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Research Article
Allocation Optimization of Farmers' Resources to Achieve Maximum Income in Parigi Moutong Regency

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Abstract

Background and Objective: In both the rural and urban areas of Parigi Moutong Regency in Indonesia, rapid socio-economic development has created a contradiction between increasing resource needs and the availability of farmers' resources. The objective of this research was to examine how the resources of farmers might be optimally allocated in order to achieve maximum income through farming. **Materials and Methods:** One hundred and seventy farms were sampled. Sampling was done by stratified random sampling based on the area of cultivated land. **Results:** The research results showed that farmers in rural areas were more efficient in resource usage, both of their own resources [especially labor inside family (LIF)] and of outside resources (fertilizer usage, labor outside family (LOF) and credit loans). As a result, the average rural farming household income of the region surveyed was much higher than the equivalent average in the urban area. Farmers in both areas (rural and urban) would be able to achieve optimal resource management. However, the optimal allocations reached by the two areas would necessarily be different. Some farmers in rural areas could choose to increase labor productivity. This would be reflected in the utilization of more controlled capital and would produce a dual value of 10.11%, much larger than that achievable by farmers in the urban area. **Conclusion:** With the best use of capital, farmers in the rural area would be able to earn a higher household income on average. The average farmer's household income in the rural area could increase by as much as 5.10%, whereas the same in the urban area would result in an increase of only 2.15%.

Key words: Linear programming, improving technical efficiency, moneylenders, rural farmers, urban farmers

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In both rural and urban areas of Indonesia, rapid socio-economic development has created a contradiction between increasing resource needs and the availability of farmers' resources. A lack of farming resources is a barrier to further socio-economic development. Moreover, due to the exploitation and utilization of resources as a result of socio-economic activities, the management and allocation of farmers' resources has gradually become increasingly complex. In managing their resources, farmers need to consider the objectives to be achieved. For most cases, farmers should aim to maximize the income of their farming through optimal resource allocation; one approach that could be used is linear programming[1-5].

The linear program (LP) is one of the most widely used operating research techniques in all fields of business[6,7]. The LP is a technique that helps decision-making in allocating resources (such as labor, money, time and raw materials)[8,9]. Operations managers use the LP in planning and making the decisions necessary to allocate limited resources[10,11].

The conversion of technical irrigated land to other developments (such as tourism and housing) has been a common feature of land management in Parigi Moutong Regency. This fact is very worrying, especially considering that highly fertile agricultural land is often targeted. Parigi Moutong Regency fertile land is much more fertile than the overall average of the province in which it is located (Central Sulawesi), a Parigi Moutong paddy produces an average 5 t ha^{-1}/season, much higher than the average Central Sulawesi production rate of only 4.65 t ha^{-1}/season[12]. If land conversion continues to occur, it will lead to increased food insecurity (most especially to a shortage of rice, which is a staple food for society as a whole). There are other socio-economic implications of land conversion, farmers whose land has been converted to non-agricultural land have higher incomes (resulting from the sale of land) short-term when compared to farmers whose land was not converted, while, from a macro perspective, less fertile land is available to the province as a whole for farming purposes, hence farming production is reduced and, in turn, the rice needs of Parigi Moutong Regency are becoming increasingly difficult to meet. This aspect is particularly alarming because the price of all basic necessities, including agricultural production tools, is gradually increasing, such that the resources and capital owned by farmers in real terms are diminishing. As a result, many farmers are unable to maintain their farms properly. As the price of seeds, fertilizers, pesticides and labor is becoming increasingly inflated, the government's directive to implement agricultural extension is no longer feasible. This research aimed to examine the allocation optimization of farmers' resources to achieve maximum income through farming even in the face of difficult economic circumstances with linear programming method. Several studies have used the same method to achieve these objectives, both in agricultural resources and in irrigation water management, among them Georgiou and Papamichail[13] Lu *et al.*[14] and Singh and Panda[15].

MATERIALS AND METHODS

The research was done from April-August 2016 in Parigi Moutong Regency, or, more precisely, in two sub-districts of the regency, namely: Bolano Lambunu district (which represents the rural area, being 260 km from the capital of Parigi Moutong Regency) and Parigi Selatan (South Parigi) district (here to represent the urban area, being situated only 6 km from the capital of Parigi Moutong Regency). The determination of the research locations was done purposively, with the consideration that, (1) The areas were different geographically; Parigi Selatan district includes lowland, while Bolano Lambunu district features lowland and mountains, (2) Farmers from South Parigi district often received agricultural extension from the government, while Bolano Lambunu district farmers did not and (3) Most of the farmers were farming in paddy fields in both locations.

