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Article

Sustainable assets and strategies for affecting the income of forestry household: Empirical evidence from South Korea

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Abstract: This study aims to identify the factors determining the income of forestry household in South Korea. We examine an empirical analysis using 3-year panel data conducted by the Korea Forest Service charged with maintaining South Korea's forest lands. The hypothesized factors determining the income of forestry household are classified into four types of assets and three types of livelihood strategies. We divided the income of forestry household (IFH) into three elements: forestry income (FI), non-forestry income (NFI), and transfer income (TI). We assessed the influences of household assets and livelihood strategies on each income. A random effect model was used as a statistical analysis with valid 979 of forestry household for three years. We found that household head's age, labor hours, savings, business category, cultivated land size, and region are significantly associated with IFH. Also, FI is influenced by labor capacity, cultivated size, business category, forestry business portfolio, and region while NFI is determined by household head's age, household head's gender, forestry business portfolio, and savings. TI is affected by household head's age, household head's education level, forestry business portfolios, savings, and region. The effect sizes and directions vary across different types of income (IFH, FI, NFI, and TI). The findings show that forestry in South Korea is highly dependent on sustainable assets and strategies. It is therefore expected that the effectiveness of forest policies to increase the income of forestry household would be differed by the source of each income. The results of this study draw attention to the need for an income support policy that should consider the characteristics of household assets and livelihood strategies in order to enhance IFH in South Korea.

Keywords: Sustainable Assets; Sustainable Strategies; Income of Forestry household; Forestry Income; Non-forestry Income

1. Introduction

Forestry in South Korea is an industry based on the forest which covers 65% of the country's land, playing significant roles in conserving biodiversity, maintaining the ecosystem, mitigating climate change, managing the land, and supporting local livelihoods in South Korea. However, the forestry industry is not significant contributing only 0.14 percent to the economy based on gross national income [1]. There are three possible explanations for the insignificant profile of South Korea's forestry industry. First, the forest resources in South Korea have been unavailable for timber supply due to the average young age of the trees. Second, the infrastructure needed for forestry, such as roads, has been underdeveloped due to the adverse topographic characteristics, such as stiff slopes

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of forestlands. Third, protection-oriented forest policies have accumulated strict regulations on forestry production and development for the last century [2]. Thanks to the forest conservation efforts for the last half-century, the country experienced forest transition [3]. However, the income level of forestry household is at the lowest among the sectors in South Korea. It is at the level of 63.6 percent of the average urban household.

In order to improve the poor environment of the forestry industry, the South Korean government has been investing in the infrastructure needed for forest management and production [4]. Also, the forest conditions have improved to such a stage that harvesting for low-grade timber is an option for forest management. For example, tree growing stock had increased from 65 million m^3 in 1968 to 925 million m^3 In 2015 [5]. Besides, most of the forests of South Korea are approaching their harvesting ages, and people's interests in healthy forest-based food products have been steadily growing recently. The government has been supporting the private forestry operation by providing financial subsidies for the modernization and commercialization of forest production [6].

Along with these efforts, measures to improve the income level of forestry household have been taken by the Government of South Korea, the budget for the income of foresty household (hereafter IFH) support within the forestry budget of South Korea has increased from 4.87% in 2014 to 9.09% in 2018 [7,8].

In order to understand the problem of underdeveloped forestry industry little contributing to the income of households practicing forestry, this study analyzed what constitutes the income of forestry household and how it differs among groups of households. We adopted the sustainable livelihood approach (SLA) as the theoretical background and investigated the income structure of forestry household in South Korea. According to the most frequently used definition of sustainable livelihood, a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base [9,10]. SLA mainstreams the livelihood sustainability of the target group as a crucial development goal. SLA has been employed by many development agencies of which most of the official development aids geared to elevate poverty in developing countries by delivering their projects. SLA helps understand the poverty structure, life of the poor, and the relevant social and institutional issues [11].

In this study, SLA is used as a lens through which we identify determinants of IFH. The following are the distinctions of this study from previous studies applying SLA in the field of forestry and agriculture. First, while some previous studies [12–14] considered household capitals as determinants of livelihood strategies, we view the capitals and strategies together as inputs that generate the household income as an output. Second, the studies on the determinants of sustainable livelihood strategy or the determinants of livelihood income using SLA are mostly based on cross-sectional data analysis of specific regions. To our knowledge, few studies have conducted time series data analyses of national range. We also attempt to expand the application of SLA from a regional level to a national level of forestry research.

Therefore, we aim to answer the research questions, “What are the determinants of IFH in South Korea?” and “How different are the determinants of different elements of household income?” Answering these questions should help us understand the forestry household’ livelihood structure and suggest a potential pathway to policy addressing the low contribution of forestry to IFH, ultimately providing policy directions for sustainable livelihood of forestry in South Korea.

