Green Manufacturing opportunity deep-dives

Insect-based animal feed

Insect-based animal feeds and by-products present an opportunity of $250M-1.2B by 2030 for Nigeria

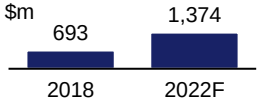
1 Description of Opportunity

Manufacturing of high-protein animal feed **from insects,** particularly **Black Soldier Flies (BSF)**. BSF are **fed on organic waste** (e.g., food or agricultural waste) and **processed** to produce animal feed (particularly for poultry and fish). Provides a **sustainable alternative** to fishmeal and soy, as BSFs can be **reared off organic waste,** producing **circular by-products** such as **organic fertiliser**.

2 Global Trends

Growing demand for insect-based proteins from aquaculture and poultry industries – growing awareness of use-cases and popularity, particularly with BSF due to lower price point and price stability compared to other insect-based protein sources[2]. From 2018-2022, the insect-based protein global market grew from **$693M to $1.4B**, representing a **CAGR of ~20%**

Insect-based protein global market, $m



~**20%** CAGR

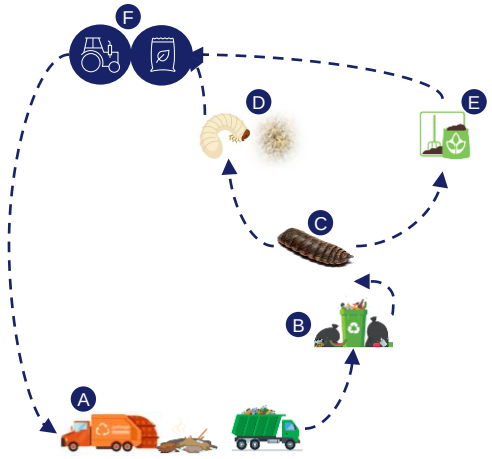
3 Relevance for Nigeria

Nigeria is well-positioned to leverage this opportunity: organic **waste is available**, **operating costs are low**, there is **significant demand** for, and currently **high importation** of, animal feeds. **Labour intensive** nature of work is well suited to large, low-skilled, and low-cost workforce. Nigerian **climate is friendlier** to raising insects than e.g. European. The Nigerian government is driving an agenda to **increase domestic production of livestock**

4 Value chain and key stakeholders

Value chain

- A Agricultural, food, and animal waste aggregated
- B Waste-based feed used to grow BSF larvae
- C Some larvae allowed to reach maturation for egg production
- D Larvae protein produced as fresh, dry, or powdered
- E Frass separated to produce crop fertilizer
- F Fertilizer and insect meal sold to feed producers and farmers, who in turn send waste streams back to BSF producers



Stakeholders

The sector is nascent with a few industrial-scale players including **MagProtein, Bioloop**, and **Unique Biotechnologies**

While no established investors have focused on the sector in Nigeria, **the Bill and Melinda Gates Foundation** has been leading investment in the sector in Africa

Public regulators include the National Agency for Food and Drug Administration and Control (**NAFDAC**) and the **Federal Ministry of Agriculture**

5 Impact Potential in Nigeria

		Key assumptions
Revenue potential, $m 2030	250 -1200	10 – 20% of feed protein from BSF
Investment size per plant, $m	15	For one manufacturing line producing 10-50 tonnes of protein per day
Total FDI potential, $m	150-200	Assuming 10 plants can serve entire market in 2030

Environmental impact[1]

- **98%** Land use reduction
- **30 – 60%** GHG emissions reduction
- **38%** Energy use reduction

6 Main challenges and potential solutions

Industry-specific	**Lack of formalized waste collection process**	Formalize **collection** of **organic waste** streams and **pilot** use of **new streams of organic waste**
	Low market awareness	Improve market **awareness** by trialling **insect feeds** with local farmers Drive local adoption through targeted government policies Introduce sale of insect-based animal feed at mainstream animal feed depots
	Insufficient local R & D	Deepen **local expertise and research**
Industry-specific	**Uncertainty on potential policies on industry**	Improve **access to finance** for farmers and manufacturers
	Lack of accessible, affordable financing	Improve **access to finance** for BSF farmers and manufacturers
	Sub-optimal access to stable power	Improve **access to power supply** for farmers and manufacturers

