The effects of rural development on main sources of farm households

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Abstract. In line with the development of the rural villages, rural employment changes. Consequently, the job opportunities of some farmers will also change. This study aims to estimate the effect of rural development and some other factors on the primary source of household income of farmers in several agroecosystems. The data analyzed were the 2013 Agricultural Census, Village Potential and "PATANAS" data. The results showed that farmers' opportunity of leaving agriculture as the main source of household income increased if cultivated land was smaller and the inequality of landholding in the village increased. In the set of variables that determine rural development, improvements in the dimensions of basic services and basic infrastructure of non-accessibility/transportation positively affect the opportunities of farmers' households to make non-agricultural work as their source of income. Improvements in the accessibility/transportation dimension, on the other hand, strengthen the ability of farm households to rely on agriculture as a source of household income. Based on the research results, increasing the agricultural sector as a significant contributor to farmer household income can be achieved by increasing accessibility/transportation facilities and improving the distribution of cultivated land.

1. Introduction
In the global scope, related to the high hunger rate, especially in Asian and African countries and the threat of climate change to global food security, agricultural development and economic transformation has always been a concern of most experts in the socioeconomic field [1]. In poverty alleviation and rural economic transformation, the role of the agricultural sector is very strategic. According to Mellor [2], conducive policies to develop innovation and adaptive institutional breakthroughs in agricultural development are critical factors for the success of economic transformation.

In the context of developing countries, where there is only a minimal presence of an effective formal insurance market, rural households look to diversify their income sources as an effective strategy to mitigate income shocks. Some rural households recognise higher income and/or lower risk in off-farm employment activities compared with deriving income solely from farming [3]. For example, Duong et al. [4] showed that off – farm employment improves income, ensures food security and contributes to poverty alleviation. The results also show that age, marital status, education, labour, financial capital, land, location, market access and losses from natural disasters are significant contributing factors to the decision to participate in off-farm employment.
In Indonesia, the agriculture sector is the most resilient sector while the economy is slowing down. For example, during the economic crisis of 1998–2000, the agriculture sector was the "savior" of the country's economy. Another example, when national economic growth is contracting due to the covid-19 pandemic, the agricultural sector is the only economic sector in with positive growth.

The majority of rural households in most rural areas in Indonesia are farmers. However, some of these farming households cannot rely on their primary income from agriculture because most Indonesian farmers are smallholders. They will be able to meet the needs of their families if they also diversify the work in the non-agricultural sector, and some rely on it as their primary source of income. The phenomena will differ across villages and are linked to the development and economic structure of the villages.

Some important targets for rural development include improving rural access to health services, education, energy, telecommunications, transportation, etc. In that context, it is necessary to build and develop physical and non-physical infrastructure. Some important targets for rural development include improving rural access to health services, education, energy, telecommunications, transportation, etc. In that context, it is necessary to build and develop physical and non-physical infrastructure.

These development activities have implications for the allocation of resources and the economic structure of the village. In general, along with the village's progress, the agricultural sector's contribution to creating added value and the absorption of labor changed [5,6]. As a result, average incomes increase even though the distribution between rural households is not always more equal. Therefore, the transformation process must be examined since it is required as an input in the formulation of policies and the design of development programs for the rural economic transformation to be on the right "track" to achieve "sustainable development."

This study aimed to analyze the level of diversity of village progress and its influence on the primary sources of the farm households income. The implications of the study results are expected to be used as part of input in the formulation of agricultural and rural development policies.

2. Materials and methods
The data analyzed was secondary data, namely Agricultural Census, Village Potential, and PATANAS (National Panel of Farmer) survey results. The population in this study was the farm households of the last Agricultural Census at the corresponding villages where the PATANAS research site was located. Farmer households are households that in the last two years manage the farm with the status of owned and non-owned.

We adopted the Central Bureau of Statistics [7] method to identify village development status from the Village Potential data. The influence of village development levels and several other factors on farm households’ main source of income is estimated by the logit model. The observation unit on merging data between the Agricultural Census, Village Potential, and PATANAS is the village level.

