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

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

50   In order to improve the poor environment of the forestry industry, the South Korean
51 government has been investing in the infrastructure needed for forest management and production
52 [4]. Also, the forest conditions have improved to such a stage that harvesting for low-grade timber is
53 an option for forest management. For example, tree growing stock had increased from 65 million m^3
54 in 1968 to 925 million m^3 In 2015 [5]. Besides, most of the forests of South Korea are approaching
55 their harvesting ages, and people's interests in healthy forest-based food products have been steadily
56 growing recently. The government has been supporting the private forestry operation by providing
57 financial subsidies for the modernization and commercialization of forest production [6].

58   Along with these efforts, measures to improve the income level of forestry household have been
59 taken by the Government of South Korea, the budget for the income of foresty household (hereafter
60 IFH) support within the forestry budget of South Korea has increased from 4.87% in 2014 to 9.09% in
61 2018 [7,8].

62   In order to understand the problem of underdeveloped forestry industry little contributing to
63 the income of households practicing forestry, this study analyzed what constitutes the income of
64 forestry household and how it differs among groups of households. We adopted the sustainable
65 livelihood approach (SLA) as the theoretical background and investigated the income structure of
66 forestry household in South Korea. According to the most frequently used definition of sustainable
67 livelihood, a livelihood is sustainable when it can cope with and recover from stress and shocks,
68 maintain or enhance its capabilities and assets, while not undermining the natural resource base
69 [9,10]. SLA mainstreams the livelihood sustainability of the target group as a crucial development
70 goal. SLA has been employed by many development agencies of which most of the official
71 development aids geared to elevate poverty in developing countries by delivering their projects. SLA
72 helps understand the poverty structure, life of the poor, and the relevant social and institutional
73 issues [11].

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

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

88 **2. Background**

89 *2.1. Sustainable livelihood approach*

90   SLA models the influences of internal and external factors that constitute livelihood in
91 understanding the livelihood of people. The internal factors are household capitals, livelihood
92 strategies, and livelihood outcome, while exogenous factors include social structures and processes
93 [11]. A household's capitals are subcategorized as natural, human, physical, social, and financial
94 capitals. In a general procedure of SLA, firstly, the accessibility and availability of each household

95   capitals are evaluated. Based on the capitals at hand of the household, a livelihood strategy is
96   determined considering the quantity, quality, and composition of the capitals. The outcome of this
97   livelihood strategy can be food production, cash income, and sustainable resource use, which enable
98   re-investment in the household capitals. On the other hand, the exogenous components deal with
99   environmental changes and institutional measures that directly affect the household's asset
100   availability and livelihood strategy [12].
101   As SLA helps understand the poverty structure, life of the poor and the relevant social and
102   institutional issues [11], it often aims at poverty alleviation and is mainly used for research in
103   developing countries. Some studies have been conducted on the poor rural areas of mid-income
104   countries such as China [15–19] and Georgia [13]. SLA is an approach applicable to understanding
105   the livelihood of local communities across different developmental stages. Since SLA targets to
106   explore as many livelihood components as possible, it is useful in understanding the livelihoods of a
107   specific rural area. SLA was not designed for reflecting the macroscopic trend but was devised to
108   understand local livelihood in detail [20]. SLA seeks to analyze the sustainability of livelihoods by
109   evaluating the characteristics of households, resource utilization and depletion, institutional change,
110   environmental change, and market accessibility in a specific area. Due to its flexible nature, SLA has
111   been used in diverse sectors including natural resource management [21], mining [20], fisheries
112   [22,23], tourism [24–26], cropping [15,27], and multi-sectoral circumstances [16,28–30].

2.2. Application of SLA to forestry research

114   Forest-dependent communities are one of the representative subjects of SLA studies. Most of
115   these studies have investigated the relationship between household capitals, livelihood strategies,
116   and household income. For example, Babulo et al. (2008) estimated the impact of the natural, human,
117   physical, social, and financial assets of local forestry on household income and resource dependency.
118   Tesfaye et al. (2011) defined activities such as forestry, crops and livestock breeding as livelihood
119   strategies, and found that livelihood strategies are significantly associated with outputs including
120   income and food security for forest-dependent households.
121   Similarly, Soltani et al. (2012) analyzed the factors affecting the livelihood strategy and its
122   outcome in rural areas of Iran and found that each household generally takes a strategy to combine
123   forestry, the livestock industry, and agriculture. They also found that livelihood outcomes, such as
124   poverty alleviation and sustainable forest management, are influenced by the endowments of
125   household assets and choice of household strategies. Zenteno et al. (2013) examined a rural
126   community's livelihood strategies that affected household income in tropical rain-forests and found
127   that differentiated livelihood strategies of individual households lead to different income levels.
128   Kemkes (2015) analyzed the impact of common pool forest resources on household income and
129   livelihood strategies in rural mountain villages under development pressure in Georgia.

