The interrelationship of households economics activities of upland rice farmers in rain-fed farming in Ponjong Sub-district, Gunungkidul District, Indonesia

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Abstract. Gunungkidul is one of the regencies at Yogyakarta, Indonesia which is 90% occupied by dry land, and thus vulnerable to climate change impact. Since dryland relies on water only from rain to meet crop water requirement, part of land management is rainfed. This condition encourages farmers to make the right decision regarding their additional income to meet household needs. Under the limited land resources, farmers decided to plant upland rice once or twice a year. The aim of the study is to analyze the interrelationship of households economics activities of upland rice farmers in rain-fed farming based on production, labor allocation, and consumption. The research method is descriptive analysis, with research site Ponjong sub-district, determined by the purposive method. Sampling method using proportional random sampling. Economics model was determined by using simultaneous equation model, with 2 SLS estimation method. The results showed that the household economics model of upland rice farmers in the rainfed land can be explained by using farmers household model and there is a linkage between production, labor allocation, and consumption.

1. Introduction
Agriculture sector plays important roles since the development of agriculture sector aims to boost production result and quality, to strengthen farmers income and living standards, to multiple employment and business opportunities, and to support industrial sectors. One of the agriculture development purposes is to intensify farmers income. Their income development can be done through many factors, such as by increasing broad unity production or productivity. Besides extensification, the agricultural productivity increment through an intensification activity becomes a source of agriculture sector prosperity. Meanwhile, most of Indonesia agricultural activities are cultivated by them as family farming with land ownership which is narrow of less than 0.5 ha [1]. it is managed by them because of their low-income, especially in dryland farming. Its potential in this country is enormous, due to it reaches 9.7 million hectares [2].
These last few years, food self-sufficiency and security began to be threatened. Simultaneously, there was a productivity level degradation especially towards rice and rice field conversion in Java which continues. Nowadays, food production circumstances are being aggravated by climate factor which is unfriendly. Farming development must notice the land character which is cultivated. According to the water state, types of land can be divided into irrigation, rain-fed, dryland, and swampland rice field. The farming achievement of those types is quite different, it depends on the plants technical and economic feasibility response towards the land characteristics which is harvested.

The problems which deal with the production factor employment is scarcity on fertile lands availability for crops production. Its crops land area development has already been difficult to be cultivated and there is a fact of rice field conversion to another use. Besides the problem of the land availability number, also faces problems with the land quality reduction problem due to erosion and pollution. The suboptimal land advancement will become an alternative for food provision in the future because many fertile irrigation rice fields switch functions to nonagricultural interests. Suboptimal lands include dryland, rain-fed land, tidal rice fields, and swampland.

The rain-fed land is the second granary after irrigation rice field. In Daerah Istimewa Yogyakarta, numerous rain-fed lands are found which have a high level of rainfall, however, it rarely performs such as in Gunungkidul district, two-seasons tropical climates area as the rainy and dry season. For farmers, the seasonal condition has a big influence towards farming activities. A 90% area of Gunungkidul district is dryland and less fertile also really depends on rainfalls, therefore it is vulnerable towards climate changes impacts. It is a district which has a site specification. Most of the farming areas belong to this area are rain-fed lands which depend on the climate cycles particularly rainfall.

The agricultural production land, dry wetlands are the farmers household income in Gunungkidul district. Although the water availability is limited, farmers attempt to manage the lands by cropping pattern which is adjusted to the land condition. That underline background is to conduct a research on farmers household’s behaviors in the rain-fed land. It is where the highland rice farmers highland decides to manage it which is one-time of highland and two times of plateau cropping pattern highland. Moreover, the household’s economics activities perspective is also being observed, the land use selection is influenced by rational farmers. The choice of farming land use is closely related to farmers decision such as being influenced by various aims namely; maintaining household food security; supporting cash income in fulfilling needs; minimizing risks, maximizing leisure which is related to time allocation, assuring family members good and prosperous condition, and also to achieve certain social class in his community [3].

The approach of farmers household’s economics research must consider the farmers and their family behavior in taking production and consumption decisions which are related to one another that will influence the income levels, labor allocation, and consumption. The aim of the study is to analyze the interrelationship of households economics activities of upland rice farmers in rain-fed farming based on production, labor allocation, and consumption.

