



GreenCape



Nutrient upcycling:
Spent brewery grain to
insect protein and more

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Purpose

Black Soldier Fly (BSF) farming leverages the insatiable appetite of BSF larvae to convert low grade organics into high value animal feed and related products, for which the global demand is increasing. These products have various applications, notably in animal feed and pet food, but also in crop production, cosmetics, and pharmaceuticals, and more applications are continually being investigated, including human food.

The number of companies in South Africa that are utilising BSF farming is increasing. Maltento is one of these Cape Town based businesses pioneering BSF farming technology. Maltento has developed a circular solution that upcycles low-value organic by-products into high value products that are good for people, good for the planet, and good for business.

This case study is written for commercial organic waste generators along the food value chain, a value chain known for considerable loss and wastage, to illustrate how circularity is a useful lens through which to imbue resilience in the food supply chain. Upcycling organic by-products is one of many circularity activities the food and beverage sector can use to alleviate pressures on the overall system. Organic waste beneficiation will reduce landfill disposal liabilities and strengthen competitiveness, which in turn contributes to building more resilient businesses and more resilient cities.

The Black Soldier Fly (*Hermetia illucens*) is a wasp looking fly. The adult is shy and avoids human interactions. It does not have mouthparts and thus do not seek out food. The purpose of the adult form is to locate mates and lay eggs. Thus, they are not associated with transmitting diseases, as is the case with the common housefly. Only in the larvae form do they consume food. The larvae digests and converts organics into, amongst others, protein. They have a low (efficient) feed conversion ratio compared to other protein sources and are able to convert 10 tonnes of feed into 1 tonne of protein. They have evolved to break down problematic bacteria and emit odours that repel pests. The excrement is rich in nutrients and can be used as an organic fertiliser. Overall, the BSF is regarded not as a pest, but as sanitary solution to food waste and a source of sustainable protein.



Black soldier fly larvae
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A circular economy keeps products, components, and materials at their highest use and / or value for as long as possible. This includes the biological nutrients embedded in animal feed and human food. When food waste prevention and value add retention are not possible, beneficiation, and more importantly upcycling, must be a priority. In addition to being a societal and environmental imperative, it is a strategic business decision to increase competitiveness

The case study discusses:

- **Upcycling organic by-products into high value products;**
- **Localising protein feed production;**
- **Facilitating a resilient food system.**

It is written for:

- **Businesses disposing of food waste to landfill;**
- **Animal feed brands / producers;**
- **Food brands looking to strengthen supply chain resilience.**

2 Background and problem

Farmed animals convert plants, and other raw materials, into products for human use and consumption. The demand for these animal-based products continues to rise year on year. Demand for meat and dairy products alone are expected to increase by 327% and 270% respectively in Sub-Saharan Africa by 2050¹. To sufficiently feed this demand, vast quantities of feed are needed, notably protein rich feed, such as soy and fishmeal, to fuel animal growth. However, to supply such vast amounts of feed requires enormous amounts of input resources. The extraction of these resources are often inherently linear, highly inefficient, and unsustainable. The ecological, social, and economic shortfalls of such a food system are well documented and expose cities, and their citizens, to chronic stresses and acute shocks. Some concerns include, but are not limited to:

Supply chain risk: The global feed market is highly volatile and dependent on global supply chains. Seasonal variations, climate instability, ecosystem pressures, coupled with geopolitical uncertainty, ensures that fluctuations in commodity prices are common and will likely continue.

Resource intensity: Producing feed for animal based products require extensive inputs: seeds, water, energy, chemicals, pesticides, antibiotics, fertilisers, labour, and capital. In turn, each input has its own footprint. The longer and more complicated the value chain, the greater the resource intensity and subsequent footprint. These inputs are often raw materials and finite in nature, and often imported.

Land intensity: Producing feed for animal based products requires vast amounts of land - land use that competes with sensitive ecosystems or land that could be used for other uses such as production of food for humans, or urban development.

