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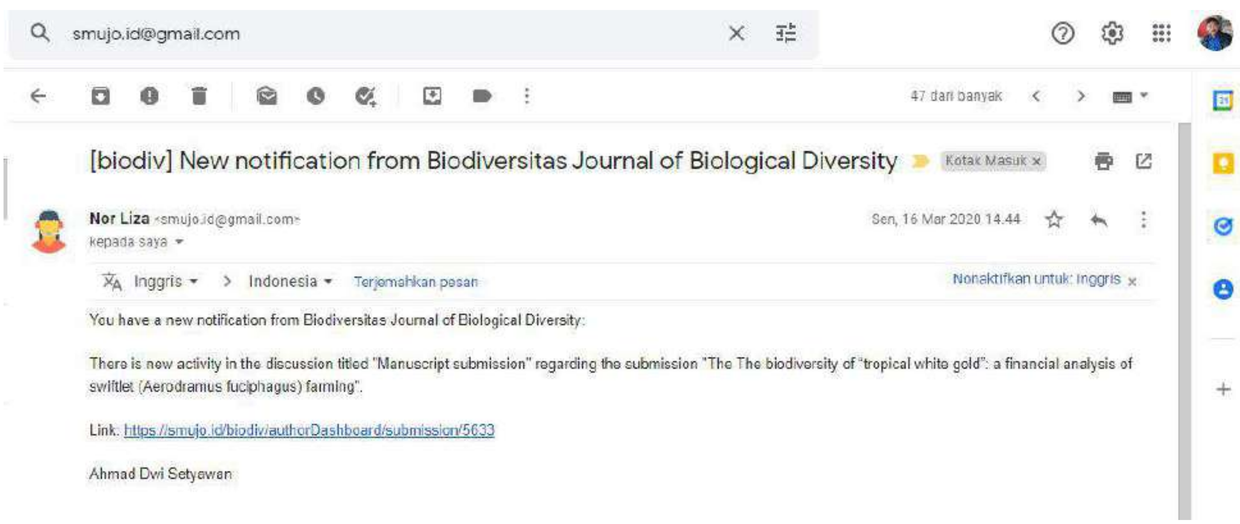

The biodiversity of "tropical white gold": a financial analysis of swiftlet (*Aerodramus fuciphagus*) farming

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Abstract. The swiftlet's nest is a high-value non-timber forest product. Harvesting techniques, which are not concerned with sustainability, diminish the swiftlet population and the availability of swiftlet nests while demand increases. Swiftlet farming involves making a swiftlet house to preserve the swiftlet population and meet the demand for swiftlet nests. A feasibility assessment for swiftlet farming is required, with objectives being to analyze the production and financial feasibility of the swiftlet-nest business in Kota Bangun District. This research was conducted between June and October of 2019 using descriptive qualitative and quantitative analysis methods. Financial feasibility was analyzed using the net B/C, NPV, IRR and Payback Period (PP) methods. This study used purposive sampling to determine the location and sample of swiftlet houses that were being observed. The results showed that swiftlet nest production 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. For example, for a swiftlet house with figures of 512 m^2, 4.06, IDR 1403.79 million, 30% and 5.44 years (area; net B/C; NPV; IRR; PP), the timespan would be 44 years. For a swiftlet house with figures of 1,600 m^2, 2.27, IDR 1774.83 million, 24.09% and 9.4 years (area; net B/C; NPV; IRR; PP). Based on the financial feasibility assessment, swiftlet farming is feasible.

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. The swiftlet is both ecologically and economically beneficial for the forest. Swiftlets are biological predators against insects considered pests for cultivated plants. Meanwhile, swiftlet nests are very valuable and economically efficacious (PS 2013), thus being termed the "caviar of the East" (Thorburn 2015; Connolly 2016; Looi et al. 2016) or "tropical white gold".

Morphologically, the swiftlet has a pair of glandulla salivales under its tongue (Shah and Aziz 2014). The more food consumed, the more saliva is produced, resulting in higher production of swiftlet nests, such that swiftlet farmers benefit (PS 2013). Foraging is very important for swiftlets and the forest land cover is the habitat of insects the swiftlet feeds on (Adiwibawa 2000; Oliver et al. 2014; Rahman et al. 2019). The preferred habitats for swifts are open waters, forests and rice fields. In these habitats, many flying insects are sources of food for the swiftlet (Petkliang et al. 2017, Ahmad et al. 2019). The availability of abundant food sources affects the swiftlets entering the swiftlet houses built by farmers.

Swiftlet nests are effective as herbal medicine (Lee et al. 2019), including for health (Careena et al. 2018; Ma and Liu 2012) 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 expensive foods and beverages (Chua and Zukefli 2016). Commercial swiftlet nests are derived from swiftlet farming and found in caves. Indonesia exports more than 75% of the swiftlet nests in the world, with the rest coming from Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (Nurshuhada et al. 2015; PS 2013).

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 from Kalimantan Island are considered the best quality in Indonesia. Swiftlet nests tend to be white because the environment still also contains many trees and little pollution (PS 2013). The easiest way to assess swiftlet nest quality is by considering its physical appearance (Jamaluddin et al. 2019).

Problems in the swiftlet nest industry, which are directly related, are market value and productivity (Nor et al. 2016). Nest collection is affected by reduction of the swiftlet population. The harvesting technique, which is not concerned with sustainability, has reduced the swiftlet population, such that the availability of swiftlet nests has decreased, while the demand has increased (Lahjie et al. 2018 ; Manchi and Sankaran 2010). To respond to this problem, swiftlet farming involves building swiftlet houses. Farming swiftlet houses in Indonesia has developed since the 1800s (Mardiastuti and Soehartono 1996).

The main production areas for bird nests in East Kalimantan are Kutai Kertanegara Regency, East Kutai Regency, West Kutai Regency, and Berau Regency (Candra 2007). Kota Bangun Subdistrict is one of the sub-districts in Kutai Kartanegara Regency where most of the population develops swiftlet nests. The high price of swiftlet nests has encouraged people to compete to build swiftlet houses. The materials and sizes of swiftlet houses vary depending on the land area and the available capital.

Considerations when choosing any business include feasibility, prospective benefits, and profits. Therefore, a financial feasibility assessment of swiftlet farming was required. This research's objectives were to analyze the productivity and financial feasibility of swiftlet farming in Kota Bangun Subdistrict using several different-sized swiftlet houses.

MATERIALS AND METHODS

Study area

This research was carried out in Kota Bangun Subdistrict, Kutai Kartanegara Regency, East Kalimantan, 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.

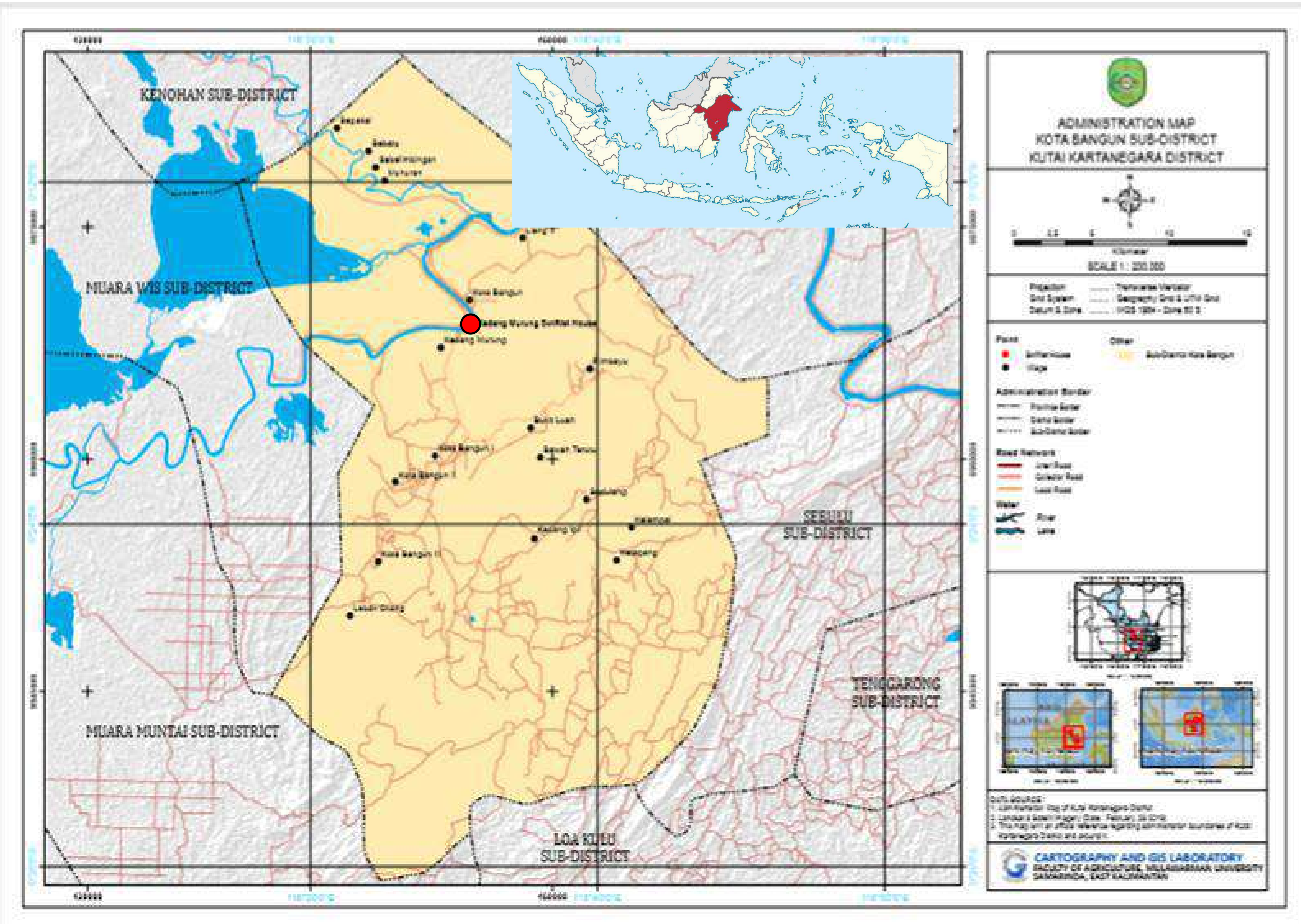

Figure 1. The location of the research (●) is in Kota Bangun Subdistrict (00°16'55.2"S, 116°35'38.4"E).

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 preparation reports. Data collected in this paper includes primary and secondary data. Primary data was obtained through direct research on the studied object, while secondary data was obtained from available reports or documents.

Data was obtained through interviews including questionnaires and observations in the field. The respondents were selected for 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 with clarifications from the respondents if necessary.

Direct observations were made of swiftlet farming conditions and the community's activities in relation to swiftlet farming. 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 is distinguished by swiftlet house area. However, there are two sizes of swiftlet houses observed: 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 is presented descriptively and quantitatively.

Table 1. the business scale of swiflet 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 floor
Model 1	16	8	512	2	4
Model 2	40	8	1,600	2	5

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 (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))

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; Hopkinson, 2016; Kunio and Lahjie 2015; Mackevičius and Tomaševič 2010； 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.

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

If Net B/C > 1, the project is feasible or profitable, but if Net B / C < 1, the project (business) 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.