2.3. Household capitals affecting household income

131   In the previous studies employing SLA, household size, household head's gender, household
132   head's age, household head's education level, and labor capacity were used as variables explaining
133   human capital [12–16,19,27,29,31–33]. Other variables for human capital include migration index and
134   female adult ratio [32], conservation and agricultural training [14], marriage [13], children staying
135   away and dead children [31]. In the present study, five variables of human capital are used:
136   household size represented by several family members, household head's gender, household head's
137   age, labor capacity, and household head's education level.
138   Physical capitals have been referred to as tangible assets required for production activities.
139   Generally, equipment [14,18,32] and livestock value [14,15,32,33] were used as physical capital.
140   Infrastructure, number, and quality of housing, livestock, tools, housing value, productive material,
141   and public service were used as constituting elements of physical capital [33] were used. Hua et al.
142   (2017) used the summed value of different physical assets such as machinery, equipment, fixtures,
143   facilities, small and medium-sized animals, livestock, and large plants. The summed value of fixed

144 capital available from the Forestry Household Economy Survey is treated as physical capital in this
145 study.
146   As explanatory variables for financial capital, some studies used savings and loans at the same
147 time [13,14,27,33], and others only loans [12,19]. Cash income, borrowing, access to loans [15,18], net
148 income [14], livestock value, non-farm business, and money lenders [27] were used. In this study, we
149 define financial capital as the immediate assets and liabilities corresponding respectively to savings
150 and loans.
151   Natural capitals have been represented by land [17–19,27,32], plot size [12], agricultural land
152 size [14], area of cropland [29], and land claimed [13]. It is widely believed that the inputs required
153 for profit-maximization in the traditional forest production theory are land-based capitals. In studies
154 the production area of a specific product (brazil nut), the number of perennial plants and expected
155 felling area [31], water resources [16], formal ownership [14], distance to road [12], distance from
156 town [29], soil fertility [32], rainfall [32], and altitude [29,32] were also used. In this study, forest land
157 size and cultivated land size are used as variables for natural capital.

