Productivity from the different rubber-based farming system models in Cotabato Province, Philippines

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Abstract. In the Philippines, the production of rubber cup lumps has decreased in recent years. Despite the expansion of the rubber industry for environmental and economic benefits, knowledge about the productivity and income of the rubber-based farming system is minimal. Hence, this research assessed and estimated the productivity and income of farmers from the different rubber-based farming system models in Cotabato Province, Philippines, where one of the major crops is rubber. It is important to determine the productivity of rubber and how its productivity was affected by the introduction of other crops. Through this, the income of farmers and welfare were measured. This research was carried out in 2016, where rubber was among the priority crops being promoted in the area. It investigated 3 different rubber-based farming models, namely: FM1 (rubber + banana), FM2 (rubber + cacao), and FM3 (rubber + coconut). The study revealed that the farmers' income increased by engaging in intercropping compared to the monocropping system. Thus, as the income of the farmer increases, the household's basic needs, particularly food consumption, will be attained since income does not solely depend on rubber production but also other crops grown. The result also shows that farming model 3 provides higher returns to the farmers than the other rubber-based farming models. Hence, the study is useful for the farmers to adopt different rubber-based farming systems to increase income and reduce risks from farming. This study also serves as a basis for the policymakers for future agricultural development.

1. Introduction
Rubber (*Hevea brasiliensis*) is an essential agro-industrial crop worldwide, particularly in Southeast Asia and South Asia. In the Philippines, rubber is primarily grown in Mindanao, with a small portion cultivated in Luzon and Visayas. The Zamboanga Peninsula, SOCCSKSARGEN (South Cotabato, Cotabato, Sultan Kudarat, Sarangani, General Santos City) Region, ARMM ( Autonomous Region for Muslim Mindanao), Davao Region, and Caraga Region are the top producing regions in Mindanao. In 2019 around 229,431 hectares of land were planted with rubber, and the top producers were the Zamboanga Peninsula, SOCCSKSARGEN, and ARMM, which contributes 40%, 28%, and 17%, respectively, to the annual production. These regions' total production accounted for 85% of the country's rubber production [1].

Rubber trees are a significant source of natural latex [2]. In Asia, latex rubberwood can also be used to make furniture and is the primary raw material for making wood-based panels like particleboard and medium-density fibreboard [3], thus rubber is economically important [4]. From July to September 2020, production of rubber cup lump at 104.43 thousand metric tons was lesser by 4% than the output in the same quarter of 2019. Recently, the top rubber-producing region is the Zamboanga Peninsula,
with 43.52MT output or 41.7% share of the country's total production. SOCCSKSARGEN follows it with a 26.6% share and BARMM with 19.5% [5].

The domestic and global market for rubber has experienced rapid growth in recent decades. The rubber industry provides an incomparable means of poverty alleviation. It provides developing nations and the poor a path out of poverty. It significantly increased rural incomes and reduced poverty [6,7]. They promote efficient and sustainable agriculture, such as rubber plantations, allowing small and large plantation owners and their workforce to enhance their living standards.

The rubber industry has continually been one of the sources of additional employment in the country. The contribution of the rubber industry to employment comes from both the industrial and agricultural sectors. The industry creates employment and income in the industry and increases the employment, income, and output of the other sectors of the economy [4]. Aside from the rubber-based product's economic contribution to the economy, rubber trees serve as erosion control, reforestation, and environmental preservation, as they are biodegradable and not petroleum-based. Rubber-based farming systems reduce the risks of loss from farming. It increases livelihood activities, leading to increased income and farmers' welfare [8].

Further, the rubber growers in the Philippines, particularly in Mindanao, are predominantly smallholders. An estimated 38,000 families rely on the commodity, most of whom are smallholders on farms of less than three hectares. Since most of the farmers in the area are smallholders, the income derived from rubber farming is mainly affected by different factors of production. Crop output is affected by climate change and unpredictable weather conditions. Agricultural research and crop production statistics show that climate variability affects crop productivity [9–13].

With these, farmers usually look at other alternatives to adapt to climate variability. Some farmers engaged in diversified farming system strategies to minimize risk from farming. Farmers may benefit from diversification to mitigate various risks, including price risk, yield risk, input, and output market concerns [14]. Through this, farmers will have a stable income and food security at the household level. Thus, the interest of the study was to determine the productivity and income from different rubber-based farming system models in Cotabato Province, Philippines. Specifically, it aimed to (a) estimate the productivity of the rubber-based farming system model, (b) compare the productivity of the different rubber-based farming system models, and (c) estimate the income from the different rubber-based farming system models.