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

(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 demanded 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 found in Bangun City are white nest swiftlets (*Aerodramus fuciphagus*) and they produce white swiftlet nests. Swiftlet farming in Kota Bangun has grown rapidly. A high selling price is the main reason for starting a swiftlet farming business (Thorburn, 2015).

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 amount 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. Most of the swiftlet houses in Kota Bangun Subdistrict are constructed using wood. Types of wood used for the swiftlet houses include ulin (*Eusideroxylon zwageri*), meranti (*Shorea sp*.), and kelampayan or jabon *(Neolamarchia cadamba or Antocephalus cadamba*) (see Figure 2). The increasing price of wood and the limited investment funds for swiftlet farmers are reasons for them to purchase cheaper wood, despite the diminished durability which results in a shorter investment life. The studied swiftlet houses were constructed using ulin and meranti (see Figure 3).

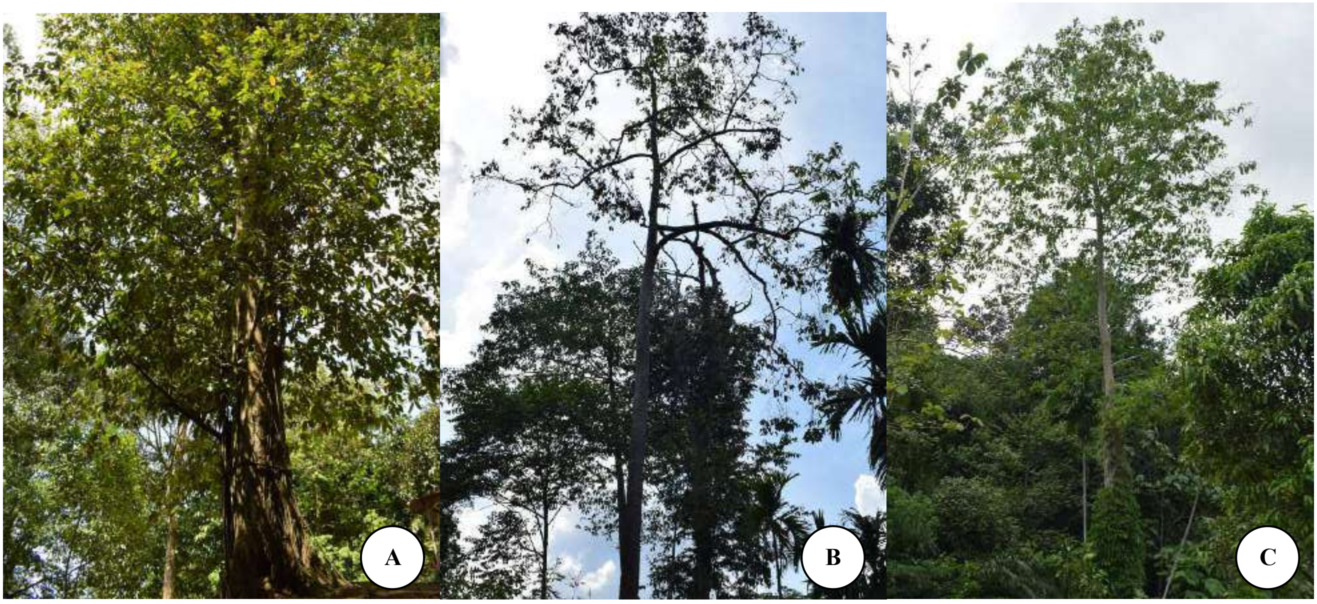

Figure 2. A. Ulin (*Eusideroxylon zwageri*); B. Meranti (*Shorea sp*.); C. Kelampayan/jabon *(Neolamarchia cadamba/Antocephalus cadamba*)

Figure 3. A. The swiftlet houses, woods B and C used for swiftlet houses

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 (PS 2013). The size of the swiftlet houses in this study were 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 the PS (2013), while the minimum height of the ceiling ranged from 2.0 to 2.5 m, with an ideal height being 2.5 to 3.0 m. The swiftlet farmers chose these sizes to facilitate the harvesting process. Figure 3A is an example of a swiftlet house 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 for the whole process of mating and then incubating, and hatching eggs, as well as caring for the swiftlet chicks until they are ready to fly (see Figure 4).

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, 21 to 30-day old swiftlet chicks, G and H are the swiftlet chicks are ready to fly, I. the swiftlet nests are ready to be harvested.

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 biodiversity of insects is dependent on the existing ecosystem (Speight et al. 1999).

Based on simulations using diets of crickets (*Gryllus assimillis*) which were dried and mashed and then fed to the swiftlet using an assembled feed flusher, the feed ranges from 2 to 3 g per bird per day, or an average of 2.5 g per bird per day. Thus, the need for swiftlet increases with the increase in productive swiftlet population in swiftlet houses. For a swiftlet house measuring 512 m^2 with a population of 900 birds, the feed requirements are 2.7 kg per day, or up to 821.25 kg per year.

Production, population, and density of swiftlet houses

Swiftlet nests begin to be harvested 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 (PS 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 giving the swiftlet the opportunity to breed, allowing regeneration to take place and the swiftlet to feel comfortable, while a disadvantage is dirty swiftlet nests that reduce the selling price.

Model 1: 512 m^2 swiftlet house

The swiftlet house was 16 m long by 8 m wide and consists of 4 floors, with a presumed economic life of 27 years. The swiftlet nests are harvested in the 3rd year with a total production of 18 kg. Production continuously increased and finally reached its highest production, 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 2; 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 arrived at by the beginning of production (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 (3rd year), with 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, maximum nest production was found on floors 1 and 2, with a distance between nests of between 0.70 and 1.00 m.

Model 2: 1,600 m^2 swiftlet house

The swiftlet house was 40 m long and 8 m wide, consisting of 5 floors, with an economic life of 45 years. The swiftlet nests began being harvested in the third year, with an initial production of 14.50 kg. The swiftlet-nest production increased every year and reached the highest production, of 111 kg, in the 23rd year. Based on the AP and MP, optimum production was achieved in the 14th year (Table 3; 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 swiftlet houses. The increase in population continued until the 23rd year, when the swiftlet population reached 5,550 birds. The population began declining the following year and continued declining until the 45th year, when there were only 400 birds left.

For the 1,600 m2 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.

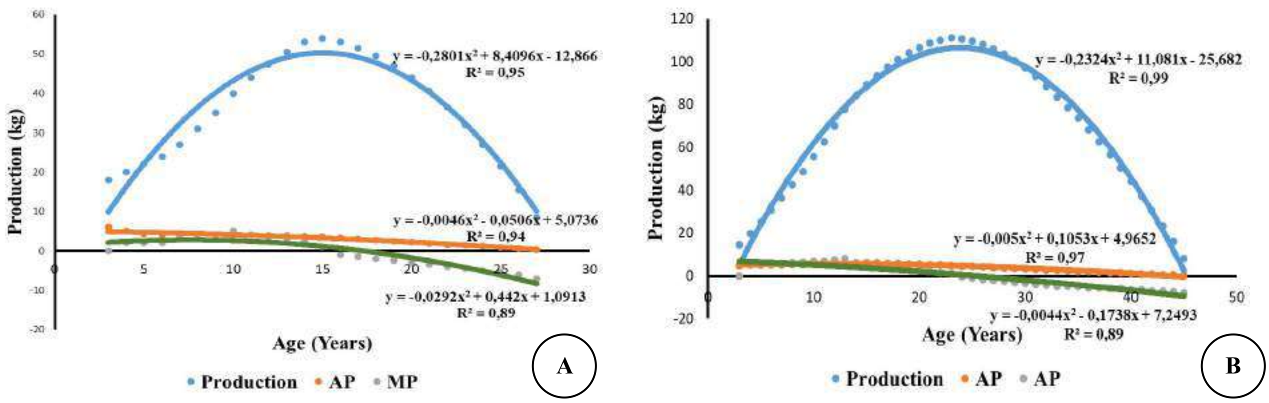

Figure 5.A . Production, AP and MP of swiftlet farming model 1 and **B**. Production, AP and MP of swiftlet farming model 2.

Table 2. Production Model 1: Swiftlet house area is 512m^2

Ages	P	AP	MP
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

Note : Ages (year); P: Production (kg); AP: average production (kg $years^{-1}$); MP: marginal production (kg)

Table 3. Production Model 2 : Swiftlet house area is 1,600m^2

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

Note : Ages (year); P: Production (kg); AP: average production (kg years^{-1}); MP: marginal production (kg)

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%.

Table 4. The financial feasibility assessment of swiftlet farming

Model	House area	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 ret urn (%); PP: payback period (years)

Model 1: swiftlet house area is 512 m^2

The net B/C was 4.06, which means that every IDR1 spent provides a benefit of IDR 4.06. Net B/C value is greater than 1, which indicates that this business is a valuable proposition. The NPV of IDR1,403.79 million shows 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 a figure for model 1 of 30%. This business is considered feasible due to the IRR being higher than the discount factor. The PP for model 1 was 5.44 years, with an investment period of 27 years, meaning it is feasible because the capital will return before the investment period ends.

Model 2: swiftlet house area is 1,600 m^2

The net B/C was 2.27, meaning that every IDR1 spent provides a benefit of IDR 2.27. This means the project is viable because the net B/C value is greater than 1. The NPV of IDR1,774.83 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 Model 1 is 9.40 years because the capital will be returned before the investment period ends (45 years); therefore, this business is feasible.

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 model 1 is more viable than model 2 because it demonstrates higher net B/C, NPV and IRR values, along with a lower PP.

This research was part of an effort to preserve populations and increase production of swiftlet farms in Kota Bangun District. 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 nature of the swiftlet houses built by swiftlet farmers. Increasing and decreasing populations caused by swiftlet-house size and swiftlet population were considered. The increase in population was due to the space between swiftlet nests being more than 1 m, while the decrease was due to an increase in population and the distance between swiftlet nests being less than 0.7 m, especially on floors 1 and 2. Room cleanliness and sanitation were related to existing bird droppings. Types of wood used for swiftlet houses included ulin (*Eusideroxylon zwageri*) and meranti (*Shorea* sp.). Kelampayan or jabon (*Neolamarchia cadamba or Antocephalus cadamba*) and benuang (*Octomelus sumatrana*) are not considered useful for swiftlet house because they rot quickly. The swiftlet house providing optimal production was 512 m^2.

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COVERING LETTER

Dear **Editor-in-Chief,**

I herewith enclosed a research article,

Title:

The biodiversity of "tropical white gold": a financial analysis of swiftlet (*Aerodramus fuchiphagus*) farming

Author(s) name:

Mursidah, Abubakar M Lahjie♥, Masjaya, Yaya Rayadin, Yosep Ruslim[1,♥♥]

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The research showed that there is a correlation between the nest distance, the population of productive swiftlet, the nest production and the finansial feasibility of swiftlet farming. If the distance between nest reach into 1m, the population and the production highly increase. This cause and effect research finding is expected to be able to give new valuable information about swiftlet farming as well as enrichment to the existing knowledge. It is also expected that this research finding can be a reference for the researchers in the future.

