

FEEDING THE FUTURE:

A Case Study on Residua Biocircular's Approach to Close the Gap Between Agro-industrial Side-Streams and Sustainable Animal Nutrition.



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1. EXECUTIVE SUMMARY

Residua is a leading insect biotechnology company in Colombia that transforms food system inefficiencies—where 34% of the national food supply is wasted—into high-value biological assets for animal nutrition and soil health. Through its strategic partnership with P4G, Residua has successfully transitioned from a pilot stage to a validated industrial operation, positioning itself as a key driver of the circular economy and decarbonization in the region.

During the implementation period, the project achieved critical operational, environmental, and product development milestones:

- **Industrial Scaling:** Operational capacity for organic waste transformation increased 2x compared to the project's baseline.
- **Advanced Product Development:** A significant portion of the partnership's focus was directed toward the technical and commercial validation of high-margin specialized products. These functional additives represent a shift from low-margin commodities to high-value biotechnological solutions that address specific needs in the animal protein industry.
- **Environmental Impact:** Residua has treated over 300 tons of organic waste to date, resulting in an estimated mitigation of +4,000 tons of CO₂e by preventing methane emissions from landfills.

Residua has demonstrated that organic circularity is a viable and scalable model. The company has built a solid foundation for follow-on investment by mitigating operational and regulatory risks. It has consolidated a vision where biotechnology is the primary tool to regenerate global food systems.

2. BACKGROUND & PROBLEM ANALYSIS

GLOBAL CONTEXT: THE CIRCULARITY GAP IN FOOD SYSTEMS

Global food production systems are currently facing a major inefficiency: approximately 13% of the world's food is lost after harvesting and before reaching retail markets (OECD, 2024), and one-fifth (19%) of all food available to consumers is wasted at the retail, food service, and household levels, amounting to over 1.05 billion tonnes annually (UNEP, 2024). The environmental impact is staggering, accounting for an estimated 8-10% of global Greenhouse Gas (GHG) emissions (UNEP, 2024). According to estimates, halving food loss and waste by 2030 could potentially reduce agricultural GHG emissions by between 3% and 5% (OECD, 2024).

In Colombia, the magnitude of this inefficiency is even more pronounced. According to the National Planning Department (DNP), the country loses or wastes approximately 9.76 million tons of food per year. This represents 34% of the total national food supply—effectively meaning that for every 3 tons of food produced, 1 ton is lost or wasted (DNP, 2016). The breakdown of this loss reveals a significant opportunity for industrial-scale intervention. While 36% of this waste occurs at the distribution, retail, and household levels, the vast majority (64%) consists of losses occurring upstream during production, post-harvest, storage, and industrial processing (DNP, 2016). These industrial side-streams are often high-quality organic materials that are currently mismanaged. This is further evidenced by Colombia's reliance on sanitary landfills, which handle 48% of solid waste treatment (OECD, 2026); with 61% of total waste being organic, the waste sector has become responsible for 6% of national GHG emissions, primarily through methane release from decomposing organics (MVCT, 2021).

This waste crisis converges with a second systemic pressure: the "Protein Challenge". As the world population approaches 9.6 billion by 2050 (United Nations, 2024), global agricultural production must increase by 14% over the next decade. However, this growth carries a profound environmental cost, as global animal production is projected to rise by 13% by 2034, accounting for nearly 70% of the projected increase in direct agricultural GHG emissions (OECD/FAO, 2025). The inefficiency is further highlighted by the fact that 25% of total world crop consumption is currently dedicated exclusively to animal nutrition rather than direct human consumption.

In the Colombian context, this hurdle manifests as a structural vulnerability in the animal protein value chain. By 2025, a staggering 78.5% of the national consumption of protein meal for animal feed was imported—a figure expected to reach 79.7% by 2034 (OECD/FAO, 2025). This underscores a deep-seated dependency on international markets and volatile supply chains. With Colombia's internal demand for animal feed protein forecasted to increase by 18%, the country faces an escalating risk to its food sovereignty. Without a radical shift in how domestic animal protein is produced, the costs of local poultry, pork, and aquaculture will remain tethered to foreign currency fluctuations and global commodity shocks.

