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The ecology, productivity and economic of swiftlet (*Aerodramus fuciphagus*) farming in Kota Bangun, East Kalimantan, Indonesia

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Abstract. *Mursidah, Lahjie AM, Masjaya, Rayadin Y, Ruslim Y. 2020. The ecology, productivity and economic of swiftlet* (Aerodramus fuciphagus) *farming in Kota Bangun, East Kalimantan, Indonesia. Biodiversitas 21: 3117-3126.* Swiftlet nest is a high-value non-timber forest product produced from the saliva of swiftlet birds. While the demands for this commodity continue to increase in global market, careless harvesting techniques have diminished the swiftlet population and the production of swiftlet nests, threatening its sustainability. One effort to solve this problem is by developing swiftlet farming which involves building swiftlet. This research aimed to analyze the ecology, productivity, and financial feasibility of swiftlet farming of different-sized swiftlet houses in Kota Bangun Subdistrict, East Kalimantan, Indonesia. This research used qualitative and quantitative analysis methods. Data were collected using purposive sampling to determine the location, sample of swiftlet houses, and interviews with respondents. Quantitative analysis on the financial performance of swiftlet farming was analyzed using the net Benefit-Cost Ratio (net B/C), Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PP) methods. The results showed that swiftlet nest production in Kota Bangun begins in the third year and ends between 27 and 45 years later, depending on the age and size of the house as well as the quality of the timber. The swiftlet house with a size of 512 m^2 had the net B/C of 4.06, NPV of IDR 1,403.79 million, IRR of 30%, and PP of 5.44 years. The swiftlet house with a size of 1,600 m^2 had the net B/C of 2.27, NPV of IDR 1,774.83 million, IRR of 24.09%, and PP of 9.4 years. Our study suggests that swiftlet farming is financially highly feasible, especially for the swiftlet house with a size of 512 m^2.

Keywords: *Aerodramus fuciphagus*, feasibility, financial analysis, swiftlet farming, swiftlet nest

INTRODUCTION

Forests contain enormous biodiversity which enables them to provide a range of products, including both timber and non-timber forest products. The swiftlet's nest is a non-timber forest product produced by swiftlets (*Aerodramus, Collocalia*). Swiftlet is both ecologically and economically beneficial for environment as well as for humans. From ecological perspective, swiftlets serve as biological predators against insects considered pests for cultivated plants. From economic views, swiftlet nests are considered as precious and luxury products, making it highly-priced in global market (Nugroho and Budiman 2013) and often being termed as "the caviar of the East" (Thorburn 2015; Connolly 2016; Looi et al. 2016) or "tropical white gold".

White swiftlet nests are among the animal products that have high selling prices, reaching IDR 40 million per kilogram in the world export market (Sankaran 2001, Lidyana 2019). This price is four times the price of raw swiftlet nests at the farm level, which is IDR 10 million per kilogram (Shukri et al. 2018). Indonesia alone dominates 75% of the swiftlet nest exports in global market (60% is exported to China, 25.7% to the United States and the rest is exported to other countries) while the rest is supplied by Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (Nugroho and Budiman 2013; Nurshuhada et al. 2015).

Morphologically, swiftlet has a pair of glandulla salivales under its tongue which produce saliva (Shah and Aziz 2014). The more food consumed by the swiftlet, the more saliva is produced, resulting in higher production of swiftlet nests and eventually benefiting the farmers or gatherers that collecting such nests (Nugroho and Budiman 2013). Foraging of insects is the main feeding activity of swiftlets and this activity is influenced by the occurrence and the quality of forest as the habitat of the insects (Adiwibawa 2000; Oliver et al. 2014; Rahman et al. 2019). The preferred habitats for swiftlets are open waters, forests, and rice fields. In these habitats, many flying insects can be found by the swiftlets as the food sources (Petkliang et al. 2017; Ahmad et al. 2019). In case that swiftlets are farmed, the availability of abundant food sources affects the swiftlets entering the swiftlet houses built by farmers (Ibrahim et al. 2009; Idris et al. 2014).

Swiftlet nests are commonly used as herbal medicine (Vimala et al. 2011; Roh et al. 2012; Zhang et al. 2012; Lee et al. 2019), including for maintaining health (Ma and Liu 2012; Careena et al. 2018) and as a supplement for the skin

(Chan et al. 2015; Babji and Daud 2019; Daud et al. 2019). They are also used to produce luxurious foods and beverages (Chua and Zukefli 2016).