Waste: Almost a third (30.8%) of annual global edible food production is lost or wasted: 13.8% takes place at farm and post-harvest², whilst 17% takes place from distribution to consumer³. South Africa fairs worse with $\pm 45.4\%$ of the ± 22.8 million tonnes of edible food never eaten⁴. Almost half (49%) of loss and waste in South Africa takes place at the processing and manufacturing stage, which is strongly associated with cities.

Environmental pollution: Traditional intensive linear agricultural activities are associated with polluting surrounding environments and sensitive ecosystems. Pesticides, chemical fertilisers, and poorly managed manure can exacerbate air pollution, contaminate soils, and leach chemicals and excessive nutrients into water bodies, causing various impacts including acidification and eutrophication.

Climate change: Greenhouse gases (GHG) are emitted at every stage of the food supply chain, especially where such supply chains are reliant on fossil fuel-based energy sources. It is estimated that the total GHG contribution of the global food system ranges between 21 - 37% of global GHG emissions⁵. Furthermore, when organics are disposed of in the anaerobic environment present in landfills, methane is produced. Methane is a potent GHG that has been responsible for 10–11% of Cape Town's emissions⁶.

Degradation of natural capital: Agriculture is a major consumer of freshwater, and has been linked to the degradation of highly productive ecosystems. Poor agricultural practices are significant contributors to soil loss and degradation, and contributes to a dramatic loss of biodiversity, increased vulnerability to pests and diseases, and greater reliance on finite chemical inputs.

¹World Bank (2020) - <https://blogs.worldbank.org/nasikiliza/lets-not-miss-chance-feed-700-million-plus-people-who-will-live-west-africa-2050>

²UNEP (2021) - www.unep.org/resources/report/unepl-food-waste-index-report-2021 www.nature.com/articles/s41893-019-0293-3

³FAO (2019) - www.fao.org/3/ca6030en/ca6030en.pdf

⁴CSIR (2021) - www.wasteroadmap.co.za/wp-content/uploads/2021/06/17-CSIR-Final_Technical-report_Food-waste.pdf

⁵IPCC (2019) - www.ipcc.ch/site/assets/uploads/sites/4/2021/02/08_Chapter-5_3.pdf

⁶CCT (2021) - https://resource.capetown.gov.za/documentcentre/Documents/City%20strategies,%20plans%20and%20frameworks/Climate_Change_Strategy.pdf