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Place and date:

March 17, 2020

Sincerely yours,
(fill in your name, no need scanned autograph)

Yosep Ruslim
Corresponding author

The biodiversity of “tropical white gold”: a financial analysis of swiftlet (*Aerodramus fuciphagus*) farming

Abstract

The swiftlet's nest is a high value non-timber forest product. Harvesting techniques, which are not concerned with sustainability, diminish the swiftlet population and the availability of swiftlet nests while demand increases. Swiftlet farming involves making a swiftlet house to preserve the swiftlet population and meet the demand for swiftlet nests. A feasibility assessment for swiftlet farming is required, with objectives being to analyze the production and financial feasibility of the swiftlet nest business in Kota Bangun District. This research was conducted between June and October of 2019, using descriptive qualitative and quantitative analysis methods. Financial feasibility was analyzed using the net B/C, NPV, IRR and Payback Period (PP) methods. This study used purposive sampling to determine the location and sample of swiftlet houses that were being observed. The results showed that swiftlet nest production 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. For example, for a swallow house with figures of 512 m^2, 4.06, 1403.79 million, 30.00% and 5 (area; net B/C; NPV; IRR; PP), the timespan would be 44 years. For a swallow house with figures of 1,600 m^2, 2.27, 1774.83 million, 24.09% and 9 (area; net B/C; NPV; IRR; PP), the timespan would be 40 years. Based on the financial feasibility assessment, swiftlet farming is feasible.

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. The swiftlet is both ecologically and economically beneficial for the forest. Swiftlets are biological predators against insects considered pests for cultivated plants. Meanwhile, swiftlet nests are very valuable and economically efficacious (PS 2013), thus being termed the "caviar of the East" (Thorburn 2015; Connolly 2016; Looi et al. 2016) or ”tropical white gold”.

Morphologically, the swiftlet has a pair of glandulla salivales under its tongue (Shah and Aziz 2014). The more food consumed, the more saliva is produced, resulting in higher production of swiftlet nests, such that swiftlet farmers benefit (PS 2013). Foraging is very important for swiftlets and the forest land cover is the habitat of insects the swiftlet feeds on (Adiwibawa 2000; Rahman et al. 2019)). The preferred habitats for swifts are open waters, forests and rice fields. In these habitats, many flying insects are sources of food for the swiftlet (Petkliang et al. 2017, Raharjo and Sinurat, 1998,

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Ahmad et al. 2019)). The availability of abundant food sources affects the swiftlets entering the swiftlet houses built by farmers.

Swiftlet nests are effective as herbal medicine (Lee et al. 2019), including for health (Careena et al. 2018) and as a supplement for the skin (Chan et al. 2015; Daud et al. 2019). They are also used to produce expensive foods and beverages (Chua and Zukefli 2016). Commercial swiftlet nests are derived from swiftlet farming and found in caves. Indonesia exports more than 75% of the swiftlet nests in the world, with the rest coming from Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (PS 2013).

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 from Kalimantan Island are considered the best quality in Indonesia. Swiftlet nests tend to be white because the environment still also contains many trees and little pollution (PS 2013). The easiest way to assess swiftlet nest quality is by considering its physical appearance (Jamaluddin et al. 2019).

Problems in the swiftlet nest industry, which are directly related, are market value and productivity (Nor et al. 2016). Nest collection is affected by reduction of the swiftlet population. The harvesting technique, which is not concerned with sustainability, has reduced the swiftlet population, such that the availability of swiftlet nests has decreased, while the demand has increased (Manchi and Sankaran 2010). To respond to this problem, swiftlet farming involves building swiftlet houses (Sankaran 2001). Farming swiftlet houses in Indonesia has developed since the 1800s (Mardiastuti and Soehartono 1996; Nugroho 1996).

The main production areas for bird nests in East Kalimantan are Kutai Kertanegara Regency, East Kutai Regency, West Kutai Regency, and Berau Regency (Candra 2007). Kota Bangun Subdistrict is one of the sub-districts in Kutai Kartanegara Regency where most of the population develops swiftlet nests. The high price of swiftlet nests has encouraged people to compete to build swiftlet houses. The materials and sizes of swiftlet houses vary depending on the land area and the available capital.

Considerations when choosing any business include feasibility, prospective benefits, and profits. Therefore, a financial feasibility assessment of swiftlet farming was required. This research's objectives were to analyze the productivity and financial feasibility of swiftlet farming in Kota Bangun Subdistrict using several different-sized swiftlet houses.

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MATERIALS AND METHODS

Study area

This research was carried out in Kota Bangun Subdistrict, Kutai Kartanegara Regency, East Kalimantan, Indonesia. The study site was located at geographical coordinates of 00º16’55.2” S and 116º35’38.4” 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 preparation reports. Data collected in this paper includes primary and secondary data. Primary data was obtained through direct research on the studied object, while secondary data was obtained from available reports or documents.

Data was obtained through interviews including questionnaires and observations in the field. The respondents were selected for 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 with clarifications from the respondents if necessary.

Direct observations were made of swiftlet farming conditions and the community’s activities in relation to swiftlet farming. 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 is distinguished by swiftlet house area. However, there are two sizes of swiftlet houses observed: 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 is presented descriptively and quantitatively.

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 (Rosyidi 2009).

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

(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))

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) (Banerjee, 2015; Constantinescu, 2010; Hopkinson, 2016; Kadariah 2001; Kunio, Lahjie 2015; Setiawan 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.

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

If Net B/C > 1, the project is feasible or profitable, but if Net B / C < 1, the project (business) 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.

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

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

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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 demanded by the project, or the period needed to return capital invested using proceeds or net cash flow.

$$\text{PP} = n + \frac{(a - b)}{(c - b)} x1\, years$$

(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.

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RESULTS AND DISCUSSION

Swiftlet farming

Swiftlet species found in Bangun City are white nest swiftlets (*Aerodramus fuciphagus*) and they produce white swiftlet nests. Swiftlet farming in Kota Bangun has grown rapidly. A high selling price is the main reason for starting a swiftlet farming business (Thorburn, 2015).

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 amount 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. Most of the swiftlet houses in Kota Bangun Subdistrict are constructed using wood. Types of wood used for the swiftlet houses include ulin (*Eusideroxylon zwageri*), meranti (*Shorea sp.*), and kelampayan or jabon *(Neolamarchia cadamba or Antocephalus cadamba*) (see Figure 2). The increasing price of wood and the limited investment funds for swiftlet farmers are reasons for them to purchase cheaper wood, despite the diminished durability which results in a shorter investment life. The studied swiftlet houses were constructed using ulin and meranti (see Figure 3).

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 (PS 2013). The size of the swiftlet houses in this study were 8.0 x 16.0 m and 8.0 x 40.0 m. The height of each floor was 2 meters, as recommended by the PS (2013), while the minimum height of the ceiling ranged from 2.0 to 2.5 m, with an ideal height being 2.5 to 3.0 m. The swiftlet farmers chose these sizes to facilitate the harvesting process. Figure 2 is an example of a swiftlet house 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 for the whole process of mating and then incubating, and hatching eggs, as well as caring for the swiftlet chicks until they are ready to fly (see Figure 4).

Diet

Swiftlets prey on insects for their daily diet (Lourie and Tompkins, 2000), 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 biodiversity of insects is dependent on the existing ecosystem (Speight et al, 1999).

Based on simulations using diets of crickets (*Gryllus assimillis*) which were dried and mashed and then fed to the swallow using an assembled feed flusher, the feed ranges from 2 to 3 g per bird per day, or an average of 2.5 g per bird per day. Thus, the need for swallow increases with the increase in productive swallow population in swallow houses. For

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a swallow house measuring 512 m2 with a population of 900 birds, the feed requirements are 2.7 kg per day, or up to 821.25 kg per year.

Production, population, and density of swiftlet houses

Swiftlet nests begin to be harvested 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 (PS, 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 giving the swiftlet the opportunity to breed, allowing regeneration to take place and the swiftlet to feel comfortable, while a disadvantage is dirty swiftlet nests that reduce the selling price.

Model 1: 512 m^2 swiftlet house

The swiftlet house was 16 m long by 8 m wide and consists of 4 floors, with a presumed economic life of 27 years. The swiftlet nests are harvested in the 3rd year with a total production of 18 kg. Production continuously increased and finally reached its highest production, 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 2; 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 swallow population was arrived at by the beginning of production (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 swallow house of 512 m^2, at the beginning of production (3rd year), with 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, maximum nest production was found on floors 1 and 2, with a distance between nests of between 0.70 and 1.00 m.

Model 2: 1,600 m^2 swiftlet house

The swiftlet house was 40 m long and 8 m wide, consisting of 5 floors, with an economic life of 45 years. The swiftlet nests began being harvested in the third year, with an initial production of 14.50 kg. The swiftlet nest production

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increased every year and reached the highest production, of 111 kg, in the 23rd year. Based on the AP and MP, optimum production was achieved in the 14th year (Table 3 ; 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 swiftlet houses. The increase in population continued until the 23rd year, when the swiftlet population reached 5,550 birds. The population began declining the following year and continued declining until the 45th year, when there were only 400 birds left.

For the 1,600 m2 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%.

Model 1: swiftlet house area is 512 m^2

The net B/C was 4.06, which means that every IDR1 spent provides a benefit of IDR 4.06. Net B/C value is greater than 1, which indicates that this business is a valuable proposition. The NPV of IDR1,403.79 million shows 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 a figure for model 1 of 30.00%. This business is considered feasible due to the IRR being higher than the discount factor. The PP for model 1 was 5.44 years, with an investment period of 27 years, meaning it is feasible because the capital will return before the investment period ends.

Model 2: swiftlet house area is 1,600 m^2

The net B/C was 2.27, meaning that every IDR1 spent provides a benefit of IDR 2.27. This means the project is viable because the net B/C value is greater than 1. The NPV of IDR1,774.83 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 Model 1 is 9.40 years because the capital will be returned before the investment period ends (45 years); therefore, this business is feasible.

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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 model 1 is more viable than model 2 because it demonstrates higher net B/C, NPV and IRR values, along with a lower PP.

This research was part of an effort to preserve populations and increase production of swiftlet farms in Kota Bangun District. 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 nature of the swiftlet houses built by swiftlet farmers. Increasing and decreasing populations caused by swiftlet-house size and swiftlet population were considered. The increase in population was due to the space between swiftlet nests being more than 1 m, while the decrease was due to an increase in population and the distance between swiftlet nests being less than 0.7 m, especially on floors 1 and 2. Room cleanliness and sanitation were related to existing bird droppings. Types of wood used for swiftlet houses included ulin (*Eusideroxylon zwageri*) and meranti (*Shorea* sp.). Kelampayan or jabon (*Neolamarchia cadamba* or *Antocephalus cadamba*) and benuang (*Octomelus sumatrana*) are not considered useful for swiftlet house because they rot quickly. The swiftlet house providing optimal production was 512 m^2.

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EDITORIAL

CERTIFICATE

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Link: https://smujo.id/biodiv/authorDashboard/submission/5633

Ahmad Dwi Setyawan

smujo.id@gmail.com

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Notifications

[biodiv] Editor Decision

2020-04-07 10:10 AM

YOSEP RUSLIM, Abubakar M. Lahjie, Mursidah, Yaya Rayadin:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "The The biodiversity of "tropical white gold": a financial analysis of swiftlet (Aerodramus fuciphagus) farming".