7 Industry case studies

MagProtein – Nigerian player, West Africa's largest producer of insect-based animal feeds, stabilised waste inputs by achieving scale and engaging with Nigerian breweries

Sanergy – a Kenyan regional player who stabilised input waste by working with local municipalities to treat organic faecal waste

8 Potential companies for MA to engage

MagProtein (already engaged**) and Bioloop (**future investment potential**)**

1 Compared with a 50:50 mixture of soybean and fishmeal. Waste stream input only.
2 Such as locusts, crickets and mealworm larvae

Source: Expert interviews; Press search; World Bank; IPIFF; Farming insects for food: Opportunities and challenges, AgriFood Tech Investing Report 2018; Press articles; Pitchbook; International Platform of Insects for Food and Feed; Guide on Good Hygiene Practice for European Union Producers of insects as food and feed; Rockefeller Foundation

1. Insect-based animal feed provides an eco-friendly alternative to traditional protein animal feed

Overview

What is the opportunity?

Replacement of traditional animal protein feed sources – such as soy and fish – **with insect-based feed for animal nutrition**, particularly for aquaculture and poultry

Alternative feed may be produced from **various insect sources such as locusts, crickets, mealworm larvae and Black Soldier Fly** (BSF) larvae

Black Soldier Fly (BSF) is one of the **most popular insect-based protein sources**, with a **lower complexity and price-point** compared to other sources

Reference industry

What does it replace?

Soybean meal – **Made from soybeans**, as a high source of protein in feed for most farm animals including pigs, poultry and aquaculture

Fish-meal – **Made from whole wild-caught fish, bycatch and fish by-products** to feed farm animals, e.g., pigs, poultry, and farmed fish.

Environmental benefits

Why is it green?

Presents a climate friendly alternative to traditional feed with **up to 60% GHG emissions reduction** compared to a 50:50 share of soymeal and fishmeal

Enables circular value chain as inputs are by-products of existing value chain – **reducing food waste**, and **feed by-product produces fertilizer**

Reduced negative impact on biodiversity due to overfishing and conversion of forests to agricultural land, also **reducing water consumption in feed production**

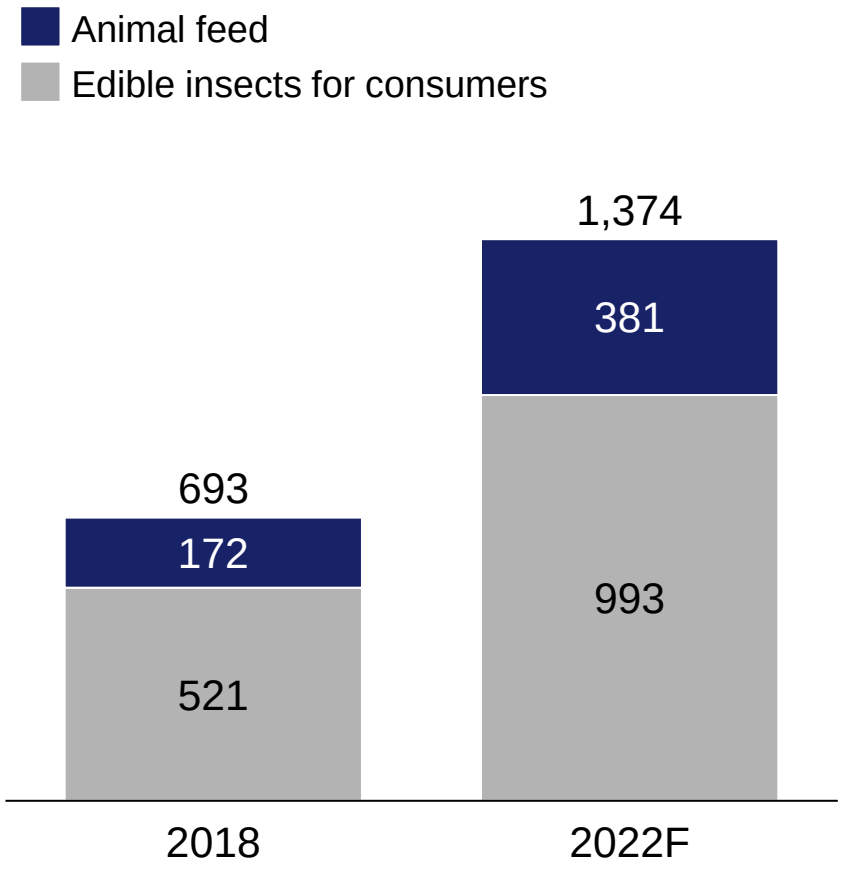
Reduced food-feed competition by providing **alternative, non-traditional protein sources** for animal feed

