Manila, 15 July 2025

Mitigating through Collaborating for Climate-Resilient Smart Agriculture Technologies:

Case Studies in Indonesia

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Universitas Gadjah Mada – Indonesia

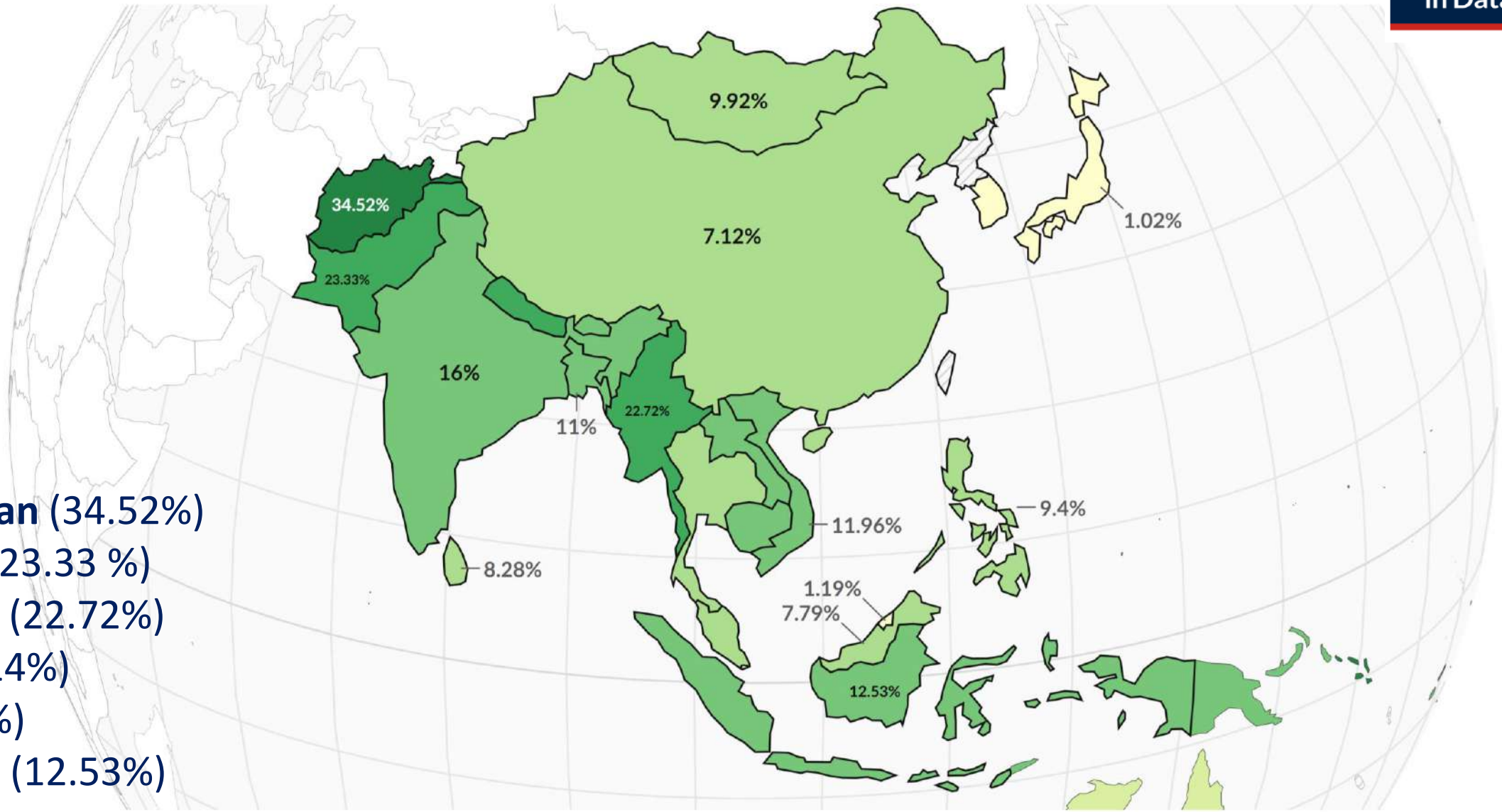
OUTLINE

- *Introduction*
- *Agriculture and the Challenges in Sustainable Development*
- *Climate-Smart Agriculture (CSA), Practices and Key Challenges*
- ***Climate-Smart Technologies and Innovations (Smart Agri Research Center – UGM Indonesia)***
- ***Case Studies in Indonesia, Collaborated Partners, and Potential IP Assets***
- ***Lessons Learned from Comparative Studies in Thailand and China***
- ***Key Strategies and Follow–Up Actions***