2.1. Materials
The most recent Agricultural Census data was 2013 because the Agricultural Census is conducted every ten years. Assuming that the shortest time-lag from the influence of village development rate on the household economy is about two years, we use the 2011 Village Potential data. PATANAS data is the primary source of agroecosystem identification and qualitative information describing current conditions.

The number of sample villages in PATANAS data is 45, spread across 36 districts in 10 provinces. It represents eight different agroecosystems namely (i) irrigated-wetland based on rice farming; (ii) rain-fed based on rice farming; (iii) rain-fed based on secondary crops farming; (iv) dry land-based on vegetable farming; (v) dry land-based on dairy farming; (vi) dry land-based on plantation farming; (vi) tidal swamp based on rice farming; and (viii) swampy land based on rice farming. The number of villages in each agroecosystem is 13, 6, 5, 5, 2, 10, 2, and 2 respectively. Out of the 45 villages, 24 villages are located on Java Island and 21 villages are located in the off-Java.
2.2. Methods

Referring to the method adopted by Central Bureau of Statistics [7], the determination of village development status is based on the computational results of the Village Development Index (IPD). With a range of IPD values between 0-100, the Central Bureau of Statistics grouped the status of rural villages development into three categories: (1) developed village, if the IPD value > 75, (2) developing villages if 50<IPD≤75, and (3) less developed villages, if IPD ≤ 50 [7].

IPD consists of 5 dimensions with different weights, namely (i) basic service conditions for basic needs, especially in the education and health sector; (ii) infrastructure conditions outside the accessibility/transportation aspects for basic needs such as local economic development, energy, fresh water and sanitation, communication and information, and sustainable utilization of natural resources; (iii) accessibility/transportation conditions; (iv) the status of public services to meet the needs of services for goods, services, and/or administrative services to strengthen democracy, social cohesion, environmental protection; and (v) the status of government administration to reflect the performance of administrative services organized by the village administration. The weight of (i) to (v) are 0.326, 0.252, 0.204, 0.109 and 0.109, respectively.

To estimate the effects of the village development level and several other factors on the farmers’ household income sources we use a logit model. Variables representing the development of villages included in the model are the five dimensions above. Using this approach, it can be identified the influence of each dimension. The estimated parameters are taken through the following logit model:

\[
Y_{ij} = f(X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5}, I_{i1,j}, I_{i2,j}, I_{i3,j}, I_{i4,j}, I_{i5,j}, D_{i1,j}, D_{i2,j})
\]

which is:

- \(Y_{ij} = \begin{cases} 
0, & \text{if main source income relay on agriculture} \\
1, & \text{if main source income relay on non agriculture}
\end{cases} \)
- \(X_{i1,j} \): number of household member
- \(X_{i2,j} \): age of household head (year)
- \(X_{i3,j} \): size of land holding (hectare)
- \(X_{i4,j} \): Gini coefficient of land holding in the village-\(j\)
- \(X_{i5,j} \): population density of the village-\(j\)
- \(I_{i1,j} \): Index representing condition of supporting system for basic needs especially for education and/or health
- \(I_{i2,j} \): Index representing condition of infrastructure non accessibility/transportation
- \(I_{i3,j} \): Index representing condition of accessibility/transportation
- \(I_{i4,j} \): Index representing condition of general services
- \(I_{i5,j} \): Index representing condition of village's government services
- \(D_{i1,j} \): Dummy variable of agroecosystem of the village-\(j\) (0=irrigated rice field)
- \(D_{i2,j} \): Dummy variable of region ( 0 = Java, 1 = off-Java)

According to the 2013 Agricultural Census, there are 37,798 farm households in the PATANAS sample villages. We randomly selected 10% of farmer families as a sample for parameter estimation using the logit model. The maximum-likelihood estimation method was used [8,9].

3. Results and discussion

Rural development is a dynamic process which is mainly concerned with the rural areas. These include agricultural growth, putting up of economic and social infrastructure, fair wages as also housing and house sites for the landless, village planning, public health, education and functional literacy, communication etc. Prerequisite and enabling condition for boosting the development is procurement and improvement of both physical and non-physical infrastructure.
The better availability infrastructure conducive for rural household including farmers to access off-farm employment. Some households might decide to specialise in either farm or off-farm activities, some might take part in both activities, while others might shift between farm and off-farm activities. In general, from PATANAS data it was shown that participation in off-farm self-employment activities reduces the probability of being poor for some, but not for all.