Our decision is: Revisions Required

Nor Liza
sectioneditor2@smujo.id

Reviewer S:

Paper review: The biodiversity of "tropical white gold": a financial analysis of swiftlet (*Aerodramus fuciphagus*) farming

The paper exquisitely tried to highlight the unsustainable harvesting of swiftlet nests and it's connection with the swiftlet farming feasibility. The need for financial feasibility assessment is pinpointed in the beginning so as to help in preservation and conservation of the species in ex-situ conditions. In the introduction section, the authors have written about the role of swiftlet in ecosystem as well as in the economics which justifies the on both the grounds.

As the introduction advances, the authors have tried to explain the importance of the edible-nest in medicine today and Indonesia being the largest exporter later being Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines which makes the study more crucial for the overall contribution of the nest trade in the country's commercial building.

The authors also familiarize the reader with the types of nests and about the assessment of the nest based on its physical appearance. The authors have also mentioned that the problem is market demand. The harvesting technique used resulted in a decreasing swiftlet population and directly affected the rate of production. The study has been done in the Kota Bangun Subdistrict, which is one of the sub-districts in the Kutai Kartanegara Regency known to the highest number of swiftlet farmer's owners to different sizes of houses. Considering why the people have chosen this farming business, what is the net profit, prospective benefits and feasibility, the study aims to do a financial feasibility assessment.

However, the author has failed to provide the details related to the global scenario of the financial aspects and productivity of the nests, which may help the readers in understanding the global scale of the swiftlet industry and its productivity.

As the paper continues towards the materials and methods, the authors, in very brief, acquaint the readers with the study area. Information about the number of swiftlet houses, total human resources presently engaged, and overall production (in kg/year) in the study location is missing. In the abstract, where the authors mention purposive sampling, in the data collection section, the information is absent. The data is collected using primary and secondary methods, which strengthens the findings altogether. The authors refer that questionnaires and observations were used as tools for the data collection, which need elaboration. The design of the sampling being purposive (being swiftlet farmers with productive swiftlet houses) and selected only 2 types of swiftlet house ($512m^2$ and $1,600m^2$ in size) for the feasibility assessment. How many swiftlet house owners were approached and how many interviews were done is not mentioned in the document.

Purposive sampling or judgmental sampling is used for qualitative exploratory analysis wherein there is no secondary data available. The choice of the sampling technique itself creates a bias in the study. Wherein, the study could have been a classical if stratified sampling was used and then after stratifying the house size into classes, the author should have considered being purposive (the farmers who appropriately fit for the sample) for analysis part. Looking at the setting the authors seem to use 'convenient sampling' and incorrectly called it 'Purposive sampling'. Further explanation by the authors is needed here.

If a person is using direct observations as a tool for data collection, it has to be done using an observation schedule. The author needs to mention what kind of information is expected by using a particular method (is the orientation of the house, floors of the building, construction material used, location of the house, and others). The study becomes weak because the secondary data which the authors claim to be used is not presented with the required references.

Logically, if most of the people are engaged in the swiftlet farming business, signifies one, there is demand in the market and second, that the business is feasible. The aim of the paper diverts when only two swiftlet houses known to be suitable sizes are considered for financial analysis. However, the author has, in detail, explained each index in a very descriptive way for the reviewer to understand.

As the paper comes to its finale, the authors gently hint the market demand as the reason for rapidly growing swiftlet business. The beginning of the business starting with the building of the house, selection of material, investment costs involved is all presented as the secondary data as an active part of discussion but the numbers are missing. The results are the presented facts which has no collection reference (whether it is a primary result or a secondary data used as discussion). The authors have given information on the diet of the swiftlet in house size $512m^2$ whereas the data for the $1600m^2$ is missing. It again causes confusion between primary and secondary data. Also, the query arises as to was the food supplement price was included in the financial analysis or not and if yes where it has been summed up?

Initially mentioned about the unsustainable harvesting pattern in the introduction, the authors introduces their types in the discussion. According to the results collected through unknown means, suggest that farmers practice hatchery harvest pattern. This is considered to be sustainable yet yields in dirty nests, leading a reduction in the nest price, that needs further attention.

The authors have collected essential data on the population decline but have contradicted the fact of the hatchery harvesting method used by the farmers. A population increase, production is seen in the $512m^2$ house from 3rd year to 16th year, leading to a sharp population decline from 17th year. Was the harvesting pattern changed after the 17th year or if continued with the hatchery pattern, logically, the fall in the swiftlet population should not take place. Whereas in the $1600m^2$ house, initially, the population was 725 birds in the third year and the 14th year, it reached 4200 birds and 5500 birds in its 23rd year and then continued to decline until 425 birds left in its 45th year. It seems the harvesting system here has changed. It can be observed if the authors can get the relative age of the swiftlet houses studied to correlate them with the calendar year of decline timing.

As the manuscript comes to its crux objective evaluation, which is financial feasibility, the comparison between two houses again takes a biased turn as in the initial phase of research, the sampling bias is observed. Comparing and contrasting two houses which have nothing in common suppresses the obvious fact that the bigger house (which also has the ideal lxb) will yield in maximum production whereas the smaller house will not. Yet the analysis bring the fact that the density of the house determines the production of the nests and will continue to occur up to a maximum distance of 1m between nests. In the absence of the correlation tests between the total yield and distance between the nests, it develops confusion in the how of the conclusion.

In the end, Swiftlet farming model 1 and model 2 both look financially feasible, but model 1 is more viable than model 2 because it demonstrates higher net B/C, NPV and IRR values, along with a lower PP. The fundamental doubt emerges when the $512m^2$ is not an ideal size for swiftlet farming yet proves to be feasible for unsustainable swiftlet farming (as population decreases in both the models). In the ecological sense, smaller houses will have dense and compact swiftlet colonies, which is obvious to result in higher nest production.

As the study was carried out as an effort to preserve populations and increase the production of swiftlet farms in the Kota Bangun District, the study fails to reflect the original purpose. In the line 304 to 306 authors have written, '*The increase in population was due to the space between swiftlet nests being more than 1 m, **while the decrease was due to an increase in population** and the distance between swiftlet nests being less than 0.7 m, especially on floors 1 and 2* this statement looks like more of a typo error and is contradictory to the line numbers 250-254. The reviewer noticed that the author stressing on the dense colonies (spacing <1m) again and realizes the maximum swiftlet population in 1st and 2nd floors.

In totality, the study delivers the promised results, but the presentation is muddled up. The concern is the preservation of swiftlet populations, evaluating financial feasibility, but the results hold a more significant potential to suggest modifications in the ideal house size (which is understood to be $1600m^2$), including the verticle levels of the house. Suitable measures on sustainable farming and preparing a harvesting plan connecting it with the net production will allow the farmers to understand the viability and future sustainability of business and the populations. Overall, the idea of production driven demand should be motivated amongst the farmers so that it helps in the longevity of the business.

Recommendation: Revisions Required

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

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. Quantitave 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 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 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 the 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. Swiftlet is both ecologically and economically beneficial for environment as well as for human. 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 are supplied by Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (Nurshuhada et al. 2015; Nugroho and Budiman 2013).

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).

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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 (Careena et al. 2018; Ma and Liu 2012) 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 luxurius 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 colour 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 intertwinned (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. 2018; 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 (Asciuto et al. 2019; Sososutiksno and Gasperz 2017). 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 00º16’55.2” S and 116º35’38.4” 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.

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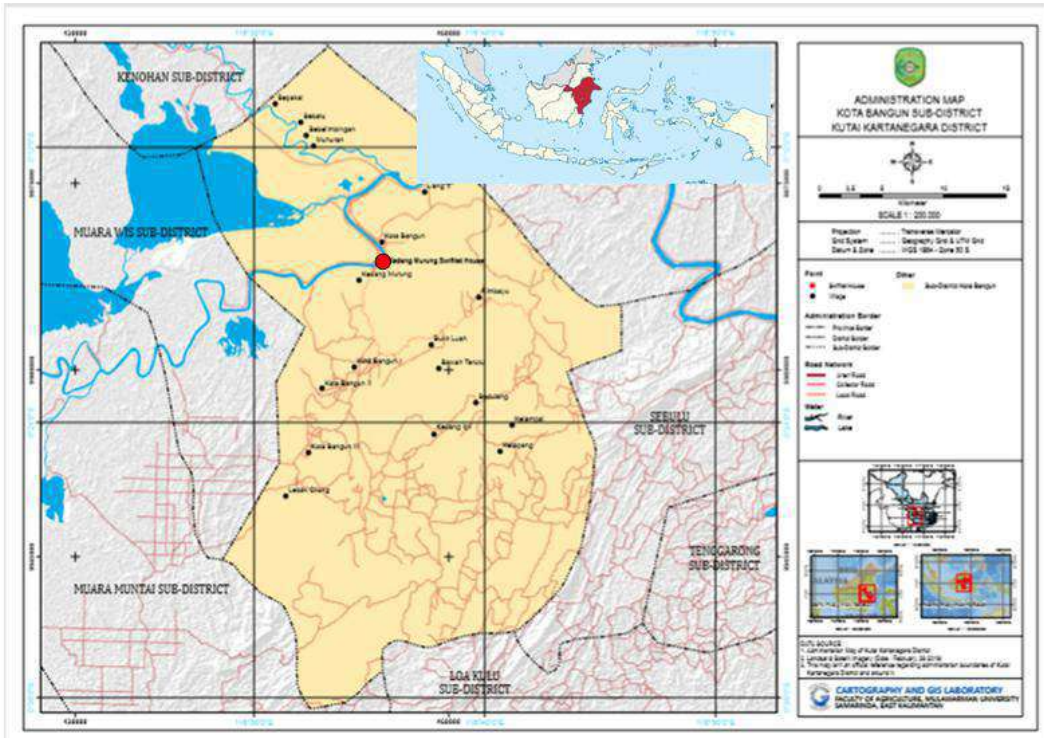

Figure 1. The location of the research (●) in Kota Bangun Subdistrict, Kutai Kartanegara District, East Kalimantan Province, Indonesia.

Data was 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 is 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 floor
Model 1	16	8	512	2	4
Model 2	40	8	1,600	2	5

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):

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Deleted[Anonymous]: **Table 1.** The business scale of swiftlet farming, including length, width, area, height of each floor and number of floors in the swiftlet house

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

where AP = average product (kg $year^{-1}$), Pt = production at age t(kg), and t = age(years))

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

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

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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; Hopkinson 2016; Kunio and Lahjie 2015; Mackevičius and Tomaševič 2010; 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.

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

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.

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Net Present Value (NPV)

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

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

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

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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.

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

where, NPV' = positive NPV, NPV'' = negative NPV, i' = the interest rate when NPV is positive, and i'' = the interest rate when NPV is negative.

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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.

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

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).

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 were 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 the 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), alternaly 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).