2. Materials and methods
The study took place in Cotabato's primary rubber-producing municipalities, where farmers used a rubber-based farming technique. The province has a land area of 9,008.90 km². It is considered a major food basket on the island of Mindanao, Philippines. It is one of the top producers of cereals, tropical fruits, vegetables, sugarcane, coffee, and other high-valued crops, freshwater fish, and livestock (see a map of the study area below). The province was chosen as a study site since SOCCSKSARGEN Region is one of the top producers of rubber in the Philippines, and Cotabato Province is the top among the provinces in the region. Almost 91% of the area planted with rubber in the region is found in the province of Cotabato. This research was carried out in 2016.

The respondents of the study were the rubber-based farmers (including their wives who are actively participating in every decision-making in the farm, from production processes to the marketing of rubber by-products). The respondents were chosen from a list provided by the Provincial Agriculture Office and several Municipal Agriculture Offices. Fifty-seven (57) respondents were found who perform rubber-based farming, with 32 of them engaged in rubber with banana farming, 8 in rubber with cacao farming, and 7 in rubber with coconut farming. Personal interviews with respondents and a field survey and observation were used to acquire the primary data. Key informant interviews were conducted with rubber experts from the Municipal Agriculture Office and the Philippine Rubber Research Institute Satellite Office in the province. The collected data was analyzed using a cost-benefit analysis.
3. Results and discussion

3.1. Cost and return of farming model 1 (rubber + banana)

Most of the rubber farmers used the RRIM 600 variety with an average of 350 trees/ha with an average price per seedling of PHP 17.75, while other farmers used PB 260 with the cost per tree amounted to PHP 19.13. The average area tilled in this model was 1.7 hectares. Out of 1.7 ha, 0.8 ha is intended for the banana, and the remaining is for rubber production. In terms of production, the estimated volume of rubber production per year was 8,221.92 kg at the price of PHP 17.77/kg. Thus, the estimated income of the farmers from rubber production amounted to PHP 146,103.52 (Table 1). This inter-cropping system, particularly crops like bananas, provides the producers with additional income [15].

On the other hand, the estimated volume produced/year was 1,838.28 kg sold at an average price of 10.22 kg for banana production. The gross income from rubber and banana for this model was PHP 164,890.74, while the total expenses amounted to PHP 58,816.06, with the estimated net income amounting to PHP 106,074.68. The costs involved in producing rubber and banana are land preparation, payment for the planters, fertilizers, pesticides, payment for the harvesters/tappers, and maintenance cost. The payment for the harvesters, which was dependent on total production, was the most significant cost faced by the farmers in this scheme. The sharing scheme adopted was 70–30% in favor of the

Figure 1. Map of the study area.
landowner/farmer from the total produced. It means that out of 100 kg produced, 70% went to the owner’s share, and the remaining 30% goes to the harvester’s share. Rubber tapping is one of the sources of income among harvesters. For instance, in other countries, smallholder families tap rubber and collect latex as a side-line aside from other sources of income [16–19].

Moreover, herbicide application was the least cost paid for the laborers hired because farmers usually did not apply herbicide in their farms and just did manual weeding. Further, the growth of weeds was not a major problem for the farmers in the rubber-based production system. Further, the banana production cost in this model was for the laborers hired in land preparation, planting, fertilizer application, and herbicide application. Farmers usually hired at least two laborers for the activities mentioned above. The payment for the laborers hired usually ranged average PHP 150.00/day. Sometimes, other farmers used self-owned resources to do the activities. Most of the farmers used self-owned resources to do the harvesting activities. In terms of marketing, the buyer goes to their respective farms and buys the commodity.

In terms of fertilizer cost, it was estimated that the average number of bags of fertilizer used by the farmers in their farms was five (5) bags/year, at 50 kgs/bag with an average price of PHP 800.00/bag. The total cost of fertilizer reached PHP 4,000.00/year. On the other hand, the average volume of pesticide used was 1.5 liters. Rubber trees are not vulnerable to pests and diseases; thus, the cost of pesticides is minimal. Since it is an integrated farming system, the fertilizer and pesticide used for one commodity might also affect other commodities in the whole system. The estimated total cost of fertilizers and pesticides for this model reached PHP 8,920.00/year.

| Variable                        | Volume produced, kg/year | Selling price/kg, PHP | Amount, PHP/year |
|---------------------------------|--------------------------|-----------------------|------------------|
| Gross income                    |                          |                       |                  |
| rubber                          | 8,221.92                 | 17.77                 | 146,103.52       |
| banana                          | 1,838.28                 | 10.22                 | 18,787.22        |
| Total gross income              |                          |                       | 164,890.74       |
| Cost of production              |                          |                       |                  |
| labor (rubber)                  |                          |                       | 47,496.06        |
| labor (banana)                  |                          |                       | 2,400.00         |
| fertilizer and pesticides (rubber & banana) | |                       | 8,920.00         |
| The total cost of production    |                          |                       | 58,816.06        |
| Estimated net income            |                          |                       | 106,074.68       |