To meet its international commitments and its own national policies, Colombia must pivot from "disposal" to "valorization," transforming these side-streams into high-value, safe inputs for other industries, such as animal nutrition.

THE UPSTREAM CHALLENGE: AGRIFOOD-INDUSTRIAL SIDE-STREAMS

Despite the nutritional potential of organic materials generated during industrial food processing, agro-industrial producers in Colombia currently operate within a rigid linear framework that treats by-products as liabilities rather than assets. These companies—from diverse sectors such as fruits, dairy, brewery, and food & beverage, among others—face a critical operational bottleneck characterized by the necessity of immediate and costly "waste" handling. At present, producers are forced to allocate significant resources and complex logistics for the treatment, transport, and final destination of these materials in sanitary landfills or wastewater plants. This burden is compounded by the diminishing capacity of regional landfills, which continues to drive disposal costs upward across the country.

Furthermore, the lack of valorization infrastructure translates into a substantial loss of embedded economic value. These producers have already invested in water, energy, and labor to process raw materials, only to pay a second time for their removal as waste. Beyond the financial and operational impact, the regulatory landscape is increasingly demanding. Companies that fail to comply with environmentally positive practices face potential legal sanctions and reputational damage. The primary obstacle remains the absence of scalable, accessible valorization technologies that can use this biomass and transform it into circular products that disrupt the linear model of production.

THE DOWNSTREAM CHALLENGE: SUSTAINABLE & RESPONSIBLE ANIMAL NUTRITION

The animal nutrition sector, encompassing both livestock production and the rapidly growing pet food industry, is currently navigating a convergence of economic, regulatory, and health-related complexity. A fundamental concern for producers in Colombia is the heavy reliance on imported raw materials for balanced feed, such as soy and corn. This dependency not only exposes the local supply chain to the extreme volatility of international commodity prices and exchange rates but also results in significant inconsistencies in nutritional quality, which directly impacts the predictability of animal growth and producer profitability.

Beyond economic volatility, a pivotal shift is occurring in the regulatory and public health landscape regarding the use of antibiotics. Historically, the administration of antimicrobials as growth promoters has been a standard practice to enhance productivity and prevent infections in healthy livestock. However, this practice is now facing rigorous legal prohibitions and international trade restrictions driven by the global fight against antimicrobial resistance. As highlighted by the World Health Organization (WHO, 2017) and the World Organisation for Animal Health (WOAH, 2024), the misuse of these substances in healthy animals poses a systemic risk to human food safety. Furthermore, scientific reviews within the Colombian context indicate that the lack of awareness regarding antibiotic traceability in food products can lead to market exclusion for exporters, as international standards increasingly mandate antibiotic-free supply chains (Martin & Arenas Suarez, 2019). This shift is critical, since the entire livestock sector is under pressure to improve productivity and biosecurity in an environment of thinning profit margins and rising global demand.

Simultaneously, the industry must respond to evolving specialized health requirements, particularly in the pet food segment. There is an increasing prevalence of food allergies and cutaneous intolerances in dogs and cats linked to traditional protein and carbohydrate sources such as soy, corn, wheat, and poultry (Leti Animal Health, 2021). This shift has accelerated the search for "novel" and hypoallergenic proteins that can provide optimal nutrition without triggering adverse immune reactions.

Finally, according to the Food and Agriculture Organization (FAO) and the FEAC (2020), the future of the industry depends on a transition toward natural, circular solutions. These international frameworks position sustainability—specifically the reduction of the environmental footprint of feed—as a non-negotiable prerequisite for commercial viability and long-term competitiveness in the global bioeconomy.

