MARKET ASSESSMENT FOR BSF PRODUCTS

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Executive Summary

Waste treatment with black soldier fly larvae (BSFL) converts biowaste into valuable insect biomass. The technology is popular given the possible revenues from sales of BSFL derived products such as BSFL based animal feed. Revenues from product sales can provide the incentive to use this approach for biowaste management, especially in low- and middle-income settings with lacking waste infrastructure and services. The market assessment study presented here was conducted to evaluate the market for a variety of BSF conversion products, especially focusing on products derived from the larva itself. Two main markets segments have been investigated for East Java, especially Surabaya area: farmed animal feed for poultry and aquaculture and domesticated animal feed mainly for birds, ornamental fish and reptiles. The main objective was to quantify the market demand for BSF products in both market segments by assessing current demand for feed products that are similar and therefore could be substituted by BSF products. Data collection for the farmed animal feed market segment relied on analyzing secondary data published by the Indonesian government, whereas data for the domesticated animal feed market segment was collected through surveys conducted with different stakeholders (e.g. retailers, breeders, end-users, etc.). Given the scale of operation, the market assessment identified the domesticated animal feed market as a promising market for sales of BSFL based animal feed products in East Java. Results estimate that the market size of this segment is around 300 tons per month with a market value of around one million US dollars per month for the Surabaya area. Pricing seems to be more flexible with prices ranging from 3.5 up to 30 US dollar per kg, which could secure revenues for a BSF waste treatment facility. Survey results show that interest in BSF products is high and because of the informal environment, there is no obvious obstacle that could hinder the introduction of BSF products in this segment. In contrast, the strictly regulated farmed animal feed market is not considered as a viable option for the introduction of BSF products. The market demand for farmed animal feed is almost 60,000 tons per month indicating that most likely the requested demands from poultry or aquaculture industry stakeholders could not be met by BSF waste treatment facilities. Even if all organic waste collected in Surabaya would be converted into BSF pellets, less than 0.01% of the current market feed pellet demand in East Java could be produced. Moreover, the average pellet price is very low with around 0.7 US dollars per kg, which suggests low market entry prices for BSF conversion products, thus generating revenues with BSF products will be difficult for BSF waste treatment facilities.

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1. Introduction

Recycling of organic waste material (biowaste) is still limited, especially in low- and middle-income settings, although this is by far the largest fraction of all generated municipal waste.

One organic waste recycling technology that is in rapid development and becoming very popular is using the larvae of the Black Soldier Fly (BSF), *Hermetia illucens*. Its popularity links to the promising opportunities of using the harvested BSF larvae as a source of protein for animal feed, thus, providing a valuable alternative to conventional feed.

Enterprises and small entrepreneurs are already investing significant amounts of money into this waste treatment technology and are interested in keeping a competitive edge on the practical aspects of operating such a facility in a cost effective way. Among other aspects, financial feasibility depends on the demand and price that can be obtained by sales of BSF products, be this for animal feed or other purposes.

Currently various products based on BSF larvae are being developed by business innovators to establish and strengthen the business opportunity for operating a BSF waste treatment facility and to meet the customer demand in different market segments.

The market assessment study presented here was conducted to evaluate the market for a variety of products from a BSF waste treatment facility but with specific focus on the products that may be derived from the BSF larvae themselves.

BSF larvae can be used directly without post-processing (alive) or may undergo different degrees of post-processing including killing of the larvae. This may involve procedures in differing sequences such as mixing with other raw materials, heating/drying (dewatering), grinding, pelletizing, or also defatting. Previous research shows that the products such as BSF meal or pellets are suitable for farmed animals market (poultry and aquaculture), and products such as “pop larvae” and fresh larvae are typically targeted for the pet (domesticated) animal market. Studies show that the properties of BSF products when used as feed are beneficial for the health of animals fed. Besides suitable protein, amino acid and lipid content, BSF also shows to have probiotic properties.

The regional extent for this study was set for the East Java region (Figure *1*) and the wider metropolitan area of Gerbangkertasusila (Gresik–Bangkalan–Mojokerto–Surabaya–Sidoarjo–Lamongan) as shown in Figure *2*. The city of Surabaya was reflected main target outlet and distribution source for consideration market assessment given its importance in the region and the focus of the Eawag project FORWARD and its partnership with this city.

Figure 1: Map of Java, highlighting East Java region (google map)

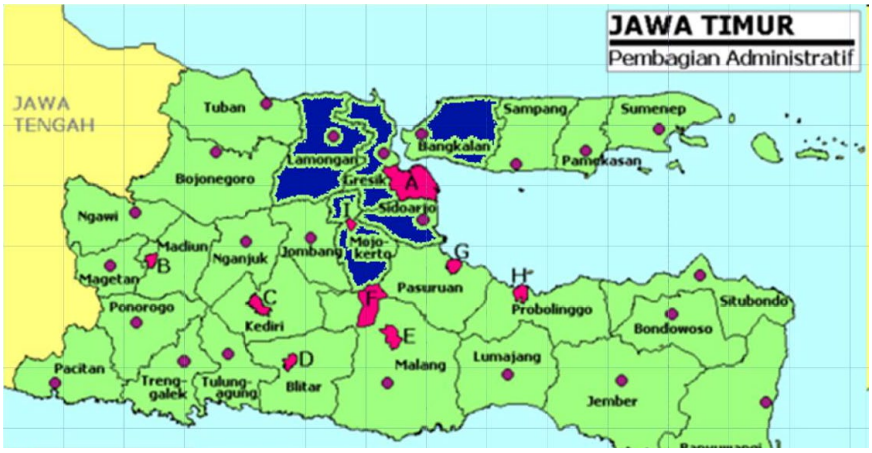

Figure 2: Gerbangkertasusila Map: in blue are the gerbangkertasusila locations, the green is the remaining part of East Java area, and red color is the capital of each province in East Java. (Source: Lembaga Pengembangan dan Pmberdayaan Antarderah)

This market assessment was structured by focusing on the use of BSF products in two main market segments:

a) the farmed animals market (poultry and aquaculture) where the feeds conventionally used are similar to BSF products, and
b) the domesticated animals market.

This selection was made, based on retracing the customers who had started ordering BSF products from the FORWARD pilot site or information from other sellers of BSF products on their current customer types.

With regard to the domesticated animal market, the most widespread and well-established pets are: birds, ornamental fish, and reptiles. In the Surabaya region these pets are very common and pet holders of all socio-economic levels are represented. Feeds used for these domesticated animals are also similar to the BSF products.

1.1. Objectives

The main objective of the study is to explore the market customer groups for the BSF products in the East Java area, especially within the city of Surabaya, and to obtain more knowledge on the potential market size (amounts) as well as market value (in IDR). Market size will be disaggregated by market customer groups and from this marketing and sales strategies shall be derived. Specific objectives of the study are:

- Quantify the market demand for BSF products in both market segments (farmed and domesticated animals) by assessing current demand for feed products that are similar and therefore could be substituted by BSF products.
- Recommend marketing and sales strategies for BSF products for the different customer groups based on a comparison how the current feed products are currently being distributed and sold.

The primary target audience for the results of this study is project internal, the FORWARD project team and their associated partners, who consist of selected private enterprises in the Surabaya region and the waste management department of Surabaya city.

2. Methodology for data collection

2.1. Market segments

Based on preliminary studies, two main market segments were distinguished: farmed animal segment and domesticated animal market segment. For each market segment then, based on existing literature and knowledge, different animal groups were identified that could be fed with BSF products (Figure 3). Data collection regarding poultry was further subdivided into free-range chickens (for meat and egg production), layer chickens (for egg production), broiler chickens (for meat production) and ducks (for meat production). Types of aquaculture can be divided into marine culture (open ocean, e.g. tuna), brackish water culture (e.g. milkfish), pond culture (e.g. common carp), cage culture (cultured in a lake or river with a bamboo pond, e.g. tilapia), fixed net cage (cultured in ocean with a pond, e.g. snapper) and rice field culture (cultured in a rice field).

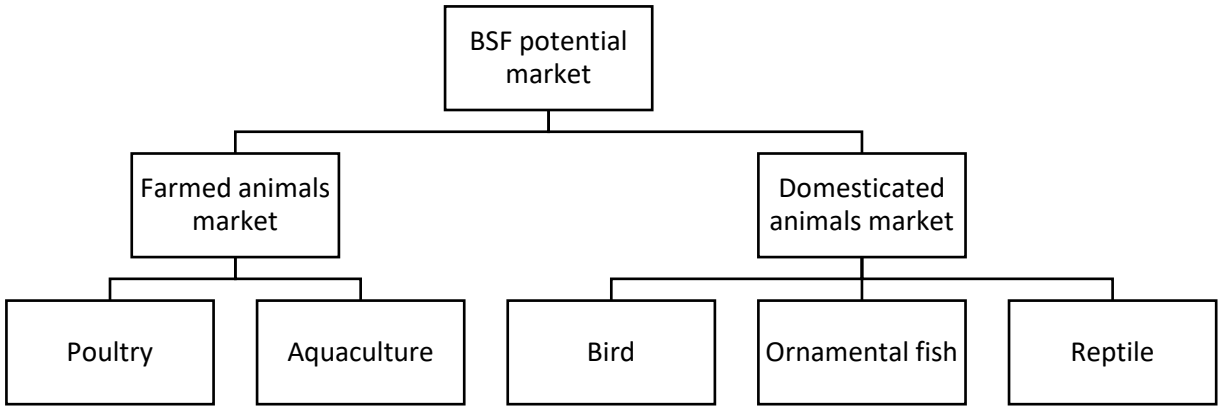

Figure 3: Mapping of BSF Potential Market

The methodology used was structured around stakeholders involved in the supply chain of the animal feed (Figure 4).

Figure 4: Supply chain of animal feed

- **Suppliers**: Companies that provide raw materials to the producers of feed. As an example this comprises a company importing soybean meal from China which is then sold to a feed mill company.
- **Feed producers**: Companies that are specialized in producing feed which are specific for certain animals and purposes. Typically, these companies are middle to large in size, covering a wide range of feed products.

- **Feed distributors**: Companies who do not produce the feed but are specialized in distributing the feed products throughout the area. Feed producers may fulfil this role directly, or may be in partnership with other companies or distribution agents.
- **Feed Retailers**: These companies or individuals (shop owners, etc.) sell the products directly to the end user. They market their products by either being present at the critical locations (bird, fish or reptile markets) or establishing other forms of customer relationships (e.g. online vendors, shops, street vendors, etc.)
- **End-User**: Are individuals (farmers, residents, etc.) that buy products to feed to their animals.