Commercial swiftlet nests are produced from swiftlet farming and gathered from caves. The easiest way to assess swiftlet nest quality is by looking at its physical appearance (Jamaluddin et al. 2019). There are several types of swiftlet nests in Indonesia, including the original nest (Bowl AAA, bowl), red nest (red swiftlet nest), triangle nest (corner), yellow or white swiftlet nest, strip nest, and broken nest. Swiftlet nests produced from Kalimantan are considered as the best quality in Indonesia since they have white color due to the high quality of environment affected by the good forest cover and little pollution (Nugroho and Budiman 2013). In East Kalimantan, the main production areas for bird nests are the districts of Kutai Kertanegara, East Kutai, West Kutai and Berau (Candra 2007).

The main problems in swiftlet nest industry are market value and productivity in which both factors are intertwined (Nor et al. 2016). The increase of swiftlet nets demands and price especially in global market, has triggered the overexploitation of swiftlet nest, often using rampant technique. Eventually, this situation results in the reduction of swiftlet population and the nests production, and leads to a more careless collection without regard to sustainability (Lahjie et al. 2018a; Manchi and Sankaran 2010).

The high price of swiftlet nests and the more limited resources of swiftlet nests collected from the wild have encouraged people to increase swiftlet nests production by developing swiftlet farming using swiftlet houses (Kamaruddin et al. 2019). The materials and sizes of swiftlet houses vary depending on the land area and the available capital. While the interest of swiftlet farming is increasing, considerations when developing swiftlet farming business include feasibility, prospective benefits and profits are still lacking (Sososutiksno and Gasperz 2017; Asciuto et al. 2019). This research aimed to analyze the productivity and financial feasibility of swiftlet farming of different-sized swiftlet houses in Kota Bangun Subdistrict, Indonesia. Kota Bangun Subdistrict is an excellent case study for this research as this is one of the sub-districts in Kalimantan where many people put their interest to develop swiftlet houses.

MATERIALS AND METHODS

Study area

This research was carried out in Kota Bangun Subdistrict, Kutai Kartanegara District, East Kalimantan Province, Indonesia. The study site was located at geographical coordinates of 00°16’55.2” S and 116°35’38.4” E (Figure 1). The swiftlet farming practice observed was selected based on the size of the swiftlet farming building.

Data collection

The study was conducted for 5 months between June 2019 and October 2019 which included research preparation, primary and secondary data collection, data analysis and report writing. Data collected in this study included primary and secondary data. Primary data was obtained through fieldwork on the studied object, while secondary data was obtained from available reports or documents.

Data were obtained through direct observations in the field and interviews using questionnaires. The determination of the sample used the purposive sampling technique, with certain considerations of the criteria that must be met by the samples used in this study (Sugiyono 2016). The respondents were selected to them being swiftlet farmers with productive swiftlet houses of different sizes (512m^2 and 1,600m^2). Interviews were conducted by asking the prepared questions in questionnaires (namely the stage of business, investment costs, operational costs, production, selling prices, revenue, and marketing) with clarifications from the respondents if necessary (if the answer given is unclear).

Direct observations were made of swiftlet farming conditions and the community’s activities in relation to swiftlet farming, include swiftlet house designs, types of woods used for swiftlet house, ways of feeding, and ways of harvesting. This method aimed to obtain objective descriptive information that could be used to support the data collected through the interviews.

Model of business scale

The scale of business was distinguished by the extent of swiftlet house. Based on the direct observation, we divided the size of swiftlet house into two: 512 m^2 and 1,600 m^2. Table 1 shows the business scale of swiftlet farming by including length, width, area, height of each floor and number of floors in the swiftlet house.

To provide an overview of swiftlet farming and swiftlet nest production, study data are presented descriptively and quantitatively.