Respondents taken in this research were all farmers who farm in paddy fields and whose land has been or has not yet been converted. The technique of taking respondents was stratified random sampling based on the area of cultivated land. Stratum I was a group of farmers with an area of cultivation greater or equal to ($\geq$) the average area of cultivation, while Stratum II was a group of farmers with an area of cultivation less than ($<$) the average area of cultivation. The number of respondents from each sub-district was set at 85 people.

Data analysis was done using a linear programming model to obtain the optimum level of resource usage within various constraints, namely: Land, capital and labor. The specific model of linear programming used in this research was to maximize the income of farmers.

In general, the mathematical form of the linear programming model that maximizes the objective function is:

Maximum:

$$Z = \sum_{j=1}^{n} C_{ij} X_j$$

Limiting factor:

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i$$

No negative activities: $Xj \geq 0$ for whole j.

Where:

i = 1, 2, 3,... m (m = Number of limiting factors
j = 1, 2, 3,... n (n = Number of production activities)
Z = Maximized goal function
C = Gross-margin
X_i = Production activities
a_{ij} = Input-output coefficient of each activities
b_i = Available resource limits

To test average farmer's rationality levels used the independent t-test, using SPSS (Statistical Package for the Social Sciences) version 17.00. Statistical significance was set at $p<0.05$ and 0.1.

RESULTS AND DISCUSSION

Rational level of farmers in resources allocation: Survey results showed that the average area of land cultivated in rural areas was 0.892 ha, larger than the average of urban areas (only 0.752 ha). This indicates that farms in urban areas had converted land from productive agricultural land to non-agricultural land. Approximately 47.54% of productive land has been converted into housing and swift-let buildings. The impact is that urban farmers have not been able to focus on their farming, and, as such, farming operational costs have increased because they relied on higher LOF. Consequently, wages for labor also increased, meaning that overall farming income has decreased. The rational level of farmers in resources allocation owned in 1 year could be seen from the variables studied, such as: The area of cultivated land, the usage of three types of fertilizers and their dosage, the usage of LIF, LIF which worked outside the farming, the usage of LOF, the frequency of extension followed by farmers, capital used, final production levels and product type and the farmer's household income[16-18].

The planting pattern implemented by farmers over 1 year was a 3-time planting season (PS): PS I and PS II were rice, while PS III was other plants and vegetables. Thus the planting pattern that occurred at the research location was rice-rice-other plants and vegetables but the primary difference was the type of other plants and vegetables cultivated. The types of commodities grown in rural areas were more varied compared with urban areas. In the urban area, the dominant commodities cultivated were corn, soybeans, peanuts, onions and chilies, while in the rural area, corn, soybeans, peanuts, onions, chilies, kale, spinach and long beans were commonly cultivated.

The technology package applied by farmers included a selection of superior seeds and the usage of urea, SP-36 and KCl fertilizers. The government weight usage recommendations for the urea, SP-36 and KCl fertilizers for rice plants in 1.0 ha were 250, 100 and 75 kg, respectively. In general, it could be argued that the technology package applied by farmers was very different from that which was recommended by the government. In PS I, the three types of fertilizer (urea, SP-36 and KCl) used by farmers in the rural area were 36.8, 50 and 56% of government recommendations respectively, while the usage of fertilizers by farmers in the urban area were 58, 74 and 77% of government recommendations respectively. In PS II, the use of fertilizers (urea, SP-36 and KCl) in the urban area, respectively were 60, 76 and 83% of government recommendations, respectively. The usage of fertilizer per fertilizer type in the urban area was 37, 20 and 25% higher than in the rural area. Farmers in the rural area were using past experience to apply technological developments to their farming practices or else information obtained from previously successful farmers. This idea conforms to the research findings of Antara and Hadayani[19], who noted that farmers in remote areas rarely obtained the agricultural extension but agricultural information was often obtained from community leaders, successful farmers and from ancestors.

Information about agriculture from agricultural extension workers was obtained only once during one PS for rural farmers. The urban farmers benefitted from easier access to extension projects; the district Agricultural Services Office and Agricultural Extension Office are located much closer and can supply agricultural extension workers. Perhaps owing to this proximity, new technologies and information are often more readily accepted over urban farming communities and agricultural extension workers use is very intensive (up to 4 times during one PS). Thus the knowledge and skills of farmers in the urban area are better developed, such that production and farming income is likely to increase similarly.

