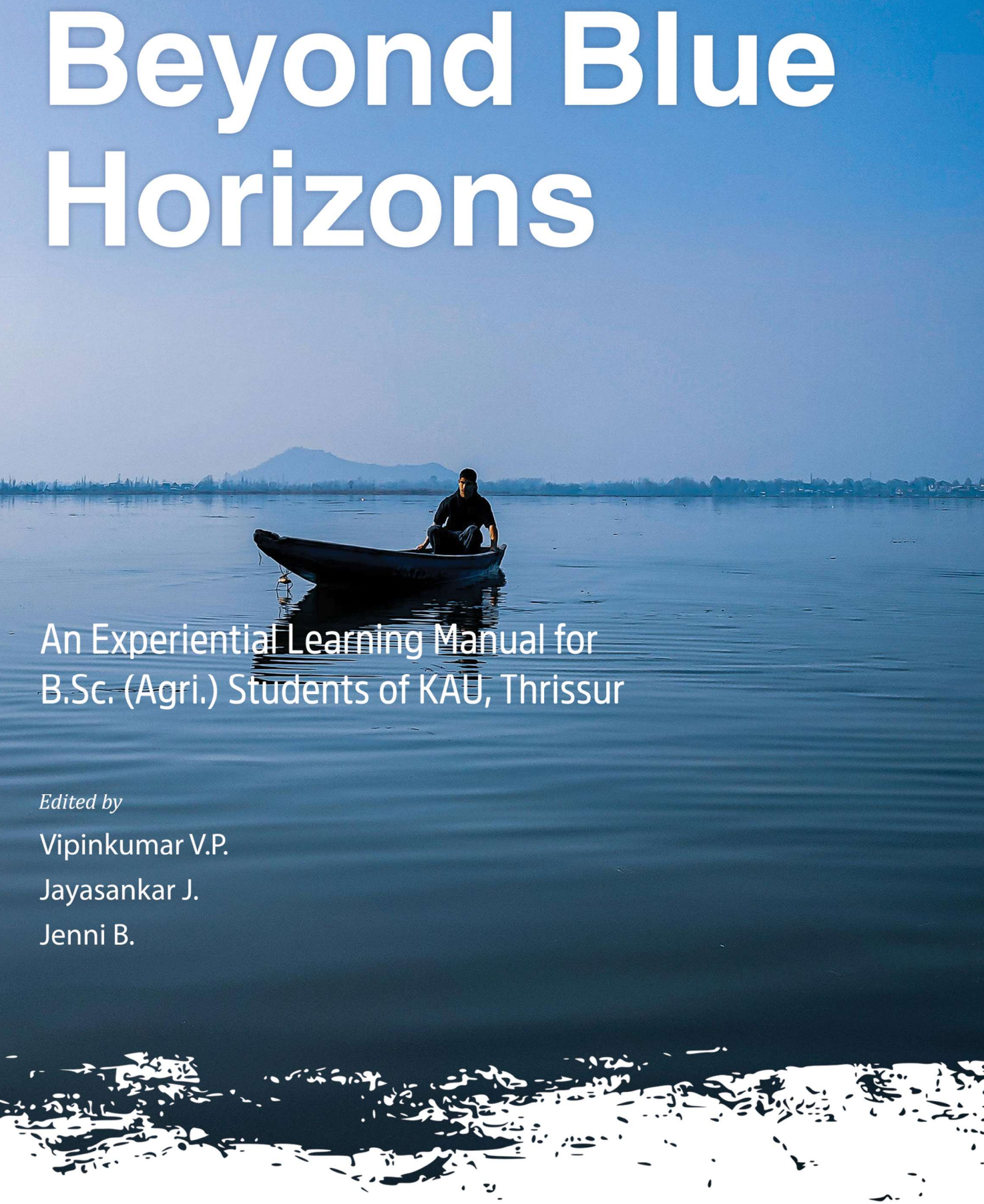
Beyond Blue Horizons



An Experiential Learning Manual for
B.Sc. (Agri.) Students of KAU, Thrissur

Edited by

Vipinkumar V.P.