Table 1. The business scale of swiftlet farming, including length, width, area, height of each floor and number of floors in the swiftlet house

Model of business scale	Length (m)	Width (m)	Area (m^2)	Height of each floor (m)	Number of floors
Model 1	16	8	512	2	4
Model 2	40	8	1,600	2	5

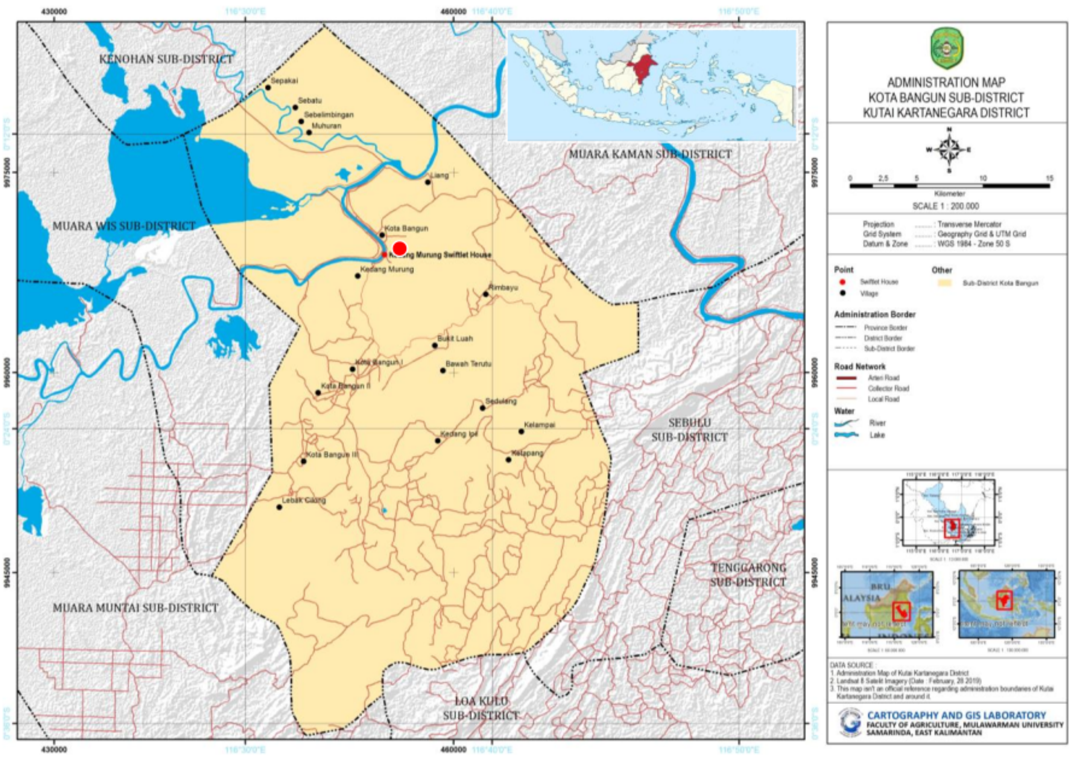

Figure 1. The location of the research (●) in Kota Bangun Subdistrict, Kutai Kartanegara District, East Kalimantan Province, Indonesia

Production evaluation

Production was calculated for each year of the economic life of the swiftlet house and then the average production per year (AP) and marginal production (MP) were calculated as follows (Rosyidi 2009):

$$AP = \frac{Pt}{t}$$

Where; AP: average product (kg year^{-1}), Pt: production at age t(kg), and t: age(years))

$$MP = \frac{P_t - P_{t-1}}{t - t_{-1}}$$

Where; MP: marginal product (kg), P_t: production at age t (kg), P_{t-1}: previous production (kg), and t: age (years).

Then production data, in the form of production, AP and MP are presented in a polynomial curve.

Financial analysis

Financial feasibility was analyzed by considering the net benefit-cost ratio (Net B/C), net present value (NPV), internal rate of return (IRR) and payback period (PP) (Arshad 2012; Banerjee 2015; Constantinescu 2010; Mackevičius and Tomaševič 2010; Kunio and Lahjie 2015; Hopkinson 2016; Setiawan et al. 2019).

Net benefit-cost ratio (net B/C)

Net B/C is a comparison between the present value of a positive net benefit and the present value of a negative net benefit.

$$Net B/C = \frac{\sum_{t=1}^{n} NBt(+)}{\sum_{t=1}^{n} NBt(-)}$$

If Net B/C > 1, the project (business) is feasible or profitable, but if Net B/C < 1, the project is not feasible, and if Net B/C equals 1 the project is neither profitable nor losing capital.

Net Present Value (NPV)

Net present value is the difference between the present value of benefits and the present value of costs.

$$\text{NPV} = \sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t}$$

Where; Bt: benefit or gross profit at year t, Ct: cost at year t, i: discount factor, and n: economic age of the project).

If NPV > 0, the project is feasible or profitable, but if NPV < 0, the project is not feasible, and if NPV: 1, the project is neither profitable nor taking a loss.