The usage of LIF in the urban area during PS I was 32% lower than in the rural area. This was due to the higher rates of informal employment in the urban area. The consequence was that LOF usage was 62.5% greater in the urban area compared to the rural area.

During agricultural off-season or in periods where the farmers were not required to work, they often worked outside the profession to increase profits or to earn wages. These include activities like opening a stall or becoming a builder, shopkeeper or other laborers in the market. The migration of labor from the agricultural to the non-agricultural sector causes major fluctuations in labor productivity and income[20-22]. As Wang *et al*.[23], Manivong *et al*.[24] and Murray[25] explain the shift in labor away from agriculture often creates significant growth in the non-agricultural sector and occurs primarily because of inadequate farming incomes. Such conditions were clearly present in Parigi Moutong district. Nevertheless, LIF in the urban area working outside of farming amounted to only 38%, while in the rural area this figure plummets even further to 4.8%. The rural area, is far from the district capital, has lower levels of formal education and fewer opportunities for work, so farm laborers working outside the farm is rare. Most family members filled their spare time by making webbing, baskets, mats and other useful goods.

The use of LOF in rice farming among farms in the urban area during PS I was 29.6%, while in the rural area only 10.72% of labor was drawn from outside the family. Labor outside the family was only used by farmers during periods of extensive land management, maintenance and harvesting. The LOF restricted only to intensive periods of farming activity reduces wage outlay (and hence overall operational costs).

In general, the capital used in farming came from the farm's own capital resources and informal credit arrangements. Informal credit is credit given by moneylenders to farmers. Several factors affect the tendency for farmers to borrow money from moneylenders. These include, (a) The ease of borrowing requirements, (b) Whether the loan is with or without collateral, (c) Whether the borrowing process itself is quick and concise and (d) How the interest rate compares to bank credit. This is relevant to research Hartono[26], Blancard *et al*.[27], Owusu-Antwi and Antwi[28] and Abdallah[29]. Credit from moneylenders was given every growing season according to the needs of farmers. All credit was given in cash with an average interest rate of 10.5% per month and a required return after harvest in cash or in kind (grain or rice).

The capital used for farming by farmers in the rural area was lower compared with the urban farmers. At PS I and II, farmers in the rural area used 32.61 and 39.20% less capital on average than urban farmers. Further details of the resource allocation and production levels per ha over the one year in Parigi Moutong Regency are listed in Table 1.

Table 1 shows that farmers in the rural area tended to allocate fewer resources to farming overall than urban farmers. Farmers in the rural area, (a) Used a lower quantity of fertilizers, LOF and capital in their farming, (b) Received fewer opportunities for agricultural extension training or labor (only once during one PS) and (c) Used more LIF, so that overall wage outlay could be as low as possible. The average quantity of rice produced per hectare on the rural farms, however, was close to double that of the urban farms, meaning that rural farmers were more efficient in allocating owned resources.

The household income of farmers was sourced from (a) Income from farming (rice and other plants and vegetables) and (b) Income from outside farming (from carpentry or building, opening a stall, providing labor in the market or from motorcycle taxis). More detail about the household income of farmers in Parigi Moutong Regency is given in Table 2.

The average farmer's household income in the urban area was 12.34% higher than that of the average farmer in the rural area as shown in Table 2. This perhaps owes to the fact that the average farmer's household consumption in the rural area was 56.40% lower than in the urban area. The differences in the average farmer's rationality levels in Parigi Moutong Regency are given in Table 3.

The t-count of all the variables studied was greater than the t-table (t-count>t-table), such that H_0 was rejected as shown in Table 3. This ultimately means that farmers in the rural area were more rational about allocating resources than farmers in urban areas.

Optimization of the allocation of resources owned by farmers: This paper employs a two-step analytical process to establish optimal practices: (1) Analysis of all activities and incomes obtained from survey results and (2) Linear programming analysis about activity and optimal income. Both forms of analysis had values in the confidence interval, meaning that the model used was valid. During PS I, in which farmers in the rural area cultivated rice plants, the optimal amount of land to use according to first the linear programming analysis and then the survey results was 0.860 and 0.892 ha, respectively. Both values were in the confidence interval of 0.852-0.932 ha. The optimal values for the urban area according to analytical type (linear programming followed by survey results-derived) were 0.737 and 0.752 ha, respectively and both values were within the confidence interval (0.698-0.806 ha). During PS II, values from both the urban and rural areas were within confidence interval in both methods of analysis.