2. Research Methods

2.1. Research site and respondent’s determination of upland rice farmers household

The applied research method was the descriptive analysis method. The research site determination was applied by employing a purposive method which resulting in Ponjong Sub-district with areas consideration are found in each zone in Gunungkidul District and there are farmers household conducting upland rice farming in a rain-fed land with one time and two times of cropping seasons in one year. The samples collecting method of upland was applied proportional random sampling method by taking 80 respondents of farmers household with 51 and 29 respondents of farmers household which planting upland two times upland and one time in one year respectively.
2.2. Models of household economics

Upland rice farmers household economics qualification was researched the first step by applying the econometrics approach method. Econometrics model describes the relationship of each independent variables towards dependent variables especially about magnitude and sign of the prior functional parameter estimated coefficients which is according to economic theories [4]. In order to identify the interconnectedness among production, labor allocation, and consumption also other aspects related to households decision, and agricultural household economics model was formulated in simultaneous equations using 16 formulas which consist of 10 structural and 6 identity equation modal.

The equation model was specified into: production, labor allocation, income, and outcome. The model built specification in this research can be explained as the following:

2.2.1. Production:

\[ \text{QPG} = a_0 + a_1 \text{LL} + a_2 \text{JB} + a_3 \text{JPU} + a_4 \text{JPN} + a_5 \text{CKDKP} + a_6 \text{CKLKP} + a_7 \text{DPG} + E_i \]  
(1)

Notes:

- QPG = upland rice production (kg/year)
- LL = land area (ha)
- JB = the number of seeds (kg/year)
- JPU = the number of urea fertilizers (kg/year)
- JPN = the number of NPK fertilizers (kg/year)
- CKDKP = labor allocation in upland rice family (Labor Days Requirements = LDR/year)
- CKLKP = labor allocation outside upland rice family (LDR/year)
- DPG = upland rice dummy (0 = pattern 1x of Uplandrice in one year, 1 = pattern 2x of upland rice in one year)

The expected estimate parameter \( a_1, a_2, a_3, a_4, a_5, a_6, a_7 > 0 \)

2.2.2. Labor allocation:

\[ \text{CKDKP} = b_0 + b_1 \text{LL} + b_2 \text{CKDKNP} + b_3 \text{CKDOF} + b_4 \text{PDRT} + b_5 \text{DPG} + E_1 \]  
(2)

\[ \text{CKDKUT} = c_0 + c_1 \text{LL} + c_2 \text{CKDKP} + c_3 \text{PDRT} + c_4 \text{DPG} + E_3 \]  
(3)

\[ \text{CKLKP} = d_0 + d_1 \text{LL} + d_2 \text{CKDKUT} + d_3 \text{CKDNPt} + d_4 \text{DPG} + E_4 \]  
(4)

\[ \text{CKDKNP} = e_0 + e_1 \text{LL} + e_2 \text{CKDKUT} + e_3 \text{CKDKOF} + e_4 \text{JTKDK} + e_5 \text{DPG} + E_5 \]  
(5)

Notes:

- CKDKNP = labor allocation in non-rice family (LDR/year)
- CKDKOF = labor allocation in off farm family (LDR/year)
- PDRT = household income (IDR/year)
- CKDKUT = labor allocation in farming activites family (LDR/year)
- CKDNPt = labor allocation in non farming family (LDR/year)
- JTKDK = the number of labors in family (people)

The expected estimate parameter \( b_1, b_2, b_3, b_4, c_2, c_3, d_1, d_2, d_3, e_1, e_2, e_3 < 0 \)

2.2.3. Income:

\[ \text{BPG} = \text{BSP} + \text{BTK} + \text{BLP} \]  
(8)

\[ \text{PDPG} = \text{PNPG} - \text{BPG} \]  
(9)

\[ \text{PDFOF} = f_0 + f_1 \text{PDPG} + f_2 \text{PDPN} + f_3 \text{CKDKOF} + f_4 \text{DPG} + E_6 \]  
(10)

\[ \text{PDPN} = g_0 + g_1 \text{PDPG} + g_2 \text{CKDNPt} + g_3 \text{PDIIK} + g_4 \text{DPG} + E_7 \]  
(11)

\[ \text{PDRT} = \text{PDPG} + \text{PDFO} + \text{PDPN} \]  
(12)