Jayasankar J.

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ICAR-Central Marine Fisheries Research Institute
(Department of Agricultural Research and Education, Government of India)
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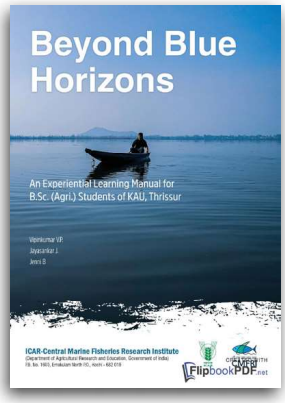

Beyond Blue Horizons
Training Manual for BSc (Agri) students of Kerala Agricultural University

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FOREWORD

It is with great pleasure and deep satisfaction that I present this foreword to the Training Manual of the Science Camp titled "Beyond Blue Horizons: An Experiential Training Manual for B.Sc. Agriculture Students." Conducted from July 14 to 18, 2025, at the STI Hub Digital Training Hall, ATIC, ICAR-CMFRI, Kochi, this programme exemplifies our continued commitment to innovative, experiential, and interdisciplinary learning in agriculture and allied sectors.

Organized by ICAR-Central Marine Fisheries Research Institute through its Agricultural Technology Information Centre (ATIC), the training served as a dynamic platform for B.Sc. Agriculture students from the College of Agriculture, Vellanikkara, Thrissur. The thematic focus on integrating field-based experiences with advanced laboratory analyses reflects a progressive approach to education—one that fosters a seamless continuum between knowledge generation, validation, and application. Such initiatives are vital in equipping students with the skills and perspectives required to address emerging challenges in agriculture and fisheries.

I place on record my sincere appreciation to Dr. Vipinkumar V.P., Principal Scientist and ATIC Manager, ICAR-CMFRI, for his exemplary leadership, meticulous planning, and unwavering dedication in organizing this programme. His efforts, along with those of the entire team, have ensured the successful conduct of this Science Camp, setting a high standard for future capacity-building initiatives.

The programme was thoughtfully designed to bridge the gap between theoretical understanding and practical application. It offered participants a rich blend of innovative lectures on emerging topics, hands-on training sessions, field exposure visits, and institutional interactions. The opportunity to access advanced laboratories, aquarium facilities, and the museum at CMFRI significantly enriched the learning experience. Equally important were the interactive sessions with farmers, which fostered meaningful exchanges between academia and practitioners, grounding scientific knowledge in real-world contexts.

Such experiential learning opportunities are invaluable in enabling students to appreciate the dynamic flow of information from field observations to laboratory insights, ultimately supporting informed decision-making and innovation in production systems. I am confident that the knowledge and exposure gained through this Science Camp will contribute significantly to the academic growth and professional development of the participants.

I extend my warm congratulations to all the students and faculty members who actively engaged in this programme. Your enthusiasm, curiosity, and commitment to learning are truly commendable. May this experience inspire you to strive for excellence and contribute meaningfully to the advancement of agriculture and fisheries.

I am confident that this training manual will serve as a lasting resource, capturing the essence of the programme and reflecting the collective efforts that made this initiative both impactful and memorable.

Dr. Grinson George
Director, ICAR-CMFRI
Kochi

PREFACE

It is with immense pleasure and a deep sense of fulfilment that I present this compendium, "Beyond Blue Horizons: A Training Manual for B.Sc. Agriculture Students of Kerala Agricultural University." This volume encapsulates a unique and inspiring journey of experiential learning, meticulously designed and conducted at the STI Hub Digital Training Hall, ATIC, ICAR-CMFRI, Kochi, from July 14 to 18, 2025.