Internal Rate of Return (IRR)

IRR is a discount rate that can formulate the NPV of a project as equal to zero or the benefit-cost ratio equals one.

$$\text{IRR} = i' + \frac{NPV'}{NPV' + NPV''}(i'' - i')$$

Where; NPV': positive NPV, NPV": negative NPV, i': the interest rate when NPV is positive, and i": the interest rate when NPV is negative.

If IRR > i, the project is feasible or profitable, but if IRR < i, the project is not feasible, and if IRR: i is is neither profitable nor taking a loss.

Payback Period (PP)

The payback period is the time required to return all the costs incurred by the project, or the period needed to return capital invested using proceeds or net cash flow.

$$\text{PP} = n + \frac{(a-b)}{(c-b)} \times 1 \ years$$

Where; n: the final year that the cash flow was not able to cover the initial investment capital, a: the amount of initial investment, b: the cumulative cash flow for the year n, c: the accumulated amount of cash flow for n + 1 year.

If PP < economic age of the project, the project is feasible or profitable, but if PP > economic age of the project, the project is not feasible, and if PP is equal to the economic age of the project is neither profitable nor taking a loss.

RESULTS AND DISCUSSION

Swiftlet farming

Swiftlet species farmed in Kota Bangun is white nest swiftlets (*Aerodramus fuciphagus*). Swiftlet farming in Kota Bangun has grown rapidly. The high selling price of swiftlet nests is the main reason in a swiftlet farming business (Thorburn 2015). The average price of raw swiftlet nest at the time of the study was IDR 10 million per kilogram.

The business of swiftlet farming begins with building a swiftlet house. In general, the selection of materials and the size of swiftlet houses is based on investment costs and the extent of land owned by the swiftlet farmer (Nor et al. 2016). The higher the quality of the material used, the longer the life span of the swiftlet house (Ramage et al. 2017). Based on observation, most of the swiftlet houses in Kota Bangun Subdistrict were constructed using wood materials. Types of wood used for the swiftlet houses included ulin (*Eusideroxylon zwageri*), meranti (*Shorea* spp.), and kelampayan or jabon (*Neolamarckia cadamba* or *Antocephalus cadamba*) (Figure 2). The increasing price of wood and the limited capital are the reasons for swiftlet farmers to purchase cheaper wood, despite the lower durability which results in a shorter investment life. In the studied areas, the studied houses were constructed using ulin and meranti (Figure 3).

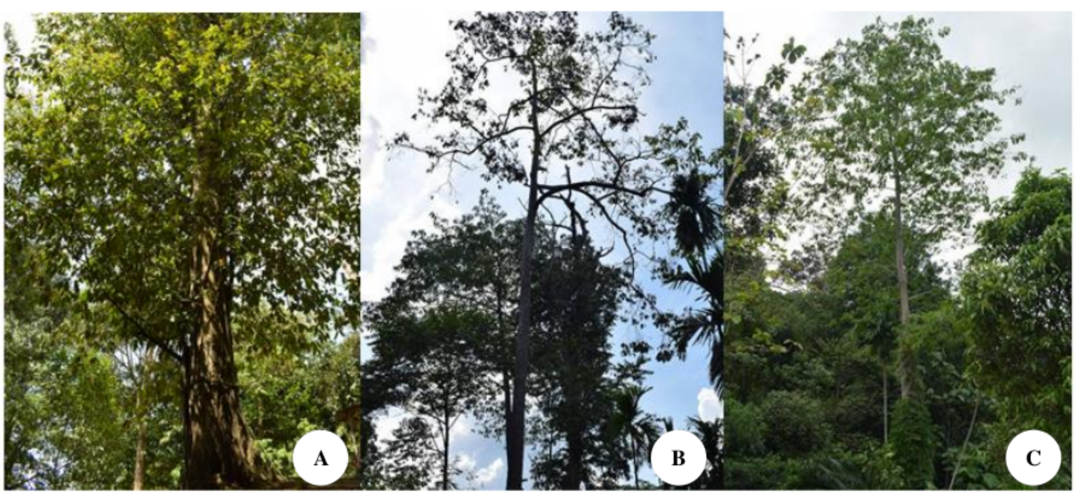

Figure 2. Timber species commonly used to build swiftlet house: A. Ulin (*Eusideroxylon zwageri*); B. Meranti (*Shorea* spp.); C. Kelampayan/jabon (*Neolamarckia cadamba/Antocephalus cadamba*)