Notes:

- BPG = the costs on upland rice farming (IDR/year)
- BSP = the costs on upland rice means of production (IDR/year)
- BTK = the costs on labors of upland rice farming (IDR/year)
BLP = other costs on upland rice farming (IDR/year)
PDPG = income from upland rice farming (IDR/year)
PNPG = acceptance from upland rice farming (IDR/year)
PDOF = income of off farm (IDR/year)
PDNP = income from non rice (IDR/year)
PDIK = spending for education (IDR/year)
PDRT = household income (IDR/year)
The expected estimate parameter $f_1, f_2, g_1 < 0$; $f_3, f_4, g_2, g_4 > 0$

2.2.4. **Consumption:**

$$PPPG = h_0 + h_1 PNPG + h_2 PDRT + h_3 JART + h_4 DPG + E8$$  \(\text{(13)}\)

$$PKP = i_0 + i_1 PDRT + i_2 JART + i_3 PKNP + i_4 DPG + E9$$  \(\text{(14)}\)

$$PKNP = j_0 + j_1 PDRT + j_2 JAS + j_3 DPG + E10$$  \(\text{(15)}\)

$$PKT = PPPG + PKP + PKNP$$  \(\text{(16)}\)

Notes:

PPPG = food expenditures from upland rice (IDR/year)

JART = the number of household members (IDR/year)

PKP = consumption expenditures (IDR/year)

PKNP = non food consumption expenditures (IDR/tahun)

JAS = the number of students (people)

PKT = total consumption expenditures (IDR/year)

The expected estimate parameter $h_1, h_2, h_3, h_4, j_1, i_2, i_4, j_1, j_2, j_3 > 0$; $i_3 < 0$

2.3. **Identification and validation of household’s economics model**

In order to estimate its parameter, a simultaneous equation model must be identified. The equation model identification result showed an overidentified equation therefore the applied method to estimate was a method of two-stage least squares (2SLS). In order to recognizer the model prediction power, Root Means Squares Error (RMSE), Root Means Squares Percent Error (RMSPE), and Theil’s Inequality Coefficient (U) were applied [5].

3. **Result and discussion**

3.1. **Model of rain-fed land upland rice farmers household’s economics**

The economics model of upland rain-fed land rice farmers household economics was constructed in this research which consists of 10 structural and 6 identity equations. The model estimated result was the following:

3.1.1. *Production:*

$$QPG = -627.4161 + 0.525116 LL + 15.40981 JB + 0.370556 JPU + 0.482637 JPN + 7.412084 CKDKP + 2.133793 CKLK P + 559.7129 DPG$$

3.1.2. *Labor Allocation:*

$$CKDKP = 1.770143 + 4.08 \times 10^{-05} LL + 0.039612 CKDKNP + 0.002714 CKDOF + 1.25 \times 10^{-10} PDRT + 0.928857 DPG$$

$$CKLK P = -0.922965 + 0.012783 LL - 0.227392 CKDKP - 1.86 \times 10^{-07} PDRT + 21.00265 DPG$$

$$CKDKOF = 7.729850 + 0.000168 LL - 1.456487 CKDUT + 0.098997 CKDKNP t + 0.669393 DPG$$

$$CKDKNP t = 14.99920 + 0.000661 LL + 0.364512 CKDUT + 0.113311 CKDOF - 0.900158 JTKDK - 8.510236 DPG$$
3.1.3. **Income:**

\[
P_DOF = 18.56963 - 0.060893 PDPG - 0.142680 PDNP + 0.222362 CKDOF - 1359695 DPG
\]

\[
P_{DN} = 8822065 - 0.075794 PDPG + 36020.77 CKDKNP + 0.336804 PDIK + 2925290 DPG
\]

3.1.4. **Consumption:**

\[
P_{PPG} = -181910.6 + 0.560528 PNPG + 0.007387 PDRT + 51233.05 JART - 224091.0 DPG
\]

\[
P_{PK} = 8626395 + 0.027729 PDRT + 927653.0 JART - 0.128651 PKNP - 523217.2 DPG
\]

\[
P_{KNP} = 14.94591 + 3.86 \times 10^{-9} PDRT + 0.511103 JAS - 0.284903 DPG
\]