Flies are considered non-pests, posing no danger to humans as grown flies to not have mouth parts and do not feed on waste, bite or transmit any diseases.

Source: Expert interviews, i\Interviews with manufacturers, Internal and external reports, Press scan

2. The global insect-based feed market was valued at ~$170M in 2018 and growing, driven by rising demand and the trend towards sustainability

Insect-based protein global market, $m



CAGR 2018-22F

22%

24%

Key growth drivers

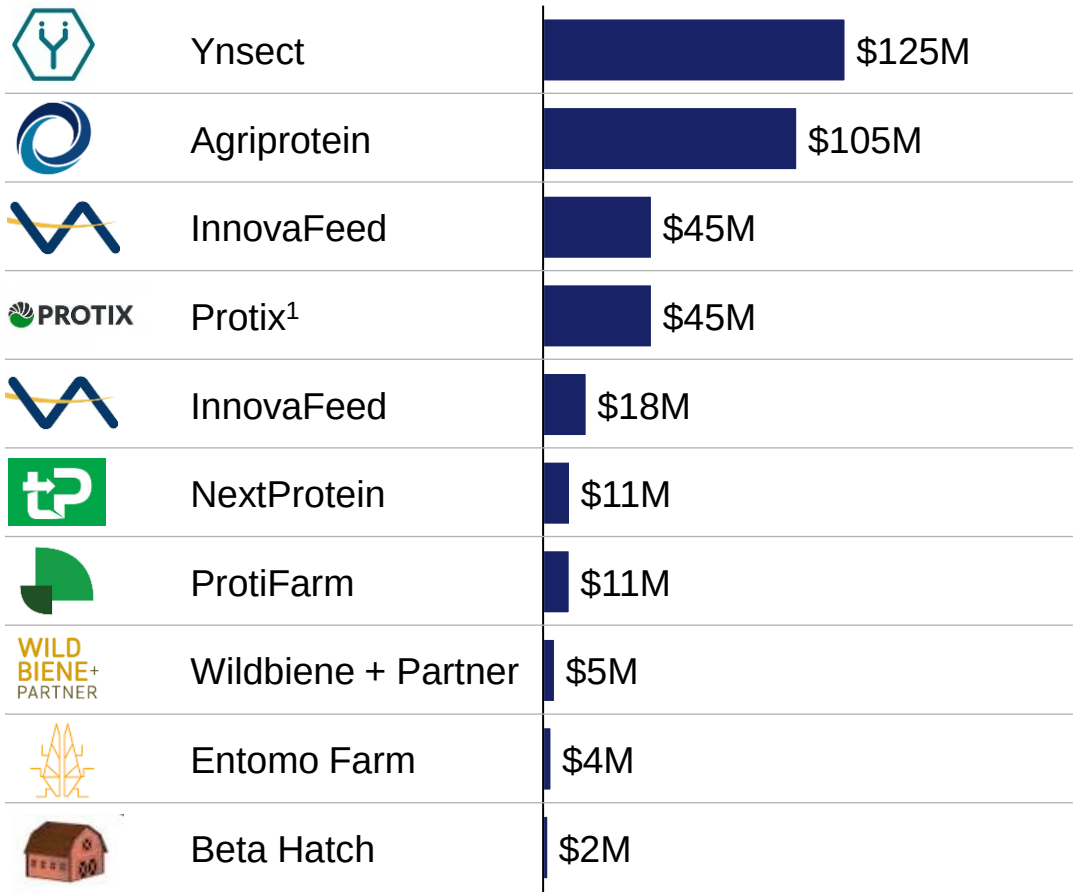
- **Growing aquaculture and poultry industry** which are the **top markets for insect feed** with ~35% and ~40% market share, respectively
  - By 2030, nearly two-thirds of seafood will be farm-raised, creating an aquaculture feed market worth around $100b[1]
  - In the EU, aquaculture consumes ~50% of European insect-based feed
- **Rising trend towards sustainability and the circular economy**
  - Insect-based proteins are sustainable alternatives to fishmeal (e.g., wild caught Omena) or land-intensive feed crops (e.g., Soy)
- Insect as a protein source is estimated to **reduce protein cost** of feed production **by 25-37.5%**