Envisioned as a transformative academic engagement, this Science Camp brought together bright and inquisitive B.Sc. Agriculture students from Kerala Agricultural University, Thrissur, and guided them through a rich continuum of learning—from field-level realities to the precision of laboratory analytics. At a time when agriculture is rapidly transitioning into a data-driven and innovation-led enterprise, the programme provided a vibrant platform for students to explore the convergence of traditional knowledge systems with modern scientific advancements, with a special emphasis on the fisheries sector.

The training was thoughtfully structured to deliver an immersive and practice-oriented learning experience. Through a dynamic blend of expert lectures, hands-on sessions, field exposure visits, institutional interactions, and meaningful dialogues with farmers, participants were encouraged not only to learn but to question, analyse, and innovate. The focus was on nurturing scientific curiosity, strengthening practical competencies, and inspiring a forward-looking approach to sustainable agriculture and fisheries development.

This manual, comprising ten thoughtfully curated chapters, reflects the thematic depth and diversity of the programme. It covers a wide spectrum of subjects including integrative analytics, digital interventions, field diagnostics, and emerging marine agri-technologies. What makes this volume particularly engaging is its strong practical orientation—each chapter offers insights, methodologies, and experiences that readers can readily connect with and apply. The concluding chapter, featuring the comprehensive report prepared by the students, stands as a testament to their active engagement and the effectiveness of the experiential learning model adopted during the camp.

I place on record my sincere gratitude to Dr. J. Jayasankar, Head of the FRAEE Division, and Dr. B. Jenni, ACTO, ATIC, for their scholarly contributions, editorial excellence, and steadfast support as co-editors of this compendium. Their efforts have been instrumental in shaping this manual into a valuable and enduring academic resource.

As the Course Director and Chief Editor, I consider this compendium not merely as a documentation of an event, but as a celebration of collaborative learning and an invitation to explore the vast and promising interface between agriculture and fisheries sciences. While this endeavour represents only a beginning—a glimpse into a much larger horizon—it is my earnest hope that this volume will inspire readers to delve deeper, think innovatively, and contribute meaningfully to this evolving domain.

I warmly invite students, researchers, academicians, and practitioners to engage with the chapters that follow—rich in practical insights, field-based observations, and scientific perspectives—and to draw inspiration for future learning and innovation.

Dr. Vipinkumar V. P.
Principal Scientist & ATIC Manager
ICAR-CMFRI, Kochi

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Black Soldier Fly larvae based Biovalorization: Transforming Waste into Sustainable Wealth

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Sanal Ebeneezar., Linga Prabu D., Sayooj P., Chandrasekar S., Adnan H. Gora., Vipinkumar V. P. and Kajal Chakraborty.
ICAR-Central Marine Fisheries Research Institute, Kochi-682018, Kerala

ICAR-CMFRI has developed an innovative **Black Soldier Fly (BSF) biovalorization technology**, revolutionizing **organic waste management** while advancing sustainable aquaculture. This eco-friendly approach **upcycles organic waste** into high-quality fish feed, promoting a **zero-waste circular economy** with a **low carbon footprint**. By aligning with the ***Swachhata Hi Seva campaign***, this initiative embodies the **waste-to-wealth** vision, ensuring environmental responsibility while enhancing India's blue economy. Through BSF bioconversion, ICAR-CMFRI sets a benchmark for **green technology**, paving the way for a more **sustainable and resource-efficient future**.