The estimated result towards 10 structural model equations which were proposed to demonstrate that the determination coefficient value \( R^2 \) that resulted from its varied parameter from 0.284370 to 0.937620. It can be presented in table 1.

| No. | Activities | Equation | \( R^2 \) | \( F \) | Prob-F |
|-----|------------|----------|-----------|--------|--------|
| 1   | Production | QPG      | 0.937620  | 167.9390| 0.000  |
| 2   | Labor allocation | CKDKP | 0.904438 | 150.5371| 0.000  |
| 3   |             | CKLKP   | 0.738829  | 56.1638 | 0.000  |
| 4   |             | CKDKOF  | 0.823234  | 4.6420  | 0.000  |
| 5   |             | CKDKPt  | 0.618998  | 31.5845 | 0.000  |
| 6   | Income     | PDOF    | 0.609177  | 23.0237 | 0.000  |
| 7   |             | PDNP    | 0.280585  | 8.1511  | 0.000  |
| 8   | Consumption | PPPG   | 0.907485  | 194.7299| 0.000  |
| 9   |             | PKP     | 0.284370  | 7.7190  | 0.000  |
| 10  |             | PKNP    | 0.771133  | 89.7261 | 0.000  |

It can be found in Table 1 from 8 equations, the \( R^2 \) value was > 0.5 and 2 equations, it was < 0.5. It exhibits the average endogenous variables variation could be explained more than 50% by exogenous included variables in the rain-fed highland rice household economics model. The F testing overall result showed that sticking all models arranging variables provided impacts towards endogenous variables in 1% of significance level which means that exogenous variables included in each equation gave impacts towards endogenous variables. Statistical test results of rain-fed upland rice farmers household economics model prediction power could be presented in table 2.

**Table 2.** Statistical test results of RMSE, RMSPE, and U-Theil values in the rain-fed land upland rice farmers household economics model, in Ponjong Sub-district, Gunungkidul District.

| Activities  | Equation | RMSE | RMSPE | UM   | US   | UC   | Notes |
|-------------|----------|------|-------|------|------|------|-------|
| Production  | QPG      | 187.1953 | 18.3532 | 0.0000 | 0.0151 | 0.9848 | Valid |
| Labor allocation | CKDKP | 0.1589  | 4.0527 | 0.0000 | 0.0234 | 0.9765 | Valid |
|             | CKLKP   | 7.1660  | 26.3601 | 0.0000 | 0.0682 | 0.9317 | Valid |
|             | CKDKOF  | 0.2752  | 4.7795 | 0.0000 | 0.0098 | 0.9901 | Valid |
|             | CKDKNP  | 2.6518  | 18.3742 | 0.0000 | 0.0063 | 0.9836 | Valid |
| Income     | PDOF    | 0.5462  | 2.5471 | 0.0000 | 0.2193 | 0.7806 | Valid |
|             | PDNP    | 4599366 | 57.8095 | 0.0000 | 0.5638 | 0.4361 | Valid |
|             | PKP     | 1823257 | 13.0548 | 0.0000 | 0.3192 | 0.5807 | Valid |
|             | PKNP    | 0.2355  | 1.2158 | 0.0000 | 0.0620 | 0.9379 | Valid |

It can be seen in Table 2 that if the RMSPE and U-Theil values as UM and US approach 0, and UC approach 1, therefore the equation which is obtained is quite valid to be used in the projection and policy simulation. Meanwhile, in equation consistency testing, it is given value based on consistency.
reflected test in RMSE. When the number which is resulted in more than one, therefore the equation produces an untrusted result. When the number which contributes minimal result, approaches zero, and it is quite consistent and feasible to become projection and simulation basics. It displayed that for 6 equations, the RMSE value was > 1 which meaning that it could not be trusted and 4 equations, the RMSE value was < 1 which it could be trusted. It can be seen from the UM and US values were approaching zero and the UC value was closed to 1 which was valid and feasible as the simulation policy basis.

3.2. The interrelationship of production, the labor allocation, and household consumption of rainfed rice farmers to the climate change

The production linkage, labor allocation, and household consumption of rainfed farmers to the climate change was in the cropping pattern. It is where the farmers of upland rice farmers decided to conduct different cropping pattern which is the one-time crop and two times crops of upland rice in one year. Therefore, there were dummy variables that show different cropping pattern due to the climate change.