The outcomes then, some of the farmers relay on non-agriculture activities as the main source of household income. The probability of the farmer to be relay either on agriculture or non-agriculture activities as main source of household income, of cause, not only affected by the infrastructure availability but also some other factors such as household characteristics, land holding, and agroecosystem.

3.1. Description of farm households by type of agroecosystems

The average number of household members and the age of household heads among agroecosystems is not much different. However, for agricultural landholding, there are differences. The smallest average landholding size is found in villages with irrigated rice farming agroecosystems, rainfed rice field agroecosystem, dry land vegetable and secondary crops agroecosystem, and dry land dairy-based farming. The lowest area in that agroecosystem is less than half a hectare, while the highest in swamp rice paddy agroecosystems. In this case, swamp rice fields villages are located outside Java Island (Table 1).

The distribution of agricultural landholding among villages varies. The most skewed is in dryland agroecosystem villages based on dairy farming, namely Margamukti Village (Gini coefficient 0.785), Pangalengan Subdistrict, Bandung District, West Java Province. On the other hand, the most equally distribution of land holding is in villages with tidal swamp rice agroecosystems, namely Upangkarya Village (Gini coefficient 0.203), Makartijaya Subdistrict, Banyuasin District, South Sumatra Province. In general, the distribution of land ownership in rural areas in Java Island is more skewed than in rural areas outside Java.

Although the correlation is weak (the coefficient 0.353), the distribution of landholding in villages with a high density of population is generally more skewed rather than in low-density villages. From PATANAS data, the differences in land distribution is caused by low growth of non-agricultural employment in rural areas and the dominance of land inheritance institutional in the transfer of agricultural land ownership.

Table 1. Descriptive statistics of the farm household by type of agroecosystem.

| Agroecosystem | Obs | Number of HH member | Age of HH head (yr) | Landholding (ha) |
|---------------|-----|---------------------|---------------------|------------------|
|               |     | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |
| SIP           | 11276 | 3.79 | 1.590     | 50.93 | 12.766     | 0.35 | 0.496     |
| STDH          | 6654  | 3.64 | 1.550     | 48.76 | 12.782     | 0.37 | 0.535     |
| LKS           | 4458  | 3.54 | 1.437     | 47.77 | 13.661     | 0.38 | 0.482     |
| LKP           | 2972  | 3.46 | 1.510     | 50.53 | 13.182     | 0.64 | 0.713     |
| LSP           | 2925  | 3.88 | 1.507     | 47.57 | 12.754     | 0.36 | 0.484     |
| LKB           | 7377  | 3.94 | 1.903     | 48.17 | 12.846     | 1.76 | 2.221     |
| SRPS          | 688   | 3.89 | 1.802     | 45.25 | 14.667     | 2.72 | 1.788     |
| SRL           | 810   | 3.66 | 1.572     | 46.18 | 12.033     | 1.29 | 0.950     |

*SIP= irrigated-wetland based on rice farming, STDH= rain-fed rice fields based on rice and secondary crops farming, LKS= dry land-based on vegetable farming, LKP= dry land-based on secondary crops farming, LSP= dry land-based on dairy farming, LKB= dry land-based plantation farming, SRP= tidal swamp land based rice farming, LRL= swamp land-based rice farming, HH = household.
3.2. Village development status and its effects on main source of farmer household income

Village development status is reflected by its IPD index, higher value indicate better condition. The index values description of each IPD dimension is presented in Table 2. The index values of each dimension vary across villages. The highest variation is in dimension I4, which reflects the condition of public service infrastructure, while the lowest is in dimension I5, the village government implementation.