158 *2.4. Livelihood strategies affecting household income*

159   Livelihood strategy is a way of making a living that is chosen based on a household's capacity
160 and needs. Business types or product items have been often used as livelihood strategies in SLA
161 studies. Jansen et al. (2006) classified the farming strategies as simple grains producer, livestock
162 producer, and coffee producer. Zenteno et al. (2013) used eight business categories, including
163 silviculture/logging, gathering, chestnut tree, astringent persimmon tree, nut tree, mushroom
164 cultivation, landscape material, and others. In many studies, forestry or agricultural product items or
165 business types are explicitly or implicitly defined as ways of sustaining a livelihood.
166   The type of forestry in South Korea reflects the situation of forestry as many households
167 practicing forestry are often engaged in other businesses other than forestry. It is common that many
168 forestry households are engaged in agriculture simultaneously. Previous studies on the determinants
169 of national farm income often included full-time or part-time engagement of the household in
170 agriculture [34–36]. By the amount of time invested in the livelihood activity in question, we consider
171 the household chooses the livelihood strategy that voluntarily. If a household is engaged in forestry
172 as well as agriculture or other business, a part-time status of forestry household is treated as a
173 livelihood strategy in this study. We further subdivide the part-time forestry business portfolio into
174 major part-time and minor part-time status by the proportion of forestry income relative to income
175 from other sources, specifically whether forestry income is more or less than other incomes.
176   Geographical location can be considered either as a natural asset or a livelihood strategy,
177 depending on the household's motivation to reside in a particular region. We view the region as a
178 livelihood strategy because of a household's decision on the location of residence impacts on their
179 production and marketing strategy. For example, forestry income can be affected by varying local
180 conditions such as climatic factors, available resources, market characteristics, regional government
181 policies, and infrastructure. Zhu et al. (2017) mentioned that regional factors significantly influence
182 household investment behavior in NTFP business. Also, Kim and Lee (2014) reported that there is a
183 difference in the structure of agricultural income in each province. Therefore, accounting the
184 differences in specific regions and differentiating the structure of forestry by geographical and
185 administrative region can be considered as effective strategies.
186   To sum up, the outcome of forest owner livelihood is generated and influenced by both the
187 household capitals and livelihood strategies. Therefore, we viewed household characteristics and
188 livelihood strategies together as determinants of household income (Fig. 1).
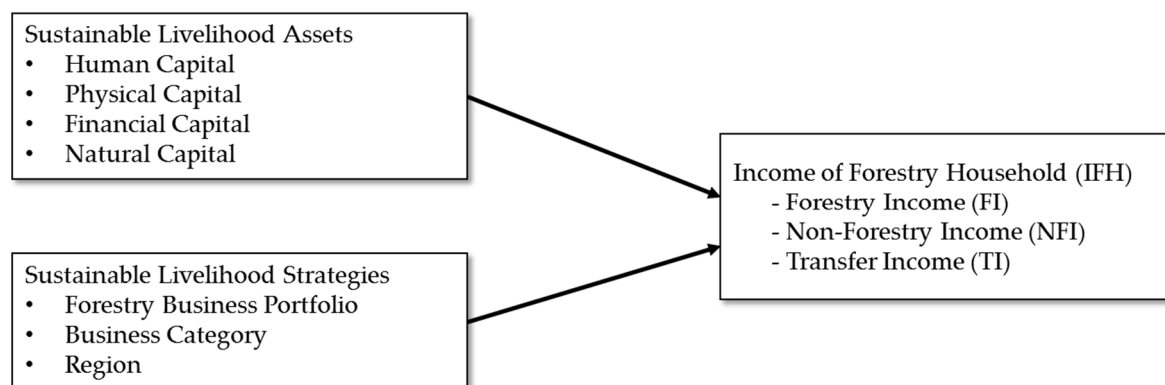
189
190 **Fig. 1.** Research Model

191 **3. Materials and Methods**

192 *3.1. Status of income of forestry household in South Korea*

193   There has been a big difference between the agriculture, fishery, and IFH (Table 1). The average
194 IFH was 90.3% and 71.3% of agriculture and fishery respectively in 2016. The difference implies that
195 the conditions of forestry are much inferior to that of agriculture and fishery. Average IFH was
196 33,585,000 KRW in 2016.
197   IFH can be divided into regular and irregular income. Irregular income is gained on an
198 occasional basis. In the regular income, there are forestry income (FI), non-forestry income (NFI), and
199 transfer income (TI) accounting 6.9 %, 1.7 %, and 8.1 % respectively (Table 2).
200
201   **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.

202
203   **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

204 *3.2. Forestry household survey data*

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

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

212   The population of the survey from 2014 to 2016 is 122,973 forestry household identified in the
213 2010 forestry census conducted by the government. The definition of forestry household is a
214 household that manages forestry business to make a living, meeting one or more of the following
215 three criteria. (1) More than 3 ha of forestry ownership and at least five consecutive years of forest
216 business experience; (2) more than 1.2 million KRW for annual earnings from forest product sales; or
217 (3) more than 90 days of labor on forestry work per year [39]. Therefore, forestry household and
218 forestry workers, even if their main job is not related to forestry, may also be included in the
219 population if they fall in one of the above.

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

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

232 *3.3. Analytical models*

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

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

247

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

249

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

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

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

4. Results

4.1. Sample description

261 Descriptive statistics, including the means, standard deviations, minimum values, and
262 maximum values of the dependent variables–IFH, FI, NFI, and TI–are presented in Table 3. There are
263 slight changes in dependent variables but no significant difference over the three years. IFH was 33.4
264 million KRW in 2014, 32.4 million KRW in 2015, and 34.2 million KRW in 2016. FI, NFI, and TI slightly
265 decreased when the year went from 2014 to 2015 and moderately increased when the year changed
266 from 2015 to 2016. Overall, FI, NFI, and TI have slightly increased over the three years. The negative
267 minimum values of IFH, FI, and NFI mean that the income of forest owner has decreased. These
268 values most likely account for logging or mushroom businesses which do not harvest or sell products
269 in the same year, counting only operational costs.
270 The mean age of the forest owner was 63.94 years old. Owners were working for 598.28 hours
271 per year on average. Labor capacity means labor hours in this paper. Also, they were working on
272 their cultivated land in an average size of 5.09 ha. The means of the owners' fixed capital, savings,
273 and loan values were 348 million KRW, 40 million KRW, and 31 million KRW, respectively. The fixed
274 capital of the panel data used in this study is reflected the depreciation cost of each year. On the other
275 hand, the average number of the owner's family was 2.41, and the average years on formal education
276 of the owner was 8.40 years. The average forest area possessed by the owner was 2.01 ha. The means,
277 standard deviations, minimum, and maximum values of the variables are presented in Table 4.
278
279