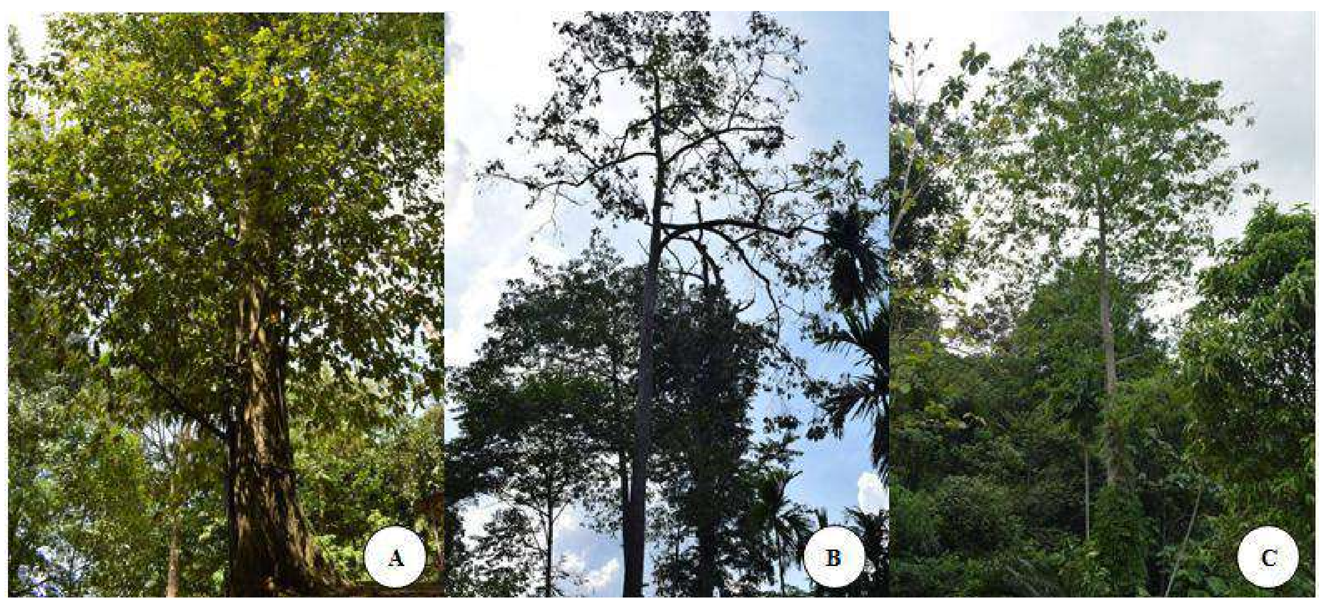

Figure 2. Timber species commonly used to build swiftlet house: A. Ulin (*Eusideroxylon zwageri*); B. Meranti (*Shorea* spp.); C. Kelampayan/jabon (*Neolamarckia cadamba/Antocephalus cadamba*)

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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 & H. The swiftlet chicks are ready to fly; I. The swiftlet nests are ready to be harvested.

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 cost (with taxes counted).

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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 were 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%).

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

Cost item	Cost (%)	
	512 m^2	1,600 m^2
Investment Cost		
Building	16	14
Equipment	12	13
Soundsystem	11	13
Operational Cost		
Harvesting	17	17
Security	14	12
Cleaning and maintenance	10	12
Taxes	10	10
Management	10	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.

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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.

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 the 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.

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.

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

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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

Model	House area (m²)	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 (m²); Net B/C: net benefit cost ratio (ratio); NPV: net present value (million IDR); IRR: internal rate of return (%); PP: payback period (year)

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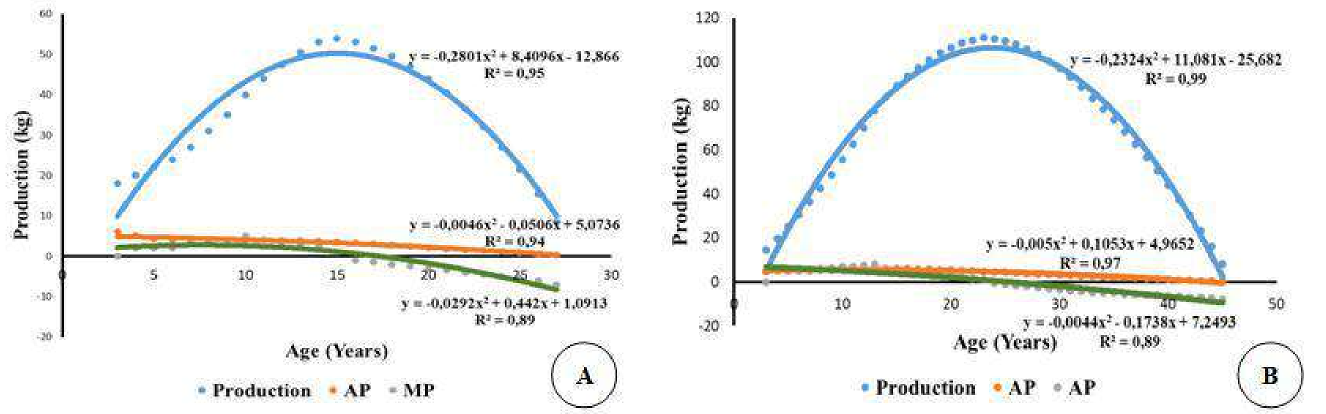

Figure 5. The production curve of swiftlet farming in Kota Bangun, East Kalimantan: A. Business Model 1; B. Business Model 2. Notes: AP: Average Production; MP: Marginal Production

Please add here two or three paragraphs to further discuss the results of the study. Some aspects that can be elaborated include (you will need to add some literatures as reference):

1. Comparison of the ecology of swiftlet farming with other regions within Kalimantan/East Kalimantan context or outside Kalimantan. For example, you can compare the strcuture and design of the swiftlet house, diet, population, etc.
2. Comparison of the financial performance (e.g. net B/C, NPV, IRR, etc.) swiftlet farming with other regions
3. Comparison of the financial performance between swiftlet farming with other timber and non-timber forest products.

Finally, you can conclude the paper by providing the implications/recommendations based on the results of the study for the management or policy of swiftlet farming in the study area in particular and Kalimantan/East Kalimantan in a broader context.

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. 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.

ACKNOWLEDGEMENTS

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Nor Liza (nliza)

YOSEP RUSLIM (yruslim)

Messages

Note	From
Dear Bapak Ahmad Dwi Seiawan Ibu Nor Liza Please find attached the revised file from our manuscripts. I hear soon about your information. Thanks for your attention and kindness. Kind regards, Corresponding author, Yosep Ruslim yruslim, S-5633-Article Text-19664-1-4-20200317_dk (April 13, 2020)-Revised.doc	yruslim 2020-04-13 10:24 AM

smujo.id@gmail.com

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Nor Liza <smujo.id@gmail.com>
kepada saya, Abubakar, Mursidah, Yaya

Rab, 10 Jun 2020 10.09

Inggris > Indonesia Terjemahkan pesan

Nonaktifkan untuk: Inggris

YOSEP RUSLIM, Abubakar M. Lahjie, Mursidah, Yaya Rayadin:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "The The biodiversity of "tropical white gold": a financial analysis of swiftlet (Aerodramus fuciphagus) farming".

Our decision is: Revisions Required

Nor Liza
sectioneditor2@smujo.id

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smujo.id@gmail.com

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Reviewer C:

Dear Editor,

Please find attached is the reviews and suggested edits for the manuscript "The biodiversity of "tropical white gold": a financial analysis of swiftlet (Aerodramus fuciphagus) farming".

Overall, this is really interesting study with rich information presented and robust methods applied despite it is not well structured and several inaccurate language. I would recommend to accept for publication. However, the paper can be strengthened by more elaboration in the Discussion. Some aspects that can be elaborated include (it will need to add some literatures as reference):

1. Comparison of the ecology of swiftlet farming with other regions within Kalimantan/East Kalimantan context or outside Kalimantan. For example, you can compare the strcuture and design of the swiflet house, diet, population, etc.
2. Comparison of the financial performance (e.g. net B/C, NPV, IRR, etc.) swiftlet farming with other regions
3. Comparison of the financial performance between swiflet farming with other timber and non-timber forest products.

Finally, the author can conclude the paper by providing the implications/recommendations based on the results of the study for the management or policy of swiftlet farming in the study area in particular and Kalimantan/East Kalimantan in a broader context.

Thank you and best regards,

Reviewer

smujo.id@gmail.com

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Yosep Ruslim <yruslim@gmail.com>
kepada Nor, Abubakar, Mursidah, Yaya

16 Jun 2020 23.59

Dear Ibu Nor Liza

Section Editor

Biodiversitas Journal,

Please find attached is the revised and edited for the manuscript "The biodiversity of "tropical white gold": a financial analysis of swiftlet (Aerodramus fuciphagus) farming".

We are very happy to say thank you for your appreciation on our journal as well as all valuable comments in order to refine the article. All of the comments from the reviewers are very meaningfull. We tried to added the comparison of the ecology of swiftlet farming with other regions within Kalimantan/East Kalimantan context or outside Kalimantan, Comparison of the financial performance (e.g. net B/C, NPV, IRR, etc.) swiftlet farming with other regions and comparison of the financial performance between swiflet farming with other timber and non-timber forest products.

We hope the revised manuscript has met the requirements for publication in the Biodiversitas Journal. Thank you very much for your help and attention.

Thank you and best regards,
Corresponding author.
Yosep Ruslim

--
Yosep Ruslim

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

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. Quantitave 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 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 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 the 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 human. 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 are supplied by Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (Nurshuhada et al. 2015; Nugroho and Budiman 2013).

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 (Careena et al. 2018; Ma and Liu 2012) 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 luxurius 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 colour 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 intertwinned (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 (Asciuto et al. 2019; Sososutiksno and Gasperz 2017). 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.

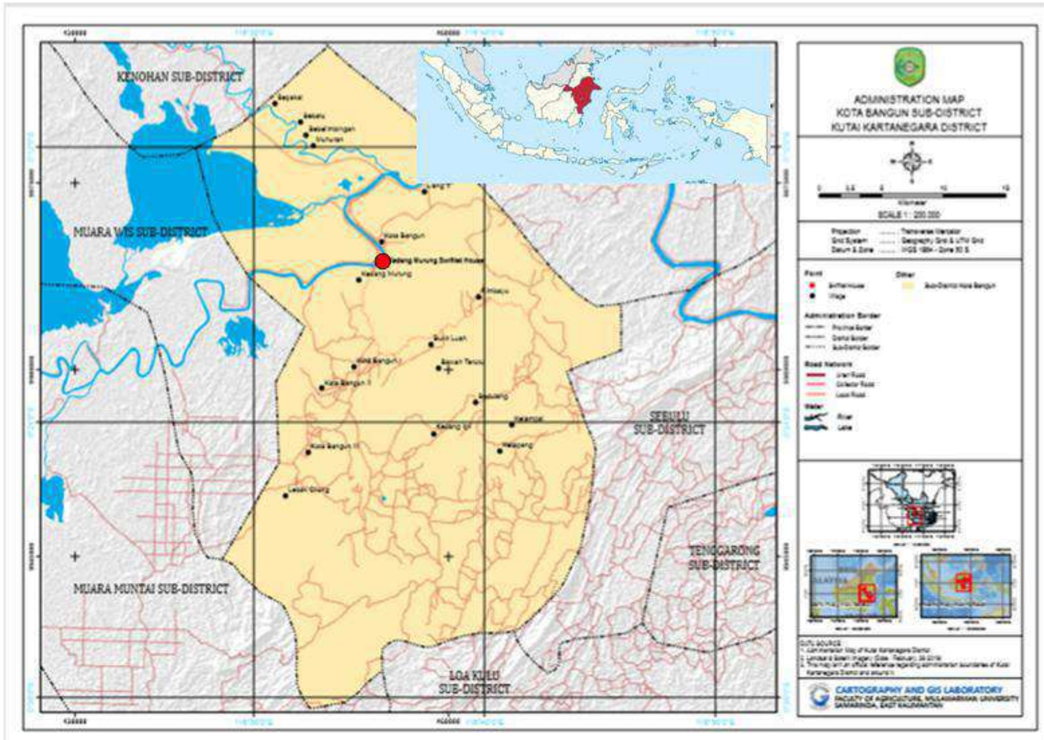

Figure 1. The location of the research (●) in Kota Bangun Subdistrict, Kutai Kartanegara District, East Kalimantan Province, Indonesia

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Data was 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 is 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 floor
Model 1	16	8	512	2	4
Model 2	40	8	1,600	2	5

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; Hopkinson 2016; Kunio and Lahjie 2015; Mackevičius and Tomaševič 2010; 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.