Box 1. Summary of Sectoral Pain Points

<i>Agrifood Industrial Sector</i>	<i>Animal Nutrition Sector</i>
• <i>Financial costs associated with waste disposal in landfills.</i> • <i>Operational burden due to difficult management of organic side-streams.</i> • <i>Sunk costs in energy, water, and labor that represent economic inefficiencies.</i> • <i>Potential compliance risks and reputational damage for improper waste management.</i> • <i>Environmental negative impact restrictions that affect business continuity.</i> • <i>Consumer concerns regarding the sustainability of products.</i>	• <i>Extreme vulnerability due to high import dependency.</i> • <i>Rising food intolerances in pets linked to traditional feed ingredients.</i> • <i>Legal prohibitions and export barriers due to the abuse of antibiotics.</i> • <i>Pressure from stakeholders to decarbonize feed and use organic, sustainable ingredients.</i> • <i>Narrow profit margins and the urgent need for natural additives that improve productivity.</i> • <i>Low availability of local, safe, high-quality alternative inputs.</i>



3. THE SOLUTION

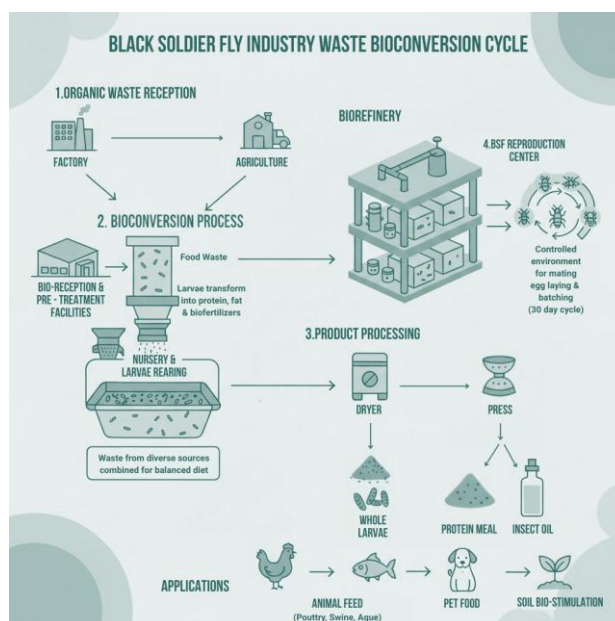
Residua Biocircular has engineered an integrated model centered on the advanced bioconversion capabilities of the Black Soldier Fly Larvae (BSF — *Hermetia illucens*). This solution serves as a high-tech bridge that intercepts agro-industrial side-streams before they lose their nutritional integrity and biosecurity, transforming them into high-value inputs for animal nutrition and soil health.

Unlike conventional waste management practices—such as large-scale composting or landfill disposal—Residua’s biotechnological approach enables nutrient recovery that is up to ten times faster while maintaining a significantly lower carbon and land footprint. By closing the loop between industrial surplus and the urgent demand for sustainable agricultural products, Residua not only mitigates environmental liabilities but also creates a new category of functional, circular products that enhance the resilience of the Colombian agricultural sector.

THE CIRCULAR BIOTECHNOLOGY

At the core of the solution is the life cycle of the Black Soldier Fly, a highly efficient biological processor capable of consuming a wide array of organic side-streams. Residua has optimized this process to manage massive flows of by-products from sectors such as food & beverage, breweries, snacks, and coffee. Within a matter of days, the larvae convert these low-value materials into biomass rich in proteins and fats, along with an organic co-product known as *frass*. This system not only diverts tons of waste from landfills—thereby reducing methane emissions—but also produces local insect-based products that decrease supply chain vulnerability to imports and naturally improve agricultural productivity.

Figure 1. BSF waste bioconversion cycle



Source: Own elaboration

PRODUCT PORTFOLIO: FROM COMMODITIES TO FUNCTIONAL SPECIALTIES

To address the diverse needs of the animal nutrition market (identified in Section 2), Residua has structured its portfolio in two stages of product development, resulting in strategic categories that balance commercial volume with specialized value-added:

- 1. Biocircular Commodities:** Products designed for the sustainable replacement of traditional inputs for higher volume needs:
 - **Dehydrated Insect Protein:** A premium ingredient with a complete essential amino acid profile and high digestibility, formulated for inclusion in balanced feed for pets, poultry, swine, and aquaculture, oriented to animal feed producers.
 - **Frass:** A by-product of the bioconversion process that acts as a powerful organic fertilizer for soil regeneration, closing the circular loop by returning nutrients to the land for agricultural production.