1. BSF can be used to replace the protein component of this

Source: Press search; World Bank; IPIFF; Farming insects for food: Opportunities and challenges, Nuffield Farming Scholarships Trust Report; Rockefeller Foundation

2. Insect farming has taken the investment landscape by storm – attracting large sized ($100M+) investments

Top 10 insect farming funding since 2018, USD millions



Insect farming is mainly driven by **protein production for animal feed** (other uses includes pollination, etc.), with Black Soldier Flies being the most predominant type of insects used

Insect farming has driven **high ticket size deals** within the overall AgTech space demonstrating investors confidence in this segment:

- **$125M for Ynsect** in 2019 which is the largest early-stage AgTech deal on record in Europe
- **$105M for AgriProtein** in 2018, one of the highest ticket sizes were in AgTech space (18th position out of ~1,400 deals in 2018)

Investments used primarily to **finance huge scale-up ambitions**:

- **20k tons/year** for Ynsect in the first phase versus a global production of ~6k tons in 2018 by IPIFF[2] members
- **x90 increase of BSF production** for Enterra

Major players spent **5-10 years developing technology and go-to-market strategy** before raising high ticket investments

1. $45M funding in 2017, additional undisclosed funding in March 2020
2. Insect farming members of International Platform of Insects for Food and Feed, including Ynsect, InnovaFeed, NextProtein and others

Source: AgFunder AgriFood Tech Investing Report 2018, Press articles, Pitchbook

3. Nigeria is well-positioned for the manufacturing of insect-based animal feed

Strategic enablers of insect-based feed manufacturing in Nigeria

1 Large, growing population and workforce

With a **population of over 200 million growing at ~3% annually** – Nigeria is experiencing **increased pressure on its food supply**, creating a need for alternative animal feed sources to relieve food-feed competition.

Additionally, the **labour-intensive nature of insect-based feed manufacturing makes it favourable for low-skill, low-cost labour**

2 Waste availability

According to the World Bank, **waste generation in Nigeria is estimated at 0.65-0.95 kg/capita/day, resulting in up to ~50Mt** annual waste output. Organic forms of agricultural and food waste are in no short supply, creating valuable inputs for the insect-rearing process.

3 Favourable climate for BSF rearing

Nigeria possesses favourable climate conditions for BSF larva development which **requires ideal temperatures of 24 - 30°C which falls within Nigerian annual temperature range.** This provides a unique advantages over countries in colder regions such as Europe which face heating cost challenges.

4 High demand for feed

The Global feed survey 2020 indicated that **Africa demands 43.7M tonnes of animal feed, and Nigeria accounts for 5-10% of the continent's demand**

In 2021, **animal feed represented ~70% of animal production spend by farmers, with ~70-90% of protein required for feed production being imported**; thus, feed costs are negatively impacted by FX fluctuations, driving demand for cheaper and price-stable alternative feed