This is not the case with PS III, during which commodities cultivated in the rural area were more varied than those grown in the urban region. The differences in land usage affect the

Table 1: Resource allocation and production over 1 year

Description	Farmers in urban area	Farmers in rural area
PS I (Rice)		
Land area (ha)	0.752	0.892
Urea fertilizer (kg ha^{-1})	145.000	92.000
SP-36 fertilizer (kg ha^{-1})	74.000	59.000
KCl fertilizer (kg ha^{-1})	58.000	42.000
LIF (DPW ha^{-1})	95.000	125.000
LIF working	36.000	6.000
Outside of farming (DPW/PS)		
LOF (DPW ha^{-1})	40.000	15.000
Frequency of extension (time/PS)	4.000	1.000
Capital used (IDR/PS ha^{-1})	4,600,000.000	3,099,940.000
Rice production (kg ha^{-1})	1,919.210	1,896.500
PS II (Rice)		
Land area (ha)	0.752	0.892
Urea fertilizer (kg ha^{-1})	149.000	94.000
SP-36 fertilizer (kg ha^{-1})	76.000	66.000
KCl fertilizer (kg ha^{-1})	62.000	48.000
LIF (DPW ha^{-1})	90.000	115.000
LIF working	39.000	7.000
Outside of farming (DPW/PS)		
LOF (DPW ha^{-1})	45.000	14.000
Frequency of extension (time/PS)	4.000	1.000
Capital used (IDR/PS ha^{-1})	5,320,000.000	3,234.060
Rice production (kg ha^{-1})	1,989.210	1,960.250
PS III (Palawija and vegetables)		
Land area (ha)	0.752	0.892
Urea fertilizer (kg ha^{-1})	71.000	60.000
SP-36 fertilizer (kg ha^{-1})	92.000	69.000
KCl fertilizer (kg ha^{-1})	75.000	65.000
LIF (DPW ha^{-1})	90.000	112.000
LIF working	42.000	17.000
Outside of farming (DPW/PS)		
LOF (DPW ha^{-1})	50.000	17.000
Frequency of extension (time/PS)	3.000	1.000
Capital used (IDR/PS ha^{-1})	7,500,000.000	4,068,000.000
Rice production (kg ha^{-1})	2,800.550	4,350.450

PS: Planting season, LIF: Labor inside family, LOF: Labor outside family, DPW: Day people work (1 DPW = 8 h)

Table 2: Average farmer's household income over 1 year

Description	Farmers in urban area	Farmers in rural area
Farming income ha^{-1}/year (IDR)	35,692,965.18	32,703,974.57
Income from outside farming (IDR)	22,020,000.50	10,650,000.00
Total income/year (A+B) (IDR)	57,712,965.68	43,353,974.57
Consumption of farmers households/year (IDR)	44,380,150.50	28,375,000.00
Farmers household income/year (C-D) (IDR)	13,332,545.18	14,978,974.57

Source: Primary data analysis results, 2017

Table 3: Results of t-test of average farmer's rationality levels

Variables studied	t-count
Urea fertilizer	7.15**
SP-36 fertilizer	4.11**
KCl fertilizer	5.63**
LIF worked in farming	3.72**
LOF worked in farming	4.93**
LIF worked outside of farming	7.21**
Frequency of extension	15.62**
Capital used	4.86**
Rice production	1.85*
Farmers household income	2.74**

**Significant at 5% level, *Significant at 10% level, PS: Planting season, LIF: Labor inside family, LOF: Labor outside family, DPW: Day people work (1 DPW = 8 h)

usage of fertilizer, LIF, LOF, LIF working outside of farming, capital expended and production. As a result, during PS III the average farmer's household income is different, where the optimal value and the survey average of household income in the urban area were IDR 5,167,337.20 and IDR 5,173,027.53, respectively, with confidence intervals IDR 5,147,162.39-IDR 5,198,892.67, while in rural area these values were IDR 6,599,957.69 and IDR 6,607,225.64, respectively, with a confidence interval IDR 6,574,189.51-IDR 6,640,261.77. More details about the optimal value and survey average are listed in Table 4.