2. Specialized Functional Additives Responding to the complexities of health, productivity, and antibiotic restrictions, Residua offers "second-generation" biotechnological products to animal producers:

- **Digest:** An advanced intestinal modulator that combines insect protein with phyto-ingredients. Its primary function is to optimize microbiota and enhance gut health for swine and poultry, leading to improved yields.
- **Proticox:** A nutritional solution specifically designed to address coccidiosis in livestock production. By leveraging the immunomodulatory properties of insect protein and natural compounds, it offers an effective alternative free of chemical residues.
- **Zytonic:** A biotechnology line based on efficient microorganisms for environmental management on farms. This product neutralizes odors and improves air quality in barns, addressing essential animal welfare, regulatory compliance issues, and ammonia emissions control.

BEYOND WASTE MANAGEMENT

The innovation of Residua lies in its transition from a traditional waste management perspective to a high-tech biorefinery model. Unlike conventional organic waste treatments such as composting or anaerobic digestion, which often focus on fertilizer generation, Residua's approach focuses on nutrient upcycling. By utilizing the BSF as a biological engine, the company can recapture nitrogen, phosphorus, and high-quality fats from industrial side-streams in a 10–15-day cycle, faster than traditional methods, requiring significantly less land.

Furthermore, the innovation extends into the functionalization of products. Residua does not merely produce a generic protein; it has pioneered the development of specialized additives like Digest and Proticox. These products leverage the unique immunological properties of insect-derived peptides and lauric acid, combined with specific phyto-ingredients, to create a "biological shield" for livestock. This biotech edge transforms a simple feed ingredient into a powerful tool for gut health modulation and pathogen control, addressing the root causes of productivity loss without the need for antibiotic intervention.



ADDITIONALITY: ADDRESSING THE MARKET FAILURE

The additionality of Residua is defined by its ability to bridge a systemic gap that the private sector and current regulations have failed to address in Colombia.

1. **Industrial Waste Valorization:** Currently, Colombian agro-industrial producers lack a scalable, reliable, and biosecure outlet for their organic side-streams. Without Residua, these materials—potentially millions of tons—would continue to burden the country's landfill infrastructure, accelerating methane emissions and increasing disposal costs for the industry. Residua offers a new, commercially viable "circularity-as-a-service" model that integrates directly into the industrial supply chain.
2. **National Food Sovereignty:** In a country where 78% of protein meal for animal feed is imported, Residua provides an additional source of domestic supply. This reduces the sector's vulnerability to global supply chain shocks and foreign currency fluctuations. By introducing a local, sustainable alternative that does not compete with human food crops, Residua is creating a new asset class within the Colombian bioeconomy.
3. **Regulatory and Environmental Catalyst:** The partnership facilitates a shift in the "status quo" of the animal nutrition sector. By providing a natural, effective replacement for antibiotic growth promoters, Residua is not only solving an operational headache for farmers but also proactively aligning the Colombian livestock industry with international health standards and export requirements. This level of systemic change would not be achievable through traditional market forces alone, as it requires a new value chain that Residua has pioneered.



4. METHODOLOGY: FROM PILOT TO BUSINESS

Residua employs a methodology designed for the unique obstacles of the emerging insect protein industry. Given the scarcity of standardized global data, our approach prioritizes internal experimentation with technical external advisory and rigorous field-testing to ensure both operational excellence and commercial credibility.

MICRO-EXPERIMENTATION

The cornerstone of Residua's production methodology is a system of continuous micro-experimentation. We integrate small-scale, controlled trials directly within our active production lines. This allows the team to test new variables—such as substrate compositions, climate control adjustments, or larval density—without disrupting daily operations.