Figure 3. The structure of swiftlet house: A. The swiftlet houses; B & C wood materials to build swiftlet houses

Figure 4. Stages of making the swiftlet nests and swiftlet breeding until the swiftlet nests are ready to be harvested. A. Flap where smear the swiftlet nest; B. Swiftlet eggs; C. Newly hatched swiftlet chicks; D. 10-day-old swiftlet chicks; E. 17-day-old swiftlet chicks; F. 21 to 30-day old swiftlet chicks; G and H. The swiftlet chicks are ready to fly; I. The swiftlet nests are ready to be harvested

Swiftlet houses are built in diverse sizes with different numbers of floors. The minimum size is 4.0 m x 4.0 m, while the ideal size for a room system is 8.0 m x 16.0 m (Nugroho and Budiman 2013). The size of the swiftlet houses in this study was 8.0 x 16.0 m and 8.0 m x 40.0 m. The height of each floor was 2 meters as recommended by Nugroho and Budiman (2013). While the minimum height of the ceiling is 2 m with an ideal height being 2.5 to 3.0 m. The swiftlet farmers in this research chosen these sizes to facilitate the harvesting process. Figure 3A shows the swiftlet house with an extent of 1600 m^2 and the general design found at the study site.

Swiftlet breeding begins with swiftlets mating to produce eggs. The mother swiftlet will build a nest (alternately applying its saliva), alternately for the whole process of mating and then incubating, and hatching eggs, as well as caring for the swiftlet chicks (by feeding the chicks) until they are ready to fly (Nugroho and Budiman 2013) (Figure 4).

Table 2. The costs incurred in swiftlet in Kota Bangun, East Kalimantan, Indonesia

Cost item	Million IDR		%	
	512 m^2	1,600 m^2	512 m^2	1,600 m^2
Investment cost				
Building	440.84	1,488.54	16	14
Equipment	330.63	1,382.22	12	13
Soundsystem	303.08	1,383.22	11	13
Operational cost				
Harvesting	468.39	1,807.51	17	17
Security	385.74	1,275.89	14	12
Cleaning and maintenance	275.53	1,275.89	10	12
Taxes	275.52	1,063.24	10	10
Management	275.53	932.62	10	9

Diet

Swiftlets prey on insects for their daily diet (Ahmad et al. 2019; Lourie and Tompkins 2000; Nituda and Nuneza 2016; Rahman et al. 2016), which are then processed into food balls, with the weight of the whole food balls ranging from 1.69 to 14.04 g (Langham 1980). The diversity of insects is dependent on the surrounding ecosystem (Speight et al. 1999).

Based on observation, the swiftlet farmers used crickets (*Gryllus assimillis*) for the main diet of the swiftlet in which the crickets were dried and mashed and then fed to the swiftlet using an assembled feed flusher at an amount of 2-3 g per bird per day, or an average of 2.5 g per bird per day. Thus, the need for feeds increases with the increase in productive swiftlet population in a swiftlet house. For a swiftlet house measuring 512 m^2 with a population of 3,500 birds, the feed requirements were 8.75 kg per day, or up to 3,193.75 kg per year. For swiftlet house measuring 1,600 m^2 with average population of 7,000 bird, the feed requirements were 17.5 kg per day, or up to 6,387.5 kg per year. Feed cost will be included in operational costs (with taxes counted).

Cost

Cost incurred in swiftlet farming included investment costs and operational costs (Nugroho and Budiman 2013). For a swiftlet house of 512 m^2, the total cost incurred was IDR 2,755.25 million (or IDR 102.25 million per year on average) with the highest cost was for harvesting (17%) and the lowest was for cleaning and maintenance, taxes and management (10%) (Table 2). For swiftlet house of 1,600 m^2, the total cost incurred was IDR 10,632.44 million (or IDR 236,28 million per year on average cost) with the highest cost was for harvesting (17%) and the lowest was for management (9%).

Production, population, and density of swiftlet houses

Swiftlet nests are able to be harvested beginning in the third year. Theoretically, optimal population density in the swiftlet houses is reached between the third and fifth years (Kuan and Lee 2005). There are several harvesting patterns including hatching, booty harvesting, egg disposal and selected harvesting (Nugroho and Budiman 2013). Swiftlet farmers in Kota Bangun have adopted the hatchery harvest pattern, which happens after the swiftlet lays eggs and leaves. The advantage of this harvesting pattern is to give the swiftlet the opportunity to breed, allowing regeneration to take place and the swiftlet to feel comfortable, while the disadvantage is it can cause dirty swiftlet nests that can reduce the selling price.