Table 4: Optimal allocation, average of survey and confidence interval of resources in farmers' households

	Urban area			Rural area		
Resource	Optimal level (LP)	Average of survey	Confidence interval	Optimal level (LP)	Average of survey	Confidence interval
PS I						
Rice field (ha)	0.74	0.75	0.698-0.806	0.86	0.89	0.852-0.932
Urea fertilizer (kg)	174.86	180.00	172.60-187.40	93.55	100.00	89.70-110,30
SP-36 fertilizer (kg)	91.15	100.00	88.40-111.60	67.13	75.00	65.21-84,79
KCl fertilizer (kg)	60.55	70.00	58.80-81.20	45.44	50.00	43.43-56,57
LIF (DPW)	88.51	90.00	85.33-94.67	122.11	125.00	119.21-130,79
LIF working outside of farming (DPW)	40.23	42.00	38.31-45.69	4.81	6.00	3.67-8,33
LOF (DPW)	46.80	50.00	42.39-57.61	11.52	15.00	9.95-20,05
Capital (IDR 000)	4,599.90	4,600.00	4,589-4,611	3,098.90	3,099.00	3,078-3.120
Rice production (kg)	1,908.30	1,919.21	1,901.52-2,008.90	1,878.81	1,896.50	1,873.90 1,919.10
Farmers household income (IDR)	3,667,075.76	3,673,116.19	3,654,750.60-3,691,481.77	3,809,451.88	3,813,646.90	3,794,578.66-4,007,715.14
PS II						
Rice field (ha)	0.73	0.75	0.698-0,806	0.88	0.89	0.860-0,924
Urea fertilizer (kg)	184.86	190.00	182.60-197,40	113.55	120.00	109.70-130,30
SP-36 fertilizer (kg)	101.15	110.00	98.40-121,60	72.13	80.00	70.21-89,79
KCl fertilizer (kg)	65.55	75.00	63.80-86,20	45.44	50.00	43.43-56,57
LIF (DPW)	86.51	90.00	85.33-94,67	112.11	115.00	109.21-120,79
LIF working outside of farming (DPW)	37.23	39.00	34.33-43,67	5.81	7.00	4.67-9,33
LOF (DPW)	41.80	45.00	37.39-52,61	10.52	14.00	8.95-19,05
Capital (IDR 000)	5,319.90	5,320.00	5,309-5,331	3,233.90	3,234.00	3,213-3,255
Production (kg)	1,978.30	1,989.21	1,971.52-2,006.90	1,907.75	1,920.25	1.897,65-1.942,85
Farmers household income (IDR)	4,481,466.40	4,486,401.45	4,463,969.44-4,508,833.45	4,551,591.76	4,556,604.03	4,533,821.01-4,579,387.05
PS III						
Other plants and vegetables land (ha)						
Corn	0.28	0.28	0.251-0.309	0.37	0.37	0.341-0.399
Soybeans	0.21	0.22	0.195-0.235	0.24	0,240	0.220-0.260
Peanuts	0.10	0.11	0.077-0.137	0.11	0.12	0.095-0.135
Onions	0.10	0.10	0.097-0.103	0.11	0.11	0.090-0.130
Chillies	0.05	0.05	0.047-0.053	0.05	0.05	0.047-0.053
Kale	-	-	-	0.00	0.00	0.0016-0.0204
Spinach	-	-	-	0.00	0.00	0.0026-0.0034
Long beans	-	-	-	0.00	0.00	0.0016-0.0204
Urea fertilizer (kg)	65.86	71.00	60.70-81.30	53.35	60.00	49.70-70.30
SP-36 fertilizer (kg)	83.65	92.00	82.81-99.79	61.13	69.00	59.21-78.79
KCl fertilizer (kg)	65.55	75.00	68.43-81.67	60.44	65.00	58.43-71.57
LIF (DPW)	88.51	90.00	85.33-94.67	109.11	112.00	106.21-117.79
LIF worked outside of farming (DPW)	40.23	42.00	38.31-45.69	15.81	17.00	14.67-19.33
LOF (DPW)	46.80	50.00	42.39-57.61	13.52	17.00	11.95-22.05
Capital (IDR)	7,499.90	7,500.00	7,485-7,515	4,067.90	4,068.00	4,051-4,085
Production (kg)						
Corn	5,755.00	5,805.00	5,735-5,875	5,600.00	5,650.00	5,575-5,725
Soybeans	4,080.00	4,155.00	4,035-4,235	3,675.00	3,750.00	3,670-3,830
Peanuts	1,985.00	2,045.00	1,970-2,115	1,799.00	1,859.00	1,789-1,929
Onions	5,450.00	5,500.00	5,430-5,570	5,100.00	5,150.00	5,080-5,220
Chilies	1,495.00	1,545.00	1,470-1,615	1,300.00	1,350.00	1,275-1,425
Kale	-	-	-	1,995.00	2,055.00	1,980-2,130
Spinach	-	-	-	2,450.00	2,500.00	2,435-2,565
Long beans	-	-	-	5,055.00	5,115.00	5,040-5,190
Farmers household income (IDR)	5,167,337.20	5,173,027.53	5,147,162.39-5,198,892.67	6,599,957.69	6,607,225.64	6,574,189.51-6,640,261.77

