10^{-1}	9.049×10^{-2}	−1.357	0.176	-4.265×10^{-2}	2.535×10^{-1}	−0.1680	0.8667	3.226×10^{-2}	6.769×10^{-2}	0.4770	0.6364
Knowledge about the law of RFs (Known)	1.639×10^{-1}	6.982×10^{-2}	2.348	0.020	1.817×10^{-1}	7.762×10^{-2}	2.3410	0.0207	8.099×10^{-2}	7.272×10^{-2}	1.1140	0.2723
Knowledge about the boundary of RFs (Known)	-6.806×10^{-2}	6.452×10^{-2}	−1.055	0.293	-8.418×10^{-2}	7.126×10^{-2}	−1.1810	0.2396	NA	NA	NA	NA
	R^2 = 0.4143 Adjusted R^2 = 0.3789 F value = 11.7 p value < 0.00001				R^2 = 0.2446 Adjusted R^2 = 0.1826 F value = 3.944 p value < 0.00001				R^2 = 0.1855 Adjusted R^2 = –0.007404 F value = 0.9616 p value = 0.4859			

Note; NA indicates that this variable was not used for regression because "Accessibility to forest" was "Good" consistently and "Knowledge" was identical between "law" and "boundary" for all the households living inside the RFs (n = 48).

4. Discussion

4.1. Forest Use Strategies for Cash Income

In this study, we found large differences in cash income strategies between households living outside and inside the RFs. All the inside-households were engaged in forest-related activities for cash income generation, whereas only half of outside-households earned cash income from forest-related activities. The other half of outside-households' cash income was from non-forest activities such as agriculture, small business including livestock raising, and labor outside the RFs (Figure 2). In this study site, all the farming was rain-fed and, therefore, farmers practiced farming only in specific months. During the rest of the year, many households collected forest products to earn extra income, which is common livelihood practice in rural regions [22]. The encroachers (the inside-households) had significantly smaller areas of farmland (0.53 ha) than the outside-households (2.33 ha), and only 73% of encroachers possessed a house in their respective villages (Table 2). Nearly all the encroachers earned their forest-related income from charcoal production (Figure 2). Therefore, the encroachment in this study was unlikely to be for permanent settlement and farming. The encroachers had significant lower average annual cash income (1090 USD) than that of the outside-households (1701 USD). This arises from lower average cash income for four of their income strategies: only charcoal production, charcoal production + non-forest activities, charcoal + bamboo + non-forest activities, and only labor in RF (Figure 3). This lower cash income may be because encroachers had smaller family sizes or had smaller farm sizes, or both (Table 2).

4.2. Forest Cash Income Dependency

Local communities living around the RFs have access to them only for subsistence and have been prohibited from using RFs for commercial purposes by the Forest Law in Myanmar. However, substantial forest cash income dependency was found not only for the inside-households (83%), but also for outside-households (32%). This is within the values reported in previous studies. For example, forest income dependency was reported in protected areas in Myanmar: 38.8% for three villages surrounding the Popa Mountain Park by Htun et al. [23] and around 50% for two villages around Natma Taung National Park by Aung et al. [11]. The forest dependency values in villages near the production forests in Bago Yoma region, Myanmar, which is the same region as this present study, were also reported to be 25% in 10 villages in both western and eastern aspects of Bago Yoma region by Khaine et al. [24], and 37% in the Taungoo District by Soe and Yeo-Chang [25]. The reported values for forest income dependency for other countries included 21% in Ethiopia [5], 12% in Malawi [6], and 47% in Pakistan [26].

The encroachers' dependence level for cash income (83%) was much higher than that of the outside-households (32%). This result is probably because most encroachers practiced year-round charcoal production as their main forest use activity (Figure 2) while many outside-households combined seasonal bamboo cutting with farming or small business. The finding that charcoal making and bamboo cutting were the main forest use activities in this study was consistent with that of [25] who conducted household surveys near the production forest in the Taungoo district, Bago Yoma region in Myanmar. Khaine et al. [24] also reported that bamboo and bamboo shoots were the most collected NTFPs in the Bago Yoma region, Myanmar.