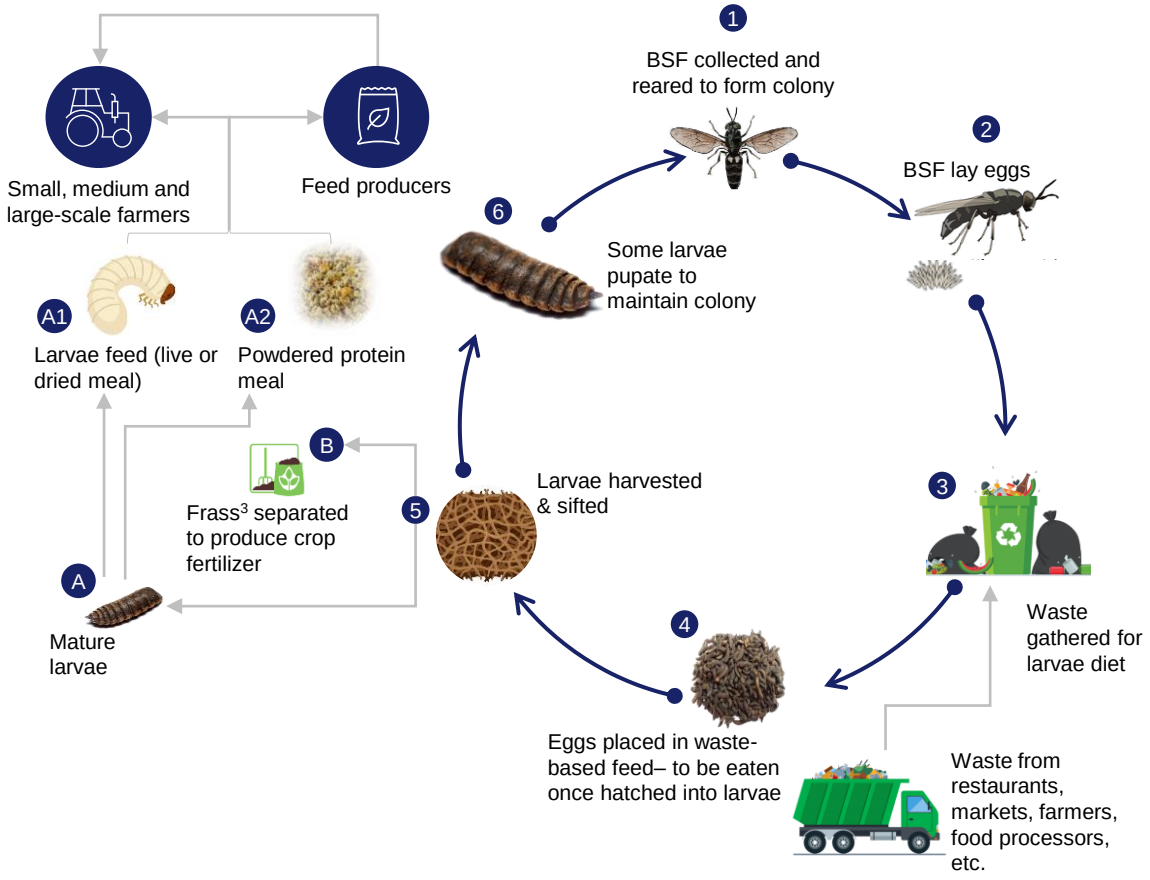
5 Favourable regulatory environment

Regulatory ban on importation of poultry products, and anticipated ban on fish products **may direct existing demand to locally produced feed**. Additionally, **financial aid programs to boost local food production** – such as the Commercial Agriculture Credit Scheme – **may improve access to lower-cost funding**

Source: Press search, National Bureau of Statistics (NBS), 2020 Global feed survey, World Bank 2012; What a Waste: A global review of solid waste management, World Bank; Climate Knowledge portal, Nigerian Institute of Animal Science

4. The insect-based feed landscape includes stakeholder involvement at multiple levels

The insect-based feed value chain includes 7 key stages...



…across multiple stakeholders

Private stakeholders

MagProtein – Working with Nature
BIOLOOP
afrimash
UNIQUE BIOTECH

Investors[1]

BILL & MELINDA GATES foundation

Public stakeholders – regulators

NAFDAC (National Agency for Food and Drug Administration and Control)
Federal agency[1] responsible product regulation, including oversight of animal feed product registration

Federal Ministry of Agriculture
Federal ministry of Agriculture regulates agricultural research, agriculture and natural resources, forestry and veterinary research

…and influenced by macro factors

Localization of food value chain: Local, sustainable animal feed production is **aligned with government drive to discourage importation of food items**

Regulatory environment: Absence of regulatory constraints to insect-based animal feed; providing **lower barriers to market entry**, and **higher likelihood of scalability**