LP: Linear programming, PS: Planting season, LIF: Labor inside family, LOF: Labor outside family, DPW: Day people work (1 DPW = 8 h)

Response of the optimal allocation, if there were an improvement of technical efficiency and economic change in farming

Level of constraint and dual value of resources: A dual problem-solving method was used to evaluate whether a change to the resource allocation was necessary or not. Production factors which can be exhausted were given a dual positive value and a non-zero value. The dual value of production factors which can be used up amounts to the shadow price or MVP (marginal value product) of the factor;

Table 5: Constraints level and dual value (shadow price) of resources owned by farmers

	Urban area			Rural area		
Resource constraints	Level	Dual value (IDR)	Slack	Level	Dual value (IDR)	Slack
Land Area of PS I	0.752	7,754,046.930	0	0.892	7,125,200.51	0
Land Area of PS II	0.752	7,925,540.550	0	0.892	7,300,500.50	0
Land Area of PS III	0.752	11,750,500.450	0	0.892	9,250,345.50	0
LIF PS I	95.000	61,000.000	0	125.000	50,115.00	0
LIF PS II	90.000	62,500.000	0	115.000	52,105.00	0
LIF PS III	90.000	60,525.000	0	112.000	54,525.00	0
Capital of PS I	4,600,000.000	6,100,000.000	0	3,099,940.000	6,899,880.00	0
Capital of PS II	5,320,000.000	6,780,000.000	0	3,234,060.000	7,268,120.00	0
Capital of PS III	7,500,000.000	7,375,000.000	0	4,068,000.000	8,136,000.00	0

this number represents by what value each additional instance of resource usage (amounting to one unit) would be able to change the output value or objective function[30].

Farmers in the urban area used less land than those of the rural area. This fact is reinforced by the narrowness of land cultivated by farmers in the urban area, such that an addition of even 1 ha of cultivated land during PS I would increase the average urban farmer's household income to IDR 7,754,046.93, while in the rural area, the same change in land area would induce an increased income of only IDR 7,125,200.51. If 1 ha of cultivated land was added during PS III the average farmer's household income in the urban area would increase to IDR 11,750,500.45, while that of the average farmer in the rural area would only increase to IDR 9,250,345.50.

LIF was not used as widely in the urban area as the rural area. This scarcity is shown by the dual value of LIF in the urban area during PSI, which amounted to IDR 61,000, while in the rural area this value was only IDR 50,115. The scarcity of LIF in the urban area was caused by the tendency of farmers to work outside of farming since the labor wage outside of farming was higher than that offered by working on the farm. In addition, there are more available job opportunities in the urban area. In the off-season, almost 80% of farmers in the urban area worked outside of farming, such as in carpentry, masonry, hair cutting and so on[31].

A higher capital dual value would be achieved by a more efficient method of capital management. Efficiency in capital management was defined as an effort to use as little capital as possible to obtain maximum production. Capital productivity in the rural area was higher than in the urban area. This is shown by the capital dual value in the rural area being higher during PS I than that of the urban area, being IDR 6,899,880 to only IDR 6,100,000, respectively. Additional capital of IDR 1,000.00 injected during PS I in the rural area, would amount to an additional income of IDR 6,899,880, while in the urban area, additional income would amount to only IDR 6,100,000. For detail, the dual values of all farmers' constraints in Parigi Moutong Regency are given in Table 5.