The following research questions were formed and aimed to answer by this market assessment:

- What is the market size (amounts) for the market of farmed animals and domesticated animals?
- What is the market value (IDR) for farmed animals and domesticated animals?
- What are potential substitutable products for BSF conversion products?
- What are prices expected for BSF conversion products?

2.2. Data collection for farmed animal feed market

Assessment of the farmed animal feed market relied predominately on the study and analysis of secondary data contained in existing literature and reports with focus on the Indonesian region. Indonesia publishes annual statistics on feed production, poultry production, and aquaculture production. For poultry and aquaculture this study collected data from the BPS (*Badan Pusat Statistika*) website, the website of Indonesia and East Java on animal husbandry (poultry, 2018), and the website of Indonesia and East Java fishery ministry (aquaculture, 2015-2016). The goal of data analysis was to evaluate:

- Market size (amounts)
- Market value (in IDR)
- Bestselling products and their price ranges

2.3. Data collection for domesticated animal feed market

As secondary data on the market for domesticated animals (pet feed) in Indonesia are scarce, special focus was given to this segment by including primary data collection through surveys conducted with different stakeholders (e.g. retailers, breeders, end-users, etc.).
Based on the key points of interest we developed semi-open questionnaires including some few multiple choice questions. The questionnaires were split up in different sections:

- **Respondent information**: obtain personal information, such as the contact information, reason for starting the business (retailers), reasons why they are keeping these animals.
- **Bestselling products, average prices:** obtain information about the products that are sold by retailers or used by end-users. This helps identifying the products that may possibly be replaced by BSF products.
- **Feed market size:** obtain information from the respondents quantity of feed sold/used.
- **BSF products**: information about the knowledge of interviewees on BSF products and their perception on these products.

Questionnaires were established in the kobo toolbox for data input and then run through excel. Two versions of the questionnaire were developed, one for surveying retailers and one for surveying the end-users. Thereafter, the data was transferred to excel for analysis. A flyer was developed to accompany the survey that summarized the composition of BSF products based on literature and reports (Source 26).

Interviewed groups and locations

- Retailers: Interviewees were randomly selected at pet markets, from street vendors, in the online marketplace (such as tokopedia, bukalapak, olx, etc).
- End-users**:** interviewees were selected randomly at gathering locations, such as animals contests, pet markets, facebook groups, etc.

All surveys were conducted either by face-to-face interviews or by phone. The field studies and interviews were conducted during the period of October 2018 to January 2019. The length of interviews was between 45 and 60 minutes.

Sample size

- Retailers:
    - Bird: 11 retailers
    - Ornamental fish: 10 retailers
    - Reptile: 5 retailers

- End-users: Table *1* shows the number of respondents and the distribution between the different groups and animals they keep.

Table 1: Respondent overview of end-user groups and the animals they keep

	Professional Hobbyist	Regular Hobbyist	Breeder
Bird	12	8	3
Ornamental Fish	7	11	3
Reptile	9	9	2

3. Data collection for farmed animal feed market

3.1.Poultry feed market

3.1.1. Market size and market value for poultry feed

The poultry industry in Indonesia is considered as the largest contributor to the meat industry, because of comparable higher prices for beef and religious reasons against pork consumption. For poultry industry, East Java ranks number 2 (Table *2*) in production with 13% of total chickens produced among all provinces of Indonesia. This includes free-range chickens, layer chickens, broiler chickens and ducks.

Table 2: The heads for each type of poultry in Indonesian for 2018. Source: data Source 4

Province *Value x1'000'000 heads*	Free-range Chicken	Layer Chicken	Broiler Chicken	Duck	Total	%
ACEH	6.0	0.5	6.0	3.5	16.0	1%
SUMATERA UTARA	16.5	16.6	58.2	3.5	94.8	4%
SUMATERA BARAT	4.2	9.3	26.2	1.1	40.8	2%
RIAU	6.4	0.2	48.9	0.3	55.8	2%
JAMBI	17.0	0.7	15.2	1.3	34.2	1%
SUMATERA SELATAN	8.9	6.7	26.4	1.9	43.9	2%
BENGKULU	4.5	0.3	6.3	0.3	11.4	0%
LAMPUNG	12.2	5.5	35.3	0.9	53.9	2%
BANGKA BELITUNG	1.7	0.2	8.5	0.1	10.5	0%
KEP. RIAU	1.4	0.6	20.5	0.0	22.5	1%
DKI JAKARTA	-	-	-	0.0	0.0	0%
JAWA BARAT	26.7	15.7	660.8	12.1	715.3	29%
JAWA TENGAH	42.4	22.8	180.9	6.7	252.8	10%
DI YOGYAKARTA	4.6	3.4	6.7	0.5	15.2	1%
JAWA TIMUR	**36.7**	**47.5**	**228.2**	**7.2**	**319.6**	**13%**
BANTEN	11.7	16.2	215.9	2.0	245.8	10%
BALI	3.3	5.3	7.9	0.6	17.1	1%
NTB	8.4	0.8	9.9	1.0	20.1	1%
NTT	10.4	0.2	6.3	0.4	17.3	1%
KALIMANTAN BARAT	6.1	2.4	56.6	0.6	65.7	3%
KALIMANTAN TENGAH	2.8	0.2	10.1	0.3	13.4	1%
KALIMANTAN SELATAN	9.9	7.7	87.7	4.2	109.5	4%
KALIMANTAN TIMUR	5.6	0.8	68.3	0.3	75.0	3%
KALIMANTAN UTARA	1.3	0.0	4.5	0.0	5.8	0%
SULAWESI UTARA	2.4	1.5	7.9	0.2	12.0	0%
SULAWESI TENGAH	5.7	2.3	12	0.9	20.9	1%
SULAWESI SELATAN	32.0	12.4	56.2	8.3	108.9	4%
SULAWESI TENGGARA	9.7	0.5	4.6	0.5	15.3	1%
GORONTALO	1.5	0.4	4.3	0.1	6.3	0%
SULAWESI BARAT	4.5	0.2	2.0	0.4	7.1	0%
MALUKU	2.1	0.0	0.1	0.4	2.6	0%
MALUKU UTARA	0.7	0.1	0.4	0.1	1.3	0%
PAPUA BARAT	1.3	0.1	1.5	0.1	3.0	0%
PAPUA	2.3	0.7	7.4	0.2	10.6	0%

INDONESIA (Total)	**310.9**	**181.8**	**1'891.7**	**60.0**	**2'444.4**	**100%**

Total poultry market size (all types) for East Java is 319.6 million heads. For East Java the market value (in IDR) of feed per head for each type of poultry sector is listed in Table *3* (based on the report from the Indonesian Feed mill Association (GPMT)). The total market value of the poultry feed in East Java is estimated at IDR 8.5 trillion for the year 2018 (Table *4*). This value was obtained by multiplying the GPMT feed data (Table *3*) with the number of heads of each poultry group (Table *2*).

Table 3: Value (IDR) of feed type per chicken head for each type of poultry for 2018

Feed type	Free-range Chicken	Layer Chicken	Broiler Chicken	Duck
Grain-based feed (IDR)	2'390	21'341	341	3'410
Processed feed (IDR)	2'000	60'668	12'640	8'580
Meal based feed (IDR)	9'150	14'070	917	26'220
Total (IDR)	**13'540**	**96,079**	**13'898**	**38'210**

Table 4: Market value (in million IDR) for poultry feed in East Java for 2018

Feed type	Free-range Chicken	Layer Chicken	Broiler Chicken	Duck	Total
Grain-based	87'713	1'013'698	77'816	24'552	1'179'227
Processed	73'400	2'881'730	2'884'448	61'776	5'839'578
Meal based	335'805	668'325	209'259	188'784	1'213'389
Total	**496'918**	**4'563'753**	**3'171'524**	**275'112**	**8'507'306**

From the market value (in million IDR) and the average price per feed type the total market size (in million kg) can be estimated for the poultry feed (Table *5*). The poultry feed used in East Java in 2018 is estimated to be in total 1'269 million kg.

Table 5: Market size (in million kg) for poultry feed in East Java for 2018

Feed type	Free-range Chicken	Layer Chicken	Broiler Chicken	Duck	Total
Grain-based	15	178	14	4	211
Processed	11	438	438	9	896
Meal-based	39	77	24	22	161
Total	65	692	476	35	**1'269**

3.1.2. Bestselling poultry feed

In order to determine the common price of the poultry feed in East Java, the sales data of the most common poultry animal feeds in Indonesia was gathered. Data on the most common commercial (processed feed) and the most common alternative feeds in Indonesia is shown below. Prices are based on the price for 50kg bags from popular online markets.

Layer chickens produce eggs and are fed predominately with commercial processed feed. Below (Table 8) are the commercial processed feeds commonly used for layer chickens in Indonesia with their respective prices. Prices range between 5'500 and 7'500, which results in an average price of 6'210 IDR per kg layer chicken feed.

Table 6: Prices of commercial processed feed for layer chicken

Producer	Brand	Type	Price (IDR/Kg)
PT. Charoen Pokphand Indonesia	324KJ	Layer chicken feed	6'400
PT. Japfa Comfeed Indonesia	KLK Super	Layer chicken feed	7'500
PT. New Hope Indonesia	7183 A	Layer chicken feed	5'500
PT. Pakindo Jaya Perkasa	J 42-1	Layer chicken feed	5'250
PT. Malindo	7605	Layer chicken feed	6'400
		Average Price	**6'210**

Broiler chickens are reared for meat production and similar to layer chicken, most of them are fed with processed feed. Below are the commercial processed feeds, commonly used for broiler chickens in Indonesia with their respective prices per kg (Table *7*). This gives a slithly higher average price of 6'866 IDR/kg for broiler feed and prices ranging from 6'500 to 7'180 IDR/kg.

Table 7: Prices for commercial processed feed for broiler chicken

Producer	Brand	Type	Price (IDR/Kg)
PT. Japfa Comfeed Indonesia	Broiler 1	Broiler chicken feed	7'100
PT. Charoen Pokphand Indonesia	511	Broiler chicken feed	7'180
PT. Wonokoyo Corporation	BR1 Super	Broiler chicken feed	6'850
PT. QL Agrofood Feedmill	9901	Broiler chicken feed	6'500
PT. Malindo	8202 SE	Broiler chicken feed	6'700
		Average Price	**6'866**

Free-range chickens and ducks are commonly fed either with grain based alternative feeds (Table *8*) or with meal based alternative feeds (Table *9*) as these animals are kept in free-range, small volume environments and they are known for their organic feeds. Grain based alternative feeds and meal based alternative feeds are also used for broiler and layer chickens but much less frequently than commercially processed feed. Meal based alternative feeds are the most expensive of all feeds with 8'700 IDR/kg and prices ranging from 3'500 to 20'000 IDR/kg. Meal based feeds are used predominately free-range chickens and ducks, which are farmed predominantly by independent smaller scale farmers. Grain-based feed is the cheapest of all feeds with a price of 5'700 IDR/kg.