1 Investments made in AgriProtein (South Africa) and Sanergy (Kenya), investments yet to be made in local players
2 The National Agency for Food and Drug Administration and Control
3 Excrement and skin shedding of BSF

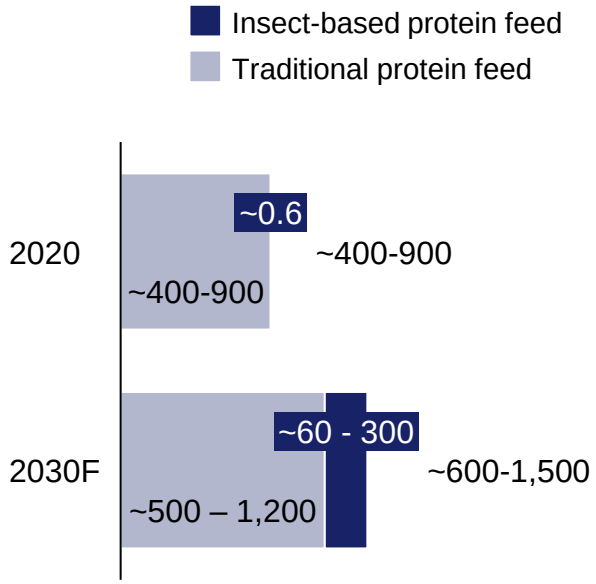
Source: Expert interviews, Press sources

5. In Nigeria, Insect-based animal feed and organic fertiliser by-product represents $250M-1.2B revenue opportunity in 2030

Calculated based on demand for protein animal feed that can potentially be met by insect-based feed in 2030

Total demand for protein for animal feed in Nigeria[1]

'000 tonnes per year



Inputs and assumptions

Insect-based animal feed

5 – 7%
Growth rate of animal protein feed demand

10 – 20%
Of animal protein demand met by insect-based feed

$1,650 – 1700
Per tonne of insect-based feed

Organic fertiliser[2]

~5
Ratio of fertilizer per ton of animal feed

~$480
Per ton of fertilizer

Total

~$100M – 500M
Revenue from insect-based animal feed

~$150M – 700M
Revenue from organic fertilizer

Revenue potential

~$100M – 500M
In 2030 from insect-based animal feed

~$150M – 700M
In 2030 from BSF animal feed

~$250M – 1.2B
In 2030 from insect-based animal feed and organic fertilizer

Environmental impact of insect-based animal feed adoption is estimated at **98% decreased land use**, **30 – 60% GHG reduction**, and **38% energy use reduction** – compared with a 50:50 mixture of soybean and fishmeal[3]

2 By-product of insect-based animal feed production process
3 Assuming insects are fed with waste inputs not being applied to other use cases such as anaerobic digestion

Source: Expert interviews, Press sources, Industry players interviews, Van Zanten et al. (2015), van Huis & Oonincx (2017), Vauterin et. al (2021)

6. Based on interviews with Nigerian manufacturers, six key challenges have been identified across the value chain

	Challenge	Description	Quotes from local manufacturers
Industry-specific	1 Lack of formalized waste collection process	Waste collection and separation are not effectively conducted; this impacts accessibility and consistency of waste inputs	“ There is a variety of potential waste streams, but **few have formal mechanisms for access**. Sometimes we just drive a truck to food markets to collect waste, but it makes scaling inputs tough
	2 Low market awareness of product	Insect-based animal feed market in Nigeria is nascent, with existing producers operating as small-scales; product is yet to be recognized at a main-stream level	“ Large feed producers and farmers are **still piloting insect-based feeds**. Creating **confidence** in product quality and **awareness of use-cases** will help with expansion
	3 Insufficient local R & D on value chain	Knowledge on the insect-based protein value chain is mainly based on individual learnings/research by manufacturers; rather than at an industry-level to ensure industry-wide accessibility	“ Research is required to investigate **use of alternative waste streams such as human waste, fish waste** and **manure** as insect feed, as well as to explore other use-cases for BSF larvae beyond animal feed manufacturing
	4 Uncertainty of potential policies/government standards on industry	Currently, there are no direct government policies impacting IBF, leading to concerns on what policies might subsequently be introduced	“ The sector is **unchartered space for the Nigeria government,** and there is no guarantee to the kinds of policy to expect in coming years
Macro-level	5 Lack of accessible and affordable financing	There are currently no dedicated funds or loan programs available for manufacturers to enable easy access to financing	“ We could rapidly scale our current operations if we had the right access to capital, it doesn’t require much more land, and larger orders could **help when engaging with waste providers**
	6 Sub-optimal access to stable power	Grid reliability and frequency of power cuts impacts manufacturing process includes electricity-based equipment	“ While the manufacturing process of insect-based animal feed is not energy-intensive, some of the **critical equipment required for larvae sifting and processing** – such as drying – **rely on power** thus, stable access to power is required for process efficiency