Business model 1 (512 m^2 swiftlet house)

The swiftlet house at this scale had 16 m long and 8 m wide and consisted of four floors with a presumed economic life span of 27 years. The swiftlet nests were harvested in the 3rd year with a total production of 18 kg. Production continuously increased and finally reached its highest production (i.e. 54 kg) in the 15th year. Based on the average product (AP) and marginal product (MP), optimum production is achieved in the 11th year (Table 3; Figure 5A).

The productive swiftlet population contained in the swiftlet houses determined the number of nests produced. Productivity of a swiftlet population is considered in terms of the number of nests produced. For the 512 m^2 swiftlet houses, a productive swiftlet population was started at the 3rd year with 900 birds. At the time of optimal production (11th year), the productive swiftlet population had reached 2,200. This swiftlet population continued to increase until the 16th year, when there were 2,700 birds. A decline in swiftlet population began to occur in the 17th year, when there were 2,650 birds. Population decline continued until the 27th year.

For a swiftlet house of 512 m^2, at the beginning of production period (3rd year) had a total production of 18 kg per year and an average distance between nests of 2.84 m. At the time of optimal production, the distance between nests was 1.64 m, while the distance between nests during the highest production (11th year) was 0.95 m. At this time, the maximum nest production was found on floors 1 and 2, with a distance between nests of between 0.70 and 1.00 m.

Business model 2 (1,600 m^2 swiftlet house)

The swiftlet house at this scale had 40 m long and 8 m wide and consisted of 5 floors with an economic life span of 45 years. The harvest of swiftlet nests began in the third year with an initial production of 14.50 kg. The swiftlet nest production increased every year and reached the highest production (i.e. 111 kg) in the 23rd year. Based on the AP and MP, optimum production was achieved in the 14th year (Table 4; Figure 5B).

For the 1,600 m^2 swiftlet house, the productive swiftlet population in the third year was 725 birds. In the 14th year, when optimal production was achieved, the swiftlet population was 4,200 in a swiftlet house. The increase in population continued until the 23rd year, when the swiftlet population reached 5,550 birds. The population began to decline the following year and continued to decline until the 45th year, when there were only 400 birds left.

For the 1,600 m^2 swiftlet house, the average distance between nests was 11.03 m in the third year (when production began). At optimal production, the distance between nests was 1.90 m on average. At the time of maximum production (the 23rd year), the average distance between nests was 1.44 m. Most nests were on the 1st and 2nd floor, with the distance between nests generally ranging from 0.30 to 0.90 m.

Financial analysis

The financial feasibility assessment of the swiftlet farming used Net B/C, NPV, IRR, and PP as its criteria. It was assumed that the applied discount factor was 10%.

Business model 1 (512 m² swiftlet house)

In this business model, the net B/C was 4.06, meaning that every IDR1 spent will provide a benefit of IDR 4.06 (Table 5). The net B/C value is greater than 1, indicating that this business is a valuable proposition. The NPV of this scale was IDR1,403.79 million, suggesting that this swiftlet farm is a viable business, because the NPV value is higher than zero. The IRR demonstrates the efficiency of investments (Romele 2013), with the value for the Business Model 1 was 30%. This business is considered feasible due to the IRR being higher than the discount factor. The PP for Business Model 1 was 5.44 years, and with an investment period of 27 years, this business is feasible because the capital will return before the investment period ends.

Table 3. The annual production of swiftlet nest using Business Model 1 (i.e. swiftlet house area is 512 m²)

Year	Production (kg)	Average Production/AP (kg year⁻¹)	Marginal Production/MP (kg)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	18.00	6.00	0.00
4	20.00	5.00	2.00
5	22.00	4.40	2.00
6	24.00	4.00	2.00
7	27.00	3.86	3.00
8	31.00	3.88	4.00
9	35.00	3.89	4.00
10	40.00	4.00	5.00
11	44.00	4.00	4.00
12	47.50	3.96	3.50
13	50.50	3.88	3.00
14	53.00	3.79	2.50
15	54.00	3.60	1.00
16	53.00	3.31	-1.00
17	51.50	3.03	-1.50
18	49.50	2.75	-2.00
19	47.00	2.47	-2.50
20	44.00	2.20	-3.00
21	40.50	1.93	-3.50
22	36.50	1.66	-4.00
23	32.00	1.39	-4.50
24	27.00	1.13	-5.00
25	21.50	0.86	-5.50
26	15.50	0.60	-6.00
27	8.50	0.31	-7.00