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

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.

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

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.

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

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.

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

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).

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 were 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 the 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), alternaly 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).

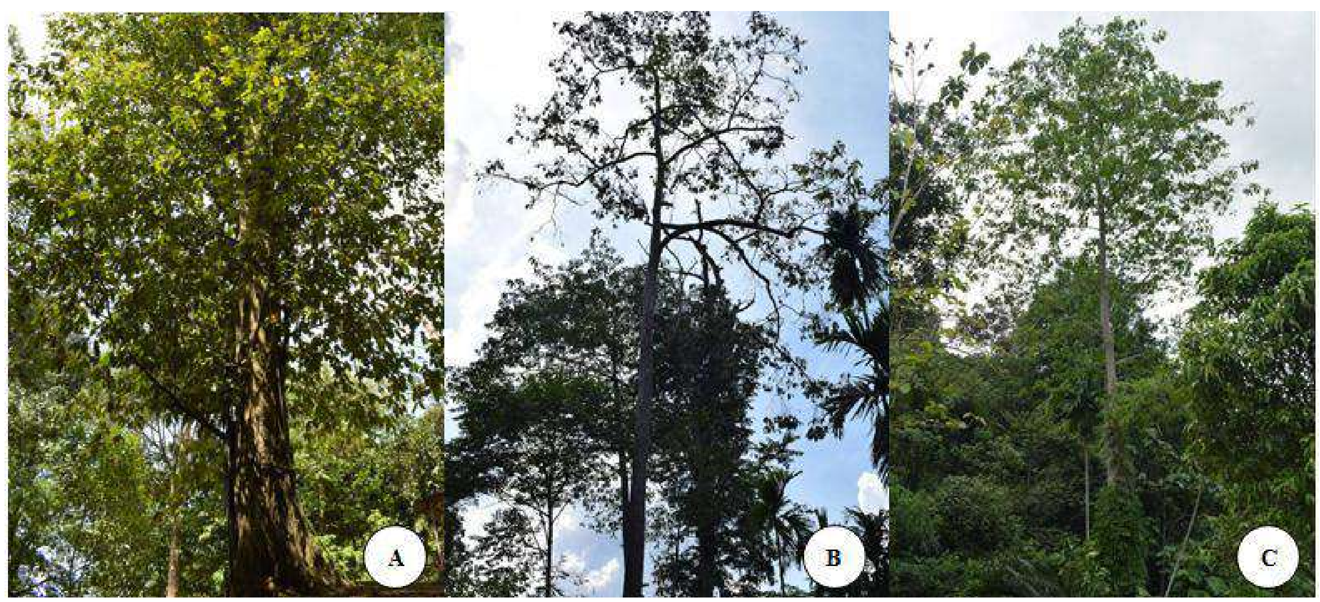

Figure 2. Timber species commonly used to build swiftlet house: A. Ulin (*Eusideroxylon zwageri*); B. Meranti (*Shorea* spp.); C. Kelampayan/jabon (*Neolamarckia cadamba/Antocephalus cadamba*)

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

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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 cost (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 were 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%).

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

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

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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.

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 the 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.

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.

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

Table 4. The annual production of swiftlet nest using Business Model 1 (i.e. swiftlet house area is 1,600 m^2)

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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

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)

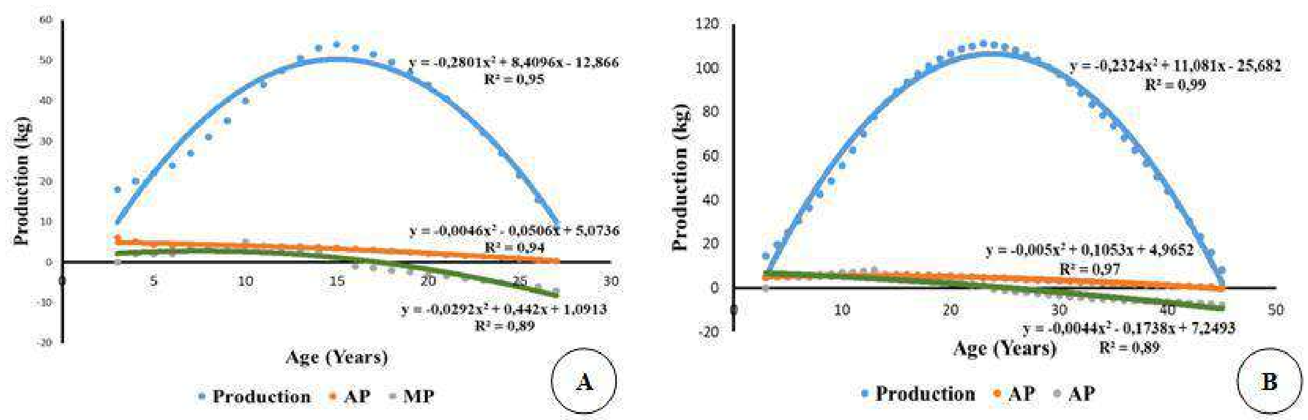

Figure 5. The production curve of swiftlet farming in Kota Bangun, East Kalimantan: A. Business Model 1; B. Business Model 2. Notes: AP: Average Production; MP: Marginal Production

The 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 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 2015), 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 swiftlett feeds. In Thailand, wetland, forest and open paddy lands are the main sources of feeed 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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The biodiversity of "tropical white gold": a financial analysis of swiftlet (*Aerodramus fuciphagus*) farming

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Abstract. *Mursidah, Lahjie AM, Masjaya, Rayadin Y, Ruslim Y. 2020. The biodiversity of "tropical white gold": a financial analysis of swiftlet* (Aerodramus fuciphagus) *farming. Biodiversitas 21: xxxx.* The swiftlet's nest is a high-value non-timber forest product. Harvesting techniques, which are not concerned with sustainability, diminish the swiftlet population and the availability of swiftlet nests while demand increases. Swiftlet farming involves making a swiftlet house to preserve the swiftlet population and meet the demand for swiftlet nests. A feasibility assessment for swiftlet farming is required, with objectives being to analyze the production and financial feasibility of the swiftlet-nest business in Kota Bangun District. This research was conducted between June and October of 2019 using descriptive qualitative and quantitative analysis methods. Financial feasibility was analyzed using the net B/C, NPV, IRR and Payback Period (PP) methods. This study used purposive sampling to determine the location and sample of swiftlet houses that were being observed. The results showed that swiftlet nest production 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. For example, for a swiftlet house with figures of 512 m^2, 4.06, IDR 1403.79 million, 30% and 5.44 years (area; net B/C; NPV; IRR; PP), the timespan would be 44 years. For a swiftlet house with figures of 1,600 m^2, 2.27, IDR 1774.83 million, 24.09% and 9.4 years (area; net B/C; NPV; IRR; PP). Based on the financial feasibility assessment, swiftlet farming is feasible.

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. The swiftlet is both ecologically and economically beneficial for the forest. Swiftlets are biological predators against insects considered pests for cultivated plants. Meanwhile, swiftlet nests are precious and economically efficient (Nugroho and Budiman 2013), thus being termed 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, around IDR 40 million a kilogram on 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 a kilogram (Shukri et al. 2018). Morphologically, the swiftlet has a pair of glandulla salivales under its tongue (Shah and Aziz 2014). The more food consumed, the more saliva is produced, resulting in higher production of swiftlet nests, such that swiftlet farmers benefit (Nugroho and Budiman 2013). Foraging is very important for swiftlets and the forest land cover is the habitat of insects the swiftlet feeds on (Adiwibawa 2000; Oliver et al. 2014; Rahman et al. 2019). The preferred habitats for swifts are open waters, forests and rice fields. In these habitats, many flying insects are sources of food for the swiftlet (Petkliang et al. 2017, Ahmad et al. 2019). 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 effective as herbal medicine (Vimala et al. 2011; Roh et al. 2012; Zhang et al. 2012; Lee et al. 2019), including for health (Careena et al. 2018; Ma and Liu 2012) 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 expensive foods and beverages (Chua and Zukefli 2016). Commercial swiftlet nests are derived from swiftlet farming and found in caves. Indonesia exports more than 75% of the swiftlet nests in the world (60% is exported to Tiongkok, 25.7% to the United States, the rest is exported to other countries) , with the rest coming from Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (Nurshuhada et al. 2015; Nugroho and Budiman 2013).

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 from Kalimantan Island are considered the best quality in Indonesia. Swiftlet nests tend to be white because the environment still also contains many trees and little pollution (Nugroho and Budiman 2013). The easiest way to assess swiftlet nest quality is by considering its physical appearance (Jamaluddin et al. 2019).

Problems in the swiftlet nest industry, which are directly related, are market value and productivity (Nor et al. 2016). Nest collection is affected by reduction of the swiftlet population. The harvesting technique, which is not concerned with sustainability, has reduced the swiftlet population, such that the availability of swiftlet nests has decreased, while the demand has increased (Lahjie et al. 2018; Manchi and Sankaran 2010).

The main production areas for bird nests in East Kalimantan are Kutai Kertanegara Regency, East Kutai Regency, West Kutai Regency, and Berau Regency (Candra 2007). Kota Bangun Subdistrict is one of the sub-districts in Kutai Kartanegara Regency where most of the population develops swiftlet nests. The high price of swiftlet nests has encouraged people to compete to build swiftlet houses (Kamaruddin et al. 2019). The materials and sizes of swiftlet houses vary depending on the land area and the available capital.

Considerations when choosing any business include feasibility, prospective benefits, and profits. The finansial feasibility of a business can be measured using finansial analysis Therefore, a financial feasibility assessment of swiftlet farming was required (Asciuto et al. 2019; Sososutiksno and Gasperz 2017). This research's objectives were to analyze the productivity and financial feasibility of swiftlet farming in Kota Bangun Subdistrict using several different-sized swiftlet houses.

MATERIALS AND METHODS

Study area

This research was carried out in Kota Bangun Subdistrict, Kutai Kartanegara Regency, East Kalimantan, 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 preparation reports. Data collected in this paper includes primary and secondary data. Primary data was obtained through direct research on the studied object, while secondary data was obtained from available reports or documents.