Source: Interviews with manufacturers

6. Challenges in the market may be addressed by implementing targeted initiatives in the sector (1/2)

Challenge	Proposed solution(s)	Initiatives	Relevant stakeholders[1]
1 Lack of formalized waste collection process	Formalize **collection** of **organic waste** streams and **pilot** use of **new streams of organic waste**	Sensitization of large-scale waste producers of potential revenue stream from sale of organic waste	Waste Management Authorities IBF Manufacturers Farmers
		Partnership between manufacturers and large scale farmers and food processors – such as breweries – for formalized waste hand-off with standard pricing	
		Identification and piloting of potential alternative organic waste streams to determine viability	
2 Low market awareness of product	Improve market **awareness** by trialling **insect feeds** with local farmers	Collaboration between large-scale aquaculture and poultry farmers, with manufacturers to test insect-based animal feed and drive full adoption	IBF Manufacturers
	Drive local adoption through targeted government policies	Engagement with the Ministry of Agriculture – and other relevant stakeholders – to introduce insect-based animal protein and its benefits, to drive policies aimed at encouraging use of alternative protein sources for animal feed	IBF Manufacturers Green-transition advocacy organizations
	Introduce sale of insect-based animal feed at mainstream animal feed depots	Collaboration between IBF manufacturers and animal feed retailers to sell products in-store and encourage adoption by farmers	IBF Manufacturers Feed retailers

1 To drive execution of initiative

Source: Interviews with manufacturers and stakeholders

6. Challenges in the market may be addressed by implementing targeted initiatives in the sector (2/2)

Challenge	Proposed solution(s)	Initiatives	Relevant stakeholders[1]
3 Insufficient local R & D on value chain	**Deepen local expertise and research**	Collaboration between manufacturers and agricultural researchers to build local understanding of the various applications of insect-based animal feed across the value chain through academic research and learnings from the manufacturing process	Research institutes – such as universities IBF manufacturers & animal farmers
		Circulation of findings with key industry stakeholders including manufacturers, farmers (end-users), large-scale waste producers	Research institutes – such as universities
4 Lack of accessible and affordable financing	Improve **access to finance** for farmers and manufacturers	Engagement of DFIs and other philanthropic stakeholders with financial institutions – such as the AfDB – to enable patient capital for sector players	DFIs
		Development of sector-specific intervention funds for insect-based animal feed manufacturers	Central Bank of Nigeria
5 Sub-optimal access to stable power	Improve **access to power supply** for farmers and manufacturers	Engagement of DFIs with government and private sector stakeholders to provide grants and subsidy schemes for set-up of solar power in insect-based feed manufacturing plants	Government DFIs and NGOs

1 To drive execution of initiative

Source: Interviews with manufacturers and stakeholders

7.Local player profile: MagProtein

Overview of company and insect-based feed product

Company overview

- MagProtein was **founded in 2017,** and is currently **one of the top insect-based animal feed producers in West Africa** – initially producing fish feed from insects and expanded to wider **insect-based animal feed production, primarily from Black Soldier Fly (BSF)**
- Aims to **enable sustainable feeding in Africa through a circular and zero-waste process** using low value waste material as inputs
- In the future, MagProtein **aims to remanufacture waste materials generated by customers** and make the food chain more sustainable