Note: Average farm size: 1.7 ha; out of 1.7 ha, 0.8 ha was intended for banana

3.2 Cost and return of farming model 2 (rubber + cacao)

The average farm size tilled by the farmers in this model was 1.5 ha. of which 1 ha was intended for rubber, 0.4 ha for cacao, and the remaining was for backyard vegetable farming. The vegetable produced was primarily used for family consumption only. The result revealed that the estimated total volume of rubber and cacao production was 7,120.08 kg/year and 680.04 kg/year, with the average selling price of PHP 17.00 and PHP 19.33, respectively (Table 2).

The total gross income of rubber and cacao reached PHP 134,186.53, while the total expenses amounted to PHP 45,827.41 with an estimated net income of PHP 88,359.13. Rubber farming may be profitable but is also risky due to fluctuating price of rubber [20]. However, this diversified farming system can help farmers maximize their utility and mitigate the different risks [14]. The costs involved in producing rubber and cacao were land preparation, payment for the planters, fertilizers, pesticides, payment for the harvesters/tappers, and maintenance cost.
In farming model 2, production practices involved the cost for the paid laborer for land preparation, planting, fertilizer, herbicide application, and harvesting. The average man-animal days hired to do the preparation and planting activities was three, while for fertilizer and pesticide application, it has an average of 2 man-animal days.

The average number of bags of fertilizer used by the farmers was three bags, while 1.5 liter was the average volume of pesticides used. The estimated cost for fertilizer and pesticides amounted to PHP 4,050. It implies that the cost of this rubber-based farming model is minimal. Overall, this farming system was profitable and promising to farmers. Farmers can boost their income by intercropping cocoa, rubber, and timberland [21]. Compared to monocultures of cacao trees, intercropping cacao with other crops can help stabilize earnings [22].

**Table 2. Cost and return of farming model 2 in major rubber areas of North Cotabato, 2016.**

| Variable                  | Volume produced, kg/year | Selling price/kg, PHP | Amount, PHP   |
|---------------------------|--------------------------|-----------------------|---------------|
| Gross income              |                          |                       |               |
| rubber                    | 7,120.08                 | 17                    | 121,041.36    |
| cacao                     | 680.04                   | 19.33                 | 13,145.17     |
| Total gross income        |                          |                       | 134,186.53    |
| Cost of production        |                          |                       |               |
| labor (rubber)            |                          |                       | 40,497.41     |
| labor (cacao)             |                          |                       | 1,280.00      |
| fertilizer and pesticides |                          |                       | 4,050.00      |
| The total cost of production |                        |                       | 45,827.41     |
| **Estimated net income**  |                          |                       | **88,359.13** |

Note: Average area tilled: 1.5 ha

3.3 Cost and return of farming model 3 (rubber + coconut)

The average farm size in farming model 3 was 2 hectares. Results showed that rubber and coconut production reached 8,400 kg/year and 1,496 kg/year. The coconut farmers conduct harvesting four times a year. The estimated average selling price of coconut (i.e., copra) was PHP 26.00/kg, and for rubber, it was PHP 18.40 (Table 3). Moreover, the estimated total costs of coconut and rubber production amounted to PHP 66,478.00. The costs incurred in coconut production include labor and transportation. The estimated net income from this farming model reached PHP 126,978.00. This farming model utilized an average of 2–3 man-animal days for land preparation and pesticide application. Many farmers used self-owned resources to do farm activities, and the family usually engaged in the production process and decision-making on the farm.

The average cost for rubber production during land preparation, planting, fertilizer application, pesticide application, and harvesting was around PHP 5,400, PHP 1,530, PHP 2,800, PHP 1,360, PHP 46,368, respectively. Thus, it has an estimated cost of around PHP 57,458. As to the used of fertilizer for this farming system, the average number of fertilizers used for rubber and coconut was two and four bags, respectively. Each bag weighs 50 kg at an average price of around PHP 750 each. The overall estimated cost of fertilizer used in this model is around PHP 7,100. Around PHP 3,900 was intended for rubber fertilization, and PHP 3,200 was for fertilizing coconut trees.
Table 3. Cost and return of farming model 3 in major rubber areas of North Cotabato, 2016.

| Variable          | Volume produced, kg/year | Selling price/kg, PHP | Amount, PHP   |
|-------------------|--------------------------|------------------------|---------------|
| Gross income      |                          |                        |               |
| rubber            | 8,400                    | 18.4                   | 154,560.00    |
| coconut           | 1,496                    | 26                     | 38,896.00     |
| Total gross income|                          |                        | 193,456.00    |
| Cost of production|                          |                        |               |
| rubber (cost of labor) |                  |                        | 57,458.00    |
| coconut (cost of labor) |                   |                        | 1,920.00     |
| fertilizers and pesticides |                   |                        | 7,100.00     |
| Total cost of production |                      |                        | 66,478.00    |
| **Estimated net income** |                  |                        | 126,978.00   |

Note: Average area tilled: 2 ha

3.4. Comparison of yield performance of the different rubber-based farming system models in Cotabato Province, Philippines, 2016.