Table 8: Prices for most common grain-based alternative feeds

Producer	Brand	Type	Price (IDR/Kg)
Local/Import	Corn	Alternative Feed	6'000
Local/Import	Soybean	Alternative Feed	6'500
Local/Import	Unshelled rice	Alternative Feed	5'000
Local/Import	Sorghum	Alternative Feed	4'000
Local/Import	Wheat	Alternative Feed	7'000
		Average Price	**5'700**

Table 9: Prices for most common meal based alternative feeds

Producer	Brand	Type	Price (IDR/Kg)
Local/Import	Fishmeal	Alternative Feed	20'000
Local/Import	Bone meal	Alternative Feed	7'000
Local/Import	Blood meal	Alternative Feed	3'500
Local/Import	Cornmeal	Alternative Feed	8'000
Local/Import	Soybean meal	Alternative Feed	5'000
		Average Price	**8'700**

3.2.Aquaculture feed market

3.2.1. Overall market size and market value for aquaculture feed

The ministry of Marine and Fisheries in 2018 has published a press release that Indonesia's fish farming has contributed 1,41% to the GDP by the end of 2015 and this number continued to rise to 5,95% in 2017. Based on the overview of tons of aquaculture production, East Java ranks 4th with 1'175.6 thousand tonnes (2016) and 7% of the total production of Indonesia (Table *10*). When distinguished by type of aquaculture, marine culture dominates with 640'800 tons followed by brackish water and pond culture, both around 1/3 of marine culture production. Pond culture distinguished itself from the others by small size. Nevertheless, production is high as this type is most common in East Java with the largest number of farmers (table 16).

Table 10: Total production of aquaculture products in Indonesia 2016 Source: Source 19

Province *1'000 tons*	Marine Culture	Brackish Water Culture	Pond Culture	Cage Culture	Fixed net cage	Rice field Culture	Total	%
ACEH	0.3	56.4	20.8	00	1.5	2.3	81.3	1%
NORTH SUMATERA	3.0	46.0	82.0	0.2	0.0	3.4	134.7	1%
WEST SUMATERA	0.3	0.1	251.1	4.2	1.0	6.0	262.8	2%
RIAU	0.7	1.0	60.8	6.2	0.1	0.0	68.8	1%
JAMBI	0.0	0.7	36.5	0.1	0.0	0.0	37.3	0%
SOUTH SUMATERA	0.0	47.2	283.6	56.2	21.1	11.9	420.0	3%
BENGKULU	0.1	6.2	65.9	0.6	2.4	3.3	78.4	1%
LAMPUNG	3.7	62.6	66.9	0.6	0.0	0.1	133.9	1%
K. BANGKA BELITUNG	1.0	1.9	0.7	0.0	1.2	0.0	4.8	0%
KEPULAUAN RIAU	68.7	0.0	12.6	0.0	0.0	0.0	81.3	1%
DKI JAKARTA	1.0	3.0	1.8	0.0	0.0	0.0	5.8	0%
WEST JAWA	8.5	382.7	559.6	1.4	0.0	35.6	987.7	7%
MIDDLE JAWA	1.4	267.1	200.3	1.4	0.0	6.9	477.0	3%
DI YOGYAKARTA	0.0	2.8	74.1	0.0	0.0	0.3	77.2	0%
EAST JAVA	**640.8**	**223.8**	**234.7**	**1.6**	**8.6**	**66.1**	**1'175.6**	**7%**
BANTEN	26.8	64.6	15.4	0.1	0.0	0.0	107.0	1%
BALI	101.7	5.3	6.5	0.0	0.0	0.7	114.2	1%
NUSA TENGGARA BARAT	1'002.3	157.5	18.2	3.1	0.0	0.7	1'181.8	7%
NUSA TENGGARA TIMUR	1'854.6	3.1	1.9	0.0	0.0	0.1	1'859.7	12%
WEST KALIMANTAN	0.0	19.8	17.9	27.4	1.2	0.0	66.3	0%
MIDDLE KALIMANTAN	0.4	12.5	35.8	29.4	0.0	0.0	78.1	0%
SOUTH KALIMANTAN	0.7	44.3	69.1	36.7	1.0	0.9	152.8	1%
EAST KALIMANTAN	5.7	66.6	3.7	35.5	0.0	0.0	111.5	1%
NORTH KALIMANTAN	523.7	45.5	4.2	0.0	0.0	0.0	573.5	3%
NORTH KALIMANTAN	220.5	1.1	122.6	0.3	1.8	31.0	377.3	3%
MIDDLE SULAWESI	1'210.6	123.2	7.1	0.1	0.5	0.0	1'341.6	8%
SOUTH SULAWESI	2'287.9	1'258.6	1.2	0.4	0.0	6.0	3'554.2	22%
SULAWESI TENGGARA	831.0	77.6	3.9	0.0	0.0	0.0	912.6	6%
GORONTALO	10.4	16.8	5.7	0.0	3.0	0.0	35.9	0%
WEST SULAWESI	72.5	47.7	4.0	0.0	0.0	2.6	126.8	1%
MALUKU	599.3	5.2	0.2	0.0	0.0	0.0	604.8	4%

NORTH MALUKU	244.0	0.4	1.4	0.0	0.0	0.0	245.9	2%
WEST PAPUA	51.1	0.5	3.3	0.0	0.0	0.0	54.9	0%
PAPUA	0.1	1.3	4.9	0.0	0.0	0.0	6.3	0%
INDONESIA	**9'773.1**	**3'053.4**	**2'278.4**	**205.3**	**43.5**	**178.0**	**1'5531.7**	**100%**

Table *11* shows the amount of different feeds for each type of aquaculture; whereby overall living feed and pellet feed dominate the demand.

Table 11: Types and amounts of aquaculture feed used for the main aquaculture types in East Java in 2016

Feeds Type *Values x 1000 ton*	Marine Culture	Brackish Water Culture	Pond Culture	Caged Culture	Fixed Net Cage	Rice Field Culture	**Total**
Living feed based	238.6	2.8	12.8	0.1	0.0	0.9	**255.3**
Pellet	20.0	312.1	141.2	2.6	5.6	11.6	**493.2**
Meal based	0.0	0.1	1.2	0.1	0.0	0.1	**1.4**
Other (vitamin)	0.0	0.1	13.2	0.1	0.0	0.0	**13.5**
Total	**258.6**	**315.1**	**168.5**	**2.9**	**5.7**	**12.6**	**763.3**

Based on that we tried to find the average price for each kind feed above on the market, we did the research based on the official available data as well as market research online (Table *12*).

Table 12: Average price for each type of feed

Feeds Type	Average price /kg
Living-fish based	50’000
Pellet	12’000
Meal based	8’700
Other (vitamin, medicine)	100’000

Therefore, the market value in IDR of the aquaculture feed industry in 2016 could be estimated by multiplying the feed requirement in kg (Table *11*) and the average price of the respective (Table *12*). Table *13* lists the result and estimates a total market value of 38 trillion IDR in the year 2016.

Table 13: Total market value (in IDR) of feed based on use in East Java in 2016

Feed types *Values x1’000’000 IDR*	Marine Culture	Brackish Water Culture	Pond Culture	Caged Culture	Fixed Net Cage	Rice Field Culture	Total
Living-feed	11’931’400	138’150	640’900	5’750	25	46’550	12’762’775
Pellets	1’000’000	15’606’450	7’062’050	129’200	281’550,	578’350	24’657’600
Meal based	0	4’400	59’250	2’850	100	4’150	70’750
Other (vitamin, medicine)	0	6’800	661’650	6’100	1’050	0	675’600
Total	**12’931’400**	**15’755’800**	**8’423’850**	**143’900**	**282’725,**	**629’050**	**38’166’725**

3.2.2. Bestselling aquaculture feed products

In order to evaluate the price range of the aquaculture feed in East Java, the sales data of the most common aquaculture feeds in Indonesia was gathered. Prices are based on the price for 50kg bags. Data was collected for the feed types: living feed, pellets, meal based feed and vitamins.

Living feeds are composed of living animals, fed directly alive or processed into dried or frozen forms. Table *14* shows the most common forms of living feed used in the aquaculture market in East Java area. The average price for living feed is 52'000 IDR/kg, with prices ranging from 15'000 to 100'000 IDR/kg.

Table 14: Prices (in IDR/kg) for common living feed in aquaculture industry

Producer	Brand	Type	Price (IDR/kg)
Local/import	Water flea	Living feed	50'000
Local/import	Shrimp	Living feed	45'000
Local/import	Blood worm	Living feed	100'000
Local/import	Small fish	Living feed	50'000
Local/import	Snail	Living feed	15'000
		Average Price	**52'000**

Pellets commercial feeds that are produced by large feed companies. Table *15* lists the most common pellets used in the aquaculture feed market in East Java area. The average price for pellet feed is 11'476 IDR/kg, with prices ranging from 6'800 to 17'020 IDR/kg.

Table 15: Prices (in IDR/kg) for common commercial feed in aquaculture industry

Producer	Brand	Type	Price (IDR/kg)
PT. Cargill Indonesia	Optimax AL 633	Manufactured Pellet	17'020
PT. Japfa Group	PA Super-1	Manufactured Pellet	10'700
PT Wonokoyo Jaya Coorporindo	Mentari/MW	Manufactured Pellet	6'800
PT. Central ProteinaPrima	Turbo FeedT-79	Manufactured Pellet	13'300
PT. Sinta Prima Feedmill Tbk	SNA	Manufactured Pellet	9'560
		Average Price	**11'476**

Meal based feeds consists of various meals, usually mixed by the farmers with the regular feed or are used as ingredients to make self-made feed. However, farmer can also directly feed to animals. Table *16* gives an overview of the common available meal based feed with an average price of 8'700 IDR/kg and prices ranging from 3'500 to 20'000 IDR/kg. The fishmeal price is more than double to other meals. This is due to its higher protein content (60%).

