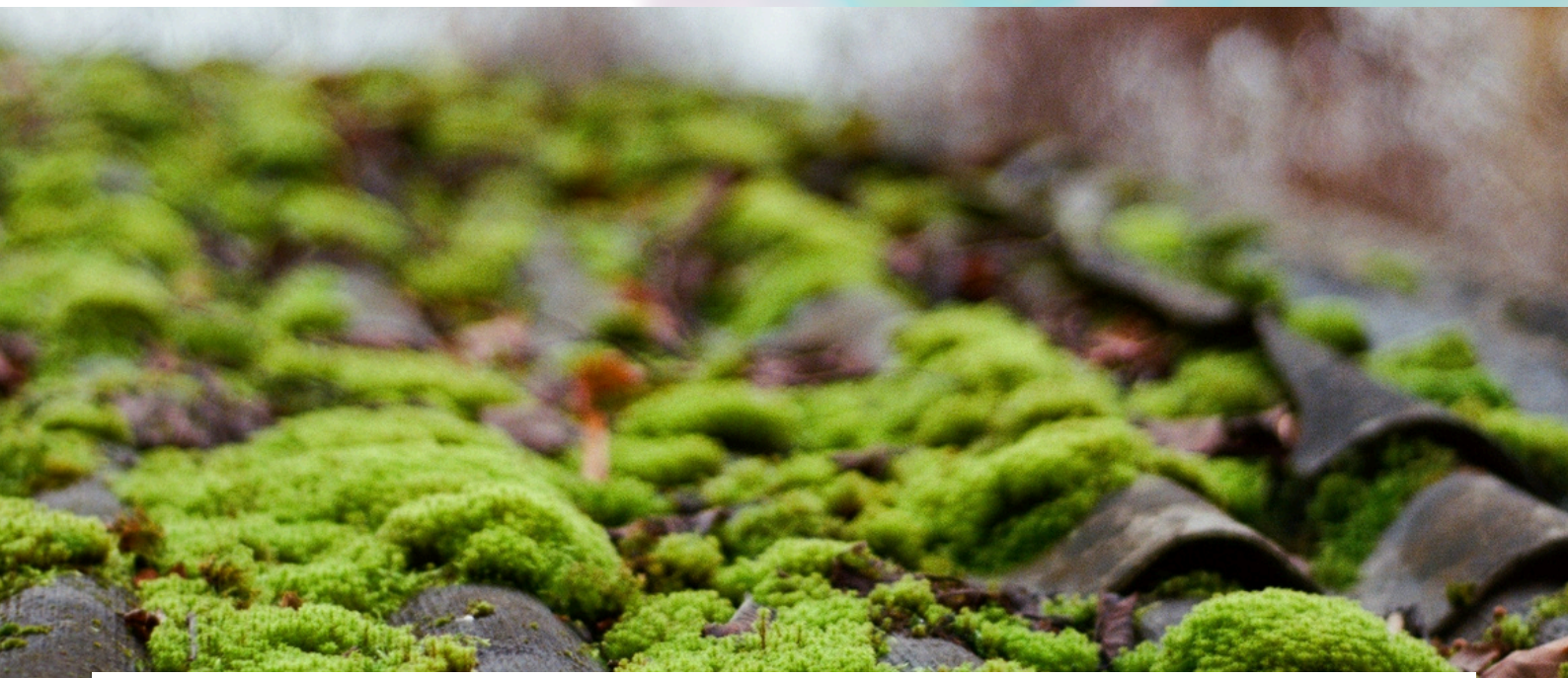
XERAYA CAPITAL
Life Venture

MICROBIOME RESEARCH IN ENVIRONMENT AND SUSTAINABILITY

The New Vanguard of Environmental Technology

MARCH 2026

The study of microbiomes, which encompasses the complex and dynamic communities of microorganisms that inhabit virtually every environment on Earth, has historically been confined primarily to the realm of human health and therapeutics.



However, a massive paradigm shift is currently underway across the scientific and financial sectors, positioning microbiome research at the vanguard of environmental management, sustainability, and green technology. The urgency of this shift is underscored by the fact that agrifood systems still account for about one-third of anthropogenic greenhouse gas emissions, and methane is responsible for roughly one-third of current warming. Consequently, investors and policymakers are aggressively looking for solutions that can improve productivity while simultaneously reducing environmental pressure. Microbiome research sits squarely in that gap because microbes already drive the natural processes behind soil fertility, waste decomposition, carbon cycling, and water quality. What is changing now is our ability to map, manage, and deploy those microscopic ecosystems with far greater precision.