Since the BSFL industry lacks extensive public documentation, this "learning-by-doing" approach has been essential. Only after a micro-experiment yields verified, consistent improvements in bioconversion or yield are the adjustments implemented at the full operational scale.

FIELD-LED PRODUCT DEVELOPMENT AND COMMERCIAL RIGOR

Our product development process is rooted in field validation. Recognizing that the animal nutrition market requires tangible proof of performance, Residua integrates product testing as a standard phase of the commercial cycle.

- **Evidence-Based Sales:** We offer potential clients rigorous product trials (typically pay-for-performance schemes) to demonstrate the real-world impact of our additives. During these trials, Residua maintains extreme rigor in data collection, analyzing performance metrics such as weight gain and health improvements.



- Performance Demonstrations: Our sales strategy is not based on theoretical claims but on demonstrated results. These field trials serve as the primary vehicle for converting leads into long-term customers, ensuring that every purchase is backed by proven data.

CUSTOMER FEEDBACK AND ITERATIVE IMPROVEMENT

Residua maintains active feedback loops with all trial participants and existing clients. This constant communication allows us to gather qualitative and quantitative insights into how our products perform across different farming environments and the products' return on investment for our clients. This feedback is immediately reflected in our production and formulation teams, allowing for rapid iterations of specialized products like *Digest* and *Proticox* to better meet the evolving needs of poultry and swine producers. This has been reflected in adjustments to product prices, physical characteristics, and presentations (liquid or premix).

TECHNICAL AND REGULATORY COMPLIANCE

To support our field data, Residua complements its methodology with periodic laboratory analysis. This ensures that while we optimize for performance in the field, we never compromise on biosecurity, maintaining strict compliance with national regulations and ensuring that our data-driven approach is supported by chemical and microbiological safety.



5. BUSINESS MODEL

Residua's business model is designed to capitalize on the high-value nutrients recovered through BSFL bioconversion while ensuring a stable, low-cost supply chain. By positioning itself as a useful partner for both agro-industrial suppliers and animal nutrition customers, Residua creates a closed-loop system that prioritizes technical robustness and long-term commercial relationships over transactional waste fees.

REVENUE GENERATION STRATEGY

Unlike traditional waste management solutions, Residua's primary income does not rely on charging waste generators for collection. Instead, we offer a "zero-cost" disposal solution to suppliers to foster deep organizational integration and ensure a consistent, secure supply of high-quality organic side-streams. Revenue is generated through three specialized commercial lines:

1. **Specialized Functional Additives:** This high-growth segment features products like *Digest* and *Proticox*. By focusing on BSFL protein attributes, we maximize value per kilogram. This segment is projected to lead the total sales as market penetration scales.
2. **Bio-circular Commodities:** The sale of dehydrated insect protein (whole or meal) as a raw ingredient serves as a foundational entry point into the animal feed market, catering to large-scale feed manufacturers. In the long term, this market constitutes the basis for industrial scalability.

FINANCIAL AND OPERATIONAL LEVERS

Residua's profitability is rooted in a lean operational model that converts traditional costs into competitive advantages by leveraging economies of scale. The primary financial driver is a low-cost procurement strategy, where the company acts as a circularity partner for large-scale agro-industrial producers. By integrating the majority of raw materials into the production cycle with low acquisition costs, Residua minimizes financial exposure and protects gross margins, ensuring that as production volume grows, fixed costs are diluted and net profitability is maximized.



Rather than viewing technical talent as an administrative expense, the company tactically directs capital toward a specialized team that drives portfolio differentiation. This focus enables the transition from low-margin commodities to high-value functional additives, ensuring that every investment in human capital generates an exponential return through biotechnological innovation. Consequently, Residua's infrastructure is designed to maintain stable operating costs against increasing output, guaranteeing efficient scalability and the capacity for continuous reinvestment into its technological core.