Sensitivity analysis results: The analysis results showed that the highest technical efficiency rating (TER) for rice farming, soybeans, peanuts and kale was 0.97. Chilies and onions reached 0.99 and other commodities (corn, spinach and beans) were 0.98. The value of TER indicates the best efficiency level that could be achieved in production with respect to the levels of fertilizer, LIF and LOF used in the farming. The Scenario I imagines farmers enacting these technical improvements and selling their crop in the form of grain, the average farmer's household income in the urban area could rise to IDR 13,749,187.34 (an increase of 3.11%), while the same enacted in the rural area could rise to IDR 15,608,091.40 (up 4.20%).

Scenario II imagines that the farmers from Scenario I were hit with an unexpected increase in fertilizer prices of 20%. The increase available to the average household income in the urban and rural areas would fall to only 0.42 and 0.67% of the original values. In this eventuality, farmers in Parigi Moutong Regency could avoid falling income in the face of simultaneously decreasing output prices and increasing input prices by selling rice, rather than grain. With the sales in the form of rice, the average farming household income in the urban area would increase by 12.36%, while the same in the rural area would increase by 14.75%, despite the heightened fertilizer prices imagined by Scenario II. This eventuality is labeled Scenario III and is given, along with the details of other Scenarios, in Table 6.

The income would plummet if rice prices were to drop by 20% and fertilizer prices increase by 20%, such that the average farming household income in the urban and rural areas would increase only by 1.52 and 1.61%, respectively (Scenario IV). However, that income may be increased by enacting simultaneous changes, (1) Improving technical efficiency, (2) Increasing loan amounts by 20% with interest rate of 10.5%/month and (3) Selling produce in the form of rice. If these three things were done, then the average farming household income in the urban area would increase by

Table 6: Several scenarios which need to be done to increase farmers household income

Scenarios	Optimal Income of farmers household ha^{-1}/year (IDR)	
	Urban	Rural
I: Improved technical efficiency	13,747,187.34 (3.11%)	15,608,091.40 (4.20%)
II: Improved technical efficiency	13,689,449.10 (0.42%)	15,498,834.70 (0.67%)
Fertilizer price increased by 20%		
Fixed output price		
Production was sold in the form of grain		
III: Improved technical efficiency	15,446,339.70 (12.36%)	17,910,284.88 (14.75%)
Fertilizer price increased by 20%		
Fixed output price		
Production was sold in the form of rice		
IV: Improved technical efficiency	13,956,144.59 (1.52%)	15,859,381.67 (1.61%)
Fertilizer price increased by 20%		
Output price decreased by 20%		
Production was sold in the form of rice		
V: Improved technical efficiency		
Credit loans increased by 20% with	15,465,585.76 (12.50%)	17,988,325.34 (15.25%)
Interest rate of 10,5% per month		
Fertilizer price increased by 20%		
Fixed output price		
Production was sold in the form of rice		
VI: Improved technical efficiency	14,042,751.87 (2.15%)	16,404,104.06 (5.10%)
Credit loans increased by 20% with		
Interest rate of 10,5% per month		
Fertilizer price increased by 20%		
Output price decreased by 20%		
Production was sold in the form of rice		

Values in brackets were higher than the current household optimal income (existing condition), when TER (technical efficiency rating) was reached, grain price was IDR 4,050 kg^{-1} and rice was IDR 8,500 kg^{-1}

12.50%, while in the rural area it would increase by 15.25%, although fertilizer prices increased by 20% (Scenario V). With the increase in capital, the farmers would be free to manage their farming as they saw fit, such as by purchasing more fertilizer so that the resulting production increased and eventually hence by increasing the amount of rice sold as well. The role of capital in farming is very prominent, as is evident from Scenario VI, in which the average farmer's household income increases by 2.15% in the urban area and by 5.10% in the rural area, regardless of the rice price decreasing by 20%.

CONCLUSION

With the best use of capital, farmers in the rural area would be able to a larger average household income. Unexpected external changes, in the form of increasing input prices and falling output prices, would have to be met by farmers in both areas in the following ways (1) Improving technical efficiency, (2) Increasing borrowing from moneylenders and (3) Selling produce in the form of rice. With these three things, rural farmers would be more resilient to face price shocks that could be detrimental when compared with urban farmers. The average farmer's household income in the rural area could increase by as much as 5.10%, whereas the same in the urban area would result in an increase of only 2.15%.

SIGNIFICANCE STATEMENT

The research results showed that farmers in rural areas were more efficient in resource usage, both of their own resources (especially labor inside family) and of outside resources (fertilizer usage, labor outside family and credit loans). As a result, the average rural farming household income of the region surveyed was much higher than the equivalent average in the urban area.

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