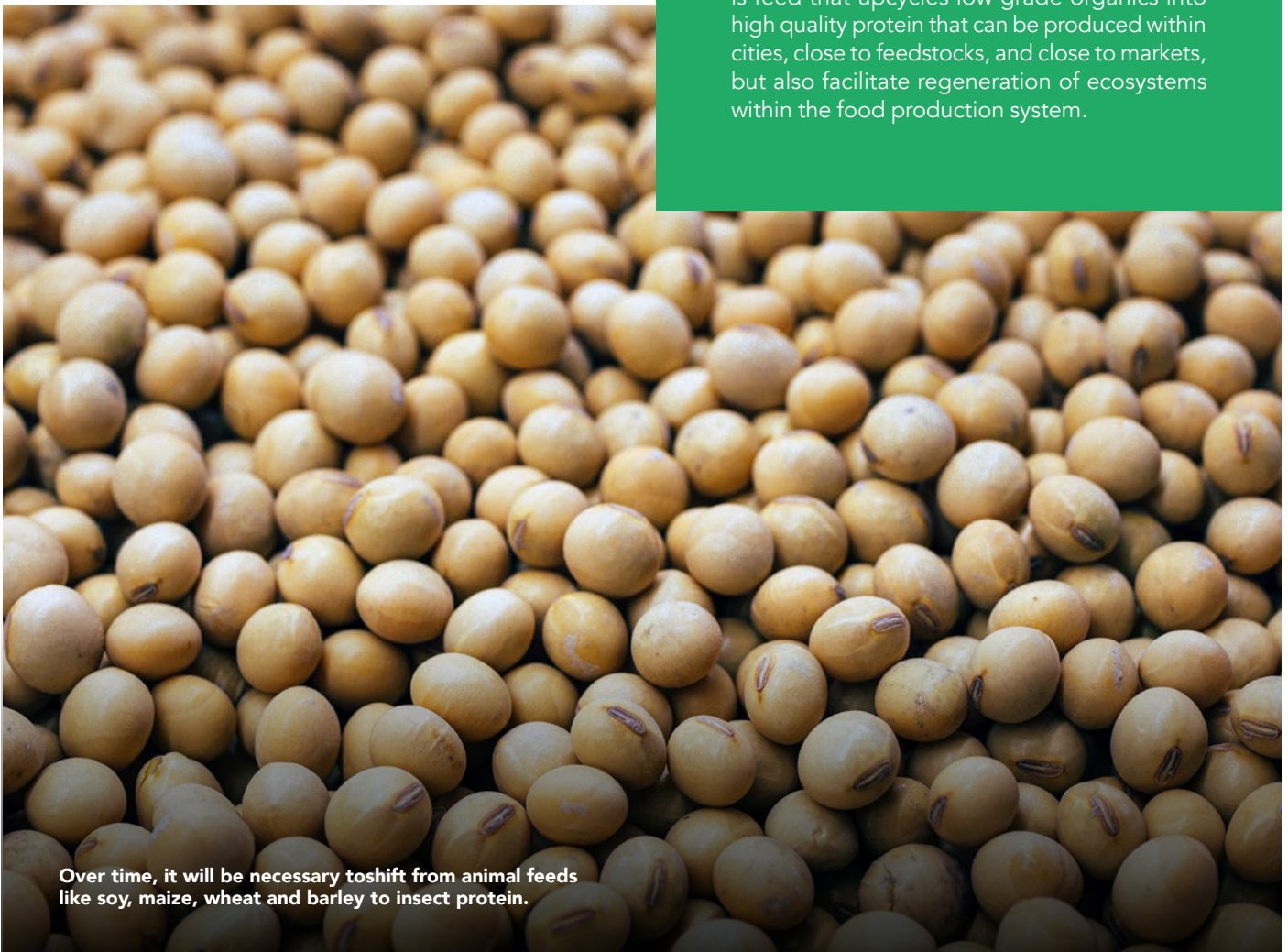
Animal-based amplification: The impacts and inefficiencies are only amplified when food supply chains are extended to include animal protein. Animals extend the energy pathway from farm-to-fork, thus decreasing the efficiency with which energy transfers from one trophic level to the next. During the transfer of organic food energy from one trophic level to the next, only $\pm 10\%$ is stored as flesh and limits the number of trophic levels an ecosystem can support⁷.

Zoonotic Diseases: Agricultural activities increase contact between humans and wild and domestic animals. This results in the increased exposure to pathogens. Since 1940, agriculture has been linked to $>25\%$ of infectious diseases that emerged in humans, of which $>50\%$ were zoonotic⁸, meaning an infectious disease transmitted between species from animals to humans. Such infections can significantly impact local and global economies; as well as, public and livestock health.

Low diversity: The animal feed system is dominated by a handful of crops which could be consumed directly by people. These include soy, maize, wheat and barley, along with other ingredients like fishmeal and fish oil. While soy and fishmeal offer high protein levels and can be produced sustainably, over time it will be necessary to reduce dependency on the use of these in feed. In order to use precious land resources to grow less feed for animals and more food for people.

Corporate image liability: Target 12.3 of the Sustainable Development Goals includes a commitment to, by 2030, halve per capita global food waste at the retail and consumer levels. This goal, as well as various numerous media publications and information has contributed to raising the public and investors awareness of food waste's impacts on the environment, and more sustainable options to manage it. This is putting pressure on brands, especially those marketing sustainability, to internalise food loss and waste commitments, and to extend these commitments to their supply chains. Not adhering to these commitments means food brands / suppliers run the risk of losing customers, investors, clients and their positive corporate sustainability image.