Accordingly, the long-term scalability of Residua is anchored by two critical levers:

- **Industrial Symbiosis:** By integrating into the supply chains of large food producers, we secure stable, high-volume, and safe biomass, meaning a significant entrance barrier to competitors.
- **Specialized Robustness:** Our focus on high-margin additives allows us to generate significant revenue with lower volumes, reducing the logistical burden compared to bulk commodity players.

CUSTOMER SEGMENTATION

Residua's customer segmentation targets two vital niches: large-scale animal producers and balanced feed manufacturers. This market is highly competitive and driven by strategic relationships, constant visibility at technical events, and robust networking. Commercial cycles in this sector are characterized by high complexity and bureaucracy at both technical and executive levels; product validations with animal producers typically extend beyond one year, while securing agreements with feed manufacturers can take up to two years. To mitigate these barriers, Residua has prioritized small and medium-sized producers as a short-term strategy to achieve faster sales, closer feedback loops, and rapid results validation. However, the long-term priority remains securing high-volume offtake agreements with major industrial players.



Furthermore, while corporate waste suppliers are not currently paying customers, the relationship with them is managed with the same level of commercial rigor. These providers demand high standards of reliability, operational compliance, and safety. Meeting these requirements demands significant organizational effort and a high level of performance, as these corporate alliances are essential for securing the stable, high-quality supply chain that fuels Residua's bioconversion engine.

POTENTIAL UPSIDES

- **Sustainable Transformation Services:** As regulatory pressure increases, monetization of sustainable waste management, such as charging a service fee, could be an interesting income source.
- **Carbon Credit Markets:** Given the methane avoidance achieved by diverting organics from landfills, our business model is positioned to enter the emerging Colombian carbon market, turning GHG reductions into tradable assets.



6. RESULTS: VALIDATING IMPACT & TRACTION

Through the execution of the P4G partnership, Residua has successfully transitioned from an early-stage biotech startup to a validated business player. The project has delivered significant quantitative environmental benefits while establishing a robust platform for social impact and investment readiness, adhering to the P4G MEL (Monitoring, Evaluation, and Learning) framework.

ENVIRONMENTAL AND OPERATIONAL METRICS

The partnership was instrumental in scaling Residua's operational capabilities. By focusing on process optimization and infrastructure improvements, we achieved the following main results:

- **Operational Capacity Growth:** The waste transformation capacity increased by 2x compared to the project's baseline. This expansion allows Residua to manage larger volumes of agro-industrial side-streams, moving from artisanal-scale management to semi-industrial responsiveness.
- **Waste Diversion:** During P4G partnership implementation (2024-2025), Residua has treated over 300 Tons of organic waste in Colombia. This diversion prevents organic matter from rotting in landfills, directly mitigating the generation of leachate and uncontrolled greenhouse gases.
- **CO2e Mitigation:** By diverting these tons of waste from landfills, Residua has avoided the emission of approximately 4,000 tons of CO2e (based on methane avoidance calculations). This metric underscores the project's contribution to Colombia's decarbonization goals in the waste sector.

INVESTMENT READINESS

Since the animal nutrition sector faces extremely long commercial cycles (often 12-24 months for B2B adoption), Residua has achieved an important advance in investment attractiveness.



- **De-risking for Investors:** The funding allowed for the technical and commercial validation of high-margin products (*Digest* and *Proticox*). This shift from a "waste management" model to a "high-value biotech" model has been the pivotal lever in attracting investor interest. The validation data acts as the primary asset to secure future equity rounds, proving that the technology is not just environmentally sound but financially viable.
- **Market Traction:** We successfully engaged with major regional poultry and swine producers, moving from initial conversations to field trials. The "Investment Readiness" achieved progress is defined by a solid pipeline of clients under commercial process, which provides the revenue visibility required by investors.
- **Supply Chain Security:** We successfully secured supply agreements with major corporate players in the national agrifood sector. These alliances guarantee the raw material volume necessary for industrial scaling, effectively laying the groundwork for the construction of a large-scale industrial facility in the medium term.
- **International Partnerships:** Residua established the foundations for key alliances with European insect protein producers. These partnerships are designed to facilitate joint industrial scaling and provide a gateway for Residua's specialized products into new, high-value international markets, validating our technology on a global stage.