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

280
281 The descriptive statistics of categorical variables are summarized in Table 5. Forestry household
282 were mostly males (2652 people, 90.3%). Among the business types, others were of the largest number
283 (624, 21.3%), followed by astringent persimmon (497, 16.9%), chestnut (371, 12.6%), landscape
284 material (353, 12.0%), nut tree (344, 11.4%), gathering (296, 10.1%), mushroom cultivation (241, 8.2%)
285 and silviculture/logging (211, 7.2%).
286 In terms of the forestry business portfolios, full-time forestry owner means at least one member
287 of the family should be engaged in paid non-forestry work for more than 30 days in the year. Major
288 part-time means forest revenues exceed non-forestry revenues, minor part-time means non-forest
289 revenues exceed forestry revenues. Among them, 120 owners (4.1%) were engaged in full-time
290 forestry. Among part-time forestry household, 1,666 of them (56.7%) were engaged in forestry as a
291 major business while 1,151 owners (39.2%) were engaged in forestry as a minor business. By region,
292 there were 654 owners (22.3%) in Gyeongsangbuk-do, 633 owners (21.6%) in Jeollanam-do, 522

293 owners (17.8%) in Gyeongsangnam-do, 315 owners (10.73%) in Chungcheongnam-do, 246 owners
294 (8.4 %) Chungcheongbuk-do, and 162 owners (5.5 %), and 99 owners (3.4 %) in Gyeonggi-do.
295
296

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

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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	

299 *4.2. ANOVA/MANOVA and correlations*

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

303 the case of transfer income, there is no significant difference in the gender of household head (F=0.01,
304 p>0.05). The results show that our categorical variables are statistically appropriate to predict
305 dependent variables. Also, we examine the multivariate analysis of variance (MANOVA) to
306 understand the linkages between the set of categorical independent variables and the set of
307 dependent variables as endogenous. As displayed in Table 6, Wilks' λ for each is larger than 0.90,
308 and all independent variables are significant for dependent variables. Results of ANOVA/MANOVA
309 lead us to assume that our estimation between categorical and dependent variables is valid.
310
311

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

312
313   To estimate coefficients of continuous independent variables on dependent variables, we run
314 Pearson-correlation analysis to examine the degrees of association between variables in Table 7. For
315 this, dependent variables are standardized, and some variables such as fixed assets, savings, and loan
316 are divided by million. The results show that except for coefficients between dependent variables,
317 most coefficients are less than 0.5 and significant at 0.05, meaning that they are not significantly
318 correlated. The main reason for the high correlation between dependent variables is that FI, and NFI
319 are structurally included in IFH (r=0.85, r=0.48, respectively). Since the area of cultivation occupies
320 some parts of the total forest land area, the correlation of them is high (r=0.54). To examine
321 multicollinearity between variables, tolerance test using variance inflation factor (VIF), and
322 Eigenvalue are checked. There are little doubts about multicollinearity if VIF is less than 10 [40], and
323 VIFs of our correlation range from a minimum of 1.06 to a maximum of 7.99. Even if we included
324 IFH, FI, and NFI where collinearity was suspected, VIF showed an average of 5.83, which was less
325 than 10. Therefore, it is reasonable to suppose there is no multicollinearity between the variables.