Table 16: Prices (IDR/kg) for common meal based feed in aquaculture industry

Producer	Brand	Type	Price (IDR(kg)
Local/Import	Fishmeal	Meal based	20'000
Local/Import	Bone meal	Meal based	7'000
Local/Import	Blood meal	Meal based	3'500
Local/Import	Cornmeal	Meal based	8'000
Local/Import	Soybean meal	Meal based	5'000
		Average Price	8'700

Vitamins are used as supplements in order to provide the fish with all required nutrition for optimal growth. Thus, vitamins are usually sold in small amounts but at higher prices, with an average price of 83'750 IDR/kg and prices ranging from 70'000 to 100'000.

Table 17: Prices (IDR/kg) for common vitamin in aquaculture industry

Producer	Brand	Type	Price (IDR/kg)
Local Brand	TON NASA	Vitamin	80’000
Local Brand	Viterna Plus	Vitamin	70’000
Local Brand	Hormonik	Vitamin	85’000
Local Brand	POC(Pupuk Organic Cair)	Vitamin	100’000
		Average Price	83’750

Based on the data above we can conclude that the most expensive feed available in East Java is living feed and also vitamin or supplement for the aquaculture animals. While, pellets and meal based feed have similar and cheaper prices.

4. Data collection for domesticated animal feed market

4.1.Survey results from retailers for domesticated animal feed

In total 26 retailers have been interviewed, 11 bird feed retailers, 10 ornamental fish feed retailers and five reptile feed retailers. The next paragraphs summarize results obtained from the questionnaire.

4.1.1. Respondents' information

- **Gender**: around 65% of the respondents were men, where around 35% are women.
- **Shop ownership**: around 96% percentage of the people we interviewed were owner of their store. 100% of the shops are independently owned.
- **Shop operation**: 85% of the stores visited have been operating for more than 5 years; 15% of them for 3-5 years; and none of the shops was less than 3 years old.
- **Reasons to start the business**: most of the respondents started their business because they were hobbyist at first (32%), around 24% of respondents started because of the market demand, while 20% of them saw a potential location for selling feed.
- **The total employee of the store**: 46% of the retailers have two people working at the shop, not include the owner
- **Annual sales revenue**: we used Undang-Undang Republik Indonesia Nr. 20 Tahun 2008, to differentiate the annual sales revenue for the respondents; most of the respondents were part of a micro business system with an annual revenue of less than IDR 300 million per year.

4.1.2. Feed types

- **Specific animal feed products sold at the shop**: around 80% of them selling products for ornamental fish, while 50% of them sell products for ornamental bird and 45% are also selling products for cats. Respondents are allow to answer more than one multiple choice in this section.
- **Retailer's portfolio of products**: respondents were asked about the products they sell at their shops. Six categories of products were considered:
    - **Processed feed**: processed feed for pets, usually produced by feed factories. The shape is usually a pellet.
    - **Dry food**: seeds, grains, or other dry feed usually from agriculture products that are used as feed.
    - **Fresh food (e.g. fruits & vegetables)**: fresh fruits and vegetables that are used as feed for some pets.
    - **Live feed (e.g.worms, cricket, dried insect)**: living feed such as worms and insect that are used for feed in for of live or dead (e.g. dried worm).
    - **Pet Animals**: The domesticated animals
    - **Accessories**: the accessories for keep pets, such as cage and pet feeder.

4.1.3. Bestselling feed products and average sales volumes

Respondents were asked by an open question, which are the bestselling products, its price and average sales volume per month.

Feed for Birds: Based on the answered of our respondents we surveyed, most of them answered repeated and this resulted in 11 bestselling products. Table *18* lists the bestselling products for bird feed in the order of percentage of respondents selling it, the type of feed, average price per pack and kg as well as average sales volumes per month.

Table 18: Bestselling products on bird feed seller. Percentage: percentage of respondents selling the products

No	Product	Feed type	Percentage	Average pack price	Average kg price (IDR/kg)	Average sales volume (kg/month)
1	Millet	dry food	21%	10’000 /kg	10’000	252
2	Chirpy (brand)	processed	13%	9’500/400gr	24’000	552
3	Cricket	living	13%	IDR 12’000/100g	120’000	35
4	Kroto	living	8%	IDR 10’000/100g	100’000	25
5	Madura Khong (brand)	processed	8%	IDR 10’000/400g	25’000	70
6	Canary Seed	dry food	8%	IDR 12’500/kg	125’000	150
7	Chicken herbal medicine (vitamin)	processed	8%	IDR 11,’000/5g	2200’000	0.59
8	Voer (brand)	processed	8%	IDR 10’500/kg	10’500	450
9	Kandang Worm	living	4%	IDR 10’000/100g	100’000	20
10	Leopard (brand)	processed	4%	IDR 8’000/100g	80’000	30
11	Corn	dry food	4%	IDR 8’000/kg	8’000	n/a

Feed for ornamental fish: Survey results identified eight bestselling products for ornamental fish feed with Takari as the most popular. Table *19* lists the bestselling products for ornamental fish feed in the order of percentage of respondents naming it, the type of feed, average price per pack and kg as well as its average sales volumes per month.

Table 19: Bestselling products on ornamental fish feed sellers. Percentage: percentage of respondents selling the products

No	Product	Feed type	Percentage	Average Price	Price (IDR/kg)	Average Sales Volume (/month)
1	Takari (brand)	processed	35%	IDR 4’200/100g	42’000	739kg
2	Small fish	living	20%	IDR 3’000/fish	-	405fishes
3	Cricket	living	10%	IDR 12’500/100g	125’000	35kg
4	Hikari (brand)	processed	10%	IDR 105’000/500g	210’000	20kg
5	Hokky (brand)	processed	10%	IDR 5’000/100g	50’000	40kg
6	Beyond (brand)	processed	5%	IDR 5’000/50g	100’000	10kg
7	Safir (brand)	processed	5%	IDR 294’000/25kg	11’800	5000kg
8	Sakura (brand)	processed	5%	IDR 5’5000/100g	55’000	20kg

Feed for reptiles: Survey results identified only two bestselling products for reptile feed with mice being the most sold feed. Table *20* lists the bestselling products for reptile feed in the order of percentage of respondents naming it, the type of feed, average price per pack and kg as well as its average sales volumes per month.

Table 20: Bestselling products on reptile feed sellers. Percentage: percentage of respondents selling the products

No	Products	Feed type	Percentage	Average Price	Price (IDR/kg)	Average sales volume (shop/month)
1	Mice	living	80%	IDR 4'000/mice	-	70 mice
2	Cricket	living	20%	IDR 10'000/100g	100'000	n/a

4.2.Survey results from end-users of feed for domesticated animals

58 end-users have been interviewed, below is the information and the survey result of our respondents.

4.2.1. Respondents' information

We ask the respondents about their basic information and about the owned animals. The objective was to get information about the typical hobbyists in Surabaya area which could be possibly future end users for the BSF products.

- **Gender**: around 83% of the respondents were men, where around 17% are women.
- **End user occupation**: around 48% of the people we interviewed were work as an employee of institution, 24% of them were students, 14% of them were business owners, and 10% of them were working as domesticated animals' breeders.
- **The animals**: we targeted our respondents to the animal's keepers who kept bird, ornamental fish, and reptile. Those three animals share almost the same percentage of the respondents we surveyed, around 30% of each owned either bird, ornamental fish, and reptiles. Other domesticated animals kept are cats, dogs, and insects.
- **Reasons doing the hobby**: we also asked the respondent why they chose to keep animals as their hobby, most of them answered because they love animals (66%).

4.2.2. Most frequent products fed by end-users

Respondents were asked about the products they usually feed. The objective was to identify common feeds used for domesticated animals (bird, ornamental fish and reptile).

Bird: Survey result showed that banana (14%), corn (10%), cricket (10%), and millet (12%) are the most common feed used by bird owners (see Table *21*). The average price for the bird feed is around IDR 47,000/kg and the respondents in average use 1kg of feed each month.

Table 21: Feed used by respondents owning birds

Name of feed	Feed type	Percentage	Average Price (IDR/kg)	Average Volume fed (kg/month)
Banana	fresh food	14%	18'375	1.75
Bejat Kenari	processed	2%	60'000	1
Canary Set	dry food	2%	11'000	1
Chirpy	processed	3%	13'750	0.625
Corn	dry food	10%	8'429	3
Cricket	living	10%	66'667	0
Ebod Canary	processed	2%	35'000	2
Green Chirpy	processed	2%	90'000	1
Hongkong Worm	living	3%	125'000	0.25

Kale	Fresh food	3%	22’500	2
Kroto (Ant's Egg)	living	7%	92’500	2.7125
Madura Khong	processed	2%	12’000	2
Milk	dry food	2%	100’000	0.2
Millet	dry food	12%	10’571	2
Pellet (no brand)	processed	3%	20’000	4.4
Power Cendet	processed	2%	15’000	2
Sun Flower Seed	seed	2%	21’000	1
Super N	processed	2%	25’000	1
Topsong	processed	3%	17’000	2
Vitakroft	processed	3%	110’000	1
White Millet	dry food	8%	10’400	1.4
Worm	living	2%	150’000	0.4
		Average	**47’000**	**1**

Ornamental fish: Ornamental fish owner we surveyed mostly use frozen blood worm (11%), pellet with no brand (11%), shrimp (11%), and the pellet brand named Takari (20%). The average price for the ornamental fish feed is around IDR 86,000/kg and the respondents in average use around 11 kg feed per month (see Table *22*).

Table 22. Feed used by respondents owning ornamental fish

Name of feed	Feed type	Percentage	Average Price (IDR/kg)	Average Volume fed (kg/month)
Black Soldier Fly's Larvae	living	2%	0	0
Centipede	living	2%	30’000	1
Cricket	living	7%	46’667	1
Frozen Blood Worm	living	11%	94’000	1.86
Green Takari	processed	2%	200’000	0.1
Hikari	processed	5%	100’000	30
Hokky	processed	2%	90’000	20
Konishi	processed	2%	110’000	75
Micro Pellet	processed	2%	150’000	3
Mosquito Larvae	living	5%	20’000	5
Pellet (no brand)	processed	11%	271’000	1.15
Sankoi	processed	2%	60’000	10
Shrimp	living	11%	76’600	6.52
Silk Worm	living	2%	50’000	0.1
Super Guppy	processed	2%	100’000	0.1
Taisho	processed	2%	100’000	10
Takari	processed	20%	56’250	0.35
Water Flea	living	5%	20’000	6.5
Wheat Germ	dry food	2%	43’000	50
Worm	living	2%	100’000	1
		Average	**86’000**	**11**

Reptiles: Reptile owners we surveyed mostly use cricket (13%), chicken (13%), and mice (13%) as their reptiles' feed. The average price for reptile feed is around IDR 151,000/kg and the reptile owners need on average around 1.6 kg of feed per month (see Table *23*).