Table 4 shows the yields from different rubber-based farming system models in Cotabato Province, Philippines. The result shows that yield of rubber differs among the different farming systems. The rubber yield from FM1, FM2, and FM3 was 8,222.92 kg/yr, 7,120.08 kg/yr, and 8,400 kg/yr, respectively*. Based on the study results, FM3 provides the highest yield among the different rubber-based farming models. A mature rubber tree usually 20–30 meters high in a mono-cropping rubber production system can yield around 907.185 kg/ha/yr to 1,632.93 kg/ha/yr [23]. This study shows that rubber farmers can gain higher income with the diversified farming system than the mono-cropping system. The benefits of intercropping on rubber growth are sustained to maturity, leading to higher economic benefits for farmers [15].

Furthermore, it reduces the cost to the farmers, increasing income, since it has been found that intercropped rubber has outperformed the sole crop even without fertilizer inputs to banana in rubber/banana intercrops [24]. The amount of fertilizer used was anticipated to vary depending on the farming system model. In FM1, the amount of fertilizer used in the production was 5 bags/year, while in FM2, and FM3 were 3 bags/year, and 6 bags/year, respectively. The 3 models are very useful in guiding the farmers for better opportunities, increasing welfare, and reducing risks. Aside from rubber production, other crops like banana, cacao, and coconut provide better performance in terms of yield.

Table 4. Yield from the different rubber-based farming models in Cotabato Province, Philippines, 2016.

| Farming model (FM) | Crops  | Yield, kg/yr |
|--------------------|--------|--------------|
| FM 1 (rubber + banana) | Rubber | 8,222.92     |
|                    | Banana | 1,838.28     |
| FM 2 (rubber + cacao) | Rubber | 7,120.08     |
|                    | Cacao  | 680.04       |
| FM 3 (rubber + coconut) | Rubber | 8,400.00     |
|                    | Coconut| 1,496.00     |

*Note: Average farm size for FM1= 1.7 ha; FM2= 1.5; FM3= 2 ha

3.5. Comparison of income from the different rubber-based farming system models in Cotabato Province, Philippines, 2016.

Table 5 shows the income from different rubber-based farming system models in Cotabato Province, Philippines. Among the 3 farming models, FM3 provides the highest yields to the farmers. It implies a higher income among the farmers engaged in this kind of farming system model.
The income derived from farming model 3 is enough to provide for the family’s basic needs for the whole year. Because most farmers’ households had four to six members, and a family of five living in Cotabato Province required at least PHP 10,056.00 per month to meet basic food and non-food needs in 2019 [25].

Table 5. Income from different rubber-based farming models in Cotabato Province, Philippines, 2016.

| Farming model (FM)                  | Total income/year, PHP | Total cost/year, PHP | Net income/year, PHP |
|-------------------------------------|------------------------|----------------------|-----------------------|
| FM1 (rubber + banana)               | 164,890.00             | 58,816.06            | 106,074.68            |
| FM2 (rubber + cacao)                | 134,186.53             | 45,827.41            | 88,354.13             |
| FM3 (rubber + coconut)              | 193,456.00             | 66,478.00            | 126,978.00            |

4. Conclusions
There were three different types of rubber-based farming system models investigated in this study, namely: farming model 1 (rubber + banana), farming model 2 (rubber + cacao), and farming model 3 (rubber + coconut). The three models differ in their production practices and the average man-animal days in doing farm activities. It also varied since different models have different activities performed.

In terms of production/ yield performance of rubber as a based crop, farming model 3 provides better and high performance among the 3 models. It was followed by farming model 1 and farming model 2, respectively. Further, it was also consistent that farming model 3 has a better performance among the three models in terms of total and net income from production. Thus, rubber is more productive when it integrates to coconut and follows by integrating banana and cacao.

Generally, the farmers’ income increases with the different rubber-based farming systems compared to the monocropping system. The farmers’ income did not solely depend on rubber production but also other income from other crops grown. As their income increases, they were able to support the needs of their families. Lastly, this study could be a basis for the farmers to possibly adapt to this kind of farming system to increase income and lessen the risks from farming. It could also be a basis for the policymakers to plan for future agricultural development in the area.

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