Amidst these concerns, it is also recognised that farmed animals, and their associated products, play an integral part in the South African food system, cultural landscape and livelihoods. To mitigate the triple challenge of limiting climate change, restoring ecosystems, and ensuring that healthy and sustainable diets are accessible to a growing population, it is necessary for South Africa to move towards more sustainable animal feeds. Such feed does exist and furthermore it is feed that upcycles low grade organics into high quality protein that can be produced within cities, close to feedstocks, and close to markets, but also facilitate regeneration of ecosystems within the food production system.



Over time, it will be necessary to shift from animal feeds like soy, maize, wheat and barley to insect protein.

⁷National Geographic (<https://education.nationalgeographic.org/resource/energy-transfer-ecosystems>)

⁸Nature (2019) www.nature.com/articles/s41893-019-0293-3

3 Solution

In natural ecosystems, insects recycle and decompose organic material into nutrients. Thus, farmed insects can be reared from a vast array of feedstocks and provide an opportunity to convert low-protein material into high-value protein - ingredients that can displace proportions of imported soy and wild-caught fish meals, whilst also being produced by processing quantities of surplus food, and enabling production co-products and other raw materials which cannot be consumed by people and might otherwise be landfilled. Cape Town hosts a number of companies that leverage BSF larvae to upcycle nutrients into high end products, notably:

Protein Meal: Defatted larvae that is dried and milled into a high quality protein meal. It serves as an alternative to wild fish and soy based protein feeds for livestock and pets. It is highly digestible, hypoallergenic, antimicrobial and anti-inflammatory.

Oil: Quality oil extracted and purified during the protein meal preparation. It is rich in medium chain lauric acid, a medium chain triglyceride that provides a number of pharmaceutical, food / feed applications; as well as alternatives to less sustainable oils from wild fish, coconut and palm oil.

Grubs: Dried larvae, high in protein, oils, and nutrients that serve as an ideal feed for poultry, aquaculture, reptile, and wild birds.



Quality oil extracted and purified during the protein meal preparation.

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Frass: An organic fertiliser / bio-stimulant consisting of a mix of excreta, insect exoskeletons, and food residues. It is high in nitrogen and is an ideal replacement to fossil fuel based chemical fertilisers.

Chitin: Larvae exoskeleton that has a wide array of applications from pharmaceuticals and cosmetics to animal feed and human food. Chitin boosts healthy gut bacteria and suppresses inflammation.

4 Solution provider:

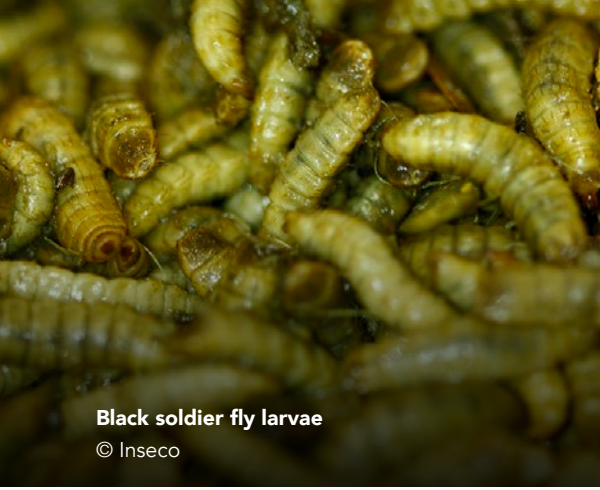
One company that leverages BSFs to produce protein is **Maltento**. The Cape Town based company supplies the animal feed and pet food industries with a consistent supply of a high quality insect proteins, fats and digestives at a more competitive and stable price than the traditional protein sources such as soy, fish meal and animal visceral digestive by-products.