Table 23: Feed used by respondents owning reptiles

Name of the feed	Feed type	Percentage	Average Price (IDR/kg)	Average Volume used (kg/month)
Banana	Fresh food	7%	19'500	1.75
Cabbage	Fresh food	2%	8'000	2
Calcium	dry food	4%	400'000	0.62
Catfish	Fresh food	2%	30'000	0.5
Chicken	Fresh food	13%	40'000	3.3
Cricket	living	13%	50'000	0.3
Dried worm	living	2%	200'000	0.2
Gutload Nutrition	processed	2%	150'000	0.5
Hokky Turtle	processed	2%	100'000	0.1
Hongkong Worm	processed	5%	183'333	1
Kale	Fresh food	2%	22'500	10
Kecoa Dubia	living	2%	80'000	1
Meat	Fresh food	2%	110'000	0.8
Mice	living	13%	250'000	0.7
Mustard Greens	dry food	4%	9'000	5.5
Pellet	processed	2%	150'000	2
Prebiotic	processed	2%	150'000	0.5
Processed Millet	dry food	2%	150'000	0.2
Quail	Fresh food	4%	30'000	3
Reptomin		2%	1'200'000	0.25
Shrimp	Fresh food	2%	60'000	1
Silk Worm	living	2%	60'000	0.1
Moss	Fresh food	2%	250'000	0.2
Sprouts	Fresh food	5%	7'667	3
Turtle Pellet	processed	4%	50'000	1.5
Worm	Living	2%	150'000	0.1
		Average	**151'000**	**1.6**

5. Market assessment for BSF conversion products

5.1. Market demand for BSF substitutable products

5.1.1. Substitutable products for BSF conversion products

Based on the data collected by analyzing secondaray data for farmed animal market and analyzing survey results for domesticated animal feed market, possible substitute produts were identfied for currently available BSF products as well as BSF nursery products. Figure *5* allocates BSF conversion products with substitute products and its applications.

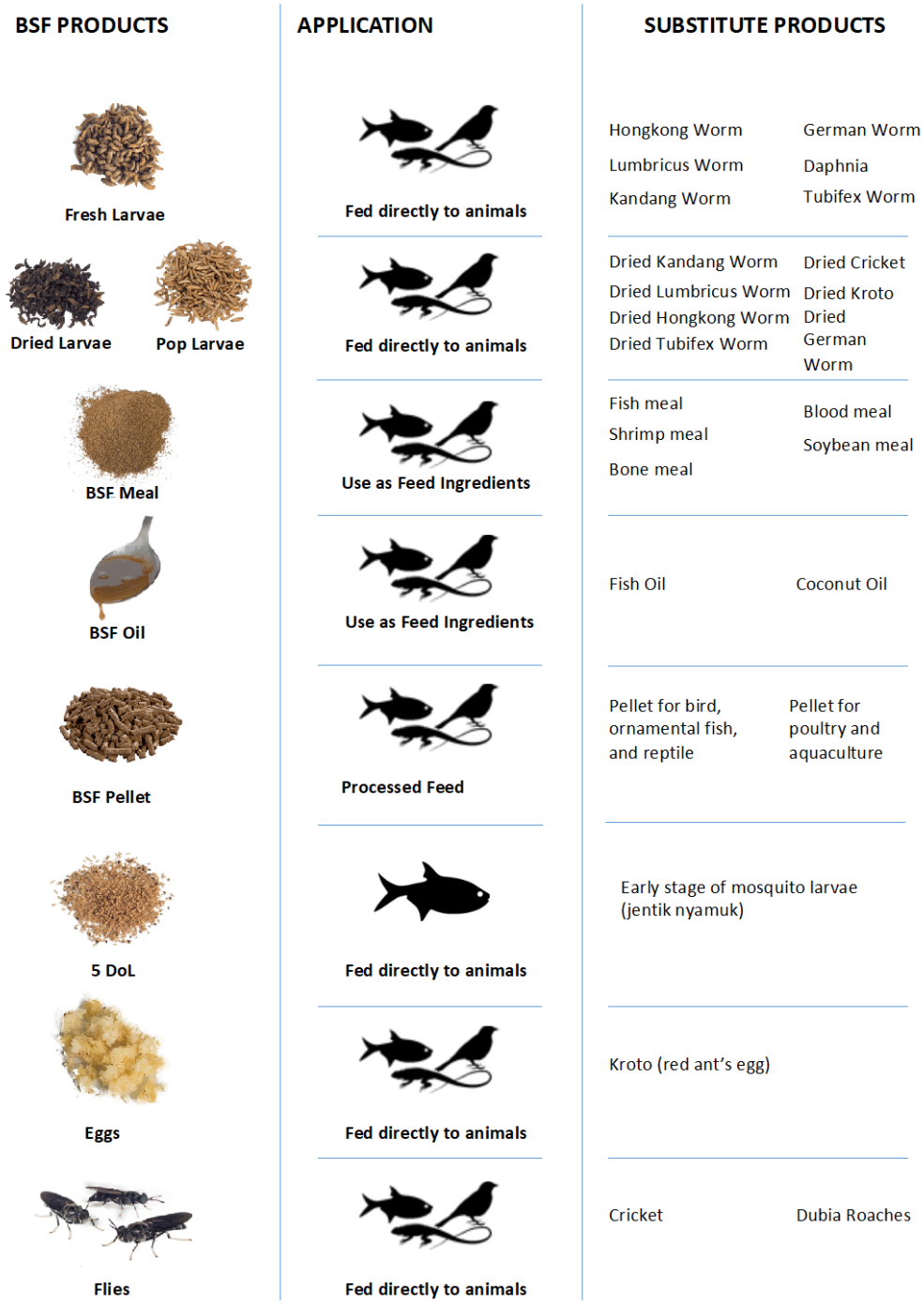

Figure 5: BSF conversion products and potential substitute product

A) Farmed animal feed market

For poultry feed the main types of feed are grains, meal based and processed feed (see 4.1.1). Meal based and processed feed could potentially be substituted by BSF meal and BSF pellets. For aquaculture feed, the main feed used is in living, pellet or meal form (see 4.2.1). All of these feed types could potentially be substituted by BSF conversion products such as fresh larvae, BSF meal and BSF pellets. Moreover, BSF oil could be a potential substitute product to fish oil and coconut oil, which are frequently used as fish feed.

B) Domesticated animal feed market

Living feed as well as processed feed for ornamental fish, birds and reptiles can potentially be substituted by BSF conversion products (see 5.1.2). Fresh larvae could be a substitute for any kind of living insect feed, e.g. Kandang worm or German worm. Dried larvae and pop-larvae could similarly be a substitute for other dried insects available in the market. Dried larvae and pop-larvae have similar substitutable products since its difference is the drying method (oven or microwave) but the purpose will be similar. BSF pellets could be a substitute product for many pellet types available on the domesticated animal feed market (see figure X, 5.1.3 and 5.2.2). For the BSF nursery products we also identified substitutable products which mainly target the domesticated animal feed market. 5 DOL's could replace mosquito larvae, a common feed for ornamental fish (see 5.2.2). BSF eggs could replace Kroto, a common feed used for birds (5.1.3 and 5.2.2).

5.1.2. Prices of substitutable products

A) Farmed animal feed market

For the identified substitute products of BSF conversion products, we listed the prices of each substitute product based on prices listed in chapters 4.1.2 and 4.2.2. Average prices for BSF substitute product groups were calculated and are shown in Table *24*. Average market prices of substitute products of BSF meal and BSF pellets targeting the farmed animal market are similarly low with under 10'000 IDR/kg. The price range for processed feed for poultry industry is around IDR 5'000/kg to IDR 8'000/kg. While for aquaculture around IDR 7'000/kg to IDR 12'000/kg. This suggest rather low market entry prices for potential BSF conversion products, such as BSF meal and BSF pellets for farmed animals. Substitute products for BSF oil have higher market prices compared to meal and pellets.

Table 24: Average price for BSF substitutable products for farmed animal feed market

BSF Products	Substitute Products	Price	Average price for BSF substitute products
BSF Meal	Fishmeal	IDR 20'000/kg	IDR 8'700/kg
	Soybean meal	IDR 5'000/kg	
	Shrimp meal	IDR 8'000/kg	
	Blood meal	IDR 3'500/kg	
	Bone meal	IDR 7'000/kg	
BSF Oil	Fish oil	IDR 25'000/l	IDR 42'500/l
	Coconut oil	IDR 60'000/l	
BSF pellets	Average pellet for poultry	IDR 7'000/kg	IDR 9'500/kg
	Average pellet for aquaculture	IDR 12'000/kg	

B) Domesticated animal feed market

Table *25* gives an overview of potential BSF products and substitute products with prices based on data collected in chapter 5.1.3. Prices not shown in chapter 5.1.3 are based on the market price from popular online marketplaces. Average prices for BSF substitute product groups were calculated and are shown in Table *24*. Highest market entry prices are expected for pop or dried larvae with 430'000 IDR/kg and lowest for 5-DoL's and BSF pellets with 50'000 and 64'000 IDR/kg respectively. Market prices are in general clearly higher compared to market prices for farmed animal market with larger price ranges. Thus, the market entry price at the domesticated animal feed market for potential BSF conversion products is expected to be higher and the pricing may be more flexible compared to farmed animal feed market.