2. Background

2.1. Sustainable livelihood approach

SLA models the influences of internal and external factors that constitute livelihood in understanding the livelihood of people. The internal factors are household capitals, livelihood strategies, and livelihood outcome, while exogenous factors include social structures and processes [11]. A household’s capitals are subcategorized as natural, human, physical, social, and financial capitals. In a general procedure of SLA, firstly, the accessibility and availability of each household

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capitals are evaluated. Based on the capitals at hand of the household, a livelihood strategy is determined considering the quantity, quality, and composition of the capitals. The outcome of this livelihood strategy can be food production, cash income, and sustainable resource use, which enable re-investment in the household capitals. On the other hand, the exogenous components deal with environmental changes and institutional measures that directly affect the household's asset availability and livelihood strategy [12].

As SLA helps understand the poverty structure, life of the poor and the relevant social and institutional issues [11], it often aims at poverty alleviation and is mainly used for research in developing countries. Some studies have been conducted on the poor rural areas of mid-income countries such as China [15–19] and Georgia [13]. SLA is an approach applicable to understanding the livelihood of local communities across different developmental stages. Since SLA targets to explore as many livelihood components as possible, it is useful in understanding the livelihoods of a specific rural area. SLA was not designed for reflecting the macroscopic trend but was devised to understand local livelihood in detail [20]. SLA seeks to analyze the sustainability of livelihoods by evaluating the characteristics of households, resource utilization and depletion, institutional change, environmental change, and market accessibility in a specific area. Due to its flexible nature, SLA has been used in diverse sectors including natural resource management [21], mining [20], fisheries [22,23], tourism [24–26], cropping [15,27], and multi-sectoral circumstances [16,28–30].

2.2. Application of SLA to forestry research

Forest-dependent communities are one of the representative subjects of SLA studies. Most of these studies have investigated the relationship between household capitals, livelihood strategies, and household income. For example, Babulo et al. (2008) estimated the impact of the natural, human, physical, social, and financial assets of local forestry on household income and resource dependency. Tesfaye et al. (2011) defined activities such as forestry, crops and livestock breeding as livelihood strategies, and found that livelihood strategies are significantly associated with outputs including income and food security for forest-dependent households.

Similarly, Soltani et al. (2012) analyzed the factors affecting the livelihood strategy and its outcome in rural areas of Iran and found that each household generally takes a strategy to combine forestry, the livestock industry, and agriculture. They also found that livelihood outcomes, such as poverty alleviation and sustainable forest management, are influenced by the endowments of household assets and choice of household strategies. Zenteno et al. (2013) examined a rural community's livelihood strategies that affected household income in tropical rain-forests and found that differentiated livelihood strategies of individual households lead to different income levels. Kemkes (2015) analyzed the impact of common pool forest resources on household income and livelihood strategies in rural mountain villages under development pressure in Georgia.

2.3. Household capitals affecting household income

In the previous studies employing SLA, household size, household head's gender, household head's age, household head's education level, and labor capacity were used as variables explaining human capital [12–16,19,27,29,31–33]. Other variables for human capital include migration index and female adult ratio [32], conservation and agricultural training [14], marriage [13], children staying away and dead children [31]. In the present study, five variables of human capital are used: household size represented by several family members, household head's gender, household head's age, labor capacity, and household head's education level.

Physical capitals have been referred to as tangible assets required for production activities. Generally, equipment [14,18,32] and livestock value [14,15,32,33] were used as physical capital. Infrastructure, number, and quality of housing, livestock, tools, housing value, productive material, and public service were used as constituting elements of physical capital [33] were used. Hua et al. (2017) used the summed value of different physical assets such as machinery, equipment, fixtures, facilities, small and medium-sized animals, livestock, and large plants. The summed value of fixed

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capital available from the Forestry Household Economy Survey is treated as physical capital in this study.

As explanatory variables for financial capital, some studies used savings and loans at the same time [13,14,27,33], and others only loans [12,19]. Cash income, borrowing, access to loans [15,18], net income [14], livestock value, non-farm business, and money lenders [27] were used. In this study, we define financial capital as the immediate assets and liabilities corresponding respectively to savings and loans.

Natural capitals have been represented by land [17–19,27,32], plot size [12], agricultural land size [14], area of cropland [29], and land claimed [13]. It is widely believed that the inputs required for profit-maximization in the traditional forest production theory are land-based capitals. In studies the production area of a specific product (brazil nut), the number of perennial plants and expected felling area [31], water resources [16], formal ownership [14], distance to road [12], distance from town [29], soil fertility [32], rainfall [32], and altitude [29,32] were also used. In this study, forest land size and cultivated land size are used as variables for natural capital.

2.4. Livelihood strategies affecting household income

Livelihood strategy is a way of making a living that is chosen based on a household's capacity and needs. Business types or product items have been often used as livelihood strategies in SLA studies. Jansen et al. (2006) classified the farming strategies as simple grains producer, livestock producer, and coffee producer. Zenteno et al. (2013) used eight business categories, including silviculture/logging, gathering, chestnut tree, astringent persimmon tree, nut tree, mushroom cultivation, landscape material, and others. In many studies, forestry or agricultural product items or business types are explicitly or implicitly defined as ways of sustaining a livelihood.