326 *4.3. Results of the random effects model*

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

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

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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

340
341   Interestingly, the forest land area is not significantly associated with FHI. It is possibly because
342 the land ownership in South Korea is often the result of passive inheritance rather than forestry
343 business motivation. On the other hand, the amount of savings deposits is positively associated with
344 FHI. However, the significance is not present regarding FI while it has a significant effect on the NFI,
345 as discussed next. It is likely that the savings of forestry household are not invested in forestry
346 businesses but non-forestry activities. Therefore, policy measures or incentives are needed to direct
347 the forestry household savings to pursue earnings from forestry businesses.
348   Regarding FI, the forestry households that have adopted full-time engagement in forestry have
349 higher FI than those who have not worked full time in forestry, whereas NFI is explained reversely.
350 To our knowledge, there are no studies abroad that include full time and part time as livelihood
351 strategy variables. Studies using such variables in South Korea [34–36] advocate our results by
352 reporting that full-time farm households earned a higher income than part-time households. On the
353 other hand, Hogarth et al. (2013) found the land size to be positively related to FI, which was not the
354 case in this study. The discrepancy may be attributed to the high proportion (83.6%) of NTFP
355 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)

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

393   the NFI were household head's gender, household head's age, savings deposits, and forestry business
394   portfolio. Fourth, the factors affecting TI are household head's age, household head's education level,
395   savings deposits, forestry business portfolio, and region. The effect sizes and directions of significant
396   factors are found to be various depending on each of the dependent variables. The determinants that
397   significantly affect IFH, FI, NFI, and TI are found to be different in the degrees of impact and direction.
398   The implications of the main results are derived as follows. First, labor capacity, a human capital,
399   and the cultivated land area, a natural capital, were significant determinants of FI. The detection is in
400   line with the theoretical principles of agricultural production that the bases of agricultural production
401   are land, labor, and capital. In this view, it is necessary to provide policy instruments to promote
402   employment in the forestry sector so that forestry can enhance the labor capacity utilization of
403   households. Also, as cultivated land area is positively related to FI, policies that encourage using
404   marginal mountainous or agricultural lands for forestry could be conducive to increasing FI. Second,
405   household head's age, a human capital, and savings deposits, a financial capital, are found to be
406   significant determinants of the NFI. Younger household heads put more emphasis on the non-
407   forestry activities such as labor-intensive primary production. Such finding suggests that the financial
408   capitals held by households tend to be invested in non-forestry activities rather than forestry activities.
409   Third, the determining factors of the level of forestry household's transfer income were household
410   head's education level, a human capital, and the forestry business portfolio, a livelihood strategy.
411   There was a tendency that household head with higher education can more easily access information
412   about the government subsidies for forestry. Also, the reason why part-time forestry households'
413   transfer income is higher than the full-time household is mainly due to the subsidies in the
414   agricultural sector.
415   The contribution of our efforts is anticipated as follows. This study identifies the factors that
416   have significant impacts on the various types of income of South Korean forestry households and
417   provide policy implications by empirically validating them. Theoretically, our study expanded the
418   application of SLA by using panel data and incorporating livelihood strategies into the independent
419   variable set. This study is considered novel in that it explores the determinants of forestry household
420   income in South Korea from an academic point of view. We have examined the determinants of the
421   forestry household's income by different sources.
422   The limitations of this study are as follows. First, we could not include variables corresponding
423   to the social capitals of SLA in the model. The social capital variables used in previous studies include
424   years of residence [31] and union membership [27,33]. Due to the absence of the relevant variables in
425   our data, we failed to include them in our analysis. Second, this study deals with the most recent
426   three-year panel data from 2014 to 2016. The complete data was collected since 2005, but the sample
427   of the data changed in 2014 based on the Agriculture, Forestry, and Fisheries Census conducted in
428   2010. It is expected that the sample will be reorganized again in 2018 based on the Agriculture,
429   Forestry, and Fisheries Census conducted in 2015. We expect to grasp the dynamic change pattern of
430   the determinants of the income by longitudinal change if we can compare the capital and strategic
431   characteristics of household income by using the same data for each periodical sample.
432   This research results can be used as basic information to help device policy measures to increase
433   forestry household income. In order to maintain a sustainable livelihood through full-time forestry,
434   the scale of forestry should be large enough to maintain adequate production, and the labor input
435   should become abundant accordingly. However, this is somewhat unrealistic because the labor cost
436   in South Korea is rapidly going up. Moreover, due to the geographical characteristics of South
437   Korea's forest, mechanized forestry is highly limited.
438   This study attempts to investigate IFH and the quality of life in terms of sustainable livelihood
439   in rural villages rather than strengthening the competitiveness of forest products like an agricultural
440   field. We hope that the results of this study will provide necessary information about the structure of
441   forestry household income in South Korea and will help them make decisions that make their
442   livelihood more sustainable in the economic aspect.
443

445   **Conflicts of Interest:** The authors declare no conflict of interest.

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