Table 25: Average price for BSF substitutable products for farmed animal feed market

BSF Products	Substitute Products	Price	Average price for BSF substitute products
Fresh larvae	Hongkong worm	IDR 100'000/kg	IDR 117'000/kg
	Kandang worm	IDR 100'000/kg	
	German worm	IDR 200'000/kg	
	Tubifex worm	IDR 100'000/kg	
	Lumbricus worm	IDR 100'000/kg	
	Daphia	IDR 100'000/kg	
Pop and dried larvae	Dried hongkong worm	IDR 350'000/kg	IDR 429'000/kg
	Dried kandang worm	IDR 350'000/kg	
	Dried German worm	IDR 450'000/kg	
	Dried tubifex worm	IDR 800'000/kg	
	Dried lumbricus worm	IDR 500'000/kg	
	Dried cricket	IDR 250'000/kg	
	Dried kroto	IDR 300'000/kg	
BSF Pellet	Chirpy	IDR 24'000/kg	IDR 64'400/kg
	Madura Khong	IDR 25'000/kg	
	Voer	IDR 10'500/kg	
	Leopard	IDR 80'000/kg	
	Takari	IDR 42'000/kg	
	Hikari	IDR 210'000/kg	
	Hokky	IDR 50'000/kg	
	Beyond	IDR 100'000/kg	
	Safir	IDR 11'800/kg	
	Sakura	IDR 55'000/kg	
	Pellet for turtle	IDR 100'000/kg	
5 DoL	Mosquito larvae	IDR 50'000/kg	IDR 50'000/kg
Eggs	Kroto	IDR 100'000/kg	IDR 100'000/kg
Flies	Cricket	IDR 100'000/kg	IDR 167'000/kg
	Beetle	IDR 200'000/kg	
	Dubia roaches	IDR 200'000/kg	

5.1.3. Market size and value of substitutable products

A) farmed animal market

Based on the data collected in 4.1 (Table *5*) and 4.2 (Table *11*) we can extract the market volume (in kg/year and IDR/year) of the substitutable products in the poultry and aquaculture industry. The data shown in Table *26* shows the total number of the potential substitutable products for BSF in East Java. Based on this data, a market value of almost 600 trillion IDR/month and market demand of around 60'000 tons/month for identified substitutable BSF products in the farmed animal feed market can be estimated. The largest contribution to the total market volume comes from pellets.

Table 26: sales volume of substitute products for BSF conversion products.
*) Source: Source 5. **) Source: based on chapter 4.1 and 4.2

Products	Applications	BSF Products	Price (IDR/kg)	Sales Volume (tons/month)	Sales Volume (million IDR/month)
Fish meal protein < 60 %	Poultry and aquaculture	BSF Meal	14'000*	23.7*	332.2*
Fish meal protein > 60%		BSF Meal	20'200*	157.1*	3'172.6*
Fish Oil		BSF Oil	25'000*	11.2*	280.3*
Pellets		BSF Pellets	10'000**	57'875.0**	578'750.0 **
			Total	58'067.0	582'535.1

B) domesticated animals market

We extrapolated the number of the substitutable products with the number of retailers in Surabaya area by identifying "hot spots" for selling feed products. We listed all the big markets in Surabaya, resulting in 4 big pet markets. The number of products per domesticated animal is listed in Table *27*.

Table 27: number of feed retailers in Surabaya area per market

Products	Bratang Bird Market	Kupang Bird Market	Gunung Sari OF Market	Patua OF Market	Total
Bird	104	51	0	0	155
OF	13	0	156	14	183
Reptile	2	0	0	0	2
Total	127	51	156	14	340

Then, we calculated the potential market size and market volume for BSF products, shown in X. From the retailer survey data, we identified the bestselling products, its selling price (d), application (b) and average sales volume per month per retailer (e) (see chapter 5.1.3). In chapter 6.1.1 we identified those products which could potentially be substituted by BSF conversion products (c), which resulted in the substitutable products (a) listed in Table *28*. With the number total of retailers in Surabaya area per application (see table Table *27*), total sales volume per month in terms of amounts (g) and IDR (h) were calculated. Based on this data, a market value of 14 trillion IDR/month and market demand of around 280 tons/month for BSF products in the domesticated animal feed market can be estimated.

Table 28: potential market size and market volume of BSF products. B: birds, OF, ornamental fish, R: reptiles
*) Assumption of sales volume for mosquito larvae and dried larvae are based on sales volumes of kandang worm due to similarity

Products (a)	Applications (b)	BSF Products (c)	Price (IDR/kg) (d)	Average sales volume /retailers (kg/month) (e)	# of retailers (f)	Sales volume (kg/month) (g) (e*f)	Sales Volume (IDR/month) (h) (d*g)
Kandang worm	B/OF/R	Fresh larvae	100'000	20	340	6'800	680'000'000
Dried mealworm	B/OF/R	Dried larvae	350'000	20*	340*	6'800	2'380'000'000
Chirpy	B	BSF Pellet	24'000	552	155	85'560	2'053'440'000
Madura khong	B		25'000	70	155	10'850	271'250'000
Takari	OF		42'000	739	183	135'237	5'679'954'000
Hikari	OF		210'000	20	183	3'660	768'600'000
Kroto	B/OF/R	Egg	100'000	25	340	8'500	850'000'000
Mosquito larvae	B/OF/R	5 DoL	100'000	20*	340*	6'800	680'000'000
Cricket	B/OF/R	Flies	120'000	35	340	11'900	1'428'000'000
					Total:	**276'107**	**14'791'244'000**

5.2.Potential market supply by BSF products

The potential market supply by BSF conversion products was estimated based on the organic waste available in the Surabaya are and measured conversions from waste to larvae and larvae to products. The amount of organic waste in Surabaya was estimated to be 60% of the total waste collected at TPS sites in Surabaya area. The total waste per month was calculated as the sum of average waste amount delivered to TPS sites per month (see Annex, Table *34*). Surabaya could receive a total of 3'105'750 kg of waste per month and thus, around 1'863'450 kg of organic waste per month.

The potential market supply by of BSF conversion products was then calculated by multiplying the amount of organic waste with the average conversion rate (10-20%) of waste to larvae and average conversion rates of larvae into processed products, i.e. oil (5-10%), meal (10-15%), pop larvae (25-35%) and pellets containing 60% fresh larvae (90%). The conversion rates are based on results obtained from a pilot scale BSF waste treatment facility in the Surabaya area, in Sidoarjo, operated by the FORWARD project (Source 24). This is illustrated in Figure 6 for BSF products targeting the farmed animal feed market (A) and domesticated animal feed market (B).

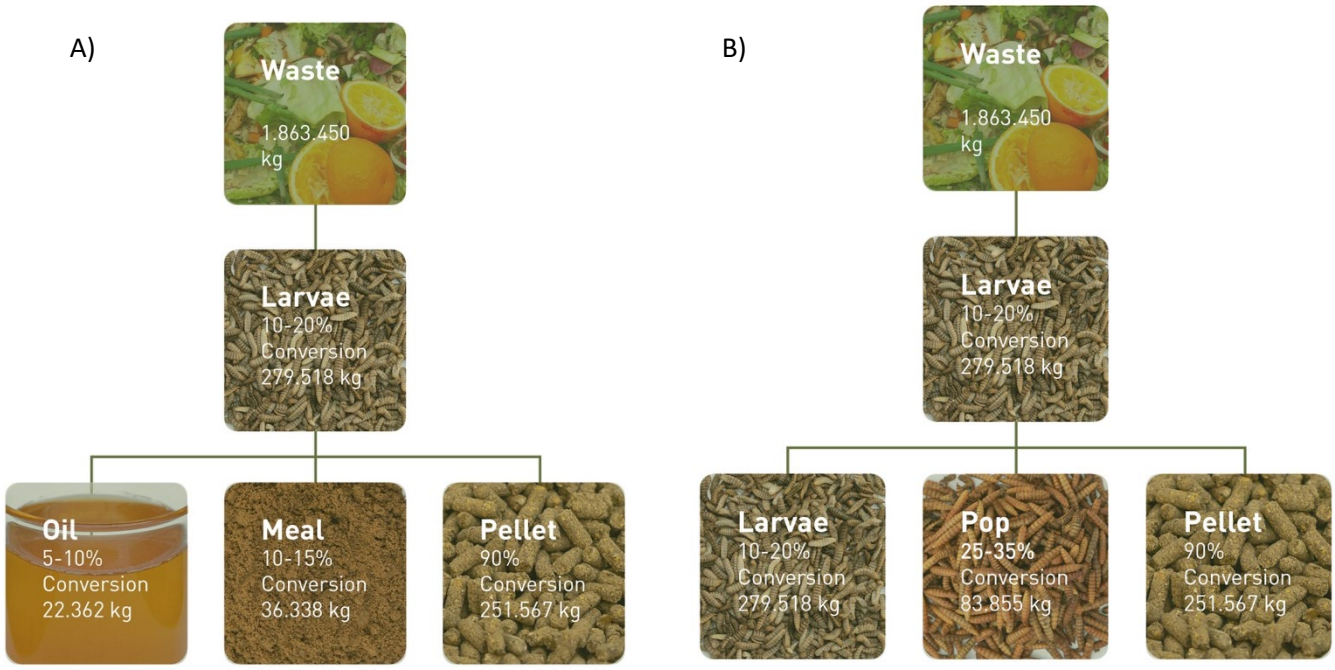

Figure 6: Conversion of organic waste into fresh larvae and into substitute products for animal feed market (A) and domesticated animal feed market (B).

The potential market supply was calculated for the feed market of farmed animals (A) and domesticated animals (B), and then compared with the estimated market demand estimated in chapter 6.1.

A) Farmed animal feed market

In Table *29* we can see the market demand for fishmeal (<60%), fish oil and pellets for the poultry and aquaculture industry in East Java versus potential market supply of BSF products in Surabaya area. Here we only considered the fishmeal quality with a protein content lower than 60%, since BSF meal contains less than 60% protein too.

Table 29: Market demand of fish meal, fish oil, pellets and potential market supply by BSF products

	Meal (<60% protein) (tons/month)	Oil (tons/month)	Pellets (tons/month)	Total (tons/month)
Market demand East Java	23.7	11.2	57'875.0	57'909.9
Potential market supply Surabaya	36.3	22.4	251.6	-

Thus, we could calculate the maximum percentage of replacement of substitutable products by BSF conversion products assuming all organic waste in the Surabaya area is converted into the respective products, BSF meal, BSF oil and BSF pellets:

- BSF meal produced in Surabaya could replace 128% the total required fishmeal (<60%) in East Java
- BSF oil could replace 200% of the fish oil required in East Java
- BSF pellets could replace less than 0.01% of the required pellets in the poultry industry in East Java

BSF feed in form of pellet could only contribute to a very low share of the total market volume. In contrast, converting all organic waste into BSF meal and BSF oil could fully meet the current demand

of lower grade fishmeal (<60%) and fish oil. The potential production of BSF oil could even be double of the market demand of fish oil in East Java.

B) Domesticated animal feed market

Form the data listed in Table *28* we can extract the market demand to supply the domesticated animal feed market in Surabaya area for living insects, dried insects and pellets. The amount for living insects is based on the amount for Kandang worm (see Table *28*) multiplied times five for five similar living insect feed types with a similar expected sales volume per month (see illustration in X). The same assumptions were made for dried insects. The market requirement for pellets is the sum of the sales volume of the four bestselling pellets for ornamental fish and bird in the Surabaya area (see Table *28*).