4.3. Factors Affecting Forest Cash Income Dependency

We found large differences in factors affecting forest cash income dependency between the outside- and inside-households. For the outside-households, farmland size had a negative correlation with the dependency level (Table 4). This is compatible with the hypothesized effect, indicating that more income generated from agriculture can lower forest dependency (Table S1). Studies have highlighted that limited access to agricultural land creates more dependency on the forest [6,27]. Similarly, a lack of land availability can drive local people to encroach into forested areas [16,28]. The duration of residence

was found to have a negative relation with the forest cash income dependency. This is also along with the hypothesis that the households living longer in a village may have more secure usufruct rights to their land and they may be less dependent on forest products (Table 4 and Table S1). Regarding knowledge of forest law, it was hypothesized to have a negative correlation, whereby people who knew about the prohibition on commercial forest use in RF would have lower forest dependency (Table S1). However, there was actually a positive relationship with the dependency level (Table 4); even though respondents knew about the prohibition, they were dependent on the forest for their livelihood. Forest Department staff made announcements to stop illegal activities and move encroachers out from the forest, but after a few months of conducting such law enforcement activities, encroachers began illegal activities again. This confirmed the finding of other studies, which showed that law enforcement and limiting access to forest resources cannot solve the problem of illegal activities [29]. According to Forest Law in Myanmar, access to forest resources for subsistence purpose is permitted, but villagers still need to earn a cash income. Having a positive association between accessibility to forest and dependency level is consistent to the finding in Cameroon that easy access to forest resources created more dependency on the forest [30].

For the inside-households, the regression model failed to explain the variation of forest cash income dependency (Table 4). This may be because the sample size and variation of the dependent variable were relatively small for the inside-households (Table 2, n = 48, mean ± SD = 83 ± 19%).

4.4. Forest Management Implications

One of the critical issues in Myanmar forestry is that there has been widespread forest degradation in selectively logged production forests [16,31]. Ecological field-surveys revealed that illegal logging occurred after legal logging operations [17,31]. Illegal logging most likely targeted first larger trees of commercially valuable timber species such as teak (*Tectona grandis*) and pyinkado (*Xylia xylocarpa*), and after depletion of these timber trees, trees of various species and sizes were illegally cut for charcoal making [32]. The socioeconomic field-surveys of this present study confirmed that illegal charcoal production was widely conducted in RFs and such charcoal production was the major income strategy for the encroachers. Because charcoal demand is likely to grow in rural areas of Myanmar, there may be an increasing risk of further forest degradation because of charcoal making [33]. To deal with this matter, more community forestry programs should be implemented to achieve sustainable production of charcoal in rural regions.

This study also found that bamboo collected in RFs was one of the important cash income strategies for households living near the RFs. Bamboos are often dominant in degraded forests in tropical mixed deciduous production forests in Myanmar, and bamboo-dominated conditions can hamper tree regeneration [32]. Thus, promoting bamboo cutting by local households may contribute not only to their income generation but also to the restoration of degraded forests. Providing legal rights to access the RFs for bamboo cutting would be an incentive for local households to facilitate sustainable production of bamboos as well as other NTFPs.

4.5. Study Limitations

In this study, the data collected in December 2013 were used for the analysis. Thus, the household cash income strategies and forest cash income dependency might have changed under changing the condition of forest management strategy and rural development in the past seven years. Regarding forest management strategy, a logging ban was introduced in 2016 for one year in the whole country and for 10 years in the Bago Yoma region, including our study site. Accessibility to the forest was highlighted as an influencing factor on forest cash income dependency. Because all the sample households were situated on the secondary roads, which were constructed mainly for use in legal logging operations, the logging ban may affect the changes of household income strategies and income dependency. Providing legal rights to access the RFs for income generation is still limited for local households. Community forestry has been practiced since 1995 in Myanmar mainly to meet the basic

needs of local people. The revised community forestry instruction in 2019 aimed not only to provide basic needs but also to enhance and employment income opportunities of local communities. However, the effectiveness of changes in forest policy on the livelihoods of local communities is still unknown. Therefore, this study calls for further study to assess the changes of income strategies and forest income dependency after seven years using the baseline information of this study to formulate more effective policy measures.

5. Conclusions

This study revealed that the selectively logged production forests (RFs) in Myanmar were largely used for income generation by households living both outside and inside the RFs, even though most households knew that the forest law prohibited access to RFs for commercial purposes without permission. The inside-households (encroachers) were more dependent on the forest for cash income than the outside-households. The main forest use activity of the encroachers was charcoal production while bamboo cutting was the main activity of the outside-households. Implementing community forestry practices may be a better option to reduce illegal dependence on selectively logged production forests. Moreover, supporting the right to extract NTFPs, such as bamboo, for commercial purposes from nearby production forests might be an incentive for the socio-economic development of forest-dependent rural people and the restoration of widespread degraded production forests in Myanmar.

Supplementary Materials: The following is available online at http://www.mdpi.com/1999-4907/11/12/1263/s1, Table S1: Hypothesized effects and references about the explanatory variables used in the regression models.

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