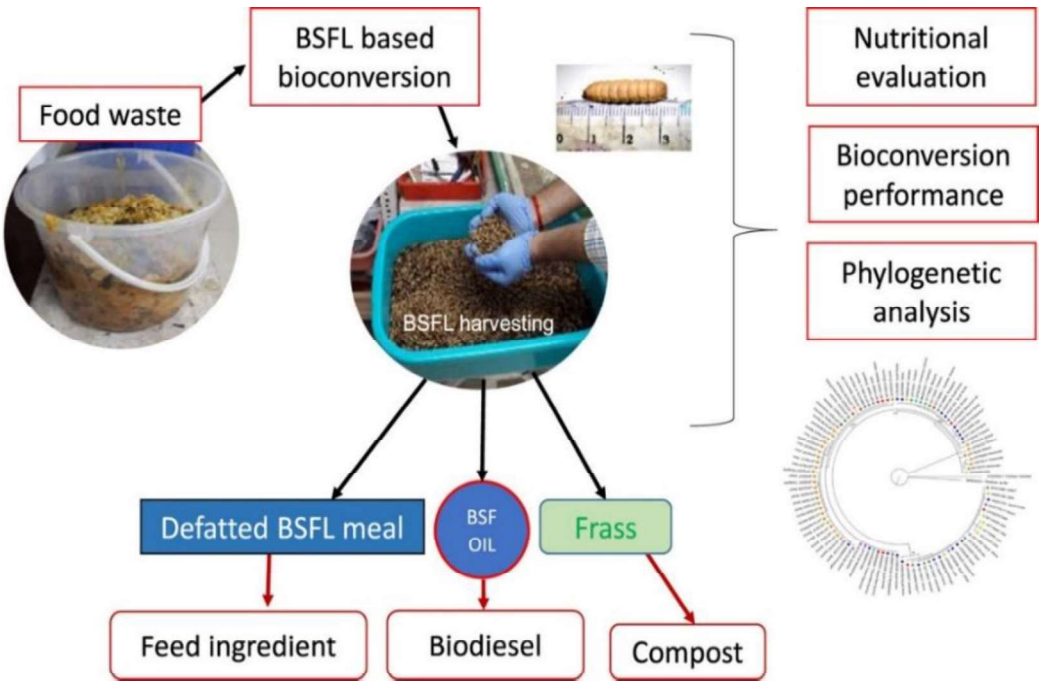
Black Soldier Fly (BSF) biovalorization technology is emerging as a game-changer in sustainable waste management and aquaculture by addressing the pressing need for an alternative to unsustainable fishmeal in aquafeeds. Traditional fishmeal production relies heavily on wild-caught fish, contributing to overfishing, marine ecosystem depletion, and a high carbon footprint.

In aquafeeds, fishmeal has been the gold standard due to its high protein content (45-63%), essential amino acids, and digestibility (above 90%). However, its increasing cost, overfishing concerns, and sustainability challenges have necessitated alternative protein sources. One of the most promising replacements is **Black Soldier Fly Larvae (BSFL) meal**. BSF larvae offer a circular economy solution by upcycling organic waste into high-quality insect protein, serving as a viable replacement for fishmeal. Moreover, BSF-derived protein is highly digestible and rich in essential amino acids, making it an excellent feedstock for aquaculture while reducing dependence on unsustainable marine resources. The frass by-product further enhances soil health, promoting regenerative agriculture and closing the loop in sustainable food production.

Advantages of BSFL as a Fishmeal Replacement:

- **High Protein Content**: BSFL meal contains approximately **40-60%** crude protein, comparable to fishmeal.
- **Essential Amino Acids**: BSFL provides essential amino acids required for fish growth and development.

- **Sustainability**: BSFL can be produced from organic waste, contributing to circular economy models. The carbon footprint of fish meal can range from **2 to 5 kg of CO2 per kg of fish meal** (Hognes et al., 2011) **while for BSFL protein, it is 0.2 – 2.5 kg of CO2 per kg** (Tadesse, 2023).
- **Cost-Effectiveness**: Large-scale BSFL production can significantly reduce feed costs compared to fishmeal-based diets.
- **Nutritional Benefits**: BSFL has beneficial lipids and bioactive compounds that enhance fish immunity and growth.