Table 30: Market demand of living insects, dried insects and pellets and potential market supply by BSF products

	Living insects (tons/month)	Dried insects (tons/month)	Pellets (tons/month)	Total (tons/month)
Market demand Surabaya	34.0	34.0	235.3	303.3
Potential market supply Surabaya	279.5	83.8	251.6	-

Then, we calculated the maximum percentage of replacement of substitutable products by BSF conversion products assuming all organic waste in the Surabaya area is converted into the respective products, fresh BSF larvae, pop-larvae (dried larvae) and BSF pellets.

- Fresh Larvae produced in Surabaya could replace more than 8 times the amount of living insects required in Surabaya.
- Pop larvae could replace around 2.5 times the amount dried insects required in Surabaya
- BSF pellets could replace 106% of the four bestselling pellets in Surabaya

The market supply for living insects outweighs the market demand by far. One reason could be that living insects, such as worms, are rarely used as regular feed for the bird and ornamental fish and reptiles are only fed 3-5 times / week. Moreover, fresh larvae have a short shelf live and are difficult to store. In contrast, dried feed and pellets are more convenient to store and have a higher shelf live making these products a better option for many retailers and end-users.

5.3. Market environment

Indonesia has general regulations related to the feed, especially for the poultry and aquaculture feed. In SNI's – Standard Nasional Indonesia – the feed quality is standardized. Table *31* shows different SNI standards related to animal feed. These regulations mainly cover poultry and aquaculture feed and only few regulations exist for domesticated animal feed. Most domesticated animal feed retailers surveyed were not aware of any feed regulation in place.

Table 31: Feed regulations for animal feed

No	Regulation	Applied market
SNI 3148.3:2009	Feed for layer chicken	Farmed animal feed
SNI 3148.5:2009	Feed for broiler chicken	Farmed animal feed
SNI 01-3910-2006	Feed for Ducks	Farmed animal feed
SNI 01-2715-1996	Fishmeal standardizations	Farmed animal feed
SNI 01-4266.-2006	Feed Standardization for common carb	Farmed animal feed
SNI 01-4087-2006	Feed standardization for catfish	Farmed animal feed
SNI 01-4413-2006	Feed Standardization for eel	Farmed animal feed
SNI 8512:2018	Feed for singing birds	Domesticated animal feed
SNI 7734:2011	Feed for Koi	Domesticated animal feed

This implies that the market environment for farmed animal feed is more formal having more regulations in place. An exception are free-range chickens, where there is no regulation for feed yet. On contrary, the market environment for domesticated animal feed seems less regulated, which could facilitate a faster market introduction of BSF conversion products.

5.4.Sales Strategy based on retailer's and end-user's perception

Retailers and end-users were asked about their knowledge about BSF, their preferred BSF products, potential animals eating BSF products, strengths and challenges of BSF products. Respondents were allowed to choose multiple questions. The results are summarized in Table *32*. In general, retailers are more knowledgeable and see more potential in BSF products compared to the more sceptical end-users.

Table 32: Retailer's and end-user's opinion on BSF products

INFORMATION	**RETAILERS**	**END-USERS**
BSF Knowledge	46% knew about it	21% knew about it
Preference BSF Products	• BSF pellet 85% • Fresh larvae: 46% • BSF meal: 27% • Pop larvae: 15% • Dried larvae: 15% • BSF oil: 0%	• BSF Pellet : 45% • Fresh larvae : 41% • BSF meal : 22% • BSF oil : 21% • Pop larvae : 12% • Dried larvae : 5%
Animals potentially eating BSF products	• Birds: 69% • Ornamental fish: 65% • Reptiles: 20%	• Birds: 26% • Ornamental fish: 21% • Reptiles: 14%
Strengths of BSF products	• High protein content: 81% • Product variety: 15%	• High protein content: 57% • Product variety: 31%
Challenges for BSF products	• New product: 38% • Non-proven product: 19% • Expensive product: 15%	• New product: 78% • Non-proven product: 24% • Disliked by animals: 14%

Based on all answers given by retailers and end-users, we identified strengths, weaknesses, opportunities and threats (SWOT) related to selling BSF products and is shown in a matrix in *Figure 7*. Strengths and weaknesses are characteristics related to a BSF product selling business, whereas opportunities and threats are element in the environment that could either be an advantage or a disadvantage for the BSF product selling business.

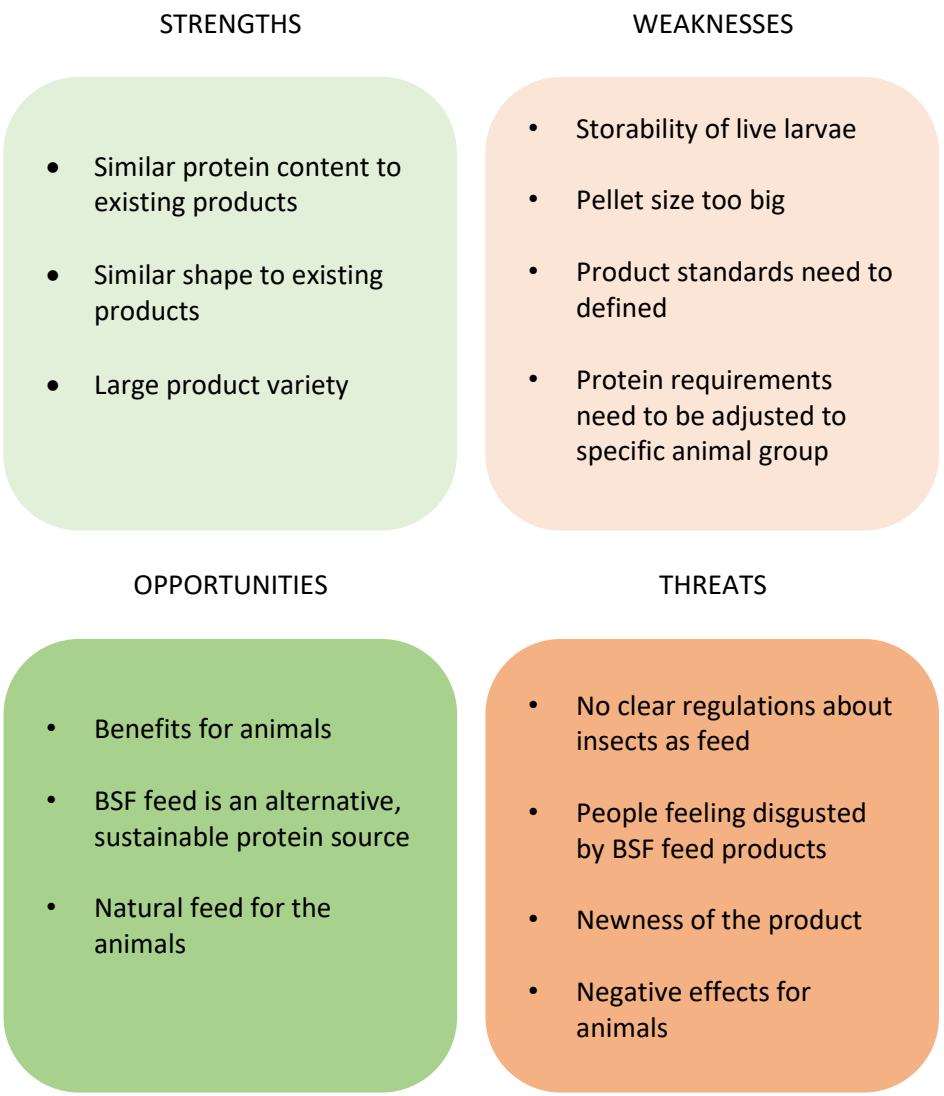

Figure 7: SWOT analysis for BSF products

6. CONCLUSION

Results obtained in this market assessment study for BSF conversion products were summarized and are presented in Table 33. From this summary, we concluded that the most potential market for BSF conversion products is the domesticated animal feed market.

Table 33: Overview of market assessment result for BSF conversion products

	Farmed animal feed market	Domesticated animal feed market
Product variety (identified substitute products)	9	30
Market size (tons/month)	57'909.9	303.3
Market value (USD/month)	70 Mio	1 Mio
Market price range (USD/kg)	1-3	3.5-30
Average pellet market price range (USD/kg)	0.7	4.6
Market environment	Formal, many regulations	Informal, less regulations

Assuming all collected organic waste in Surabaya will be treated with BSF waste treatment technology, a total of 280 tons of fresh larvae will be produced every month. The market demand for farmed animal feed of almost 60'000 tons per month indicates that most likely the requested demands from poultry or aquaculture industry stakeholders could not be met by BSF waste treatment facilities operating in Surabaya. Moreover, the price range of 1-3 USD per kg and an average pellet price of 0.7 USD per kg are very low and suggests low market entry prices for BSF conversion products, thus generating revenues with BSF products will be difficult for BSF waste treatment facilities. Last but not least, the product variety seems to be limited and many regulations are in place which standardize the feed. These could be obstacles for a fast market introduction for BSF conversion products and therefor the farmed animal feed market is not considered as a viable option for the introduction of BSF products. In contrast, the market size of around 300 tons and a market value of around one million USD per month, suggest that the domesticated animal feed market is large enough for the introduction of BSF products. Pricing seems to be more flexible for this market segment with prices ranging from 3.5 up to 30 USD/kg, which could allow for revenues for a BSF waste treatment facility. The market seems to be more informal with few regulations and many different product types. Therefore, based on this market assessment study we recommend introducing BSF products to the domesticated animal feed market.