The type of forestry in South Korea reflects the situation of forestry as many households practicing forestry are often engaged in other businesses other than forestry. It is common that many forestry households are engaged in agriculture simultaneously. Previous studies on the determinants of national farm income often included full-time or part-time engagement of the household in agriculture [34–36]. By the amount of time invested in the livelihood activity in question, we consider the household chooses the livelihood strategy that voluntarily. If a household is engaged in forestry as well as agriculture or other business, a part-time status of forestry household is treated as a livelihood strategy in this study. We further subdivide the part-time forestry business portfolio into major part-time and minor part-time status by the proportion of forestry income relative to income from other sources, specifically whether forestry income is more or less than other incomes.

Geographical location can be considered either as a natural asset or a livelihood strategy, depending on the household's motivation to reside in a particular region. We view the region as a livelihood strategy because of a household's decision on the location of residence impacts on their production and marketing strategy. For example, forestry income can be affected by varying local conditions such as climatic factors, available resources, market characteristics, regional government policies, and infrastructure. Zhu et al. (2017) mentioned that regional factors significantly influence household investment behavior in NTFP business. Also, Kim and Lee (2014) reported that there is a difference in the structure of agricultural income in each province. Therefore, accounting the differences in specific regions and differentiating the structure of forestry by geographical and administrative region can be considered as effective strategies.

To sum up, the outcome of forest owner livelihood is generated and influenced by both the household capitals and livelihood strategies. Therefore, we viewed household characteristics and livelihood strategies together as determinants of household income (Fig. 1).

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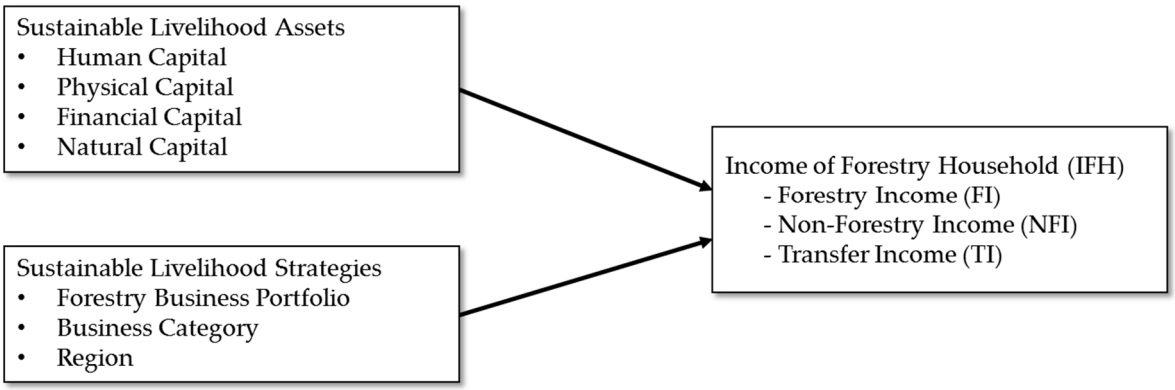

Fig. 1. Research Model

3. Materials and Methods

3.1. Status of income of forestry household in South Korea

There has been a big difference between the agriculture, fishery, and IFH (Table 1). The average IFH was 90.3% and 71.3% of agriculture and fishery respectively in 2016. The difference implies that the conditions of forestry are much inferior to that of agriculture and fishery. Average IFH was 33,585,000 KRW in 2016.

IFH can be divided into regular and irregular income. Irregular income is gained on an occasional basis. In the regular income, there are forestry income (FI), non-forestry income (NFI), and transfer income (TI) accounting 6.9 %, 1.7 %, and 8.1 % respectively (Table 2).

Table 1. Forestry household income and incomes of primary industries in South Korea

Division	**2014**	**2015**	**2016**
Forestry household income[a]	31,058	32,223	33,586
Agriculture household income[a]	34,950	37,215	37,197
Fishery household income[a]	41,015	43,895	47,077
National household income[a]	51,628	52,477	52,790
Forestry/ Agriculture income[b]	88.9	86.5	90.3
Forestry/ Fishery income[b]	75.7	73.4	71.3
Forestry/ National income[b]	60.2	61.4	63.6

Note: [a] 1,000 KRW, [b] %

Source: Korea Forest Service (2015a, 2016a, 2017a) revised.

Table 2. The income of forestry household in South Korea from 2014 to 2016

Division	2014		2015		2016	
	Income[a]	Ratio[b]	Income[a]	Ratio[b]	Income[a]	Ratio[b]
Forestry household income	31,058	100	32,223	100	33,586	100
Regular Income	28,843	92.9	30,086	93.4	31,551	93.9
Forestry income	9,761	31.4	10,586	32.9	11,314	33.7
Non-forestry income	13,382	43.1	13,098	40.6	13,318	39.7
Transfer income	5,701	18.4	6,401	19.9	6,918	20.6
Irregular Income	2,214	7.1	2,138	6.6	2,034	6.1

Note: a 1,000 KRW, b %

Source: Korea Forest Service (2015a, 2016a, 2017a) revised

3.2. Forestry household survey data

South Korea defines forestry, agricultural, and fishing households in its law for the primary industrial group, which is aimed to clarify the targets of its policy support. The survey for forestry

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household economy conducted annually since 2005, after 20 years of government attempts to build the data for understanding the economy of forestry since 1985 is used for this study. The survey aims to provide general knowledge about forestry economy indicators and trends that are used to design forestry support policies. The analytic indicators and data about household income and expenditure, and household assets and liabilities are provided for empirical studies on forestry policies [39].

The population of the survey from 2014 to 2016 is 122,973 forestry household identified in the 2010 forestry census conducted by the government. The definition of forestry household is a household that manages forestry business to make a living, meeting one or more of the following three criteria. (1) More than 3 ha of forestry ownership and at least five consecutive years of forest business experience; (2) more than 1.2 million KRW for annual earnings from forest product sales; or (3) more than 90 days of labor on forestry work per year [39]. Therefore, forestry household and forestry workers, even if their main job is not related to forestry, may also be included in the population if they fall in one of the above.

Three-year panel dataset consisting of 1,105 forestry household in each year of 2014-2016 was retrieved from the forestry household economy survey. Then, a stratified two-step extraction method was used to select samples as follows [39]. First, proportional probability extraction based on the forestry business types was carried out for each eup, myeon or dong (unit of city district) of major cities and provinces. Then, random sampling was conducted in each of the extracted groups based on business types. These samples were stratified by size of industry represented by cultivation area and production amount for each of the nine regions in the country.

Reflecting the heterogeneity of the panel entity based on the selected variables, the random effect model for hypothesis testing estimated coefficient values. The choice of the model is confirmed through a Hausman test. By eliminating missing values in the panel data, a balanced panel was formed minimizing errors. As a result, 979 forest owner data for each year of 2015-2017, aggregating to a total of 2,937-panel data were finally extracted and standardized.

3.3. Analytical models

All independent variables are treated as either categorical or continuous variables when their effects on the dependent variable (IFH, FI, NFI, or TI) are estimated. In this research, a random effect model was applied to test the hypotheses for the following three reasons. First, the forestry household economy survey has a balanced dataset. That is, the data of forestry owners remain unchanged every year without missing values. Estimation errors tend to increase as panel data become unbalanced. Second, in the balanced panel data, the number of forestry household is large while the number of years is small, which may lead to loss of degrees of freedom if a fixed effects model is used. A Hausman test is used to check if this problem is salient. Third, a random effects model estimates the effects time-invariant dummy variables (e.g., gender of household head and forestry business portfolio) in the given time, while a fixed effect model leaves out variables that are fixed over time.

To prevent any autocorrelation problem, we use generalized least squares (GLS) estimation to make sure no correlation between explanatory variables and object property error terms. A Breusch-Pagan Lagrange multiplier (LM) test and a Hausman test was used to confirming the use of the stochastic effect.

$$y_{it} = \alpha y_{it-1} + \beta x_{it} + \eta_i + \varepsilon_{it} \quad \text{----------(1)}$$

Based on equation (1), it is a static analysis if $\alpha = 0$ while it is dynamic if $\alpha \neq 0$. If x_{it} is correlated with η_i, uncontrolled heteroskedasticity may be in error and need to be controlled.

In the processing of η_i, it can be classified into fixed effect and random effect using panel data. While the fixed effect is preferred when it needs to control completely η_i, the random effect is reasonable when it partly allows η_i. Generally, if there are time-invariant variables with no time dependence, a random effect model is preferable. If η_i Is treated as N-1 individual piles, and the OLS is applied to the mean-deviated model, the model is analyzed as a fixed effect model. If η_i is regarded

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as a random variable independent of x_{it} moreover, GLS is applied; it should be analyzed as a random effect model.

4. Results

4.1. Sample description

Descriptive statistics, including the means, standard deviations, minimum values, and maximum values of the dependent variables–IFH, FI, NFI, and TI–are presented in Table 3. There are slight changes in dependent variables but no significant difference over the three years. IFH was 33.4 million KRW in 2014, 32.4 million KRW in 2015, and 34.2 million KRW in 2016. FI, NFI, and TI slightly decreased when the year went from 2014 to 2015 and moderately increased when the year changed from 2015 to 2016. Overall, FI, NFI, and TI have slightly increased over the three years. The negative minimum values of IFH, FI, and NFI mean that the income of forest owner has decreased. These values most likely account for logging or mushroom businesses which do not harvest or sell products in the same year, counting only operational costs.

The mean age of the forest owner was 63.94 years old. Owners were working for 598.28 hours per year on average. Labor capacity means labor hours in this paper. Also, they were working on their cultivated land in an average size of 5.09 ha. The means of the owners' fixed capital, savings, and loan values were 348 million KRW, 40 million KRW, and 31 million KRW, respectively. The fixed capital of the panel data used in this study is reflected the depreciation cost of each year. On the other hand, the average number of the owner's family was 2.41, and the average years on formal education of the owner was 8.40 years. The average forest area possessed by the owner was 2.01 ha. The means, standard deviations, minimum, and maximum values of the variables are presented in Table 4.