Research on Black Soldier Fly Larvae (BSFL) for Sustainable Aquaculture

This initiative was aimed to develop an efficient model for converting organic waste into high-value protein for aquaculture (**Waste-biomass conversion ratio= 6.80, Bioconversion efficiency (%)= 24.31±0.62, Substrate reduction (%) = 72.38±1.37**) (Sanal-Ebeneezar et al., 2021). Nutritional analysis revealed that BSFL contains **40.42% crude protein, 39.89% crude lipid, 8.16% crude fiber, 10.71% total ash, and 0.82% nitrogen-free extract (NFE).** Additional studies on nutritional evaluation, bioconversion efficiency, and phylogenetic assessment were conducted.

Expansion of infrastructure for R & D in Black soldier fly larvae as a aquafeed ingredient and bio-waste valorization

BSF ZW: A Zero-Waste Bio-Conversion System was established at the CMFRI headquarters in Kochi. This specialized setup utilizes black soldier fly larvae (*Hermetia illucens*) to convert organic waste into high-quality fish feeds. The major components of the unit include- Dark-light chamber for breeding, egg laying and pupal incubation, Unit for early larval rearing (up to 6 DOL), Unit for advanced larval rearing, Self-harvesting bioconversion unit and Units for composting of frass. The pilot-scale system, is a testament to his commitment to sustainable and innovative solutions for bioconversion and waste valorization. Organic waste including canteen waste and fish sampling wastes from the various research Divisions of CMFRI are being valorized into alternative protein and lipid rich aquafeed ingredients and compost. This facility includes a dark-light chamber for breeding, an egg-laying and pupal incubation unit, an early larval rearing unit, an advanced larval rearing section, a self-harvesting bioconversion unit, and composting units for frass processing. Capable of handling 50 to 60 kilograms of organic waste per day, this unit efficiently converts waste into high-quality insect protein, oil, and organic manure. In recognition of this initiative, the **BSFL-based bioconversion unit was inaugurated by Shri George Kurian, Hon'ble Minister of State for Fisheries, Animal Husbandry, and Dairying, on September 26, 2024, as part of the *Swachhata Hi Seva* campaign.**

Inauguration of the Black soldier fly larval rearing cum bioconversion unit by Shri George Kurian, Hon'ble Minister

BSFL as a Sustainable Fish Feed Alternative

The use of BSFL as a fish feed ingredient was validated through feeding trials on Indian pompano (*Trachinotus mookalee*). A sixty-five-day feeding trial assessed the potential of BSFL meal (BSFLM) as a substitute for traditional fish meal (FM) in fish diets. Nine treatments with varying combinations of FM, BSFLM, and taurine were tested. Results showed that the diet containing 100% BSFLM with 1% taurine supplementation resulted in the highest weight gain and optimal feed utilization. Digestive enzyme activities, such as amylase, lipase, and protease, were comparable across treatments, while antioxidant enzyme activity in the liver and gills was significantly higher in the control group. No histopathological abnormalities were detected in fish fed BSFLM-based diets, confirming its safety and efficiency. **The study concluded that BSFLM-based diets can completely replace fish meal in Indian pompano (*Trachinotus mookalee*).**

Release of *Cadalmin™ BSF Pro*- fishmeal free feed for Indian Pompano

Commercialization and Licensing of BSFL aquafeed Technology

A major milestone was the commercialization and licensing of BSFL-based fish feed technology to two start-ups. **On October 22, 2024, ICAR-CMFRI signed a Memorandum of Understanding (MoU) with Amala Ecoclean Pvt. Ltd., Kerala, for the production of insect protein-based fish feed. Another MoU was signed on January 6, 2025, with Bhairav Renderers, Coimbatore, Tamil Nadu, for similar technology transfer.** This initiative supports sustainable aquaculture by promoting insect protein as a viable fish meal alternative. The project has also gained global recognition, being featured in *FeedStrategy*, an international magazine specializing in animal feed sector innovations.

Signing of MoUs with Amala Ecoclean Pvt. Ltd., Kerala, and Bhairav Renderers, Coimbatore, Tamil Nadu

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