7. Source:

- *Source 1 : Badan Pusat Statistik, Hasil Survei Struktur Ongkos Usaha Peternakan 2018, pg.*
- *Source 2 : Badan Pusat Statistik, Jumlah Perusahaan Peternakan Unggas Menurut Badan Hukum Usaha Tahun 2000 – 2017, https://www.bps.go.id/dynamictable/2015/12/22/1088/jumlah-perusahaan-peternakan-unggas-menurut-badan-hukum-usaha-tahun-2000---2017.html*
- *Source 3 : Badan Pusat Statistik, Statistik Perusahaan Peternakan Unggas 2017, pg. 14*
- *Source 4 : BPS (Badan Pusat Statistika) about the poultry population in Indonesia*
- *Source 5 : Buletin Statistik Perdagangan Luar Negeri Impor Oktober 2018.pdf*
- *Source 6 : Dinas Peternakan Jawa Timur BPS 2013-2017*
- *Source 7 : http://infoakuakultur.blogspot.com/p/blog-page_5718.html*
- *Source 8 : http://pakanayamdanikan.blogspot.com/2015/12/agen-pakan-ikan-wonokoyo-berkwalitas.html*
- *Source 9 : http://setkab.go.id/en/gdp-of-indonesias-fisheries-sector-rises-significantly-minister-of-marine-and-fisheries/*
- *Source 10 : http://setkab.go.id/en/gdp-of-indonesias-fisheries-sector-rises-significantly-minister-of-marine-and-fisheries/*
- *Source 11 : http://www.fao.org/faostat/en/#data/QC*
- *Source 12 : https://cvsumbertaniindustri.wordpress.com/daftar-harga/*
- *Source 13 : https://farmbos.com/harga-pakan-ayam-broiler/#z*
- *Source 14 : https://jatim.bps.go.id/statictable/2017/06/15/528/produksi-perikanan-budidaya-menurut-kabupaten-kota-dan-subsektor-di-provinsi-jawa-timur-ton-2016-.html*
- *Source 15 : https://jatim.bps.go.id/statictable/2018/11/14/1418/jumlah-rumah-tangga-perikanan-budidaya-menurut-kabupaten-kota-dan-jenis-budidaya-di-provinsi-jawa-timur-2017.html*
- *Source 16 : https://ternakpedia.com/784/harga-pakan-ikan-pelet-oktober-produksi-pt-sinar-prima-feedmill/*
- *Source 17 : https://www.agromaret.com/jual/18461/Menjual_pakan_ikan_Comfeed*
- *Source 18 : https://www.bps.go.id/dynamictable/2015/12/22/1088/jumlah-perusahaan-peternakan-unggas-menurut-badan-hukum-usaha-tahun-2000---2017.html*
- *Source 19 : https://www.bps.go.id/statictable/2009/10/05/1706/produksi-perikanan-budidaya-menurut-provinsi-dan-jenis-budidaya-2000-2016.html*
- *Source 20 : https://www.tokopedia.com/pdmekar/pakan-ikan-turbo-feed-t-79-2mm-berat-30kg-protein-18-ikan-bawal-lele*
- *Source 21 : Indonesian Feedmill Association (GPMT) reported in Feed Use Estimation: Data, Methodologies, and Gaps – The Case of Indonesia, Research Paper No. 3 (b) of Agricultural Market Information System, http://www.amis-outlook.org/fileadmin/user_upload/amis/docs/resources/3b%20Feed%20use%20estimation%20%E2%80%93%20Data,%20methodologies%20and%20gaps%20(Indonesia)%20October%202013.pdf*
- *Source 22 : Statistik Budidaya Provinsi Jawa Timur Tahun 2015.pdf*
- *Source 23 : Statistik Perusahaan Perikanan 2017.pdf*
- *Source 24 : Conversion rates are based on results from FORWARD project*
- Source 25 : Questionnaire:

1. How many animals (pet and farming) and farmers/owners do we count in East Java?
2. What is the volume ($ and quantities for the main type of feed: processed, seeds, etc.) of feed consumed for those animals market in East Java every year?
3. What are the trends in terms of volume of feed sold in Java/East Java?
4. How many (registered) farming and retailers of feed in East Java? (What about informal market?)
5. Where the feed does usually to be sold? (feed market/online/street vendor/etc)
6. How does the supply chain of feed for those animals? Who are the actors in the region?
7. What are the key species/groups of those farming and pet animals are?
8. How much are these usually sold on the market?
9. How long do people usually keep them? How long do they live?
10. How can we segment the farmers and pet keepers?
11. What kind of feed is typically used? (Processed feed, seeds, insects, etc.)
12. What are the top selling feed products for those animals? ($ & volume)
13. What is the characteristics of the feed for those specific animals?
14. What is the current regulation and standards for those animals in Indonesia?
15. What is existing on the market as insect products?
    - What do people appreciate them for?
    - What issues /challenge /limitation do people see about using insect products?
    - What about live insect?

- *Source 26:* Flyers used when doing the survey

BLACK SOLDIER FLY

BSF larvae (*Hermentia illucens*), also known as maggot, is a rich source of protein for animal feed. In addition to that, it is reported that BSF can be beneficial for the health of the animal thanks to probiotic properties naturally present in BSF. Today, various product based on BSF larvae are being developed for meeting the demand of different markets. This includes "BSF meal" or "pellets" for live stock farming (chicken, fish, shrimp, ets), as well as new products such as "pop larvae" or fresh larvae that target competition singing birds, colorful ornamental fishes or reptiles

COMPOSITION*

	%DM
Protein	**41**
Water	**64.7**
Ash	**14.6**
Fat	**28.9**
Fiber	**6.2**

BSF LARVAE

POP LARVAE

DRIED LARVAE

BSF MEAL

BSF OIL

PELLET

AMINO ACID*

	g/100 g		
Alanine	**6.6**	Lysine	**6.0**
Arginine	**5.0**	Methionine	**1.8**
Aspartic Acid	**8.5**	Phenylalanine	**4.2**
Cysteine	**0.6**	Proline	**5.6**
Glutamic Acid	**10.4**	Serine	**3.9**
Glycine	**5.6**	Threonine	**4.0**
Histidine	**3.3**	Tryptophan	**1.5**
Isoleucine	**4.6**	Tyrosine	**5.5**
Leucine	**7.2**	Valine	**6.3**

*) Scientific data for BSF "prepupae" based on several research publication (median value)

- *Source 27: Retailles questionnaires : https://ee.kobotoolbox.org/x/#84feziMR*
- *Source 28: End-user questionnaires : https://ee.kobotoolbox.org/x/#hPsC0oCa*

8. Annex

8.1.Glossary

5DoL	Black soldier fly larvae that is only has been fed for 5 days.
Aquaculture market	farming market that includes fish and shrimp from many ways of keep it.
Badan Pusat Statistika (BPS)	statistic department in Indonesia who has the data of Indonesia industry
Breeders	people whose job is not only keeping the domesticated animals for hobby but also for profit reason.
BSF Larvae	larvae that has been harvest and ready to be processed to other BSF products.
BSF Meal	fresh larvae of Black Soldier Fly that has been processed as a meal.
Chicken herbal medicine	a processed vitamin uses for chicken or some bird.
Contest	a domesticated animals' event where the keepers usually compete to show off their animals' uniqueness, the event have winners and also prizes.
Domesticated animal market	a market specialized for animals that are kept by people, such as
Dubia cockroaches	known as dubia roach, medium-sized species of cockroach found in Central and South America, beginning in Costa Rica.
Dried larvae	fresh larvae of Black soldier fly that has been dried through heating process with microwaved or oven with specific temperature.
Exhibition	a domesticated animal's event, usually where the animal's keepers or breeders show their unique animals.
Farmed animal market	a market specialized for farming animals such as chicken, fish farming, shrimp and duck.
Gerbangkertasusila	the main metropolitan cities or planning area in East Java
German worm	known as super worm, the worm form of bigger beetle, biggest size compares to other worms.
Hongkong worm	known as mealworm, the worm form of regular beetle, medium size compares to other worms.
Kandang worm	known as *lesser mealworm*, the worm form of small beetle, the smallest worm compares to the others.
Keepers	people who own and keep animals
Kobo	a site platform used for running a survey data, after running the interview we put what we got on www.kobotoolbox.com , we made two different kind of kobo forms, one is for the retailers survey and one is for end-users survey, anyone with the link of the kobo form could input the data. After that we downloaded the in excel form and we run it.
Kroto	red ant eggs, usually use as bird feed
Lumbricus worm	a worm usually lives in the soil, recently use for composting

Micro business	a really small business
Official distributor agent	an agent that is part of the feed producer companies, they usually drop the products in the market.
Poultry market	farming market that includes chickens and ducks
Professional hobbyist	a pet keeper who often compete in pet competition.
Regular distributor	an individual agent, usually a shop but sell the products in cheaper price, they usually buy directly to the factories
Regular hobbyist	a pet keeper who keep their pets and not compete in any competition.
Respondents	people who are interviewed
Street vendor	pet retailers usually placed in street area, not in the market area.
Tokopedia, olx, and etc	online market places commonly used by Indonesians.
Tubifex worm	sludge worm, or sewage worm segmented worm that inhabits the sediments of lakes and rivers on several continents.
UU No 2, 2008	an Indonesia regulation about the characteristic of business based on the asset of annual revenue.

8.2.Waste collection Surabaya

Table 34: available waste in Surabaya. Source: Source 2

No	TPS	Kg/day	kg/month
1	Pasar Pahing	1060	31’800
2	DTC	1040	31’200
3	Tambak Rejo	1010	30’300
4	Keputran	4490	134’700
5	Penyisiran pasar	450	13’500
6	Pasar Pahing	550	16’500
7	Keputran	4490	134’700
8	DTC	940	28’200
9	Penyisiran pasar	400	12’000
10	Keputran	4390	131’700
11	DTC	1040	31’200
12	Tambak rejo	1010	30’300
13	Keputran	5490	164’700
14	DTC	1140	34’200
15	Keputran/PIOS	6490	194’700
16	Pasar Pahing	550	16’500
17	Keputran/PIOS	5490	164’700
18	Penyisiran pasar	450	13’500
19	DTC	940	28’200
20	Pasar Pahing	1090	32’700

21	Pasar Pahing	660	19’800
22	Keputran	4390	131’700
23	DTC	840	25’200
24	Penyisiran pasar	350	10’500
25	DTC	940	28’200
26	Keputran	5390	161’700
27	Keputran/PIOS	3520	105’600
28	Pasar Pahing/ Penyisiran	1250	37’500
29	DTC	940	28’200
30	Keputran/PIOS	4520	135’600
31	Keputran/PIOS	5520	165’600
32	DTC	1140	34’200
33	Pasar Pahing	940	28’200
34	DTC	1100	33’000
35	Keputran	4490	134’700
36	Pasar Pahing/Penyisiran	1150	34’500
37	Keputran	2520	75’600
38	Jojoran	780	23’400
39	Penyisiran pasar	500	15’000
40	Keputran	2420	72’600
41	DTC	940	28’200
42	Pasar Pahing	700	21’000
43	Keputran/PIOS	4420	132’600
44	DTC	830	24’900
45	Keputran	3690	110’700
46	Pasar Pahing/Penyisiran	1050	31’500
47	DTC	925	27’750
48	Jojoran	780	23’400
49	Keputran	4320	129’600
Total /month			**3105’750**
Total /year			**37’269’000**

8.3.List of figures:

8.4. List of tables: