ROADMAP PENELITIAN DAN PENGABDIAN

PS TEKNIK PERTANIAN DAN BIOSISTEM

PERIODE 2026-2030

FAKULTAS TEKNOLOGI PERTANIAN

UNIVERSITAS UDAYANA

2026

DAFTAR ISI

PENDAHULUAN

Program Studi Teknik Pertanian dan Biosistem (TPB), Fakultas Teknologi Pertanian, Universitas Udayana memiliki peran strategis dalam menjawab tantangan pembangunan pertanian berkelanjutan di Bali yang unik karena keterkaitan erat antara sistem produksi pangan, budaya lokal seperti Subak, serta sektor pariwisata. Dalam konteks ini, penelitian dan pengabdian tidak hanya berorientasi pada pengembangan teknologi, tetapi juga harus mampu menjaga keseimbangan antara produktivitas, keberlanjutan lingkungan, dan nilai-nilai sosial budaya.

Pendekatan roadmap ini disusun dengan mengintegrasikan kekuatan berbagai Kelompok Bidang Keahlian (KBK), yaitu pascapanen, rekayasa pangan, energi dan alat mesin pertanian, pertanian cerdas, serta sumber daya alam dan lingkungan. Integrasi ini menjadi fondasi untuk menghasilkan inovasi yang tidak terfragmentasi, melainkan saling menguatkan dalam satu ekosistem riset dan pengabdian.

VISI

Menjadi pusat unggulan dalam pengembangan teknologi pertanian dan biosistem berbasis inovasi, keberlanjutan, dan kearifan lokal Bali yang mendukung sistem pangan dan pariwisata berkelanjutan.

KERANGKA STRATEGIS

Roadmap ini dibangun atas tiga pilar utama:

1. inovasi teknologi berbasis kebutuhan lokal,
2. integrasi sistem pertanian–pascapanen–industri–pariwisata, dan
3. penguatan keberlanjutan melalui pendekatan ekologis dan sosial.

INTEGRASI SUBAK DAN PARIWISATA

Subak tidak hanya dipandang sebagai sistem irigasi, tetapi sebagai ekosistem sosial-ekologis yang menjadi dasar pendekatan penelitian dan pengabdian. Teknologi yang dikembangkan diarahkan untuk memperkuat efisiensi air, kualitas produksi, serta nilai tambah produk yang mendukung rantai pasok pariwisata Bali.

ROADMAP PENELITIAN

2026	Penguatan baseline, pemetaan potensi Subak, identifikasi bottleneck rantai pasok.

2027	Pengembangan teknologi (smart farming, pascapanen, nano pangan).
2028	Validasi teknologi dan prototipe.
2029	Integrasi sistem (IoT, AI, supply chain).
2030	Hilirisasi dan pembentukan pusat inovasi.

ROADMAP PENGABDIAN

2026 – 2027	Edukasi dan pelatihan berbasis KWT/Desa/Subak.
2028 – 2029	Pengembangan teknologi (smart farming, pascapanen, nano pangan). Implementasi teknologi per KBK dan integrasi teknologi (Multi KBK).
2030	Validasi teknologi dan prototipe melalui smart and sustainable village (desa model).

KEBERLANJUTAN

Pendekatan sustainability mencakup efisiensi sumber daya, pengurangan limbah, ekonomi sirkular, dan dukungan terhadap SDGs. Setiap riset diarahkan untuk memiliki dampak lingkungan dan sosial yang terukur.

KEY PERFORMANCE INDICATOR

Publikasi internasional, paten, prototipe, kemitraan industri, dampak masyarakat, serta pembentukan pusat inovasi pascapanen dan smart farming Bali.

PENUTUP

Roadmap ini menjadi dokumen hidup yang akan terus diperbarui sesuai dinamika kebutuhan masyarakat, perkembangan teknologi, serta arah kebijakan nasional dan global.

LAMPIRAN

ROADMAP PENELITIAN
KELOMPOK BIDANG KEAHLIAN (KBK)
REKAYASA PASCAPANEN DALAM SISTEM RANTAI NILAI HORTIKULTURA

PERIODE 2026-2030

CABANG ILMU TEKNIK PERTANIAN DAN BIOSISTEM
POHON ILMU TEKNIK ATAU REKAYASA-REKAYASA
UNIVERSITAS UDAYANA

TIM PENELITI

KELOMPOK BIDANG KEAHLIAN (KBK)
REKAYASA PASCAPANEN DALAM SISTEM RANTAI NILAI HORTIKULTURA

FAKULTAS TEKNOLOGI PERTANIAN
UNIVERSITAS UDAYANA

(SK Rektor Universitas Udayana Nomor : 4506/UN14/HK.KP/2025, 20 Oktober 2025)

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Preface

The preparation of this roadmap marks a pivotal milestone in the development of the Postharvest Teaching, Research and Innovation Lab (PTRI Lab) at Universitas Udayana. In a time where postharvest losses remain a critical bottleneck to food security and economic progress—especially in tropical and tourism-driven regions like Bali—this document articulates a forward-thinking, structured plan to respond to these challenges through scientific rigor, collaborative innovation, and inclusive education.

This roadmap was conceived not merely as a planning tool, but as a strategic declaration of PTRI Lab's identity, purpose, and future trajectory. It represents the collective aspirations of faculty, students, government collaborators, and private sector partners who believe in the transformative power of science when aligned with local realities and global standards. The roadmap captures the Lab's vision to serve as a hub for applied research, technology development, and regional capacity building—positioning Universitas Udayana at the forefront of postharvest innovation in Southeast Asia.

We hope this document will serve as both a reference and a catalyst for action. It is intended for use by policymakers, funders, academic institutions, industry stakeholders, and students who wish to engage with PTRI Lab's programs or replicate its model. Its pages are filled with detailed strategies, performance indicators, innovation portfolios, and funding frameworks that chart a clear and measurable path toward institutional growth and societal impact.

Our gratitude extends to all contributors who have provided insight, expertise, and encouragement throughout the roadmap's development. May this document guide not only the Lab's next five years, but also inspire a broader movement toward smarter, safer, and more sustainable postharvest systems in Indonesia and beyond.

INTRODUCTION

The Postharvest Teaching, Research and Innovation Lab (PTRI Lab), operating under the Faculty of Agricultural Technology at Universitas Udayana, serves as a foundational platform for academic excellence, research advancement, and industry-aligned innovation in postharvest science. In a world increasingly shaped by the dynamics of climate variability, shifting consumer demands, and a growing need for sustainable food systems, the PTRI Lab is envisioned as a critical node for developing solutions tailored to tropical agri-food systems. It specializes in exploring the biological, technological, and safety dimensions of postharvest handling, ensuring that postharvest losses are reduced and product quality is maintained from farm to consumer.

At the heart of PTRI Lab's vision for the 2025–2030 period is an ambition to transition from a local academic research facility to a nationally recognized center for integrated postharvest innovation. This will be accomplished through a systematic strengthening of research infrastructure, strategic alignment with global research themes, and active collaboration with regional stakeholders, including smallholder producers, supply chain actors, and tourism-linked enterprises. Such positioning allows the Lab to contribute meaningfully to Indonesia's broader food security agenda while also generating knowledge that is both locally grounded and globally relevant.

In pursuit of academic impact, the Lab will continue to prioritize the development of human capital through experiential teaching, hands-on research training, and interdisciplinary project-based learning. Undergraduate and graduate students will play a central role in the Lab's mission, with structured research leadership programs and access to high-impact projects that align with national development goals. This integration of education and innovation not only strengthens academic output but ensures a talent pipeline equipped to respond to real-world challenges in agriculture and food systems.

Moreover, PTRI Lab will emphasize translational research that leads to usable technologies, scalable prototypes, and commercialized innovations. By fostering strong ties with both private and public sector partners, the Lab seeks to become a trusted provider of scientific insights and technical solutions. Through incubator initiatives and co-development projects, PTRI Lab will support Bali's transformation into a hub for safe, efficient, and traceable postharvest systems that serve both domestic and tourism-driven food markets.

This strategic roadmap is a call to action for stakeholders across research, policy, and industry domains to engage with and invest in a forward-looking, innovation-driven postharvest agenda. It outlines the structural phases, research priorities, performance indicators, and resource strategies that will guide PTRI Lab's evolution over the next five years. With this roadmap, Universitas Udayana reaffirms its commitment to regional

development through scientific leadership and innovation excellence in postharvest research.