Maltento is very specific in what they feed their BSF larvae. This allows the company to guarantee consistency and ensure traceability for demanding clients. In addition to maize and molasses, Maltento procures spent grain from a local craft brewery, and fruit and vegetable pulp from a local agro-processors which supplies the premium retail segment. Maltento's industrial food partners supply the insect farm with un-contaminated, clean and traceable organic by-products.

These organics are mixed into a homogenous substrate. The slurry is subsequently inoculated with millions of BSF eggs that are left to hatch and feed off the carefully curated slurry. Coupled with strict control over ingredients, Maltento also leverages controlled environment technologies to optimise and standardise larvae growth. After several days, the larvae are processed into various high end products, including protein and oils for the animal feed and pet food industry. In the short term, Maltento's Epping facility has a processing capacity of ~20 tonnes a day of co-product inputs, before scaling up to ±50 tonnes in the medium term, and eventually 100s of tonnes in the long term. This will be driven by the adoption of the model for the larvae growth stage where they will utilise a similar approach to battery chicken farming where they identify out growers⁹. This will build a whole new revenue stream for farmers and factories that have additional space and are looking for alternate revenue streams during traditional downtimes.

For more information on Maltento visit www.maltento.com.

⁹ Is a farmer who undertakes to supply a buyer with livestock at some future time and meeting certain requirements in return, the buyer agrees to make the purchase and may provide other support.



Black soldier fly larvae
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Maltento has developed a circular solution that upcycles spent brewery grain into high value insect protein.

5 Impact / Outcome

Companies like Maltento's impact on Cape Town's economy can be significant in ensuring that Cape Town has an efficient, resilient and competitive food system. Below are the general benefits and specific impact Maltento made for 2021. This is expected to triple in the coming year due to extensive market development locally, in the USA and Europe, coupled with Maltento achieving EU export certification, one of the most stringent of certifications from a food safety perspective.

Economic benefits

-  **Localise production:** Maltento produces insect proteins and derivatives within Cape Town, thus replacing riskier more volatile imports like soy and wild fish based proteins and other imports that the animal feed companies cannot access due to the fragile supply chains.
-  **Reduce consumption:** Maltento uses industrial by-products to produce their insect protein. These by-products replace raw commodities like wild fish and soy; but can also reduce the reliance on imported fossil fuel based fertilisers, and potentially the need for antibiotics.
-  **Extend landfill airspace:** of the ~6 000 total tonnes of organics processed, ~3 000 tonnes was likely destined for landfill. This equates to ~2 400 m³ of landfill airspace being made available to accommodate more problematic waste.
-  **Extract value:** Maltento is able to extract ~R14 300 from one tonne of organic inputs. In total, Maltento has added over ~R85.7 million worth of product back into the economy, thus shifting a liability into value.
-  **Create jobs:** Maltento employs 30 full time staff, of which 20 are low-skilled, 4 are semi-skilled, and the remaining 6 are skilled.
-  **Enable land efficient protein:** Maltento produces ~360 tonnes of specifically digestible protein from its 5 000 m² facility per year. This will increase to ~1 800 tonnes by June 2023. This equates to ~2,7 tonnes of protein a year for every 1m² of footprint.
-  **Upcycle organic waste:** the insect larvae are able to quickly and efficiently convert low-grade organics into a high quality and highly sought after products. For every tonne of organics entering the Moltento BSF facility, 200kg of frass (fertiliser), and 250kg of larvae are produced. The larvae are processed further into digestible protein, oil and other derivatives, some of which have potentially extremely high value applications in the future.
-  **Food security:** Insect protein and its derivatives increases the diversity of local protein supply, including for animal feed and pet food. Currently, the feed system is dominated by a few terrestrial crops which could be consumed directly by people, including soy, maize, wheat and barley. Localising and diversifying South Africa's protein supply reduces its reliance on imports, supply of traditional feed commodities, and their supply chains, that are susceptible to disease and geopolitical strife. Furthermore, though insect protein enters the human food chain indirectly in animal feed, it may one day enter human diets in a more direct way, thus increasing the supply of local food in cities and consequently also freeing up food for humans that would otherwise have been used as animal feed and pet food.
-  **Support innovation:** Maltento forms part of a growing ecosystem of Cape Town based insect solutions, thus making Cape Town one of the global hubs for insect based protein innovation and supply. Maltento is the first company in the world to develop an insect based palatant that is applied to dry dog food to enhance the flavours and aromas of the dog kibble. This was done in collaboration with Martin & Martin, a trusted pet food business which has traded in SA for over 100 years. This diversifies the application of BSF derived products beyond just a protein source.