Table 3. Descriptive statistics – dependent variables (unit: million KRW)

Variable		Obs	Mean	S.D.	Min	Max
2014	FHI	979	33.40	57.70	-121.00	932.00
	FI	979	11.40	52.00	-141.00	935.00
	NFI	979	13.90	22.70	-95.60	220.00
	TI	979	5.62	6.53	0.00	71.20
2015	FHI	979	32.40	47.80	-122.00	713.00
	FI	979	10.80	38.70	-65.60	709.00
	NFI	979	13.00	21.70	-158.00	237.00
	TI	979	6.27	7.30	0.00	118.00
2016	FHI	979	34.20	41.20	-73.70	528.00
	FI	979	11.70	31.50	-73.70	531.00
	NFI	979	13.80	21.50	-115.00	158.00
	TI	979	6.57	6.93	0.00	64.60

The descriptive statistics of categorical variables are summarized in Table 5. Forestry household were mostly males (2652 people, 90.3%). Among the business types, others were of the largest number (624, 21.3%), followed by astringent persimmon (497, 16.9%), chestnut (371, 12.6%), landscape material (353, 12.0%), nut tree (344, 11.4%), gathering (296, 10.1%), mushroom cultivation (241, 8.2%) and silviculture/logging (211, 7.2%).

In terms of the forestry business portfolios, full-time forestry owner means at least one member of the family should be engaged in paid non-forestry work for more than 30 days in the year. Major part-time means forest revenues exceed non-forestry revenues, minor part-time means non-forest revenues exceed forestry revenues. Among them, 120 owners (4.1%) were engaged in full-time forestry. Among part-time forestry household, 1,666 of them (56.7%) were engaged in forestry as a major business while 1,151 owners (39.2%) were engaged in forestry as a minor business. By region, there were 654 owners (22.3%) in Gyeongsangbuk-do, 633 owners (21.6%) in Jeollanam-do, 522

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owners (17.8%) in Gyeongsangnam-do, 315 owners (10.73%) in Chungcheongnam-do, 246 owners (8.4 %) Chungcheongbuk-do, and 162 owners (5.5 %), and 99 owners (3.4 %) in Gyeonggi-do.

Table 4. Descriptive statistics - continuous variables (Unit: million KRW)

Variable	Obs	Mean	S.D.	Min	Max
Household head's age[a]	2,937	63.94	9.06	32.00	84.00
Labor capacity[b]	2,937	595.28	901.50	0.00	12096.00
Cultivated land size[c]	2,937	5.09	8.23	0.00	109.50
Fixed capital[d]	2,937	348.00	579.00	21.80	17100.00
Savings[d]	2,937	40.00	59.80	0.00	810.00
Loan[d]	2,937	31.00	64.40	0.00	939.00
Household size[e]	2,937	2.41	1.03	1.00	8.00
Household head's education[a]	2,937	8.40	7.29	0.00	18.00
Forest land size[c]	2,937	2.01	5.22	0.00	60.50

Notes: [a] year, [b] hour, [c] ha, [d] mil. KRW, [e] number of people

Table 5. Descriptive statistics - categorical variables

Variables	Freq.	Percentage	Cum.
Gender of the household head			
Female	285	9.7	9.7
Male	2,652	90.3	100
Business Category			
Silviculture / Logging	211	7.18	7.18
Gathering	296	10.08	17.26
Chestnut tree	371	12.63	29.89
Astringent persimmon tree	497	16.92	46.82
Nut tree	344	11.71	58.53
Mushroom cultivation	241	8.21	66.73
Landscape material	353	12.02	78.75
Others	624	21.25	100
Forestry business portfolio			
Full-time	120	4.09	4.09
Major part-time	1,151	39.19	43.28
Minor part-time	1,666	56.72	100
Region			
Gyunggi-do	99	3.37	3.37
Gangwon-do	246	8.38	11.75
Chungcheongbuk-do	162	5.52	17.26
Chungcheongnam-do	315	10.73	27.99
Jeollabuk-do	306	10.42	38.41
Jeollanam-do	633	21.55	59.96
Gyeongsangbuk-do	654	22.27	82.23
Gyeongsangnam-do	522	17.77	100
Total	2937	100	

4.2. ANOVA/MANOVA and correlations

Analysis of variance (ANOVA) was conducted to analyze the differences among IFH, FI, NFI, and TI depending on the categorical independent variables. Most of the independent variables used in this study were significant at the significance level of 0.05 for dependent variables. However, in

the case of transfer income, there is no significant difference in the gender of household head (F=0.01, p>0.05). The results show that our categorical variables are statistically appropriate to predict dependent variables. Also, we examine the multivariate analysis of variance (MANOVA) to understand the linkages between the set of categorical independent variables and the set of dependent variables as endogenous. As displayed in Table 6, Wilks' λ for each is larger than 0.90, and all independent variables are significant for dependent variables. Results of ANOVA/MANOVA lead us to assume that our estimation between categorical and dependent variables is valid.