For institutional investors, venture capitalists, and corporate strategists, this represents a multi-billion-dollar opportunity.

The core opportunity is not merely "microbes" as a broad theme, but the conversion of biological complexity into measurable business outcomes. In Malaysia, the imminent enforcement of the 2026 Carbon Tax marks a watershed moment, fundamentally altering the economics of industrial emissions. Malaysia is especially relevant to this global transition because it combines a large agricultural base, rising waste volumes, expanding aquaculture, and an emerging domestic carbon market.

Sustainable Agriculture and Food Security

Global agricultural systems currently face a severe dual mandate: they must aggressively increase crop yields to feed a growing population while simultaneously slashing their reliance on ecologically damaging synthetic chemicals. Soil microbiomes, composed of diverse microorganisms such as *Rhizobium* and *Bacillus* species, serve as the biological engine for essential nutrient cycling, enhancing soil fertility, and naturally suppressing destructive plant pathogens. Recent scientific reviews suggest that plant microbiome technologies could become an important lever for sustainable crop production, although they also highlight real bottlenecks such as inconsistent field performance, competition with native microbiota, and environmental variability. The sector is moving beyond academic promise toward biofertilizers, biostimulants, and microbial consortia. Ultimately, the winners will be the companies that can deliver repeatable performance across different farms, climates, and crop systems.

In Malaysia, this is particularly relevant as palm oil remained the largest contributor to agricultural value added at RM38.1 billion in 2024, representing 36.8% of the sector, while palm-product export revenue reached RM109.39 billion. In a crop system of that immense scale, even modest gains in nutrient efficiency, yield stability, residue management, or soil regeneration matter commercially. Microbiome-based inputs can help reduce dependency on conventional chemicals, improve soil quality after repeated planting cycles, and support stronger sustainability credentials across the supply chain.

Beyond terrestrial farming, Department of Statistics Malaysia data show that brackishwater aquaculture production reached 392.4 thousand tonnes in 2024, while freshwater aquaculture production increased by 5.7%. Malaysia is actively targeting aquaculture to account for 40% of total fisheries production by 2030. To meet this ambitious target sustainably, the industry is rapidly integrating probiotics into aquaculture systems to improve fish health, optimize feed conversion ratios, and reduce reliance on antibiotics.

Waste Management and the Circular Economy

Waste management may be the clearest, most immediate example of microbiome research translating into near-term environmental value. Malaysia generates around 39,000 tonnes of solid waste every single day, pushing the nation toward producing over 15 million tonnes annually. The national recycling rate improved to 37.9% in 2024 but still sat just below the 40% target under the Twelfth Malaysia Plan, leaving landfills heavily overburdened. Malaysian Investment Development Authority (MIDA) has noted that waste management is now the country's second biggest contributor to greenhouse gas emissions.

Microbial systems underpin composting, anaerobic digestion, leachate treatment, and industrial wastewater cleanup, which means they are central to turning waste from a cost centre into a resource stream. By deploying specialized methanogenic archaea and bacterial consortia through anaerobic digestion, operators can efficiently convert massive volumes of municipal organic waste into high-yield biogas. This aggressively reduces reliance on overflowing landfills and captures methane emissions, converting them into renewable energy.

The capital signal for this transition is highly visible. MIDA reported that the integrated waste management and recycling sector had attracted RM22.7 billion in investments as of June 2025, including RM3.2 billion across 17 approved integrated waste management projects. Furthermore, the Bursa Carbon Exchange launched Malaysia's first technology-based carbon credit auction in June 2025 through the Monsoon Methane Avoidance from Industrial Wastewater in Malaysia Grouped Project. This project captures and uses biogas generated in industrial wastewater treatment systems, with its first project activity instance directly linked to a palm oil mill wastewater facility in Perak.

For investors, this clearly demonstrates how microbial processes can successfully underpin a stack of distinct revenue lines: waste treatment, electricity generation, and tradable environmental attributes.