VISION AND MISSION

The Vision and Mission statements of the Postharvest Teaching, Research and Innovation Lab (PTRI Lab) represent the strategic compass by which the Lab navigates its research, teaching, and innovation activities. In a period marked by unprecedented transformations in agriculture and food systems, institutions such as PTRI Lab play a critical role in aligning scientific pursuits with pressing societal needs. Through clear articulation of its aspirations and operational goals, the Lab seeks to position itself as a leader in postharvest development and a proactive contributor to sustainable food systems.

These guiding statements are more than symbolic declarations; they define a roadmap for collective action, collaboration, and academic rigor. As Bali's agricultural sector evolves to meet both domestic and global demands, PTRI Lab's clarity of purpose ensures that its work remains relevant, evidence-based, and future-oriented. The articulation of these statements is thus not only strategic but also a reflection of a deep commitment to excellence, sustainability, and innovation.

The vision and mission collectively serve as both anchor and engine for the Lab's activities. They provide a shared language for engaging stakeholders—from students and faculty to government and industry partners—around a coherent set of values and priorities. With this foundation in place, PTRI Lab is poised to contribute significantly to the scientific, economic, and social advancement of postharvest systems in Bali and beyond.

Vision

To become Bali's leading center for postharvest research, technology innovation, and industry-supported solutions, strengthening sustainable and competitive agri-food value chains through science, education, and partnerships.

The vision of the PTRI Lab serves as a long-term aspiration that captures the essence of its purpose and its intended future impact. It encapsulates the Lab's ambition to not only lead in postharvest research but also to become an active agent in shaping Bali's food system through innovative technologies, education, and strategic partnerships. This vision is grounded in a recognition of the Lab's geographic and cultural context—leveraging Bali's unique agricultural landscape and tourism economy as a springboard for transformative agri-food solutions.

A defining feature of this vision is its holistic perspective on postharvest challenges. Rather than isolating scientific inquiry from social and economic realities, the Lab aims to integrate cross-disciplinary approaches to address the complexity of quality loss, food safety, and value chain inefficiencies. This orientation makes the PTRI Lab uniquely positioned to catalyze sustainable change through evidence-based interventions and inclusive innovation.

By positioning itself as a regional center of excellence, the Lab also seeks to attract national and international collaborators who share its commitment to impactful research. This outward-looking posture enables PTRI Lab to contribute not just locally, but to global discourses on sustainable agriculture, food security, and postharvest systems development. The vision thus aligns scientific ambition with societal relevance, making it both inspirational and actionable.

Mission

- Conduct impactful research in postharvest physiology and technology.
- Develop tropical postharvest innovations to improve quality and reduce losses.
- Train students and researchers through hands-on laboratory and industrial exposure.
- Build market-oriented technologies in collaboration with industry partners in a value chain system.
- Secure sustainable research and innovation funding from diverse sources.

The mission of PTRI Lab is articulated through five operational commitments that define the scope of its work and its contributions to the academic, industrial, and community sectors. These mission points are designed to translate the Lab's vision into tangible outcomes by addressing both the technical and institutional dimensions of postharvest challenges. From rigorous scientific research to collaborative technology development, the Lab's mission encompasses the full spectrum of the innovation value chain.

Central to this mission is the Lab's role as an educational platform. PTRI Lab not only trains students in technical competencies but also instills a culture of inquiry, ethics, and societal contribution. Through structured research teams, internships, and innovation fellowships, students gain practical experience that prepares them for leadership roles in academia, industry, and public service. This commitment to capacity building is foundational to the Lab's identity and long-term sustainability.

STRATEGIC INNOVATION PILLARS

The Postharvest Teaching, Research and Innovation Lab (PTRI Lab) at Universitas Udayana has structured its research and innovation agenda around four strategic pillars. These pillars respond to critical challenges and opportunities in the tropical agri-food system, aligning scientific inquiry with applied innovation and commercialization. By organizing its efforts around clearly defined domains, PTRI Lab ensures focused progress across all facets of postharvest research and application.

Each pillar represents a dedicated thematic area that addresses specific needs within the postharvest value chain. Together, they enable a holistic and systems-based approach, integrating disciplines such as crop physiology, engineering, microbiology, and entrepreneurial development. The framework encourages collaborative research and interdisciplinary innovation, with the ultimate goal of improving food system resilience, safety, and economic performance.

This structure allows PTRI Lab to channel expertise and resources into coherent programs that produce measurable outcomes. It also serves as a blueprint for student engagement, policy relevance, and industry partnerships. The four pillars thus act as the operational core of PTRI Lab's vision for a dynamic, sustainable, and inclusive future in postharvest innovation.

Postharvest Physiology

This pillar investigates the biological responses of tropical crops to postharvest handling and environmental conditions. It focuses on mechanisms that influence freshness, shelf-life, and quality deterioration—such as ethylene behavior, ripening control, and senescence. By understanding these physiological factors, the Lab can develop predictive models and preservation strategies tailored to tropical horticultural systems.

Research within this domain emphasizes the impacts of abiotic stress, including chilling injury, heat damage, and dehydration, which are increasingly relevant under climate variability. Tools such as SPAD meters, colorimeters, and respiration monitors are used to quantify physiological changes in produce during storage and distribution.

Key deliverables include a regional postharvest physiology atlas for fruits and vegetables, student research publications, and physiology-based decision tools. These resources are critical for both scientific advancement and practical application across Bali's agricultural and tourism food supply chains.

Postharvest Technology

The Postharvest Technology pillar emphasizes innovation in handling, storage, and packaging systems to reduce food loss and improve operational efficiency. It focuses on low-energy, scalable technologies that can be adopted by smallholders and regional producers—especially those supplying high-demand tourism markets.

Major areas of innovation include modified atmosphere packaging (MAP), biodegradable films, cold chain optimization, minimal processing, and non-thermal preservation. These interventions address infrastructure gaps while promoting food quality, safety, and shelf-life.

Outcomes from this pillar are expected to include field-ready prototypes, cold chain manuals, and patent submissions. The Lab also prioritizes training for technology adoption, ensuring that new tools are both technically robust and socially accessible.

Food Safety and Quality Innovation

This pillar enhances the safety and quality of fresh produce by addressing microbial contamination, hygienic processing, and food traceability. With the tourism industry playing a vital role in Bali's economy, ensuring safe, high-quality food for HORECA sectors is essential.

The Lab's research explores the development of plant-based antimicrobials, sanitizing coatings, and postharvest safety protocols. It also investigates the integration of digital traceability tools to improve transparency and build consumer trust.

Expected outputs include validated sanitation protocols, commercializable safety formulations, and data systems for tracking microbial risks. These innovations support both public health and market competitiveness.

Applied Innovation and Commercialization

This pillar bridges scientific discovery and market deployment, focusing on turning research outputs into commercial products and services. It champions functional packaging, smart sensors, and slow-release protective technologies, designed to extend shelf-life and add value.

Innovation acceleration includes pilot testing, incubation, and licensing pathways. Through the creation of an Innovation Hub, PTRI Lab supports the full lifecycle of product development—from lab prototype to commercial launch.

In parallel, entrepreneurship is fostered through student-led projects, training programs, and industry co-development. This ensures that the Lab not only generates new knowledge but also contributes directly to Bali's innovation economy.

FIVE-YEAR DEVELOPMENTAL PHASES
(Concise Narration)

The strategic roadmap for PTRI Lab is structured into five consecutive phases over a five-year period (2025–2030), designed to ensure progressive capacity building, application, commercialization, and institutionalization. Each phase builds on the outcomes of the previous, forming a cohesive trajectory that reflects PTRI Lab's vision of becoming a leading center for postharvest innovation in Bali and beyond.

Phase 1 (2025–2026): Capacity Strengthening

This foundational phase focuses on equipping the Lab with essential research infrastructure including SPAD meters, cold rooms, and colorimeters, alongside the development of SOPs and teaching modules. The Lab will form thematic research clusters and initiate student research teams to conduct baseline studies supported by internal funding, setting the stage for structured, high-quality research activity.

Phase 2 (2026–2027): Applied Research and Industry Engagement

PTRI Lab will begin collaborating with Bali's agricultural supply chains to test early-stage innovations like smart packaging and coating systems. Pilot trials, research publications, and patent filings will validate prototypes and enhance stakeholder engagement, laying a foundation for scalable and context-specific postharvest technologies.

Phase 3 (2027–2028): Innovation Acceleration

Building on validated research, this phase launches the Lab's Innovation Incubation Program to refine, validate, and commercialize technologies. It focuses on developing market-ready prototypes, forging industry co-development agreements, and securing external grants to support licensing and expansion.

Phase 4 (2028–2029): Digital Integration

PTRI Lab will incorporate AI and IoT into postharvest systems through the creation of digital dashboards, predictive models, and smart monitoring tools. These digital tools will optimize cold chain management, quality control, and traceability, supporting real-time data-driven decision-making.

Phase 5 (2029–2030): Innovation Hub Establishment

The roadmap culminates in the establishment of the Bali Postharvest Innovation Center, a regional hub for research, technology transfer, and entrepreneurship. With sustained industry partnerships, innovation services, and formalized MoUs, the Lab transitions into a long-term innovation ecosystem with regional influence.

FUNDING FRAMEWORK

PTRI Lab's long-term success and institutional resilience rely on a robust, diversified funding model. This model integrates multiple funding channels—domestic, international, industry-based, and entrepreneurial—to support various aspects of the Lab's research, innovation, and commercialization pipeline. By ensuring financial sustainability through a balanced mix of grants, partnerships, and revenue-generating activities, the Lab can maintain agility, expand its capabilities, and pursue high-impact science and development agendas.

Key Funding Sources and Strategies

Internal University & National Funding:

Includes institutional grants from UNUD such as Hibah Unggulan and support from national programs like PKKM, Kedaireka Matching Fund, and BRIN flagship schemes. These will fund baseline research, infrastructure, and student-led initiatives, forming the backbone of the Lab's early-stage growth.

National Ministries and Governmental Bodies:

Funding sources include the Ministry of Agriculture (Kementerian Pertanian), Ministry of Tourism and Creative Economy (Kemenparekraf), BPDPKS, BPDP Kakao, and Bappenas innovation funds. These are vital for scaling research into broader development programs and aligning with Indonesia's national food and innovation strategies.

International Development Agencies:

Strategic partnerships with agencies such as ACIAR, JICA, USAID, USDA, EU Horizon, Erasmus+, FAO, and UNIDO enable transnational collaboration. These partnerships support research on sustainable agriculture, digital postharvest systems, and global food safety initiatives.

Industry and CSR-Based Funding:

Includes revenue from contract research, co-development projects, licensing agreements, testing services, and equipment sponsorships. These mechanisms bridge the gap between academic discovery and market deployment, while encouraging innovation with practical relevance.

Laboratory Entrepreneurship:

PTRI Lab will generate internal revenue through training and certification services, shelf-life and microbiology testing, prototype formulation sales, and consultancy. This entrepreneurial model promotes financial independence while reinforcing the Lab's societal mission.

GOVERNANCE AND KEY PERFORMANCE INDICATORS

Effective implementation of PTRI Lab's roadmap demands a strong and agile governance structure capable of coordinating multidisciplinary teams, managing complex partnerships, and ensuring accountability to institutional and strategic objectives. The governance framework integrates operational, scientific, and commercialization functions to deliver results across the Lab's diverse programs and stakeholder ecosystems.

At the core of this structure is a dedicated management team, responsible for aligning day-to-day activities with strategic milestones. This team is supported by several operational units: a Scientific Committee to ensure research integrity and thematic coherence, and an Innovation & Commercialization Unit to oversee partnerships, patents, and market readiness.

Additional support comes from a Training & Capacity Building Team tasked with delivering professional development and curriculum enrichment, as well as a Student Research Leadership Program designed to elevate youth-led research, enhance leadership competencies, and embed students into applied innovation pathways.

These interconnected units work collaboratively to foster a dynamic research environment that values both academic excellence and societal relevance. Governance decisions will be informed by performance data, external feedback, and internal review mechanisms to ensure continuous improvement and mission alignment.

Key Performance Indicators (KPIs)

- ≥ 5 Scopus-indexed publications to reflect the Lab's commitment to international research excellence.
- ≥ 5 market-ready prototypes developed and validated for real-world deployment.
- ≥ 3 patent applications submitted to secure intellectual property and support commercialization.
- ≥ 3 formalized industry partnerships to co-develop, test, and scale postharvest innovations.
- ≥ 15 trained student researchers annually to cultivate a pipeline of skilled professionals and innovators.
- Establishment of the Bali Postharvest Innovation Hub by 2030 as a regional center for research, entrepreneurship, and collaboration.

INNOVATION PORTFOLIO

The PTRI Lab Innovation Portfolio provides a structured and forward-looking view of the Lab's scientific and technological ambitions between 2025 and 2030. Anchored in the four strategic pillars of postharvest physiology, postharvest technology, food safety and quality, and applied commercialization, the portfolio outlines a comprehensive suite of thematic projects designed to deliver both academic and market impact.

The portfolio encompasses 18 distinct research and development projects, each curated to address a key problem or opportunity within the tropical postharvest value chain. These projects span a continuum of innovation, from concept validation to prototype development and field deployment, with clear milestones defined by Technology Readiness Levels (TRLs). This systematic classification enables the Lab to track progress and ensure alignment with commercialization pathways and stakeholder needs.

Highlight innovations include the development of AI-powered shelf-life prediction systems, the deployment of IoT-enabled cold chain monitoring platforms, and the modeling of postharvest stress physiology in response to climate variability. These initiatives exemplify the Lab's ability to merge foundational science with cutting-edge technologies, translating data and experimentation into real-time, actionable insights for food systems.

Complementing these high-tech solutions are student-led entrepreneurial initiatives, which foster innovation culture, peer collaboration, and applied problem-solving among emerging researchers. Through startup incubation, certification programs, and prototype refinement, the Lab positions itself as a catalyst for youth-driven innovation.

Ultimately, the Innovation Portfolio's long-term vision is to develop a digital-twin-enabled postharvest ecosystem for Bali. This ecosystem will simulate storage, logistics, shelf-life, and quality management scenarios—enabling smarter decision-making for producers, distributors, and policymakers alike. This approach cements PTRI Lab as a regional leader in both physical and digital innovation in agri-food systems.

CONCLUSION

The PTRI Lab's 2025–2030 roadmap encapsulates a transformative vision for research, innovation, and education in the domain of tropical postharvest systems. As both a strategic blueprint and an operational framework, the roadmap emphasizes scalability, sustainability, and societal impact—qualities essential for navigating the complex challenges of agri-food transitions in the 21st century.

By aligning with Universitas Udayana's broader academic mandate and Indonesia's development priorities, the Lab positions itself at the intersection of science, industry, and community. Its integrative approach—merging postharvest biology, engineering, entrepreneurship, and digital transformation—ensures that its outputs are not only scientifically robust but also economically viable and socially inclusive.

Through the roadmap's phased implementation, the PTRI Lab aims to establish new benchmarks in research excellence, stakeholder collaboration, and innovation-driven education. It will serve as a testbed for cutting-edge technologies, a hub for regional partnerships, and a catalyst for youth empowerment through research leadership and entrepreneurship.

Ultimately, this document reaffirms the Lab's commitment to academic rigor, public service, and international collaboration. As the PTRI Lab charts its journey from a university-based research unit to a regional innovation powerhouse, it contributes not only to local agricultural resilience but also to the global discourse on food system sustainability, digital agriculture, and knowledge-driven development.

ANNEX

INNOVATION PORTFOLIO 2025–2030

Postharvest Teaching, Research and Innovation Lab
Faculty of Agricultural Technology, Universitas Udayana
Laboratory Manager:

A. Introduction

The Innovation Portfolio provides a structured overview of the technologies, research themes, and commercial innovations being developed by the Postharvest Teaching, Research and Innovation Lab (PTRI Lab) during 2025–2030.

It is organized according to the four strategic pillars of the laboratory:

1. *Postharvest Physiology,*
2. *Postharvest Technology,*
3. *Food Safety & Quality Innovation, and*
4. *Applied Innovation & Commercialization.*

Each innovation area includes thematic project titles, expected outputs, technology readiness trajectories, and potential funding pathways.

B. Innovation Portfolio Overview

The laboratory's innovation portfolio consists of 18 thematic projects grouped into four innovation pillars

1. Postharvest Physiology Innovations

Thematic Project Titles

a. "*Resilience of Tropical Fresh Produce: Modeling Physiology, Quality, and Shelf-Life Under Climate Variability."*
b. *"Biology of Freshness: Understanding Ripening, Senescence, and Quality Decay in Bali's Horticultural Systems."*
c. *"Stress Physiology for a Changing Climate: Chilling Injury, Heat Mitigation, and Quality Protection Strategies."*

Innovation Focus

- *Predictive models for ripening & quality decay*
- *Stress-resilience protocols for high-value crops*
- *Physiology-based shelf-life engineering*

Expected Outputs (2025–2030)

- 4 physiology-driven shelf-life models
- Illustrated postharvest physiology atlas
- ≥ 8 Scopus-indexed publications

Potential Funding Sources

- BRIN (Fundamental Research)
- BRIDA Provinsi Bali
- ACIAR (Tropical Horticulture Physiology)
- EU Horizon (Food Quality Modellin)

2. Postharvest Technology Innovations

Thematic Project Titles

a. *"Reimagining Postharvest Handling: Low-Energy Technologies for Smallholder and Tourism Supply Chains."*
b. *"Next-Generation Tropical Packaging: MAP, EMAP, and Bio-Based Films for Quality Retention."*
c. *"Smart Cold Chain for Bali: Temperature Integrity, Monitoring, and Postharvest Efficiency."*

Innovation Focus

- *Low-energy preservation*
- *Packaging innovation*
- *Cold chain strengthening*
- *Curing, drying & fermentation improvements*

Expected Outputs

- *3 prototypes (packaging, drying, minimal processing)*
- *Cold chain guide for Bali tourism sector*
- *National/international patent filings*

Potential Funding

- Kedaireka Matching Fund
- Kementerian Pertanian (Teknologi Pascapanen)
- JICA Grassroots Innovation
- Industry co-development

3. Food Safety & Quality Innovations

Thematic Project Titles

a. *"Food Safety for a Tourism Island: Microbial Risk Mapping and Mitigation Across Bali's Fresh Produce System."*
b. *"Natural Solutions for Safer Produce: Plant-Based Coatings and Antimicrobial Systems."*
c. *"Traceability You Can Trust: Digital Systems for Safe, Fresh, and Transparent Food Chains."*

Innovation Focus

- Microbial contamination detection
- Natural antimicrobial and sanitizing systems
- Food safety protocols for hotels and HORECA
- Digital traceability platforms

Expected Outputs

- Food safety protocol for tourism supply chains
- Risk assessment reports
- 2 commercial-ready coating/sanitizing products

Potential Funding

- BRIN
- BRIDA Provinsi Bali
- USAID – Food Safety
- USDA – Sanitary & Phytosanitary (SPS)
- Kemenparekraf – Safe Food Tourism Program
- FAO/UNIDO – Food Systems Upgrading

4. Applied Innovation & Commercialization

Thematic Project Titles

a. *"Active Protection Technologies: Slow-Release Stickers, MFC Systems, and Functional Packaging for Shelf-Life Extension."*
b. *"Biopolymers of the Future: MFC, Nanocellulose, and Nature-Based Innovations for Postharvest Applications."*
c. *"From Lab to Market: Commercializing Tropical Postharvest Innovations Through Industry Partnerships."*

Innovation Focus

- *Advanced biopolymer systems*
- *Slow-release antimicrobial/antioxidant delivery*
- *Smart packaging indicators*
- *Technology licensing & incubation*

Expected Outputs

- *3–5 commercial prototypes*
- *Innovation Hub partnerships*
- *Licensing-ready technologies*

Potential Funding

- *BRIN*
- *BRIDA Provinsi Bali*
- *Industry partners (co-development)*
- *CSR innovation funding*
- *Kedaireka Matching Fund*
- *Patent commercialization schemes*

5. Digital Postharvest & IoT Innovations

Transformasi digital dalam sistem pascapanen di Bali perlu dijalankan secara bertahap melalui **alur transisi yang terstruktur**, dimulai dari mekanisasi dasar, otomasi sederhana, hingga integrasi IoT, *data analytics*, dan teknologi kecerdasan buatan seperti *deep learning*. Pendekatan berjenjang ini disesuaikan dengan kondisi agroekosistem lokal, kapasitas petani, serta kebutuhan rantai pasok hortikultura (termasuk jeruk Kintamani, sayuran dataran tinggi, dan berbagai buah tropis) yang pada umumnya masih berada pada tingkat mekanisasi dasar dan memiliki keterbatasan infrastruktur *cold chain*, listrik stabil, dan jaringan internet. Berdasarkan kajian dan pengalaman laboratorium dalam kegiatan penelitian dan pendampingan lapangan, strategi transisi teknologi tersebut dipandang sebagai jalur paling realistis sekaligus futuristik untuk membangun ekosistem pascapanen yang adaptif terhadap tuntutan pasar.

Pendekatan bertahap ini dirancang untuk menjawab kebutuhan seluruh mata rantai dari petani, pengepul, pasar tradisional, hingga HORECA, serta mendukung sektor pariwisata Bali yang menuntut kualitas produk, keamanan pangan, dan konsistensi suplai. Melalui penguatan mekanisasi, otomasi, pemantauan berbasis IoT, dan pemodelan mutu berbasis AI, transformasi digital diharapkan mampu meningkatkan mutu produk hortikultura secara berkelanjutan, memperkuat sistem rantai dingin, dan meningkatkan daya saing komoditas lokal di pasar regional maupun industri pariwisata Bali.

5.1 Thematic Project Titles (Bali Context)

a. ***Smart Mechanization to IoT Transition***: Membangun Tahap Awal Digitalisasi Pascapanen untuk Petani Bali. **Fokus**: sensor sederhana, alat ukur kualitas manual hingga digital, monitoring suhu/kelembapan skala kebun & gudang.
b. ***AI Freshness Intelligence***: Model Prediksi Umur Simpan dan Penurunan Mutu Berbasis Data Pascapanen Jeruk, Sayuran Dataran Tinggi, dan Buah Tropis Bali. **Fokus**: data fisiologi, *visual quality*, model *machine learning & deep learning*.
c. ***Digital Twin Postharvest Bali***: Simulasi Pergerakan Produk Hortikultura dari Kintamani hingga Rantai Pasok Pariwisata. **Fokus**: simulasi *cold chain*, skenario logistik, prediksi kerusakan.

5.2 Innovation Stage

Berikut ini adalah tahapan inovasi untuk transformasi digital pascapanen di wilayah Bali, disajikan dalam tabel berikut ini.

Tahun	Tahap Transformasi	Deskripsi	Fokus Inovasi Utama
2026	**Mekanisasi Dasar**	Sebagian besar petani hortikultura Bali masih berada pada tingkat mekanisasi minimal, dengan keterbatasan cold chain, jaringan internet,	a. Alat ukur mutu portabel (suhu, kelembapan, warna) b. Sortasi & grading semi-mekanis

		dan infrastruktur pendukung lainnya. Tahap awal diarahkan pada penguatan mekanisasi dan digitalisasi dasar.	c. Pencatatan mutu berbasis aplikasi offline d. Pelatihan teknis dasar untuk petani dan pengepul
2027	**Otomasi Sederhana**	Kebutuhan konsistensi dan efisiensi meningkat, terutama untuk memenuhi standar pasar modern dan sektor HORECA. Otomasi sederhana menjadi fondasi sebelum pengembangan IoT.	a. Sistem *auto-logging* suhu & kelembapan b. Timbangan otomatis untuk sortasi c. Rancangan "*Smart Packhouse Bali*" biaya rendah d. *Dashboard* lokal untuk monitoring mutu
2028	**Integrasi IoT**	IoT mulai diintegrasikan untuk meningkatkan ketertelusuran dan pemantauan mutu secara real-time, terutama untuk komoditas yang memasok rantai pasok pariwisata.	a. Sensor IoT gudang, kendaraan, dan *cold box* b. Tracking rantai dingin rute Kintamani–Denpasar–Ubud–Nusa Dua c. Platform data berbasis *cloud* d. Penyusunan *Digital Cold Chain Toolkit for Bali*
2029	**Data Analytics & AI Dasar**	Ketersediaan data dari sensor dan pencatatan mutu memungkinkan pengembangan model prediksi yang mendukung keputusan teknis dan logistik.	a. *Machine learning* untuk prediksi umur simpan b. Analisis temperatur–kelembapan–mutu c. Deteksi cacat visual berbasis citra d. Penyusunan dataset mutu pascapanen Bali
2030	**Deep Learning & Digital Twin**	Tahap lanjutan digitalisasi pascapanen mencakup pemanfaatan deep learning dan pengembangan digital twin untuk simulasi sistem rantai pasok.	a. Model *deep learning* untuk prediksi penurunan mutu b. Visi komputer untuk deteksi kerusakan mikro c. Prototipe *Digital Twin Postharvest* Bali d. Rekomendasi kebijakan berbasis simulasi untuk penguatan *cold chain* regional