Table 6. Results of ANOVA and MANOVA for categorical variables

Dependent	Independent (categorical)	df	F	P
IFH	Gender of the household head	1	15.97	0.00
	Business Type	7	13.09	0.00
	Forestry business portfolio	2	3.84	0.02
	Region	7	9.75	0.00
FI	Gender of the household head	1	4.97	0.03
	Business Type	7	13.70	0.00
	Forestry business portfolio	2	40.49	0.00
	Region	7	6.95	0.00
NFI	Gender of the household head	1	27.06	0.00
	Business Type	7	7.03	0.00
	Forestry business portfolio	2	97.88	0.00
	Region	7	4.76	0.00
TI	Gender of the household head	1	0.01	0.93
	Business Type	7	11.61	0.00
	Forestry business portfolio	2	5.49	0.00
	Region	7	13.61	0.00

Independent (categorical)	Wilks' λ	df	F	P
Gender of household head	0.99	1	8.45	0.00
Business Type	0.92	7	8.49	0.00
Forestry business portfolio	0.90	2	36.46	0.00
Region	0.94	7	6.80	0.00

To estimate coefficients of continuous independent variables on dependent variables, we run Pearson-correlation analysis to examine the degrees of association between variables in Table 7. For this, dependent variables are standardized, and some variables such as fixed assets, savings, and loan are divided by million. The results show that except for coefficients between dependent variables, most coefficients are less than 0.5 and significant at 0.05, meaning that they are not significantly correlated. The main reason for the high correlation between dependent variables is that FI, and NFI are structurally included in IFH (r=0.85, r=0.48, respectively). Since the area of cultivation occupies some parts of the total forest land area, the correlation of them is high (r=0.54). To examine multicollinearity between variables, tolerance test using variance inflation factor (VIF), and Eigenvalue are checked. There are little doubts about multicollinearity if VIF is less than 10 [40], and VIFs of our correlation range from a minimum of 1.06 to a maximum of 7.99. Even if we included IFH, FI, and NFI where collinearity was suspected, VIF showed an average of 5.83, which was less than 10. Therefore, it is reasonable to suppose there is no multicollinearity between the variables.

4.3. Results of the random effects model

The results of the random effects model are summarized in Table 8. Since the results of Breusch-Pagan LM are statistically significant, we can confirm that the use of the random effect model is appropriate. Hausman test is also fulfilled, and its significant level is larger than 0.05, which also supports the appropriateness of a random effect model.

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As for FHI, we found that the household head engaged in the landscape tree growing industry has a higher income than the household heads engaged in the silviculture/logging industry. Different income among household heads running different types of business have also been evidenced by some national studies on agricultural household heads [34,35]. Therefore, the strategy adopted to run a business is a significant factor that influences FHI. Also, an increase in labor capacity or cultivated land area is related to increase in FHI, while forest area showed no significant relationship with FHI. Kwon and Kang (2013) also found that farm income increased with larger farmland.

Table 7. Pearson-correlations for continuous variables (N=2,937)

	Variables	1	2	3	4	5	6
1	FHI	1					
2	FI	0.85*	1				
3	NFI	0.48*	0.01	1			
4	TI	0.13*	-0.01	-0.02	1		
5	Forest land size[a]	0.04*	0.04*	-0.01	0.02	1	
6	Cultivated land size[a]	0.01*	0.11*	0.01	-0.03	0.54*	1
7	Household size[b]	0.12*	0.07*	0.17*	-0.12*	0.02	0.06*
8	Household head's education[c]	0.04*	-0.02	0.12*	-0.00	0.08*	0.09*
9	Household head's age[c]	-0.12*	-0.04*	-0.27*	0.29*	0.00	-0.09*
10	Labor capacity[d]	0.22*	0.27*	-0.02	-0.00	0.07*	0.20*
11	Fixed capital[e]	0.04*	0.03	0.03	-0.01	0.10*	0.11*
12	Savings[e]	0.14*	0.05*	0.18*	0.06*	0.03	0.04*
13	Loan[e]	0.05*	0.03	0.07*	-0.03	0.05*	0.13*
	Variables	7	8	9	10	11	12
7	Household size[b]	1					
8	Household head's education[c]	0.11*	1				
9	Household head's age[c]	-0.45*	-0.23*	1			
10	Labor capacity[d]	0.07*	0.02	-0.10*	1		
11	Fixed capital[e]	0.04*	0.08*	-0.07*	0.01*	1	
12	Savings[e]	0.06*	0.04*	-0.06*	0.01*	0.05*	1
13	Loan[e]	0.18*	0.01*	-0.27*	0.19*	0.15*	0.01

Notes: * $p<0.05$; [a] ha, [b] # of people, [c] year, [d] hour, [e] mil. KRW

Interestingly, the forest land area is not significantly associated with FHI. It is possibly because the land ownership in South Korea is often the result of passive inheritance rather than forestry business motivation. On the other hand, the amount of savings deposits is positively associated with FHI. However, the significance is not present regarding FI while it has a significant effect on the NFI, as discussed next. It is likely that the savings of forestry household are not invested in forestry businesses but non-forestry activities. Therefore, policy measures or incentives are needed to direct the forestry household savings to pursue earnings from forestry businesses.