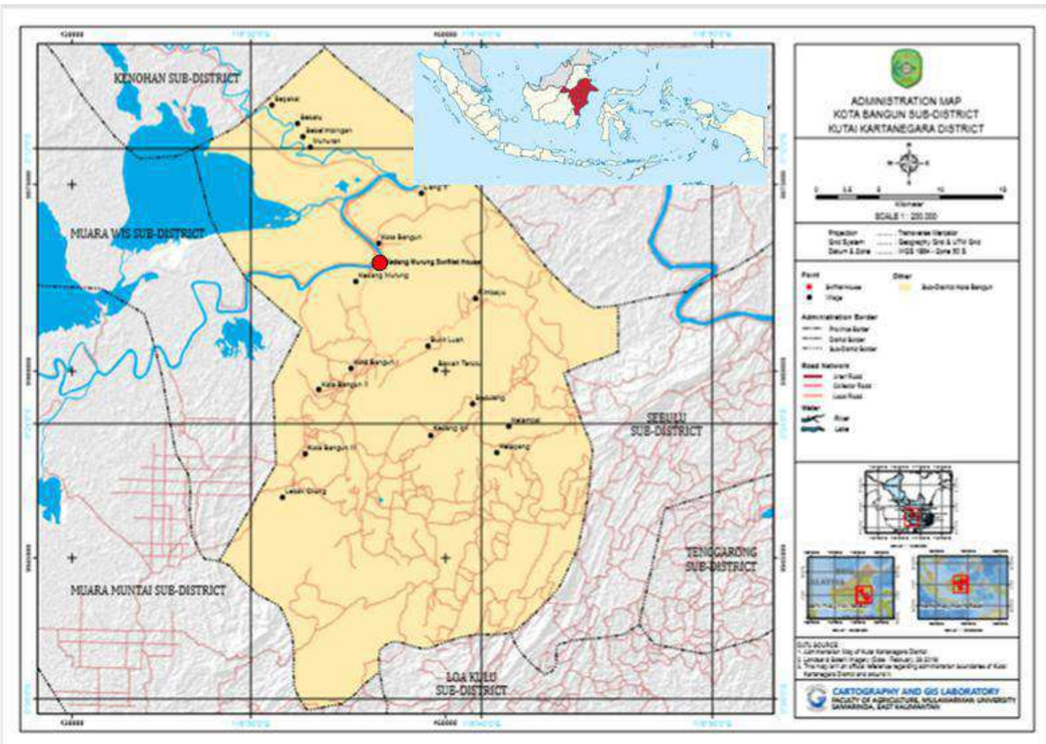

Figure 1. The location of the research (●) is in Kota Bangun Subdistrict (00°16'55.2"S, 116°35'38.4"E)

Table 1. The business scale of swiflet 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 floor
Model 1	16	8	512	2	4
Model 2	40	8	1,600	2	5

Data was obtained through interviews including questionnaires and observations in the field. Determination of the sample using 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 for 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 is distinguished by swiftlet house area. However, there are two sizes of swiftlet houses observed: 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 is presented descriptively and quantitatively.

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 (Rosyidi 2009).

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

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

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

(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; Hopkinson 2016; Kunio and Lahjie 2015; Mackevičius and Tomaševič 2010; 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.

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

If Net B/C > 1, the project is feasible or profitable, but if Net B/C < 1, the project (business) 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 demanded 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 found in Bangun City are white nest swiftlets (*Aerodramus fuciphagus*) and they produce white swiftlet nests. Swiftlet farming in Kota Bangun has grown rapidly. A high selling price is the main reason for starting a swiftlet farming business (Thorburn 2015). The average price of raw swiftlet nest at the time of the study was IDR 10 million a kilogram.

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 amount 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 are constructed using wood. Types of wood used for the swiftlet houses include ulin (*Eusideroxylon zwageri*), meranti (*Shorea* sp.), and kelampayan or jabon *(Neolamarchia cadamba or Antocephalus cadamba*) (Figure 2). The increasing price of wood and the limited investment funds for swiftlet farmers are reasons for them to purchase cheaper wood, despite the diminished durability which results in a shorter investment life. The studied swiftlet houses were constructed using ulin and meranti (Figure 3).

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 were 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 the Nugroho and Budiman (2013), while the minimum height of the ceiling 2m, with an ideal height being 2.5 to 3.0 m. The swiftlet farmers in this research chose these sizes to facilitate the harvesting process. Figure 3A is the swiftlet house with figures 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), alternaly 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).

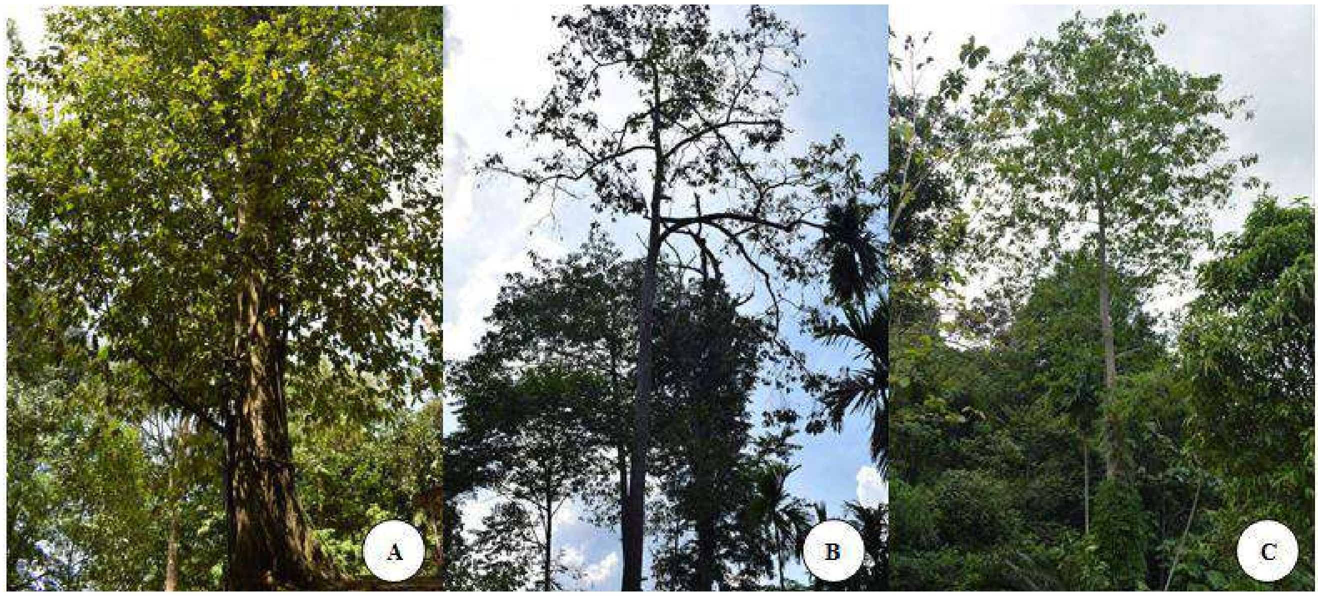

Figure 2. A. Ulin (*Eusideroxylon zwageri*); B. Meranti (*Shorea* sp.); C. Kelampayan/jabon (*Neolamarchia cadamba/Antocephalus cadamba*)

Figure 3. A. The swiftlet houses, woods B and C used for 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, 21 to 30-day old swiftlet chicks, G and H are the swiftlet chicks are ready to fly, I. the swiftlet nests are ready to be harvested.

Table 2. Swiftlet farming cost

Cost description	**Cost**	**(%)**
	512 m²	**1,600 m²**
Investment Cost		
Building	16	14
Equipment	12	13
Soundsystem	11	13
Operational Cost		
Harvesting	17	17
Security	14	12
Cleaning and maintenance	10	12
Taxes	10	10
Management	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 biodiversity of insects is dependent on the existing ecosystem (Speight et al. 1999).

Based on observation, the simulations conducted by swiftlet farmer using diets of crickets (*Gryllus assimillis*) which were dried and mashed and then fed to the swiftlet using an assembled feed flusher, the feed ranges from 2 to

3 g per bird per day, or an average of 2.5 g per bird per day. Thus, the need for swiftlet increases with the increase in productive swiftlet population in swiftlet houses. For a swiftlet house measuring 512 m^2 with a population of 3,500 birds, the feed requirements are 8.75 kg per day, or up to 3,193.75 kg per year. For swiftlet house 1,600 m^2 with average population of 7.000 bird, the feed requirements are 17.5 kg per day, or up to 6,387.5 kg per year. Feed cost will be included in operational cost.

Cost

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

Production, population, and density of swiftlet houses

Swiftlet nests begin to be harvested 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 giving the swiftlet the opportunity to breed, allowing regeneration to take place and the swiftlet to feel comfortable, while a disadvantage is dirty swiftlet nests that reduce the selling price.

Model 1: 512 m^2 swiftlet house

The swiftlet house was 16 m long by 8 m wide and consists of 4 floors, with a presumed economic life of 27 years. The swiftlet nests are harvested in the 3rd year with a total production of 18 kg. Production continuously increased and finally reached its highest production, 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 arrived at by the beginning of production (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 (3rd year), with 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, maximum nest production was found on floors 1 and 2, with a distance between nests of between 0.70 and 1.00 m.

Model 2: 1,600 m^2 swiftlet house

The swiftlet house was 40 m long and 8 m wide, consisting of 5 floors, with an economic life of 45 years. The swiftlet nests began being harvested in the third year, with an initial production of 14.50 kg. The swiftlet-nest production increased every year and reached the highest production, of 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 swiftlet houses. The increase in population continued until the 23rd year, when the swiftlet population reached 5,550 birds. The population began declining the following year and continued declining until the 45th year, when there were only 400 birds left.

For the 1,600 m2 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%.

Model 1: swiftlet house area is 512 m^2

The net B/C was 4.06, which means that every IDR1 spent provides a benefit of IDR 4.06. Net B/C value is greater than 1, which indicates that this business is a valuable proposition. The NPV of IDR1,403.79 million shows 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 a figure for model 1 of 30%. This business is considered feasible due to the IRR being higher than the discount factor. The PP for model 1 was 5.44 years, with an investment period of 27 years, meaning it is feasible because the capital will return before the investment period ends (Table 5).

odel 2: swiftlet house area is 1,600 m^2

The net B/C was 2.27, meaning that every IDR1 spent provides a benefit of IDR 2.27. 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 Model 1 is 9.40 years because the capital will be returned before the investment period ends (45 years); therefore, this business is feasible (Table 5).

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 model 1 is more viable than model 2 because it demonstrates higher net B/C, NPV and IRR values, along with a lower PP.