Bioremediation and Environmental Restoration

Bioremediation is another critical area where the microbiome story is becoming increasingly investable, although market expectations need to stay grounded. Current research continues to consistently show that microbial consortia can drastically improve the degradation of organic pollutants and support the remediation of contaminated wastewater, soil, and sediments. Historically, bioremediation was utilized primarily to neutralize heavy metals and detoxify agricultural pesticides.

However, the most lucrative modern frontier is the biological degradation of synthetic plastics. Since the seminal discovery of Ideonella sakaiensis, a bacterium uniquely capable of degrading poly (ethylene terephthalate) plastics, the biotech landscape has evolved at breakneck speed. As of 2025 and 2026, the industry uses advanced multi-omics frameworks, such as Plastic-MBR databases, to map plastic-degrading enzymes across vast microbial taxa. Environmental remediation now heavily leverages optimized aquatic bacterial consortia that have demonstrated remarkable efficacy in breaking down microplastics in wastewater effluents.

Simultaneously, the rapidly growing sub-field of "entomoremediation" is capturing significant venture interest as scientists unlock the potential of insect larvae gut microbiomes to metabolize highly recalcitrant polymers. In practical terms, however, the near-term investment opportunities are likely to be less about science-fiction narratives of plastic-eating bacteria and much more about enabling tools. These tools include microbial formulations, sequencing and monitoring platforms, engineered bioprocesses, and performance analytics. In other words, much of the true commercial value may sit not only in the microbes themselves, but in the sophisticated operating system built around them.

Carbon Markets and Natural Capital

The financialization of environmental conservation has truly arrived, and it is largely underpinned by biological activity. Microbes are the unseen, foundational architects of the global carbon cycle. In 2025, researchers reported finding phylogenetically and metabolically diverse active carbon-fixing microbes in mangrove sediments, while another study found that soil moisture and microbiome composition help explain greenhouse-gas exchange in global peatlands. Understanding and optimizing these microbial ecosystems in natural carbon sinks, specifically Malaysia's extensive mangrove forests and tropical peatlands, is the absolute key to maximizing carbon sequestration efforts. These findings improve our understanding of exactly how carbon is stabilized, lost, or measured in living ecosystems. That understanding is increasingly relevant as natural-capital markets begin to demand better integrity, stronger monitoring, and far more defensible baselines.

Malaysia's own carbon-market developments actively reinforce that shift. The Bursa Carbon Exchange's first Malaysian nature-based carbon credit auction in July 2024 was based entirely on the Kuamut Rainforest Conservation Project in Sabah, which protects and restores 83,381 hectares of tropical forest. The auction cleared at RM50 per contract, successfully helping establish a local benchmark for Malaysian nature-based credits.

Microbiome science is not the sole driver of such projects, but over time it can significantly strengthen project design, methane management, soil and sediment carbon assessment, and ecosystem-health verification. High-quality, nature-based carbon credits generated from microbiologically vibrant ecosystems command premium pricing on exchanges like the BCX. For corporate emitters facing severe 2026 Carbon Tax liabilities, investing in these verified, microbiome-backed offset projects provides a critical financial hedge and a clear pathway to net-zero compliance.

The Biological Capital Imperative

The central question for investors is not whether microbiomes matter, because they unequivocally do. The much more practical question is where true defensibility and commercial scale will eventually come from. In this space, four specific indicators are worth watching closely: efficacy outside the lab, unit economics versus incumbent solutions, regulatory clarity around product claims and environmental attributes, and the depth of proprietary data or partnerships. Companies that turn microbial complexity into simple, reliable customer outcomes will be the best positioned. Farmers do not buy metagenomics; they buy higher yields, healthier soils, and lower input costs. Likewise, waste operators do not buy microbial diversity; they buy cleaner effluent, lower methane leakage, and usable biogas.

Microbiome research is gradually moving from a supporting science to a strategic layer in environmental sustainability. In Malaysia, that transition is especially relevant across palm oil, aquaculture, industrial wastewater, waste management, and natural-capital markets. For the general public, the message is straightforward: invisible microbial ecosystems already shape our food, water, waste, and climate. For investors, the most compelling opportunities lie exactly where microbiome science can improve productivity, lower emissions, and create measurable environmental value at commercial scale. Microbiome research is not only about understanding nature better; it is also about building more resilient systems around it and unlocking the vast, untapped reservoir of biological capital beneath our feet.

XERAYA CAPITAL
Life Venture

www.xeraya.com