SOCIAL IMPACT: THE COMMUNITY BIOCONVERSION MODEL CASE STUDY

Beyond its industrial scope, Residua launched a high-impact social pilot designed to decentralize biotechnology and bring circular solutions to rural communities through the deployment of "Domestic Bioconversion Units." This initiative successfully validated the model with five initial pilot families, who utilized BSF to transform household and crop waste into high-quality bio-fertilizer and protein for backyard animals, thereby enhancing local food security and reducing agricultural input costs. Qualitative results demonstrate the technical feasibility and potential adoption of this biotechnology to solve rural waste problems.

Figure 2. Domestic BSF bioconversion pilots



However, the pilot also highlighted significant structural hurdles inherent to rural deployments, particularly the high level of informality and the resulting difficulty in maintaining standardized data collection for rigorous analysis within short project timeframes. Acknowledging these challenges as lessons learned, Residua is refining its monitoring protocols to better align with this sector's dynamics, setting a clear roadmap to scale this solution in the mid-term and foster a networked model of sustainable development and social integration in the Colombian countryside.

7. PATH TO INVESTMENT READINESS

The journey to industrial scaling and investment readiness in the Colombian insect biotechnology sector presents a unique set of structural and market hurdles. Residua has adopted a proactive approach, turning these impediments into opportunities for organizational learning and regulatory leadership.

OPERATIONAL LEARNING AND KNOWLEDGE BARRIERS

Challenge: The scarcity of localized technical information on BSFL rearing in tropical climates means that Residua must invest heavily in proprietary R&D. Every operational adjustment requires a cycle of micro-experimentation that, while necessary, consumes resources and time.

Solution: We have institutionalized a culture of continuous experimentation. By integrating small-scale trials within our active production lines, we ensure that knowledge development happens in parallel with revenue generation. This "learning-by-doing" methodology has allowed us to build one of the most significant proprietary databases on tropicalized BSF bioconversion in the region, which is now a core intangible asset of the company. In addition, alliances with scientific institutions such as the International Center for Tropical Agriculture (CIAT) allowed us to boost our R&D progress and understand potential applications of BSF in different waste streams.

FINANCIAL ECOSYSTEM AND INVESTMENT CLIMATE

Challenge: Accessing capital is hindered by a traditional banking system that lacks instruments for innovative ventures. Furthermore, the local impact investment landscape has been affected by the withdrawal of major international cooperation programs (such as USAID) and a general investor preference for software over Capex-intensive technologies. This is compounded by macroeconomic uncertainty and the perceived political risk in the region.



Solution: By shifting our product focus from low-margin commodities to high-margin specialized additives (*Digest/Proticox*), we are presenting a more robust financial model supported by product development and lower capex requirements. Moreover, alliances with producers in other regions, with robust industrial experience, serve as a de-risk factor for institutional investors.

REGULATORY FRAMEWORK AND "PIONEER" HURDLES

Challenge: Being a pioneer in the BSF industry in Colombia means operating in a space where specific regulations are still evolving. This lack of a pre-established roadmap requires significant time and financial resources to develop internal knowledge and navigate complex sanitary and environmental compliance.

Solution: Residua has taken a leadership role in shaping the enabling environment. We maintain an active and transparent dialogue with regulatory bodies, contributing technical data to help define the standards for insect-based animal feed. By showcasing the industry, Residua is developing a supportive ecosystem for future producers while ensuring our own long-term success.

EXTENDED COMMERCIAL CYCLES AND MARKET INERTIA

Challenge: As noted in our operational experience, the commercial cycle for large-scale agro-industrial players can exceed 24 months. Many potential clients exhibit "innovation inertia," preferring traditional, less-efficient methods to avoid the perceived risk of new technologies. Additionally, many producers lack the technical rigor required to conduct the complex field trials necessary for product validation.