Business Model 2 (1,600 m² swiftlet house)

In this business model, the net B/C was 2.27, meaning that every IDR 1 spent will provide a benefit of IDR 2.27 (Table 5). This means the project is viable because the net B/C value is greater than 1. The NPV of IDR 1,774.83 million indicates that this swiftlet farm is viable because the NPV value is greater than zero. The IRR figure of 24.09% indicates that this business is feasible because the IRR is higher than the 10% discount factor. The PP for Business Model 2 is 9.40 years because the capital will be returned before the investment period ends (45 years); therefore, this business is feasible.

Table 4. The annual production of swiftlet nest using Business Model 1 (i.e. swiftlet house area is 1,600 m²)

Year	Production (kg)	Average Production/AP (kg year⁻¹)	Marginal Production/MP (kg)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	14.50	4.83	0.00
4	19.80	4.95	5.30
5	25.20	5.04	5.40
6	30.70	5.12	5.50
7	36.40	5.20	5.70
8	42.40	5.30	6.00
9	48.60	5.40	6.20
10	55.50	5.55	6.90
11	62.50	5.68	7.00
12	70.00	5.83	7.50
13	78.00	6.00	8.00
14	84.00	6.00	6.00
15	89.00	5.93	5.00
16	93.50	5.84	4.50
17	97.50	5.74	4.00
18	101.00	5.61	3.50
19	104.00	5.47	3.00
20	106.50	5.33	2.50
21	108.50	5.17	2.00
22	110.00	5.00	1.50
23	111.00	4.83	1.00
24	110.50	4.60	-0.50
25	109.50	4.38	-1.00
26	108.00	4.15	-1.50
27	106.00	3.93	-2.00
28	103.50	3.70	-2.50
29	100.50	3.47	-3.00
30	97.00	3.23	-3.50
31	93.00	3.00	-4.00
32	88.50	2.77	-4.50
33	83.50	2.53	-5.00
34	78.50	2.31	-5.00
35	73.50	2.10	-5.00
36	68.00	1.89	-5.50
37	62.50	1.69	-5.50
38	56.50	1.49	-6.00
39	50.50	1.29	-6.00
40	44.00	1.10	-6.50
41	37.50	0.91	-6.50
42	30.50	0.73	-7.00
43	23.50	0.55	-7.00
44	16.00	0.36	-7.50
45	8.00	0.18	-8.00

Table 5. The financial feasibility assessment of swiftlet farming in Kota Bangun, East Kalimantan, Indonesia

Model	House area (m^2)	Net B/C	NPV	IRR	PP
1	512	**4.06**	1,403.79	**30.00**	5.44
2	1,600	2.27	1,774.83	24.09	9.40

Note : House area (m^2); Net B/C: net benefit cost ratio (ratio); NPV: net present value (million IDR); IRR: internal rate of return (%); PP: payback period (year)

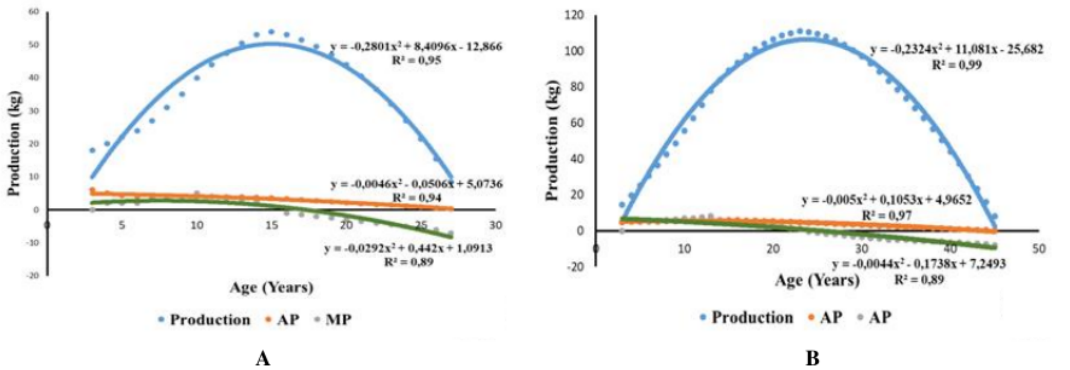

Figure 5. The production curve of swiftlet farming in Kota Bangun, East Kalimantan: A. Business Model 1; B. Business Model 2. Notes: AP: Average Production; MP: Marginal Production

The size of swiftlet houses and materials used are based on the investment capital of the swiftlet farm. Harvesting begins in the third year. The density of the swiftlet house determines the production. Increased production will continue to occur up to a maximum distance of 1m between nests. Swiftlet farming Model 1 and Model 2 are both financially feasible, based on the four criteria applied, but Business Model 1 is more viable than the Model 2 because it demonstrates higher net B/C, NPV and IRR values, along with a lower PP.