Product offerings

- **Protein meal** – Environmentally-friendly and **high-protein alternative to fishmeal and pet feed**, produced from larvae of the BSF; core MagProtein product
- **Frass** - Natural by-product of BSF larvae production, made up of insect castings and exuviae; produces **high-quality soil fertilizer**, as well as fish feed

Production capacity

- Insect-rearing facility with a colony that introduces **500 BSF every minute**
- Daily capacity of **1 – 1.5 tonnes of dried insect protein powder**, with expansion target of 5 tonnes per day
  - Feed had initially been produced from wet waste (e.g., fruit waste) and moved to dry waste to enable scale and logistic efficiency
- Daily production of **6 – 7 tonnes of organic fertilizer**, as a by-product of BSF rearing and protein production process

Target customers

- **Small and medium-scale farmers** located in the Lagos[1] axis – **constrained by production capacity**

Requirements for scale

- Capital – **~$15-16M investment required** to enable incremental production capacity and increase daily output
- Space – **Additional land area required for BSF rearing**, with 300 – 400kg produced per sq meter every 10 days
- Input consistency – Potential **partnerships with large scale agricultural businesses** such as cassava producers, beer processors, etc. **to ensure consistency of inputs and nutrient content of feed**, as well as to ensure availability of alternatives

1 Particularly Epe and Ijebu-Ode

7.Regional player: Sanergy

Overview of company and insect-based protein value chain

Company overview

- Sanergy was created in 2011 **in response to the inadequate access to safe sanitation and waste management services** experienced by Nairobi residents living in slums.
- Through its partnership **with Bill and Malinda Gates Foundation, it** has **developed technology to manufacture agricultural inputs**, such as insect-based protein for animal feed and organic fertilizer
- In 2021, Japan International Cooperation Agency (Jica) has made **a $2.5 million capital investment** into Sanergy

Operation description

- Sanergy's recycling factory is the largest in East Africa with a stated capacity of ~12,000 tons of organic waste per year
- As of December 2019, Sanergy had installed **3,247 Fresh Life Toilets in 11 informal settlements, serving over 80,000 urban residents**
- The company utilizes **BSF larvae and thermophilic** composting to treat and upcycle faecal sludge, agricultural waste, and market and kitchen food waste
- Its BSF treatment plant treats **7 tonnes of faecal sludge and organic waste** daily, with a planned capacity expansion to 200 tonnes per day

Initial challenges faced

- Establishing optimal environmental conditions to support BSF reproduction and growth cycles
- Land acquisition for toilet facilities in informal settlements
- Constraining government policies regarding manufacture and sale of waste-based products

Source: Press search

SANERGY

Key learnings applicable to Nigerian players

Investment in R&D: Sanergy leveraged continuous research in R&D to improve product quality, standard operating procedures and build staff capabilities to improve process efficiency and product quality

Stakeholder partnerships: The company worked with the government, and other regulators to create an enabling environment for its operations and ensured ease of waste accessibility by partnering with large-scale waste generators

Active customer engagement: Sanergy operates with frequent customer engagement to continuously tailor output to customer needs

8. In examining the insect-based animal feeds market, the team looked for opportunities to add to the TF pipeline and find fora for engagement

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NON-EXHAUSTIVE

LOCAL PLAYERS OF INTEREST

	Scaling Need	Status
MagProtein	~$10m over next 5-7 years; scale production to 3-4kt/ year from 0.5kt/year	Already in contact
Bioloop	$5-6m over next 5-7 years; scale production to 15-20kt/year from 0.1kt/year	Introduced
Unique Biotechnology	$3-5m (Q4 this year to Q2 next year)	Highlighted

Other players mentioned include:

- Uptake Farms ltd, Ekiti state
- 5 kids farms, Delta state
- Fly Doctor, Ogun state
- Fly Colony, Ogun state
- Ent'O'ganics Fly Farm
- Breex Black Soldier Maggot Farm
- Dailyfresh Farm

ENGAGEMENT FORA

- Local players can be invited to a roundtable. No formal industry association for insect-based protein producers exists
- Feed Nigeria Summit: Agro Nigeria & Federal Ministry of Agriculture and Rural Development
- Nigerian Institute for Animal Science
- Nigerian Agricultural Cooperative (and other farming co-operatives)