5.3 Expected Outputs

a) ***Digital Cold Chain Toolkit for Bali (Basic & Advanced Version)***
Untuk petani, pengepul, dan pemasok hotel/restoran.

b) ***AI-Based Shelf-Life Predictor***
Model prediksi umur simpan berbasis citra dan sensor.

c) ***Digital Twin Platform (Prototype)***
Simulasi rancangan rantai pasok dari kebun ke pasar/hotel.

d) ***Smart Mechanization Starter Kit***
Solusi low-cost: sensor mini, otomasi sederhana, dashboard offline.

e) ***Database Mutu Pascapanen Bali***
Dataset standar untuk riset lanjutan AI/IoT.

5.4 Potential Funding

- BRIN
- BRIDA Provinsi Bali
- EU Horizon – Digital Food Systems
- JICA – Smart Agriculture
- FAO Digital Innovation Fund

6. Ecosystem, Capacity Building, and Human Capital

Thematic Project Titles

a. *"Building the Bali Postharvest Innovation Ecosystem: Training, Partnerships, and Capacity Strengthening."*
b. *"Future Food Innovators: Student-Led Research, Startup Incubation, and Innovation Acceleration Programs."*
c. *"Postharvest for Sustainable Tourism: A Model for Safe, High-Quality, and Traceable Food Systems in Bali."*

Innovation Focus

- *Capacity building*
- *Incubation & entrepreneurship*
- *Partnerships for sustainable tourism*
- *Regional innovation ecosystems*

Expected Outputs

- *Annual certification programs*
- *Industry-research training modules*
- *Innovation Hub established (2030)*

Potential Funding

- BRIDA Provinsi Bali
- PKKM
- Bappenas Regional Innovation Funding
- Kemenparekraf (Food Safety & Sustainable Tourism)
- Private sector sponsorships

C. Technology Readiness & Development Timeline (Summary)

Innovation Cluster	2025	2026	2027	2028	2029–2030	TRL Target
Edible Coatings	✓ Concept	✓ Lab trials	✓ Field trials	–	–	TRL 7
Minimal Processing	✓ Concept	✓ Validation	✓ SOP	✓ Industry adoption	–	TRL 8
Slow-Release Stickers	–	✓ Concept	✓ Lab trials	✓ Field validation	✓ Commercialization	TRL 9
Smart Packaging	–	✓ Concept	✓ Prototype	✓ Trials	✓ Scale-up	TRL 8–9

IoT Monitoring	–	–	✓ Concept	✓ Prototype	✓ Deployment	TRL 9
Digital Twin	–	–	✓ Modelling	✓ Beta platform	✓ Full deployment	TRL 9

D. Expected Innovation Outputs (2025–2030)

- 10–12 commercially relevant prototypes
- 5–7 patent filings
- 1 AI-based shelf-life prediction platform
- 1 digital cold-chain decision-support system
- At least 3 licensing or co-branding agreements
- Establishment of the Bali Postharvest Innovation Center

E. Conclusion

The Innovation Portfolio 2025–2030 provides a structured framework for advancing the PTRI Lab's scientific excellence, applied innovation, commercialization potential, and strategic partnerships.

It shows that the Lab is not only a research facility but a regional hub for future-ready food systems, advanced postharvest technologies, and industry-oriented innovation.

ROAD MAP PENELITIAN
KELOMPOK BIDANG KEAHLIAN (KBK)
REKAYASA PANGAN
PERIODE 2026-2030

CABANG ILMU TEKNIK PERTANIAN DAN BIOSISTEM
POHON ILMU TEKNIK ATAU REKAYASA-REKAYASA
UNIVERSITAS UDAYANA

TIM PENELITI

KELOMPOK BIDANG KEAHLIAN (KBK)

REKAYASA PANGAN

FAKULTAS TEKNOLOGI PERTANIAN

UNIVERSITAS UDAYANA

(SK Rektor Universitas Udayana Nomor : 4506/UN14/HK.KP/2025, 20 Oktober 2025)

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PENDAHULUAN

Roadmap penelitian merupakan dokumen strategis yang memetakan arah, tahapan, dan target penelitian secara sistematis dalam kurun waktu tertentu. (misalnya 5–10 tahun). Dalam konteks rekayasa pangan, roadmap ini disusun berupa peta jalan pengembangan teknologi pangan dari level dasar hingga aplikasi industri dan komersialisasi. Di dalamnya memuat tema utama dan subtema penelitian, urutan dan keterkaitan antar riset, target luaran setiap tahap serta kontribusi riset terhadap ilmu pengetahuan, industri, dan masyarakat.

Roadmap penelitian kelompok bidang keahlian rekayasa pangan di Pertanian Universitas Udayana ini disusun mempertimbangan dari sisi internal maupun eksternal universitas. Dari sisi internal Universitas Udayana dimaksudkan untuk menjamin keselarasan antara pelaksanaan tridharma, pengembangan program studi, dan arah kebijakan universitas. Sedangkan dari sisi eksternal dimaksudkan agar penelitian-penelitain yang dilaksanakan oleh civitas academika Universitas Udayana dapat memberikan solusi nyata pemecahan masalah yang dihadapi dunia usaha dan duni industri (DUDI) pangan baik pada level lokal, nasional maupun global sekaligus menjaga keterhubungan dengan salah satu pencapaian SDG's (SDG 9 *Industry, Innovation and Infrastructure*).

Dari sudut pandang kelompok tim peneliti, roadmap penelitian ini dimaksudkan untuk menjamin arah dan konsistensi penelitian, memastikan bahwa setiap penelitian bersifat saling melengkapi, berbasis pada hasil riset sebelumnya dan bergerak menuju tujuan besar yang sama. Dengan adanya dokumen ini juga diharapkan dapat mendukung akuntabilitas dan penilaian kinerja, penting untuk memperkuat daya saing dalam pendanaan nasional/internasional, akreditasi program studi dan penilaian jabatan fungsional dosen. Roadmap ini akan menuntun tim peneliti bekerja secara terencana dan berkelanjutan dan memiliki visi menuju hilirisasi dan komersialisasi.

Tujuan penyusunan roadmap penelitian KBK Rekayasa Pangan di Fakultas Teknologi Pertanian Universitas Udayana ini terdiri dari (a) tujuan akademik dan keilmuan, yaitu mengembangkan ilmu rekayasa pangan yang khas dan unggul, mendorong publikasi bereputasi dan sitasi tinggi dan menjadi rujukan ilmiah di bidang teknologi dan model

bisnis pangan, (b) tujuan teknologi dan inovasi, yaitu menghasilkan proses pengolahan pangan inovatif, teknologi peningkatan mutu dan keamanan pangan, mendukung pengembangan paten, prototipe, dan produk siap industri, serta pengembangan model bisnis pangan yang efisien dan berkelanjutan, dan (c) tujuan industri dan hilirisasi yautu menjawab kebutuhan nyata industri pangan dan mendorong kerja sama riset–industri.

Secara umum roadmap untuk bidang keahlian rekayasa pangan dapat dirinci menjadi tiga jalur prioritas penelitian yang saling terkait, yaitu prioritas (1) Produksi & Keberlanjutan Agro-pangan, (2) Hilirisasi & Nilai Tambah Industri, dan (3) prioritas penelitian Sistem Cerdas & Digitalisasi. Roadmap penelitian KBK Rekayasa Pangan-FTP-UNUD memilih perioritas Hilirisasi & Nilai Tambah Industri. Arah strategis yang ingin dicapai yaitu menghasilkan teknologi pengolahan dan produk inovatif yang menguatkan industri pangan nasional, mengurangi kehilangan hasil panen, dan menjawab tuntutan konsumen modern (kesehatan, nutrisional, keberlanjutan).