The structure and design of swiftlet houses in Kota Bangun Subdistrict are generally made of wood, consisting of several floors, with conditions that make the swiftlets comfortable to live and nest in. The type of swiftlets house in this study is single lots of building, with the aim to facilitate supervision and reduce interference from various activities in the vicinity (Rahman et al. 2019). Making swiftlet houses that are similar to their natural habitat is something that must be considered, including light intensity, temperature, air circulation and humidity to create a comfortable environment for swiftlets (Looi et al. 2016; Thorburn 2015). The swiftlets farmer has never specifically monitored the entry and exit of swiftlets into swiftlet houses (Chua and Zukefli 2016), as well as their diets. Feed supply still depends entirely on nature. Land cover in Kota Bangun District, which consists mainly of shrubs and forests, also supports the availability of flying insects as swiftlet feeds. In Thailand, wetland, forest and open paddy lands are the main sources of feed supply for swiftlets (Petkliang et al. 2017).

If seen from the financial valuation of the swiftlet house in Kota Bangun with a size of 512 m^2, it has a net B/C of 4.06, an NPV of IDR 1,403.79 million, an IRR of 30% and a PP of 5.44 years. The swiftlet house with a size of 1,600 m^2 had the net B/C of 2.27, an NPV of IDR 1,774.83 million, an IRR of 24.09% and a PP of 9.4 years. For swiftlet farming in Matan Hilir Subdistrict, Central Kalimantan, a net B/C of 2.27, NPV of IDR 287,642,243.80, IRR of 21.79%. and PP of 2 years 1 month (Yuniarti et al. 2013), while swiftlet farming in Telaga Antang District, Central Kalimantan net B/C of 2.19, NPV of IDR 334,415,629, IRR of 35.18% and PP of 4.4 years (Sumardi et al. 2018).

If the financial performance of swiftlet farming is compared to that of timber and non-timber forest products, then the financial performance of swiftlet farming is far better. In rubber plantation, net B/C of 0.93, NPV IDR of 3,240,000, IRR of 4.6% and PP of 17.4 years (Lahjie et al. 2018a). In the combination of rubber with *Shorea* spp. obtained a net B/C of 2.79, an NPV of IDR 58,999,000, an IRR of 8.7% and a PP of 20.2 years. Whereas financial performance on the combination of *Shorea* spp. with agarwood a net B/C of 6.4, NPV of IDR 160,688,000 IRR of 14% and PP of 9.7 years (Lahjie et al. 2018b).

The results of the study suggest that swiftlet nest production is highly dependent on the productive swiftlet population, the availability of food for swiftlets and the condition of the swiftlet houses built by swiftlet farmers. We found that the swiftlet house providing optimal production was 512 m^2. Increasing and decreasing populations caused by swiftlet-house size and swiftlet population were considered. Swiftlet population that is too dense will decrease swiftlet nest production. This can be overcome by making a new swiftlet house. Room cleanliness, sanitation and existence of predators were related to existing bird droppings. Types of wood used for swiftlet houses included ulin (*Eusideroxylon zwageri*) and meranti (*Shorea* sp.). Kelampayan or jabon (*Neolamarckia cadamba*/*Antocephalus cadamba*) and benuang (*Octomelus sumatrana*) are not recommended for swiftlet house because they rot quickly. This research was a part of efforts to preserve the population of swiftlets and to increase the production of swiftlet nests through farming in Kota Bangun Subdistrict, East Kalimantan. Policies are needed that are able to preserve population, production and availability of natural food, because these three things are interrelated. Policies that can be done by maintaining the presence of land cover (wetland, forest, and open paddy lands) as a natural habitat for flying insects which is a natural food swiftlet. The availability of feed sources will increase swiflet population, which will ultimately increase swiftlet nest production.

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