Table 2. Descriptive statistics of the dimension representing village development.

| Index of dimension | Obs | Mean | Coef. Var | Min | Max |
|--------------------|-----|------|-----------|-----|-----|
| I1                 | 45  | 18.08| 0.19      | 9.00| 22.74|
| I2                 | 45  | 12.42| 0.23      | 5.48| 19.83|
| I3                 | 45  | 13.37| 0.17      | 9.54| 17.06|
| I4                 | 45  | 6.46 | 0.24      | 3.40| 9.35 |
| I5                 | 45  | 7.65 | 0.10      | 6.14| 9.43 |
| Index of dimension | 45  | 57.98| 0.14      | 40.29| 70.50 |

The average IPD value is about 58, with a range of 40–71. Referring to the categorization of village development levels implemented by Central Bureau of Statistics [7], out of the 45 villages studied, none of the villages was a developed village. Most (38 villages) are classified as developing, and the rest (7 villages) are classified as under developing villages. Although most of farm households (81%) still rely on agriculture as the main source of income, conditions across villages vary. In general, the highest percentage is in rural under developing categories (Table 3). The influence of village development levels and several other factors on farm households’ main source of income estimated by the logit model is presented in Table 4.

Table 3. Percentage of farm household by village development status and source of main income.

| Development status | Agriculture | Non-agriculture | Total |
|--------------------|-------------|-----------------|-------|
| Under developed    | 96.12       | 3.88            | 100   |
| Developing         | 79.88       | 20.12           | 100   |
| Total              | 81.26       | 18.74           | 100   |

Pearson chi²(1) = 502.4374  Pr = 0.000

Table 4. Factors affecting the main source of farm household income.

| Main source of income: 0=agriculture, 1=non-agriculture | Coef. | Odds | Std. Err. |
|--------------------------------------------------------|-------|------|-----------|
| Number of a household member                           |       |      |           |
| Age of household head                                  | 0.0498| 1.051| 0.032     |
| Size of land holding (ha)                              | -0.0120| 0.988| 0.004     |
| Gini coefficient of landholding in the village         | -1.8266| 0.161| 0.168     |
| Population density                                    | 1.8464| 6.337| 0.596     |
| An index representing the level of village development:|       |      |           |
| I1: basic services and supporting infrastructure       | 0.1514| 1.163| 0.038     |
| I2: basic infrastructure excluding accessibility/transportation | 0.1196| 1.127| 0.031     |
| I3: accessibility/transportation                        | -0.1738| 0.840| 0.038     |
| I4: public services and supporting infrastructure     | -0.0804| 0.923| 0.051     |
| I5: village government                               | -0.1578| 0.854| 0.118     |

*) a = significant at α = 0.01, b = significant at α = 0.05
### Table 4. Factors affecting the main source of farm household income (continued).

| Main source of income: 0=agriculture, 1=non-agriculture | Coef. | Odds  | Std. Err. |
|--------------------------------------------------------|-------|-------|-----------|
| Dummy agroecosystem (control var: irrigated rice field): |       |       |           |
| Rain-fed rice/secondary crops farming \(^a\)              | -0.9597 | 0.383 | 0.175     |
| Dry land vegetable farming                               | 0.0954 | 1.100 | 0.200     |
| Dryland -based secondary crops farming \(^b\)            | 0.4862 | 1.626 | 0.230     |
| Dry land- based on dairy farming                         | 0.3041 | 1.355 | 0.243     |
| Dry land-based plantation farming                        | 1.0749 | 2.930 | 0.216     |
| Tidal swamp rice farming \(^a\)                          | 2.8386 | 17.092| 0.771     |
| ‘Lebak’ swamp rice farming                               | 0.4216 | 1.524 | 0.445     |
| Dummy island (Java=0, off-Java =1)                       | 0.2014 | 1.223 | 0.195     |
| Constanta (intercept)                                   | -1.7451 | 0.175 | 1.233     |

Logistics regression

- Number of ob.s.= 3.440
- \(LR \chi^2 (18)= 510.84\)
- Prob>\(\chi^2 = 0.0000\)
- Pseudo R\(^2\)= 0.1507

*) \(a = \text{significant at } \alpha = 0.01, \(b = \text{significant at } \alpha = 0.05\)

The effects of explanatory variables excluding the factors that represent the level of development of the village is:

a. The age of the household head: the older, the greater the household opportunity of primary income source comes from agriculture.

b. The area of agricultural landholding: the narrower, the greater the opportunity the household relies on non-agricultural as the main source of income.

c. Distribution of agricultural landholding in the village: the more skewed, the fewer opportunity households rely on agriculture as the main source of income.