Share of Asian GDP from Agriculture, Forestry, Fishery**, 2023**

by percentage

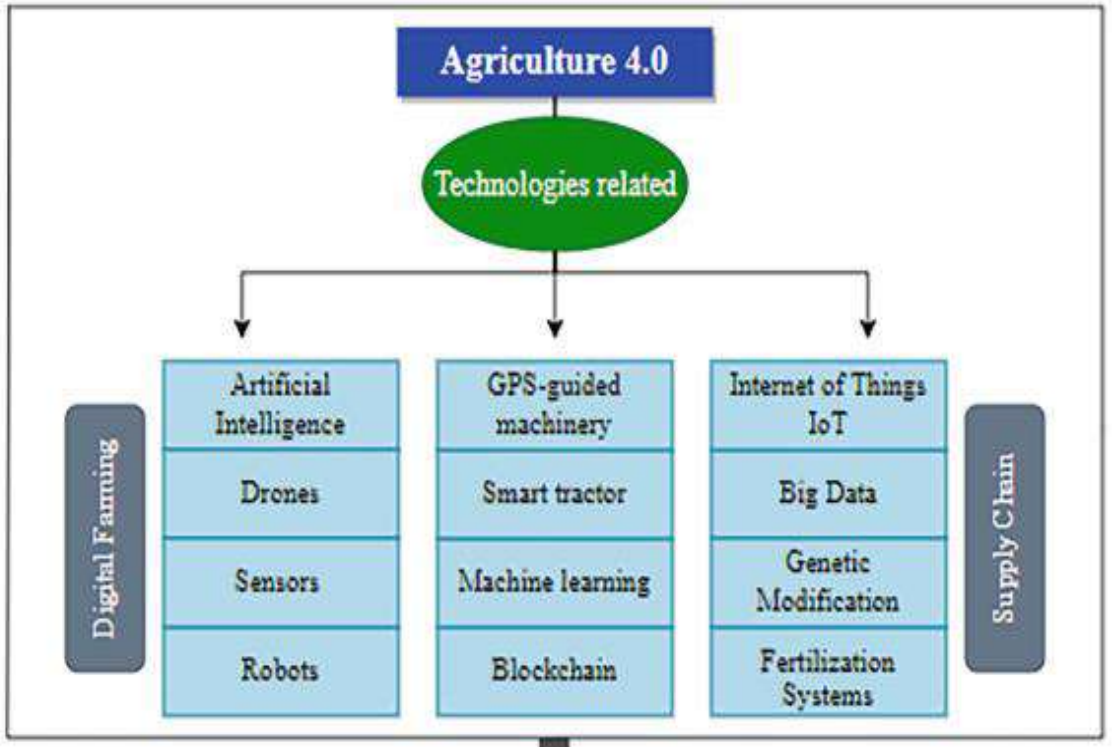
Our World in Data



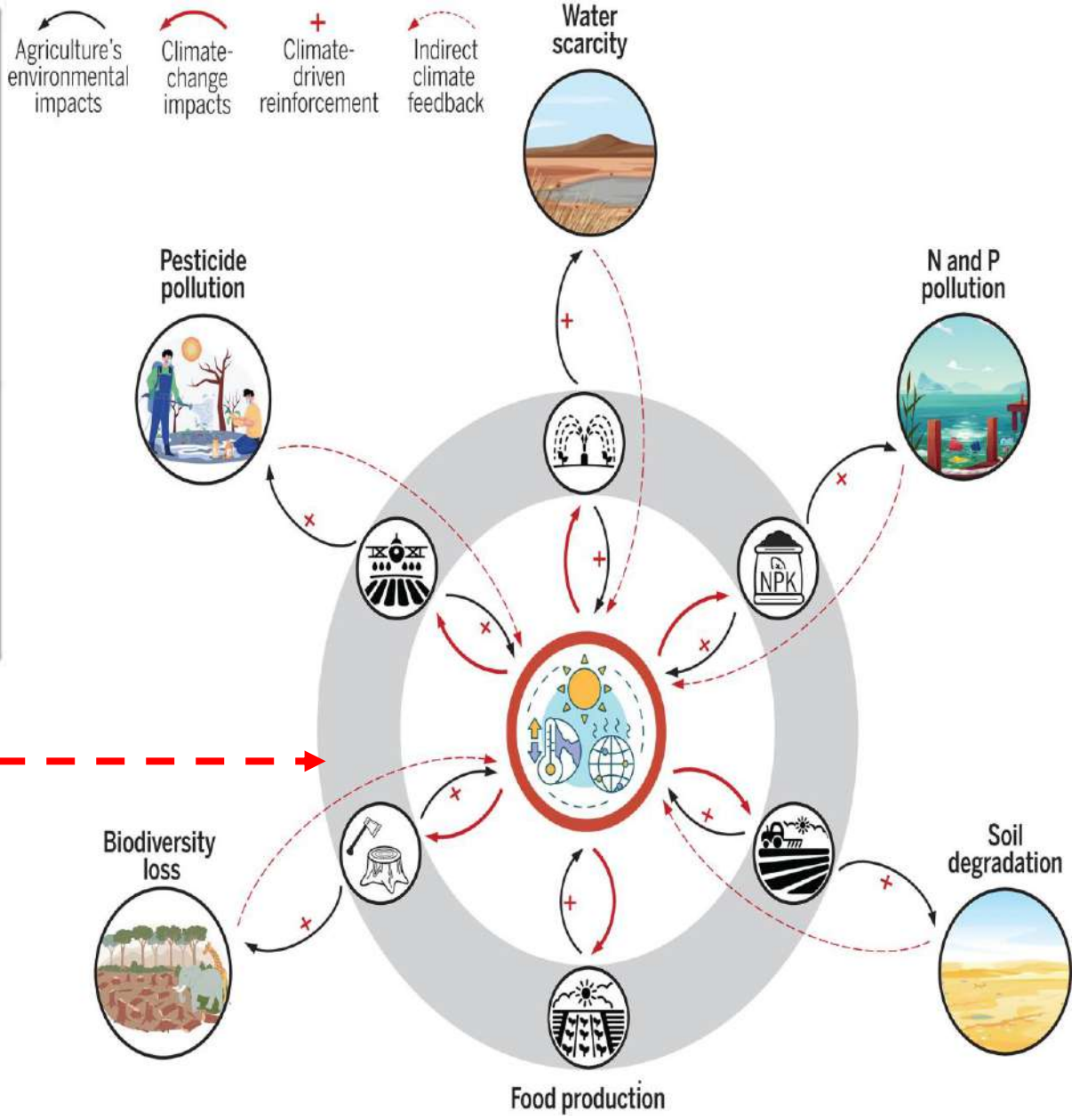
1. **Afghanistan** (34.52%)
2. **Pakistan** (23.33 %)
3. **Myanmar** (22.72%)
4. **Laos** (16.14%)
5. **India** (16%)
6. **Indonesia** (12.53%)

Data source: World Bank and OECD national accounts (2025)

Agriculture 4.0 and The Challenges in Sustainable Development



(Renzcherchen et al., 2024)