Regarding FI, the forestry households that have adopted full-time engagement in forestry have higher FI than those who have not worked full time in forestry, whereas NFI is explained reversely. To our knowledge, there are no studies abroad that include full time and part time as livelihood strategy variables. Studies using such variables in South Korea [34–36] advocate our results by reporting that full-time farm households earned a higher income than part-time households. On the other hand, Hogarth et al. (2013) found the land size to be positively related to FI, which was not the case in this study. The discrepancy may be attributed to the high proportion (83.6%) of NTFP cultivation business among forestry households in South Korea.

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360 **Table 8.** Results for Random-effect model.

Variables	FHI	FI	NFI	TI
Forestry business portfolio				
- Reference group: Full-time				
Major part-time	-0.09	-0.20***	0.11*	0.12**
	(-1.86)	(-4.30)	(2.39)	(2.61)
Minor part-time	-0.07	-0.25***	0.22***	0.15**
	(-1.42)	(-5.10)	(4.71)	(3.15)
Business Category				
- Reference group: Silviculture/Logging				
Gathering	0.02	-0.01	0.08	-0.02
	(0.59)	(-0.19)	(2.44)	(-0.72)
Chestnut tree	0.00	0.00	0.02	0.06
	(0.04)	(0.04)	(0.53)	(1.48)
Astringent persimmon tree	0.01	-0.01	0.05	0.06
	(0.32)	(-0.37)	(1.30)	(1.47)
Nut tree	0.07*	0.06	0.06	0.03
	(1.97)	(1.53)	(1.72)	(0.96)
Mushroom cultivation	-0.03	-0.03	0.01	-0.01
	(-0.99)	(-0.97)	(0.21)	(-0.34)
Landscape material	0.14***	0.15***	0.03	0.01
	(3.75)	(3.90)	(0.82)	(0.39)
Others	-0.05	-0.04	-0.01	0.02
	(-1.22)	(-0.97)	(-0.15)	(0.43)
Region				
- Reference group: Gyunggi-do				
Gangwon-do	0.12*	0.11*	0.04	0.01
	(2.53)	(2.24)	(0.77)	(0.30)
Chungcheongbuk-do	0.16***	0.12**	0.07	0.13**
	(3.77)	(2.77)	(1.65)	(3.15)
Chungcheongnam-do	0.10	0.09	-0.02	0.05
	(1.84)	(1.65)	(-0.31)	(1.04)
Jeollabuk-do	0.07	0.03	0.02	0.13*
	(1.40)	(0.65)	(0.38)	(2.49)
Jeollanam-do	0.15*	0.08	0.05	0.17**
	(2.29)	(1.33)	(0.78)	(2.66)
Gyeongsangbuk-do	0.09	0.06	-0.01	0.08
	(1.31)	(0.98)	(-0.08)	(1.16)
Gyeongsangnam-do	0.11	0.07	0.06	0.03
	(1.78)	(1.14)	(1.05)	(0.51)
Gender of the household head				
- Reference group: female				
Male	0.05	0.03	0.07**	-0.01
	(1.79)	(1.01)	(2.60)	(-0.51)
Forest land Size (ha)	0.01	0.01	-0.03	0.03
	(0.27)	(0.56)	(-1.38)	(1.01)
Cultivated land size (ha)	0.05*	0.04*	0.02	-0.01
	(2.28)	(2.08)	(0.96)	(-0.42)
Family size (# of people)	0.03	0.03	0.02	0.02
	(1.08)	(1.14)	(0.58)	(0.69)
Household head's education (year)	-0.00	-0.04	0.04	0.07**
	(-0.11)	(-1.43)	(1.43)	(2.73)

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Household head's age (year)	-0.08**	-0.02	-0.22***	0.31***
	(-2.73)	(-0.67)	(-7.49)	(10.30)
Labor capacity (hour)	0.09***	0.11***	-0.02	0.04
	(4.25)	(5.26)	(-0.97)	(1.87)
Fixed capitals (mil. KRW)	-0.01	-0.01	-0.00	0.03
	(-0.21)	(-0.59)	(-0.19)	(1.10)
Savings (mil. KRW)	0.11***	0.04	0.13***	0.04*
	(5.43)	(1.87)	(6.61)	(2.04)
Loan (mil. KRW)	-0.01	-0.02	0.01	0.02
	(-0.60)	(-1.03)	(0.26)	(0.93)
Breusch and Pagan LM	862.15	870.75	984.22	982.47
(Prob>chi2)	0.00	0.00	0.00	0.00
Observations	2,937	2,937	2,937	2,937
Degree of Freedom	26	26	26	26
R2	0.13	0.12	0.16	0.14
ρ (rho)	0.57	0.57	0.6	0.59
σ_u	0.7	0.7	0.7	0.72
σ_e	0.61	0.61	0.58	0.6

Notes: Standardized beta coefficients; *t* statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001

The analysis on NFI shows that younger forestry household heads tend to have higher NFI, which is aligned with Choi and Ko (2005)'s findings that younger agricultural household heads had higher total forest household income and non-farm income. In South Korea, the sales of forestry or agricultural products processed are classified as NFI. It is possible that younger forestry households are keener on sales and marketing techniques or production technologies, which lead to an increase in NFI. Also, forestry households with more savings are expected to have higher NFI. Kim and Lee (2014) have reported that more capitals lead to a decrease in the inequality of agricultural household income. Our finding that savings do not significantly affect FI but do affect NFI implies that the investment capacity of forestry households is often used for non-forestry activities.