Roadmap penelitian KBK Rekayasa Pangan 2026–2030 diarahkan pada prioritas hilirisasi dan nilai tambah dalam bidang Rekayasa Pangan dengan satu target SDG yang dipilih yaitu SDG 9 — *Industry, Innovation and Infrastructure* (Industri, Inovasi, dan Infrastruktur). Fokus subjek penelitian yaitu mensinergikan peran nanoteknologi untuk memperkuat manajemen rantai pasok (*supply chain management*). Fokus Objek penelitian yaitu produk/proses pangan berbasis perikanan dan hortikultura. Topik-topik penelitian yang akan dikerjakan selama lima tahun kedepan merujuk pada Tema (Payung) penelitian, yaitu “Hilirisasi Teknologi Rekayasa Pangan Berbasis Nanoteknologi untuk Peningkatan Nilai Tambah Produk, Efisiensi Proses, dan Ketahanan Rantai Pasok Industri Pangan.

VISI KBK REKAYASA PANGAN (2026–2030)

Menjadi pusat riset rekayasa pangan yang menghasilkan teknologi, inovasi, dan solusi terapan untuk memperkuat daya saing industri pangan lokal, ketahanan pangan nasional, dan mendukung pencapaian SDGs-9 (*Industry, Innovation and Infrastructure*).

STRUKTUR TAHAP-TAHAPAN PENELITIAN (5 TAHUN)

Tema Payung Penelitian "Hilirisasi Teknologi Rekayasa Pangan Berbasis Nanoteknologi untuk Peningkatan Nilai Tambah Produk, Efisiensi Proses, dan Ketahanan Rantai Pasok Industri Pangan"

TAHUN 1: 2026

Tahap Hulu Terapan – Fondasi Hilirisasi

Fokus: kesiapan teknologi & relevansi industri

Topik Prioritas

- Sintesis dan karakterisasi nanomaterial food-grade (nanoemulsi, nanopartikel biopolimer, nanokapsul senyawa bioaktif)
- Nanoteknologi untuk perlindungan nutrien & bioaktif dan stabilitas produk selama distribusi
- Pemetaan kebutuhan industri & rantai pasok pangan dan analisis bottleneck mutu & losses di rantai pasok

Target Luaran

- Publikasi internasional
- Database nanomaterial pangan
- Peta kebutuhan industri & SCM
- Tingkat Kesiapan Teknologi (TKT) 2–3

TAHUN 2 : 2027

Tahap Rekayasa Proses & Sistem

Fokus: integrasi nanoteknologi ke proses industri

Topik Prioritas

- Rekayasa proses produksi pangan berbasis nano-delivery system
- Integrasi nanoteknologi pada pengolahan dan pengemasan aktif & cerdas
- Pemodelan sistem dinamik rantai pasok berbasis mutu dan optimasi proses untuk efisiensi energi & biaya

Target Luaran

- Prototipe proses skala laboratorium
- Model sistem rantai pasok berbasis mutu
- HKI/paten sederhana
- Tingkat Kesiapan Teknologi 4–5

TAHUN 3 : 2028

Tahap Aplikasi Industri Awal

Fokus: validasi teknologi & nilai tambah

Topik Prioritas

- Uji kinerja nanoteknologi pada produk nyata industri
- Smart packaging nano-sensor untuk monitoring mutu
- Evaluasi dampak teknologi pada umur simpan, losses logistic dan efisiensi distribusi
- Analisis kelayakan teknis & ekonomi

Target Luaran

- Prototipe produk pangan bernilai tambah
- Publikasi terapan
- Paten
- Model bisnis awal
- Tingkat Kesiapan Teknologi (TKT) 6

TAHUN 4: 2029

Tahap Hilirisasi Lanjut – Pilot & SCM

Fokus: integrasi ke rantai pasok industri

Topik Prioritas

- Uji coba skala pilot industri

- Integrasi smart nano-packaging dengan sistem logistik
- Digitalisasi monitoring mutu rantai pasok dan analisis keberlanjutan & jejak karbon

Target Luaran

- Prototipe skala pilot
- Kerja sama industri
- Standar operasional teknologi
- Tingkat Kesiapan Teknologi (TKT) 7–8

TAHUN 5 : 2030

Tahap Komersialisasi & Dampak Industri

Fokus: adopsi industri & kebijakan

Topik Prioritas

- Scale-up dan adopsi industri
- Standardisasi & regulasi nanoteknologi pangan
- Pengembangan model SCM berbasis kualitas real-time
- Penyusunan policy brief & roadmap industri

Target Luaran

- Produk siap komersialisasi
- Lisensi teknologi
- Policy brief
- Center of Excellence Nanoteknologi Pangan
- Tingkat Kesiapan Teknologi (TKT) 9

KPI & MILESTONES OPERASIONAL ROADMAP BK REKAYASA PANGAN

Tahun	Fokus Utama	KPI Penelitian yang Relevan
2026	Pemetaan Teknologi Nano & Proof-of-Concept	- 1 review sistematis publikasi nanoteknologi pangan industri (Scopus/WoS) - 2 whitepaper tema nano untuk produk perikanan/hortikultura - 1 proposal joint industry partnership
2027	Pengembangan Nanoformulasi Produk	- 3 formulasi nano yang diuji stabilitas dan bioavailabilitas - 2 publikasi jurnal Q2/Q1 - 1 paten aplikasi nano-delivery
2028	Nanokomposit Kemasan Cerdas	- 4 material kemasan nano diuji barrier & mikroba - 2 kolaborasi industri paket kemasan - 1 prototipe kemasan siap evaluasi industri
2029	Nanosensor untuk Quality & Safety	- 3 prototipe nanosensor diuji di cold chain - 2 publikasi konference/ech - 1 roadmap integrasi sensor dengan database produksi
2030	Pilot Skala Industri & Commercial Readiness	- 2 pilot produksi industrial produk nano-enhanced - 3 standard operating procedure (SOP) evaluasi safety - 1 roadmap policy/regulatory alignment

ROADMAP PENELITIAN
KELOMPOK BIDANG KEAHLIAN (KBK)
ENERGI DAN REKAYASA ALAT

PERIODE 2026-2030

CABANG ILMU TEKNIK PERTANIAN DAN BIOSISTEM
POHON ILMU TEKNIK ATAU REKAYASA-REKAYASA
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ENERGI DAN REKAYASA ALAT

FAKULTAS TEKNOLOGI PERTANIAN

UNIVERSITAS UDAYANA

(SK Rektor Universitas Udayana Nomor : 4506/UN14/HK.KP/2025, 20 Oktober 2025)

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ROADMAP PENELITIAN KBK
ENERGI DAN REKAYASA ALAT
Periode 2026-2030

Fokus Utama: Digitalisasi Mekanisasi, Dekarbonisasi Pertanian, dan Kemandirian Pangan.

1. Riset Unggulan (Research Timeline)

Tahun	Fokus Riset (Tema Besar)	Target Luaran (Output)
2026	Optimasi Alsinpas & Energi Terbarukan	Prototipe alat pengolah limbah menjadi bioenergi (biogas/pelet) dan pupuk granul komersial.
2027	Smart Farming & IoT Integration	Alat Sensor tanah/tanaman yang terintegrasi dengan alat irigasi otomatis.
2028	Autonomous Machinery & Robotika	Drone untuk pemupukan presisi dan robot pemanen modular.
2029	Sistem Energi Hybrid & Efisiensi Tinggi	Implementasi panel surya pada traktor listrik dan pompa air tenaga angin/surya.
2030	Green Technology & Carbon Sequestration	Alat mekanisasi yang rendah emisi (Zero Carbon Agriculture).

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2. Pengabdian Kepada Masyarakat (Community Engagement)

Pilar pengabdian harus menjadi jembatan agar teknologi dari KBK tidak berhenti di rak laboratorium.