Table 3. Production Model 1: Swiftlet house area is 512m^2

Ages	P	AP	MP
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

Note : Ages (year); P: Production (kg); AP: average production (kg years^{-1}); MP: marginal production (kg)

Table 4. Production Model 2 : Swiftlet house area is 1,600m^2

Ages	P	AP	MP
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

Note : Ages (year); P: Production (kg); AP: average production (kg years^{-1}); MP: marginal production (kg)

Table 5. The financial feasibility assessment of swiftlet farming

Model	House area	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 ret urn (%); PP: payback period (years)

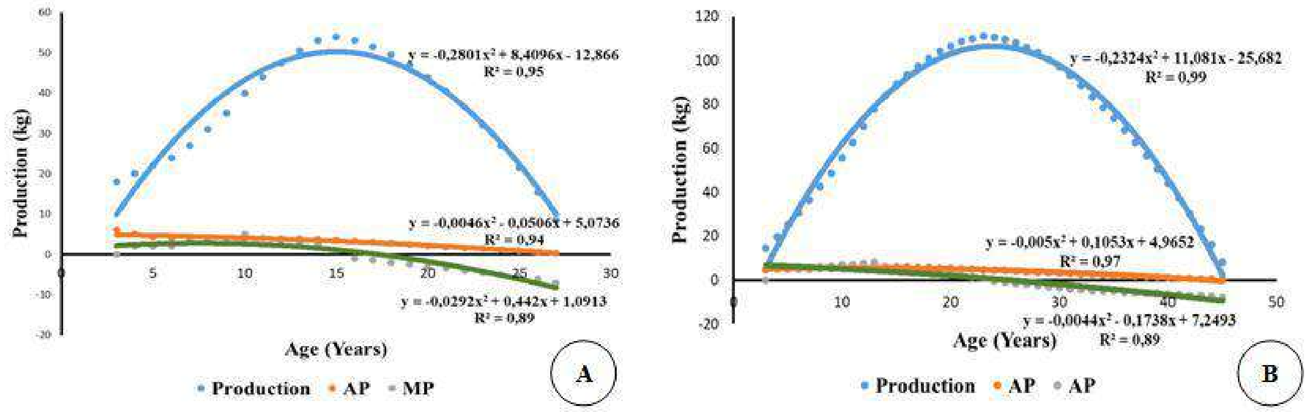

Figure 5. A. Production, AP and MP of swiftlet farming model 1 and **B**. Production, AP and MP of swiftlet farming model 2

This research was part of an effort to preserve populations and increase production of swiftlet farms in Kota Bangun District. 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 nature of the swiftlet houses built by swiftlet farmers. 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 (*Neolamarchia cadamba or Antocephalus cadamba*) and benuang (*Octomelus sumatrana*) are not considered useful for swiftlet house because they rot quickly. The swiftlet house providing optimal production was 512 m^2.

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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: xxxx.* 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. Quantitave 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 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 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 the 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 human. 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 are supplied by Malaysia, Thailand, Myanmar, Vietnam, Southern China, and the Philippines (Nurshuhada et al. 2015; Nugroho and Budiman 2013).

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 (Careena et al. 2018; Ma and Liu 2012) 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 luxurius 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 colour 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 intertwinned (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 was 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 is 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 floor
Model 1	16	8	512	2	4
Model 2	40	8	1,600	2	5

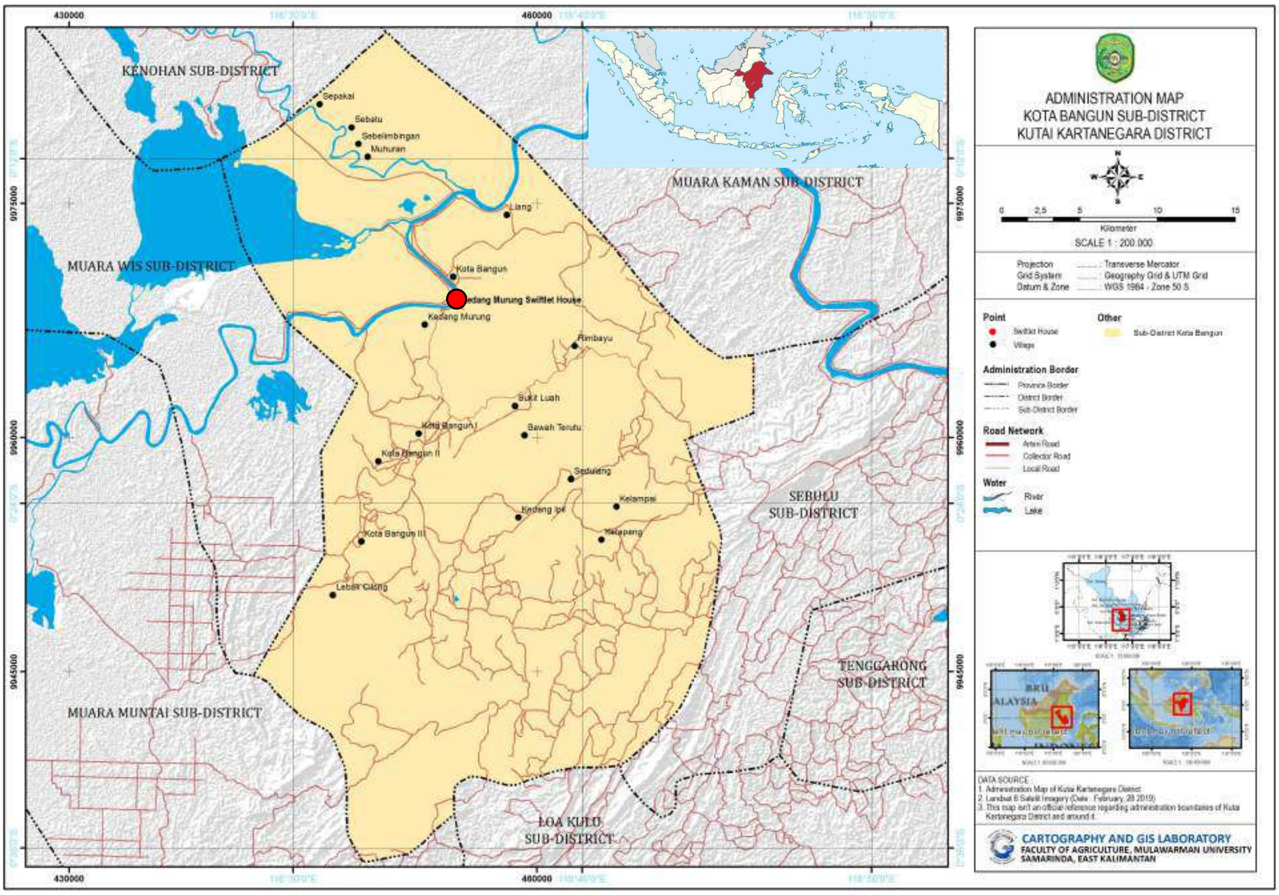

Figure 1. The location of the research (●) in Kota Bangun Subdistrict, Kutai Kartanegara District, East Kalimantan Province, Indonesia

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.

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

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.

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

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).

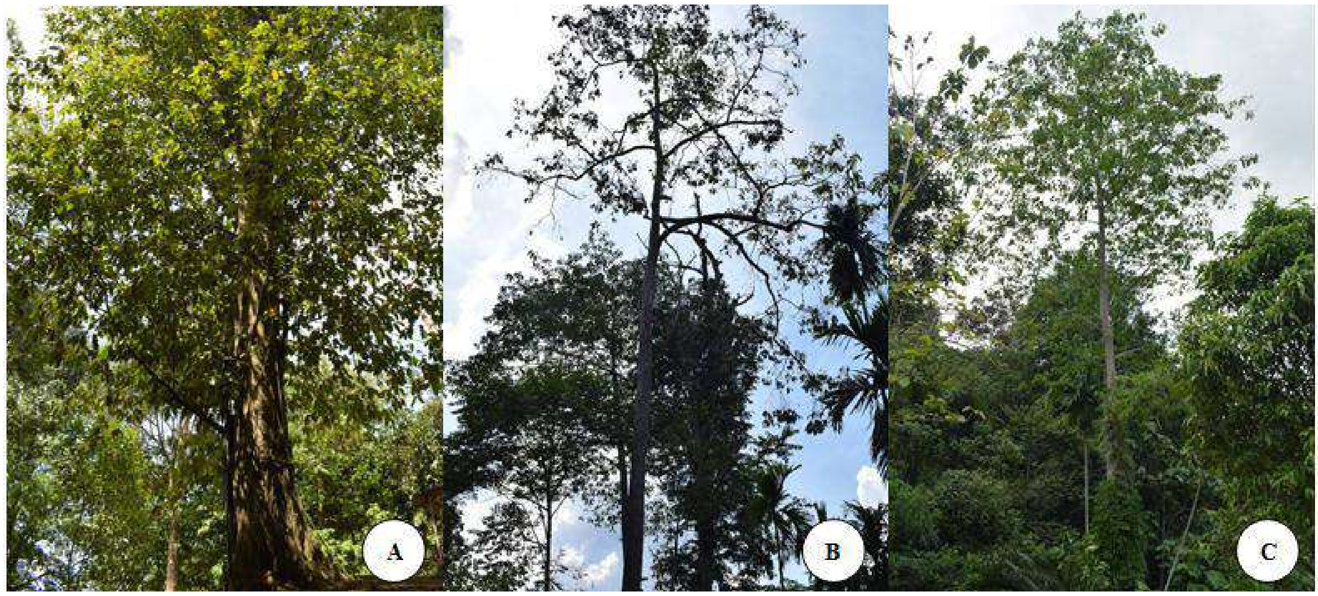

Figure 2. Timber species commonly used to build swiftlet house: A. Ulin (*Eusideroxylon zwageri*); B. Meranti (*Shorea* spp.); C. Kelampayan/jabon (*Neolamarckia cadamba/Antocephalus cadamba*)

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 were 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 the 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), alternaly 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 cost (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 were 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 the 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)

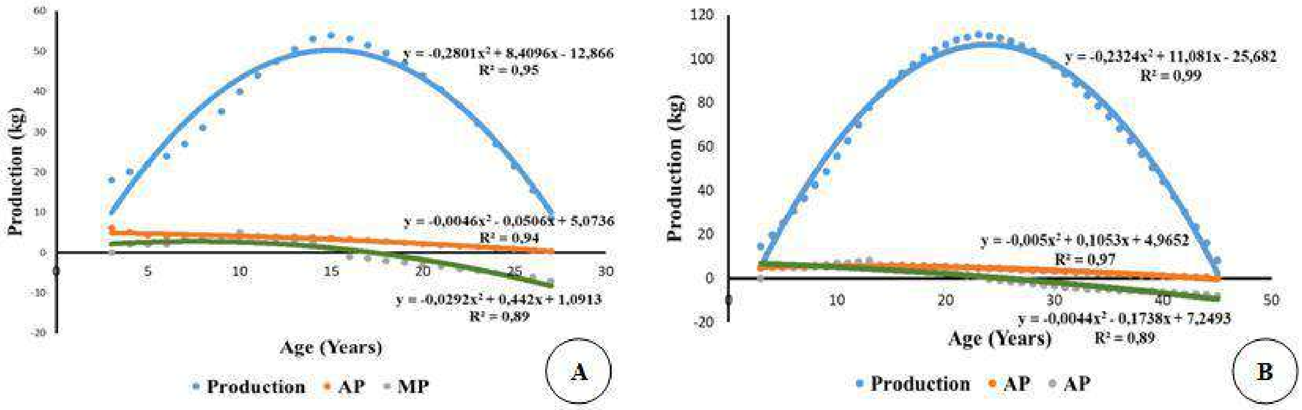

Figure 5. The production curve of swiftlet farming in Kota Bangun, East Kalimantan: A. Business Model 1; B. Business Model 2. Notes: AP: Average Production; MP: Marginal Production

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 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 swiftlett feeds. In Thailand, wetland, forest and open paddy lands are the main sources of feeed 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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The ecology, productivity and economic of swiftlet (Aerodramus fuciphagus) farming in Kota Bangun, E

Abstract

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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.