TI of forestry households tends to be higher in part-time forestry households than in full-time forestry households. Most of the part-time forestry households are engaged in agriculture at the same time, by which they receive a lot of agricultural subsidies that contribute to their TI. Also, household head's education level is positively related to TI. Because TI is in big part composed of government subsidies, people with lower education level may face more difficulties utilizing such information. Therefore, policy measures and information system that provide high accessibility for people with all levels of education are required.

To enhance our understanding of the determinants and relevant factors of forestry household income in Korea, adding various aspects to the survey for forestry household economy to further explore household income variables is necessary. This study can play a guiding role for the government to make policymaking more effective and to bring about greater policy effects.

5. Discussion and Conclusions

IFH is a significant indicator of the sustainable livelihood of households practicing forestry. Thus, it is necessary to find out under what conditions the IFH can be improved. In order to identify the factors affecting the IFH, individual forestry households who owned capitals and selected livelihood strategies must be systematically understood and analyzed in various perspectives. In this study, FHI as a main indicator of IFH is divided into FI, NFI, and TI. We tried to investigate in detail how household capitals and livelihood strategies influence their various income.

The main results are presented as follows. First, factors affecting IFH are household head's age, labor capacity, savings deposits, cultivated land area, business category, forestry business portfolio, and regional characteristics. Second, the factors affecting FI include labor hours, cultivated land area, business category, forestry business portfolio, and regional characteristics. Third, factors influencing

the NFI were household head's gender, household head's age, savings deposits, and forestry business portfolio. Fourth, the factors affecting TI are household head's age, household head's education level, savings deposits, forestry business portfolio, and region. The effect sizes and directions of significant factors are found to be various depending on each of the dependent variables. The determinants that significantly affect IFH, FI, NFI, and TI are found to be different in the degrees of impact and direction.

The implications of the main results are derived as follows. First, labor capacity, a human capital, and the cultivated land area, a natural capital, were significant determinants of FI. The detection is in line with the theoretical principles of agricultural production that the bases of agricultural production are land, labor, and capital. In this view, it is necessary to provide policy instruments to promote employment in the forestry sector so that forestry can enhance the labor capacity utilization of households. Also, as cultivated land area is positively related to FI, policies that encourage using marginal mountainous or agricultural lands for forestry could be conducive to increasing FI. Second, household head's age, a human capital, and savings deposits, a financial capital, are found to be significant determinants of the NFI. Younger household heads put more emphasis on the non-forestry activities such as labor-intensive primary production. Such finding suggests that the financial capitals held by households tend to be invested in non-forestry activities rather than forestry activities. Third, the determining factors of the level of forestry household's transfer income were household head's education level, a human capital, and the forestry business portfolio, a livelihood strategy. There was a tendency that household head with higher education can more easily access information about the government subsidies for forestry. Also, the reason why part-time forestry households' transfer income is higher than the full-time household is mainly due to the subsidies in the agricultural sector.

The contribution of our efforts is anticipated as follows. This study identifies the factors that have significant impacts on the various types of income of South Korean forestry households and provide policy implications by empirically validating them. Theoretically, our study expanded the application of SLA by using panel data and incorporating livelihood strategies into the independent variable set. This study is considered novel in that it explores the determinants of forestry household income in South Korea from an academic point of view. We have examined the determinants of the forestry household's income by different sources.

The limitations of this study are as follows. First, we could not include variables corresponding to the social capitals of SLA in the model. The social capital variables used in previous studies include years of residence [31] and union membership [27,33]. Due to the absence of the relevant variables in our data, we failed to include them in our analysis. Second, this study deals with the most recent three-year panel data from 2014 to 2016. The complete data was collected since 2005, but the sample of the data changed in 2014 based on the Agriculture, Forestry, and Fisheries Census conducted in 2010. It is expected that the sample will be reorganized again in 2018 based on the Agriculture, Forestry, and Fisheries Census conducted in 2015. We expect to grasp the dynamic change pattern of the determinants of the income by longitudinal change if we can compare the capital and strategic characteristics of household income by using the same data for each periodical sample.

This research results can be used as basic information to help device policy measures to increase forestry household income. In order to maintain a sustainable livelihood through full-time forestry, the scale of forestry should be large enough to maintain adequate production, and the labor input should become abundant accordingly. However, this is somewhat unrealistic because the labor cost in South Korea is rapidly going up. Moreover, due to the geographical characteristics of South Korea's forest, mechanized forestry is highly limited.

This study attempts to investigate IFH and the quality of life in terms of sustainable livelihood in rural villages rather than strengthening the competitiveness of forest products like an agricultural field. We hope that the results of this study will provide necessary information about the structure of forestry household income in South Korea and will help them make decisions that make their livelihood more sustainable in the economic aspect.

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