The research production result, in this case of its upland rice equation model, showed that there was a different sign from the expected estimate parameter which was negative in the urea fertilizers number, which indicates that the urea fertilizers precisely addition would decrease rice production. This condition can be explained that urea fertilizers are sources of nitrogen (N) in ammonium. Urea is easily decomposed by urease enzyme which is produced by a microorganism in wet condition or humid so, the urea application in rain-fed land becomes ineffective unless the water condition is sufficient, therefore, a microorganism which producing urease enzyme can live. Other production equation variables were in accordance with the expected parameter. The rice cropping pattern dummy variables were indicated a positive value which implying different rice production cropping pattern. It can be explained that upland rice farmers household has one-time cropping pattern of upland rice in one year has become farmers routines. This is because by having experiences of previous years related to the rainy season condition in the second planting season, rainfalls rarely occur so they are no longer plant upland rice, but palawija which does not need a lot of water. For upland rice farmers which apply two times cropping pattern in one year, they would get benefits from this. This is because 2016 climate changes in the second planting season still often appeared. Therefore, in the second season, they could still get production like previous planting season.

The estimated results of labor allocation indicated that the labor allocation equations in the highland rice farming family. Its nonrice family labor allocation, of off-farm family and household incomes did not match the expected estimation, the result displayed a positive sign. It happened due to the farmers household family members did not only allocate their working time in rice and non-rice farming but also assign their times to find other incomes sources by wandering seasonally, trading, working as bricklayers, and other professions. Therefore, the relation between labor allocation in rice family, non-rice family, and off-farm family could complete each other, and also did household income members. Dummy cropping pattern showed a positive value which means that there was a difference in the family of upland rice cropping pattern family. The labor allocation equation of upland rice outside the family of, it was obtained that all signs were in accordance with the estimated parameter. The dummy cropping pattern, it was indicated positive sign that there was a labor use difference of outside family. From the off-farm equation, it was obtained two signs of variables which were not in accordance with the estimated parameter such as, land area and labor allocation variable in nonfarming activities family which were supposed to be negative, but its result indicated positive sign. It occurred because off-farm activities were only conducted by the head of the family so the land area and labor allocation in nonfarming activities, the result indicated positive sign. Dummy cropping patterns variables indicated a positive sign which means that there was a difference of off-farm labor use. The labor allocation equation in nonfarming family activities, was obtained three signs of variables which were not in accordance with the estimated parameter such as, land area and labor allocation variables in farming which were supposed to indicate negative sign however, it contributed a positive result and the family labors number variables which were supposed to be positive, but the
result was negative, it was gained negative result. It has related one another that the nonfarming activities condition was conducted only by the head of the family. It indicated negative sign which means that there was no difference labor allocation in agriculture for nonfarming activities.

The income estimated result, its equation of off-farm, indicated that all signs of estimated parameter were in accordance with the expectation. Dummy cropping pattern variables indicated positive sign, which means that there was a different off-farm income. In the non-rice income equation, was obtained that all estimated parameter signs were in accordance with the expectation. It indicated positive sign, it means that there was a different non-rice income.

The consumption estimated result was upland rice food expenditures equation indicated that all estimate parameter signs were in accordance with the expectation which was highland rice acceptance variables having a positive value. Dummy cropping pattern variables indicated negative sign, it means that there was no difference in upland rice food expenditures. The food expenditures equation was obtained that all estimate parameter signs were in accordance with the expectation. It indicated negative signs which mean that there was no difference in upland rice food consumption expenditures of. By non-rice consumption expenditures equation was obtained a positive value of household income variables parameter which was in accordance with the expectation. It pointed out that there was no difference in non-rice consumption expenditures.

4. Conclusion
Based on the research result, a conclusion can be drawn that the model of rain-fed land upland rice farmers household economics could explain the interconnectedness among production, labor allocation, and consumption with the climate change. Its implication is that every activity in an economic activity will influence other economics activities

5. Suggestion
Associated with the limited condition of land especially the water availability which depends on rainfalls, farmers need to pay attention to climate condition which cannot be predicted therefore, they can determine the decision of choosing cropping pattern which will be conducted because it will influence production, labor allocation, income, and farmers household expenditures. The government needs to intervene in providing information and counseling towards upland rice farmers about the climate changes and their condition in order to optimize the available resources potential.

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