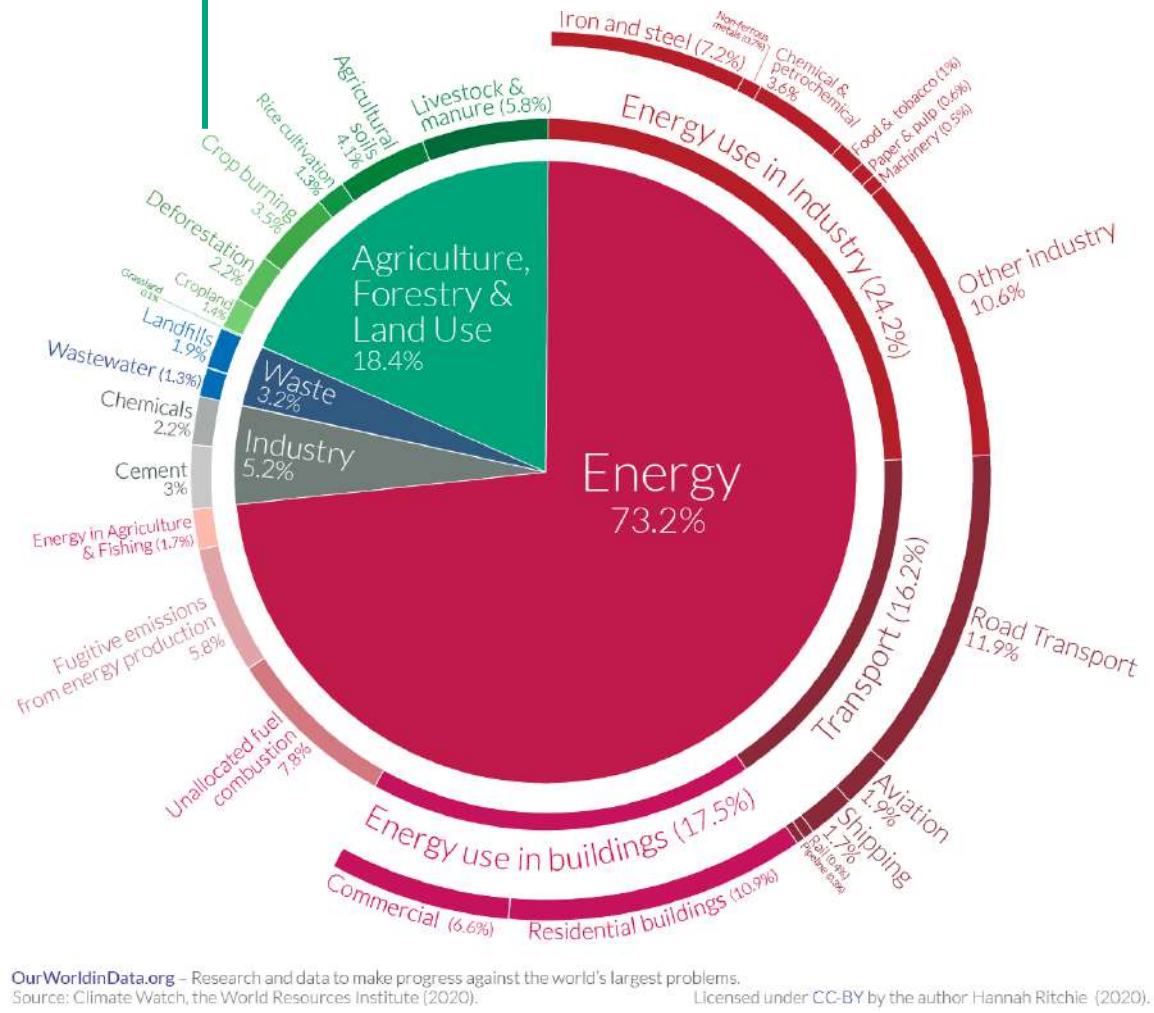


(Yang et al., 2024)