Of the five dimensions representing village development, dimensions 1, 2, and 3 significantly affected the main source of farm household income. Thus, it can be concluded that:

a. The improvement of basic services, especially in the education and health field and supporting infrastructure, increases the opportunities of farm households to access employment opportunities outside agriculture and, therefore, the opportunity to make outside of agriculture work as the main source of household income increases. Furthermore, the workforce's increasing education and health quality improve their access to rural employment opportunities and urban employment opportunities with commuter and circular migration patterns.

b. The improvement of basic infrastructure (outside accessibility/transportation), which among others consists of economic infrastructure (market, hospitality, banking, etc.), or infrastructure improvement in the field of energy, electricity, clean water and sanitation, as well as communication and information improves the access of farmers' households on non-agricultural employment opportunities. Thus, the opportunity to make non-agricultural work as the main source of income of his household increased. Furthermore, this improvement of basic infrastructure encourages new employment opportunities based on processing agricultural products and businesses in the non-agricultural sector, both formal and non-formal.

c. Increasing accessibility/transportation, mainly with the increasing availability and increasing quality of transportation facilities and infrastructure, increases the opportunity to increase farm households' income from their farming. With these conditions, the opportunity for households to rely on employment in agriculture as the main source of household income increases. In addition, better rural road conditions are conducive to cutting transaction costs to obtain lower price in the input market and get higher output prices \([10–12]\). Thus, on an appropriate scale, the improvement
of accessibility/transportation of rural areas is also conducive to creating agricultural and rural development coherence. It is also conducive to equalising welfare between regions (village vs city) and between developed villages with vs underdeveloped villages, and between farming communities vs non-farm communities.

In general, infrastructure development in rural areas, especially rural roads and electrification, encourages new job opportunities. Thus, its contribution to economic growth, diversification of work and business, and poverty reduction are significant [13]. At the same time, the relative share of agriculture in the village economy decreased. But its strategic role in poverty alleviation never fades [14–18]. The phenomenon is especially happened in most developing countries as well as in Indonesia. Moreover, the agricultural sector remains the most extensive absorbent labor for rural residents and the determinant of food security for large-population countries like Indonesia.

The effect of agroecosystem conditions on the opportunities of farm households to maintain the agricultural sector as the primary source of diverse household varies. There are two agroecosystems which conditions are no different from irrigated rice paddy agroecosystems. On the other hand, there is one agroecosystem with a higher opportunity and three agroecosystems with lower opportunities.

One of the significant elements of agroecosystems is the climate. In agroecosystems with water availability is highly dependent on rainfall, the negative impact of climate change on productivity and income of farming is enormous. Meanwhile, farmers' adaptation capacity in facing climate change, in general, is still low. For example, the capacity of adaptation of rice farmers were less than 20% [19].

The relevance and urgency of increasing the adaptation capacity of Indonesian farmers are (i) Indonesia is located in tropical regions; and (ii) the potential threat of climate change in tropical regions is higher than in temperate latitudes [20]. One of the promising adaptation means is crop diversification. Crop diversification has an important role on risk aversion due to crop failure or losses by natural calamities included extreme climate. According to Rahaman [21] crop diversification for developing countries offers many opportunities to boost the economic, social, environmental, and cultural life of people.

4. Conclusions
The agricultural landholding significantly influences household opportunities to make agriculture a source of household income. The smaller the land holding, the less opportunity. The more skewed the distribution of agricultural landholding in the village, the less opportunity.

On the village development level, three dimensions significantly influence the prominent source farm households' income changes. First and foremost, basic services and supporting infrastructure, particularly in the fields of education and health. Second, basic infrastructure facilitates marketing and financing services, energy supply, electrification, communication, and information services improvement. Third, infrastructure that facilitates increased access and transit.

The most strategic to improve rural and agricultural development synergy is through the dimension of accessibility/transportation. The implications are the appropriate policies and programs of rural road development and the increasing availability and quality of efficient transportation facilities that need to be prioritized and carried out systematically and consistently.

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