Localisation in action: Maltento sources its spent grain from a local craft brewery located ±2km from its facility, whilst its fruit/veg pulp processor is also located only ±2km away. These organic by-products are then processed and upcycled into a high-value protein meal and sold to various clients. One of these clients is a local dog food manufacture called Happy Hounds, purpose-driven pet food manufacturer located ±9 kms from Maltento. Maltento has been working closely with Happy Hounds, and expert pet nutritionists, to expand on Happy Hound's product range to include insect flavoured pet food. In total, Maltento and its BSF solution have unlocked a hyper-localised regenerative and resilient protein feed ecosystem that does not rely on external inputs and thus external risks.

Business benefits



Reduce disposal liability: Maltento strengthens Cape Town's diverse mix of organic waste / co-product solutions that businesses can leverage to meet the 2027 provincial organic waste landfill ban.



Provide landfill cost savings: Maltento charges a lower gate fee than traditional landfill disposal¹⁰. Maltento saved Cape Town based companies between R0,5 - R2 million in landfill gate fee savings.



Unlock revenue: Maltento procures its organic inputs thus turning industrial by-products into a commodity. Maltento has procured ~R7million worth of by-product that would otherwise have been landfilled, given away or would have incurred cost to treat.



Provide stable protein price: The production of insect protein is less reliant on raw material inputs than traditional protein feed sources. As such, they are not as affected by the rising costs associated with global inflation. In fact, BSF is reliant on a material already seen as liability and a disposal cost. This means fewer overheads along the value chain. Thus, the price of insect protein and its derivatives are more stable and potentially cheaper in the long term compared to traditional protein.



Enable corporate social responsibility: Maltento provides a means for businesses to meet their internal and external food loss and waste reduction commitments made by many of South Africa's largest food brands. It is also enables the integration of more sustainable ingredients into supply chains.

Environmental benefits



Reduces GHG emissions: Although unverified and unrecorded, based on conversion rates for other BSF production facilities. Maltento may have saved between 6 200 – 7 100 tonnes of GHG emissions compared to disposing the organic input material to landfill.



Replace chemical fertilisers: Maltento can produce ~200kg of frass from one tonne of input organics. In total, Maltento produced ~1 200 tonnes of non-fossil fuel based organic fertiliser that supports not only plant health, but a healthy soil too.



Support biodiversity: One tonne of BSF protein can replace five tonnes of wild fish. Thus, Maltento replaced the equivalent of 1 800 tonnes of wild fish in a year. Insect protein also displaces soy protein, a major driver of deforestation. Maltento takes this one step further by producing its insect protein in already transformed urban land that is within Cape Town urban edge. As such, less land is needed that could otherwise infringe on sensitive ecosystems. As insect protein may one day replace livestock as a major source of protein for human consumption, it will reduce the need of vast tracks of land needed to raise livestock and to produce feed, often land that encroaches on sensitive ecosystems.

Circular economy elements / strategies

CORE ELEMENTS



Use waste as a resource



Preserve and extend what's already made



Strengthen and advance knowledge



Rethink the business model



Collaborate to create joint value

Source: www.circle-economy.com/circular-economy/key-elements

¹⁰The City of Cape Town charged a landfill gate fee of R556.61 (excl. VAT) per tonne of general waste in 2022/23

¹¹IFFO (2009) www.iffo.com/system/files/downloads/EAS%20FIFO%20September2009%202_0.pdf



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