Solution: To bridge this gap, Residua has implemented a two-fold strategy. First, we prioritize small and medium-sized producers for rapid validation and immediate cash flow. Second, we have professionalized our evidence-based sales process, where Residua takes a leading role in data management and analysis during trials. This minimizes the technical burden on the client and provides the "hard data" needed to justify their transition to bio-circular inputs.

SYSTEMIC GAPS IN GOVERNANCE AND CIRCULAR INCENTIVES



Challenge: Despite growing global trends and increasing pressure for mandatory waste recovery, significant systemic gaps persist that hinder a true circular transition in the region. First, current policy and corporate efforts remain disproportionately focused on "recyclable" inorganic materials, such as plastics and packaging, leaving the more complex segment of organic waste largely unaddressed. This is exacerbated by a profound lack of governance and data transparency; there is a scarcity of reliable information regarding exact waste volumes, current usage, or the true costs associated with traditional management.

Finally, while there is a rising willingness toward sustainable transformation, the current regulatory framework lacks sufficient financial or policy-driven incentives. In the absence of robust catalysts, corporate commitment is often conditional on not requiring operational or financial adjustments. Consequently, whenever sustainable transformation threatens the immediate bottom line, industries tend to favor the status quo, prioritizing traditional disposal over high-value valorization.

Solution: Residua is actively working to bridge these gaps by becoming a primary source of high-quality data and technical evidence. By providing waste generators with transparent metrics on the bioconversion efficiency and environmental impact of their side-streams, we help them quantify the "hidden costs" of traditional disposal. Through participation in policy forums and industry associations, Residua also advocates for a regulatory shift that recognizes and rewards the superior carbon-mitigation potential of organic waste valorization compared to traditional recycling.

8. LESSONS LEARNT & FINAL REFLECTION

Through the P4G partnership, Residua has consolidated its roadmap for insect-based biotechnology in emerging markets. The following are the key takeaways and recommendations derived from this experience:

- **Technical Rigor:** Success in scaling an insect-based business depends as much on the consistency and quality of the final products (protein and fertilizer) as on the security of the waste processed. Technical validation and biosecurity are what truly open commercial doors in the B2B sector.
- **Mismatched Investment Cycles:** Conventional startup acceleration timelines often clash with the biological and industrial realities of biotechnology. Scaling requires a solid working capital structure and a long-term investment mindset to sustain commercial cycles that often exceed 24 months.
- **Innovation Inertia in Clients:** There is a significant "inertia to innovation" among large agro-industrial producers. Many prefer to maintain inefficient traditional methods to avoid operational risks, requiring the startup to take an active role in results-analysis and return-on-investment metrics to convert leads into clients.

RECOMMENDATIONS

- **Foster "Patient Capital":** Investors and support programs need to develop and promote financial instruments specifically designed for "hard-tech" and biological assets, which do not follow linear growth curves like software.
- **Incentives for Organic Waste:** Regulatory bodies should create specific incentives for organic waste valorization that go beyond traditional inorganic recycling (plastics/packaging), recognizing its superior potential for methane mitigation.



- "Bottom-Up" Commercial Strategy: For new ventures in the sector, we recommend prioritizing small and medium-sized producers in early stages. They are the best allies in product development. This allows for rapid results, direct feedback, and immediate cash flow, serving as evidence to convince large corporations later.
- Data Governance: Invest in simple digital tools so that waste providers and stakeholders can access information about volumes and traceability, transforming informality into actionable data.

CONCLUSIONS

Despite the systemic hurdles of long commercial cycles and regulatory gaps, the project has successfully de-risked the business model, secured strategic corporate alliances, and opened doors to international markets. Looking forward, Residua stands as a pioneer in the Colombian bio-industry, ready for follow-on investment and prepared to scale its impact. Our commitment remains firm: to transform the regional challenge of organic waste into a localized engine for food security, decarbonization, and social equity.

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