- **Tahun 1-2: Edukasi & Adaptasi**
  - Pelatihan pemeliharaan alat mesin pertanian (alsintan) bagi kelompok tani.
  - Workshop pemanfaatan limbah pertanian menjadi sumber energi rumah tangga dan pupuk granul komersial.
- **Tahun 3-4: Implementasi Teknologi Tepat Guna (TTG)**
  - Hibah alat pengering (dryer) berbasis biomassa untuk pasca-panen.
  - Instalasi sistem irigasi cerdas berbasis panel surya di lahan kering.

- **Tahun 5: Desa Mandiri Energi & Teknologi**
    - Pembentukan "Desa Digital Pertanian" sebagai percontohan integrasi alsinpas modern dan energi hijau.

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3. Strategi Pencapaian (Action Plan)

Untuk memastikan roadmap ini berjalan, ada tiga pilar yang harus diperkuat:

1. **Laboratorium & Fasilitas:** Modernisasi alat uji performa mesin dan laboratorium konversi energi.
2. **Kemitraan:** Kolaborasi dengan industri alat berat pertanian dan Kementerian Pertanian untuk uji coba lapangan dan BRIN.

Publikasi & Paten: Target minimal 2 paten sederhana dan 3 publikasi jurnal internasional bereputasi (Scopus/Sinta) setiap tahunnya.

ROAD MAP PENELITIAN
KELOMPOK BIDANG KEAHLIAN (KBK)
PERTANIAN CERDAS DAN TEKNOLOGI DIGITAL
PERIODE 2026-2030

CABANG ILMU TEKNIK PERTANIAN DAN BIOSISTEM
POHON ILMU TEKNIK ATAU REKAYASA-REKAYASA
UNIVERSITAS UDAYANA

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KELOMPOK BIDANG KEAHLIAN (KBK)

PERTANIAN CERDAS DAN TEKNOLOGI DIGITAL

FAKULTAS TEKNOLOGI PERTANIAN

UNIVERSITAS UDAYANA

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PENDAHULUAN

Sektor pertanian merupakan salah satu pilar penting dalam pembangunan ekonomi, ketahanan pangan, dan kesejahteraan masyarakat. Dengan meningkatnya populasi dunia dan tantangan yang dihadapi, seperti perubahan iklim, keterbatasan sumber daya, dan kebutuhan akan produksi pangan yang lebih efisien, muncul kebutuhan mendesak untuk mengadopsi teknologi modern dalam praktik pertanian. Dalam konteks inilah, bidang keilmuan Sistem Pertanian Cerdas dan Teknologi Digital menjadi sangat relevan dan krusial.

Visi dari kelompok ini adalah untuk menciptakan inovasi dan teknologi digital yang mendukung sistem pertanian cerdas yang berkelanjutan. Kami bercita-cita menjadi pusat pengembangan teknologi yang meningkatkan efisiensi dan produktivitas sektor pertanian, membantu petani menghadapi tantangan yang ada, serta mendorong pertumbuhan ekonomi lokal dan global.

Misi kami meliputi pengembangan teknologi inovatif yang dapat memodernisasi praktik pertanian, memberikan pendidikan dan pelatihan yang komprehensif kepada petani, serta melakukan riset terapan untuk mendapatkan solusi yang responsif terhadap masalah pertanian saat ini. Kami juga berkomitmen untuk menjalin kemitraan dengan berbagai pemangku kepentingan, termasuk lembaga penelitian, universitas, pemerintah, dan sektor industri, guna mendukung kolaborasi yang menghasilkan hasil yang lebih baik.

Dengan tujuan meningkatkan adopsi teknologi dalam pertanian dan menemukan solusi inovatif untuk berbagai tantangan yang dihadapi, kelompok ini berfokus untuk tidak hanya meningkatkan kapasitas petani dalam menggunakan teknologi cerdas, tetapi juga mengimplementasikan praktik pertanian yang berkelanjutan. Pertanian berkelanjutan tidak hanya penting untuk menjaga ekosistem tetapi juga untuk menjamin keberlangsungan produksi pangan bagi generasi mendatang.

Sasaran yang ditetapkan, termasuk melaksanakan proyek riset yang menghasilkan publikasi ilmiah, menyelenggarakan pelatihan untuk petani, mengimplementasikan teknologi baru, dan membangun kemitraan strategis, menjadi langkah-langkah konkret untuk mewujudkan visi dan misi kelompok ini. Melalui sistem monitoring dan evaluasi

yang ketat, dampak dari setiap program yang dilaksanakan akan terus dievaluasi dan disempurnakan demi mencapai efektivitas maksimal.

Dengan roadmap penelitian yang terstruktur ini, diharapkan kolaborasi antara ilmuwan, petani, dan pemangku kebijakan dapat terjalin dengan baik. Kami percaya bahwa melalui inovasi dan penerapan teknologi digital, sektor pertanian dapat menjadi lebih efisien, produktif, dan berkelanjutan, mendukung pencapaian ketahanan pangan dan kesejahteraan masyarakat.

VISI, MISI, TUJUAN, DAN SASARAN

Visi

Menjadi pusat pengembangan inovasi dan teknologi digital dalam sistem pertanian cerdas yang berkelanjutan untuk meningkatkan efisiensi, produktivitas, dan keberlanjutan sektor pertanian di tingkat lokal, nasional, dan global.

Misi

1. **Inovasi Teknologi**: Mengembangkan dan menerapkan teknologi cerdas yang dapat memodernisasi praktik pertanian dan meningkatkan kinerja sektor pertanian.
2. **Pendidikan dan Pelatihan**: Memberikan pendidikan yang komprehensif dan pelatihan kepada petani dan pemangku kepentingan tentang penggunaan teknologi digital dalam pertanian.
3. **Riset dan Pengembangan**: Melakukan penelitian terapan untuk menciptakan solusi berbasis data yang menyelesaikan tantangan dalam sektor pertanian, termasuk ketahanan pangan dan perubahan iklim.
4. **Kolaborasi dan Kemitraan**: Membangun kemitraan strategis dengan lembaga penelitian, universitas, pemerintah, dan sektor industri untuk mendorong kolaborasi dan inovasi.
5. **Sustainable Development**: Mendukung praktik pertanian yang berkelanjutan dengan mempromosikan penggunaan sumber daya yang efisien dan ramah lingkungan.

Tujuan

1. **Meningkatkan Adopsi Teknologi**: Mendorong petani untuk mengadopsi teknologi cerdas dan digital melalui pendidikan dan penyuluhan yang efektif.
2. **Menemukan Solusi Inovatif:** Menghasilkan solusi inovatif untuk masalah yang dihadapi oleh sektor pertanian, termasuk pengelolaan air, perubahan iklim, dan keberlanjutan.
3. **Pengembangan Kapasitas**: Meningkatkan kapasitas dan pengetahuan pemangku kepentingan dalam menerapkan teknologi pertanian modern.

4. **Audit dan Evaluasi Praktik Pertanian**: Melakukan audit performance untuk menilai dampak penerapan teknologi terhadap produktivitas dan keberlanjutan.

Sasaran

1. **Riset dan Publikasi**: Melaksanakan sejumlah proyek riset yang diharapkan menghasilkan publikasi di jurnal akademik internasional terkait teknologi pertanian cerdas.
2. **Pelatihan dan Workshop**: Menyelenggarakan pelatihan dan workshop untuk petani dan penyuluh mengenai penggunaan teknologi digital dalam pertanian.
3. **Implementasi Teknologi**: Mengimplementasikan teknologi baru dalam praktik pertanian di komunitas lokal.
4. **Kolaborasi**: Membangun kemitraan strategis dengan institusi lokal dan internasional dalam bidang teknologi pertanian.
5. **Monitoring dan Evaluasi**: Mengembangkan dan menerapkan sistem monitoring dan evaluasi untuk mengukur keberhasilan program yang dilaksanakan setiap semester.

ROADMAP PENELITIAN:
SISTEM PERTANIAN CERDAS DAN TEKNOLOGI DIGITAL
Periode 2026-2030

Tahun	Fokus Penelitian	Sub-Topik	Deskripsi	Target / Hasil
2026-2027	Pertanian Presisi dan IoT	1. Implementasi Pertanian Presisi	Menerapkan teknologi pertanian presisi di lahan percobaan dengan penggunaan drone dan sensor.	Sistem monitoring yang dapat memberikan data akurat untuk pengambilan keputusan.
		2. Sensor Tanah, Air irigasi, dan Tanaman	Pengembangan sensor untuk memantau kondisi tanah, air irigasi dan tanaman secara real-time.	
		3. Survey tingkat adopsi teknologi pertanian presisi	Mendapatkan data kebutuhan petani, tingkat penerapan teknologi pertanian presisi dan kendala yang dihadapi.	
		4. Pelatihan Teknologi	Memberikan pelatihan kepada petani mengenai teknologi pertanian presisi dan cara penggunaan sensor.	Peningkatan keterampilan dan pemahaman petani tentang teknologi baru.
2027-2028	Data dan Analisis	1. Pengumpulan Data untuk Pertanian Presisi	Pengembangan metode untuk mengumpulkan data dari berbagai sensor dan drone.	Model analisis yang memberikan wawasan untuk pengelolaan yang lebih baik.
		2. Analisis Data Sensor	Analisis data yang diperoleh untuk mengidentifikasi pola pertumbuhan tanaman dan kebutuhan nutrisi.	
		3. Sistem Umum untuk Data Monitoring	Membangun platform terpadu untuk pengumpulan dan visualisasi data.	Sistem yang memungkinkan petani untuk mendapatkan laporan yang mudah dipahami dan analisis data.

2028-2029	Integrasi AI	1. Prediksi Hasil Panen Menggunakan AI	Mengembangkan model AI untuk memprediksi hasil panen berdasarkan data historis dan saat ini.	Algoritma yang membantu petani dengan prediksi hasil dan risiko potensial.
		2. Model Risiko Penyakit	Pembentukan model untuk mendeteksi kemungkinan serangan hama dan penyakit.	
		3. Aplikasi Mobile untuk Keputusan Pertanian	Mengembangkan aplikasi yang menggunakan data dari AI untuk memberikan rekomendasi kepada petani.	Aplikasi pengguna yang memberikan saran spesifik untuk tindakan yang diperlukan.
2029-2030	Pertanian Berkelanjutan	1. Praktik Pertanian Ramah Lingkungan	Studi tentang praktik pertanian berkelanjutan yang mengurangi dampak lingkungan.	Prototipe metodologi baru yang mempromosikan keberlanjutan dalam pertanian.
		2. Penggunaan Sensor Lingkungan	Pengembangan sensor untuk memantau dampak lingkungan dari praktik pertanian.	
		3. Edukasi untuk Petani	Program penyuluhan untuk meningkatkan kesadaran tentang pertanian berkelanjutan.	Petani lebih siap untuk menerapkan praktik berkelanjutan dan lebih sadar akan dampak lingkungan.
		4. Integrasi dengan Sistem Sosial Ekonomi	Memastikan bahwa teknologi yang diterapkan dapat diakses oleh petani dari berbagai latar belakang sosial ekonomi.	Rencana masa depan yang inklusif tentang penggunaan teknologi di kalangan petani.
2030-2031	Robotika dan Otomatisasi	1. Pengembangan Robot untuk Pertanian	Penelitian design robot yang mampu melakukan tugas seperti penyiraman dan penanaman.	Robot dan sistem otomatis yang berfungsi dalam meningkatkan efisiensi dan produktivitas pertanian.
		2. Automatisasi dalam Proses Pertanian	Membangun sistem otomatis untuk irigasi yang terintegrasi dengan sensor pemantauan.	
		3. Uji Coba Robot di Lapangan	Melakukan pengujian sistem robotika di lahan	Penilaian efektivitas robot dan sistem

			real-world untuk validasi.	otomatis dalam meningkatkan hasil dan efisiensi.
		4. Penelitian Keberlanjutan Robotika	Mengevaluasi dampak lingkungan dari penggunaan robot dalam pertanian dan bagaimana dapat dioptimalkan.	Rekomendasi untuk praktik penggunaan robot yang ramah lingkungan dan berkelanjutan.
		5. Kolaborasi dengan Universitas dan Peneliti	Membangun kemitraan dengan lembaga akademis dan peneliti untuk inovasi lanjutan dalam teknologi pertanian.	Proyek kolaboratif yang menghasilkan solusi berbasis riset yang inovatif untuk pertanian.

ROADMAP PENELITIAN
KELOMPOK BIDANG KEAHLIAN (KBK)
REKAYASA SUMBER DAYA ALAM DAN LINGKUNGAN

PERIODE 2026-2030

CABANG ILMU TEKNIK PERTANIAN DAN BIOSISTEM
POHON ILMU TEKNIK ATAU REKAYASA-REKAYASA
UNIVERSITAS UDAYANA

TIM PENELITI

KELOMPOK BIDANG KEAHLIAN (KBK)

REKAYASA SUMBER DAYA ALAM DAN LINGKUNGAN

FAKULTAS TEKNOLOGI PERTANIAN

UNIVERSITAS UDAYANA

(SK Rektor Universitas Udayana Nomor : 4506/UN14/HK.KP/2025, 20 Oktober 2025)

Ketua :

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Ida Ayu Gede Bintang Madrini, S.TP., M.Agr., Ph.D.

Mentari Kinasih, S.TP., M.T.

Hertiyana Nur Annisa, S.T.P., M.Sc.

ROADMAP PENELITIAN KBK
REKAYASA SUMBERDAYA ALAM DAN LINGKUNGAN
Periode: 2026–2030

1. Topik Utama Penelitian :

- **Topik A:** Manajemen Sumberdaya Air & Infrastruktur Hijau.
- **Topik B:** Pengolahan Limbah dan Ekonomi Sirkular.
- **Topik C:** Konservasi dan Rehabilitasi Lingkungan.

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2. Tahapan Strategis (Timeline)

Fase	Fokus Utama	Target Capaian
Fase I: 2026-2027 (Inventarisasi & Digitalisasi)	Inventarisasi potensi lokal, pemetaan kualitas lingkungan, audit SDA, dan identifikasi kerentanan wilayah.	Publikasi Jurnal Terakreditasi (Sinta), Database potensi dan kualitas lingkungan,
Fase II: 2028-2029 (Inovasi & Optimasi)	Pengembangan teknologi tepat guna, pengembangan sistem monitoring sensor (IoT) untuk optimasi sumberdaya alam dan pengelolaan limbah, dan konservasi tanah presisi.	Prototipe alat/metode, Kerjasama ndustri/Pemerintah Daerah, Publikasi jurnal internasional bereputasi.
Fase III: 2030 (Implementasi & Komersialisasi)	Analisis ekonomi sirkular, dan sistem kota/desa mandiri sumberdaya (Smart Eco-Village).	Naskah Akademik Kebijakan, Pengabdian Masyarakat berskala nasional.

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3. Detail Program Riset Unggulan

A. Konservasi Sumberdaya Air Terpadu

Fokus pada ketersediaan air di tengah ketidakpastian iklim.

- Evaluasi Teknik Terasering dan *Vegetative Strip* dalam Menekan Laju Erosi di Perkebunan Hortikultura

- Model *Incentive & Disincentive* untuk Petani dalam Mempertahankan Lahan Sawah Abadi di Bali: Menghitung nilai ekonomi jasa lingkungan (*payment for ecosystem services*)
- Pemanenan air hujan (*Rainwater Harvesting*) perkotaan, pemodelan hidrologi DAS kritis, dan teknologi desalinasi energi rendah.
- Penggunaan sensor IoT untuk monitoring kualitas air dan udara secara real-time

B. Ekonomi Sirkular & Pengolahan Limbah

Mengubah paradigma limbah menjadi bahan baku bernilai.

- Pemanfaatan limbah untuk meningkatkan kesehatan tanah dan produktivitas.
- Pemanfaatan limbah pertanian menjadi biochar, pengolahan limbah B3 secara biologis (bioremediasi), dan ekstraksi energi dari air limbah domestik.
- Fortifikasi Kompos Limbah Pertanian dengan Mikroba Lokal (EM-Bali) untuk Mempercepat Dekomposisi
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C. Teknologi Lingkungan Cerdas (Smart Environmental Tech)

Menggunakan AI dan IoT untuk efisiensi sumberdaya.

- *Precision Agriculture* untuk efisiensi pupuk dan air,
- Deteksi dini pencemaran sungai berbasis AI,
- Pemetaan stok karbon menggunakan drone/satelit.