Our World in Data

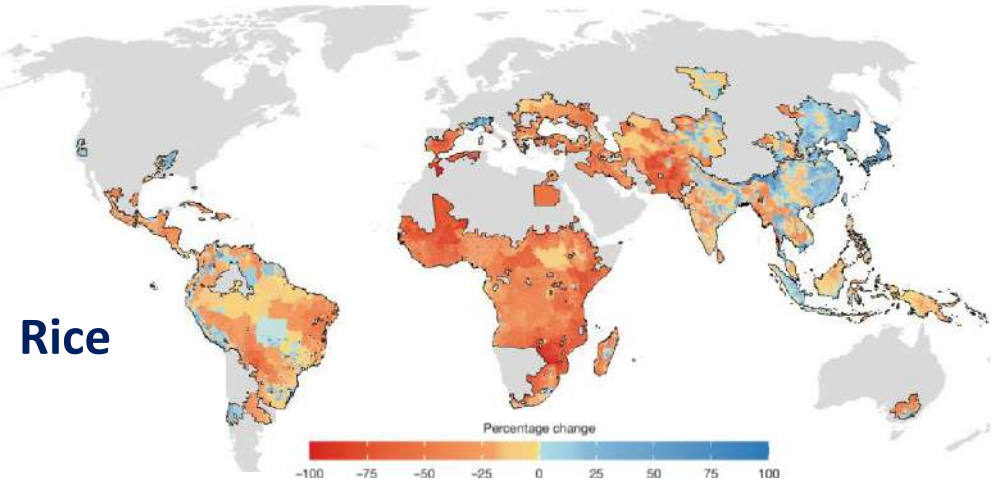
Agriculture, Forestry, and Land Use contribute to **18.4%** of Greenhouse Gas (GHG) emissions globally

Crop Residue Burning after harvest to prepare land for the resowing of crops

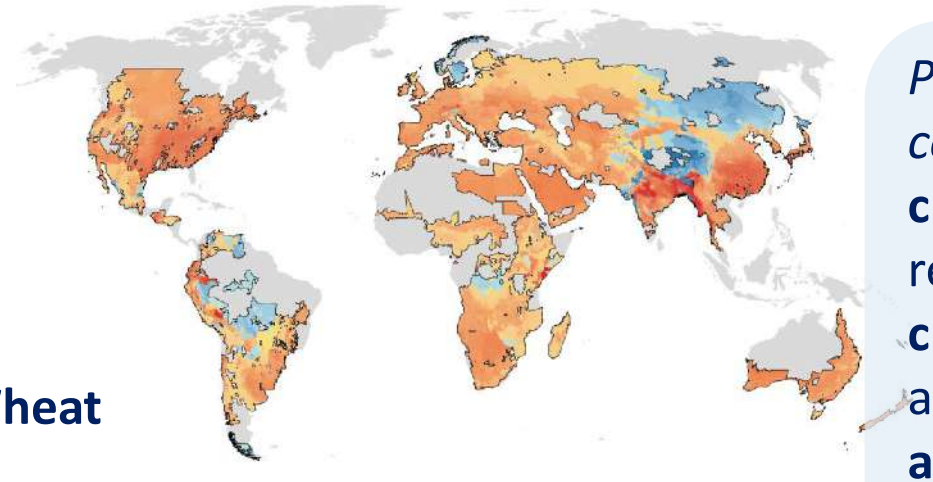


OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020). Licensed under CC-BY by the author Hannah Ritchie (2020).

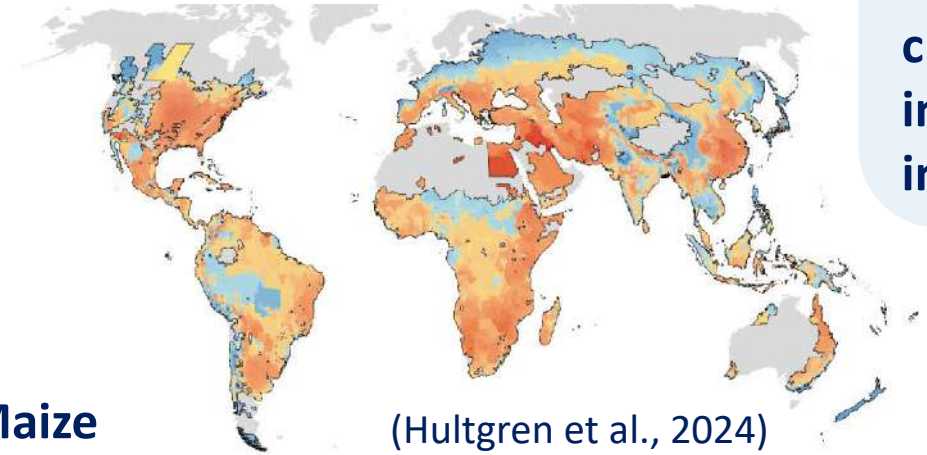
Rice



Wheat



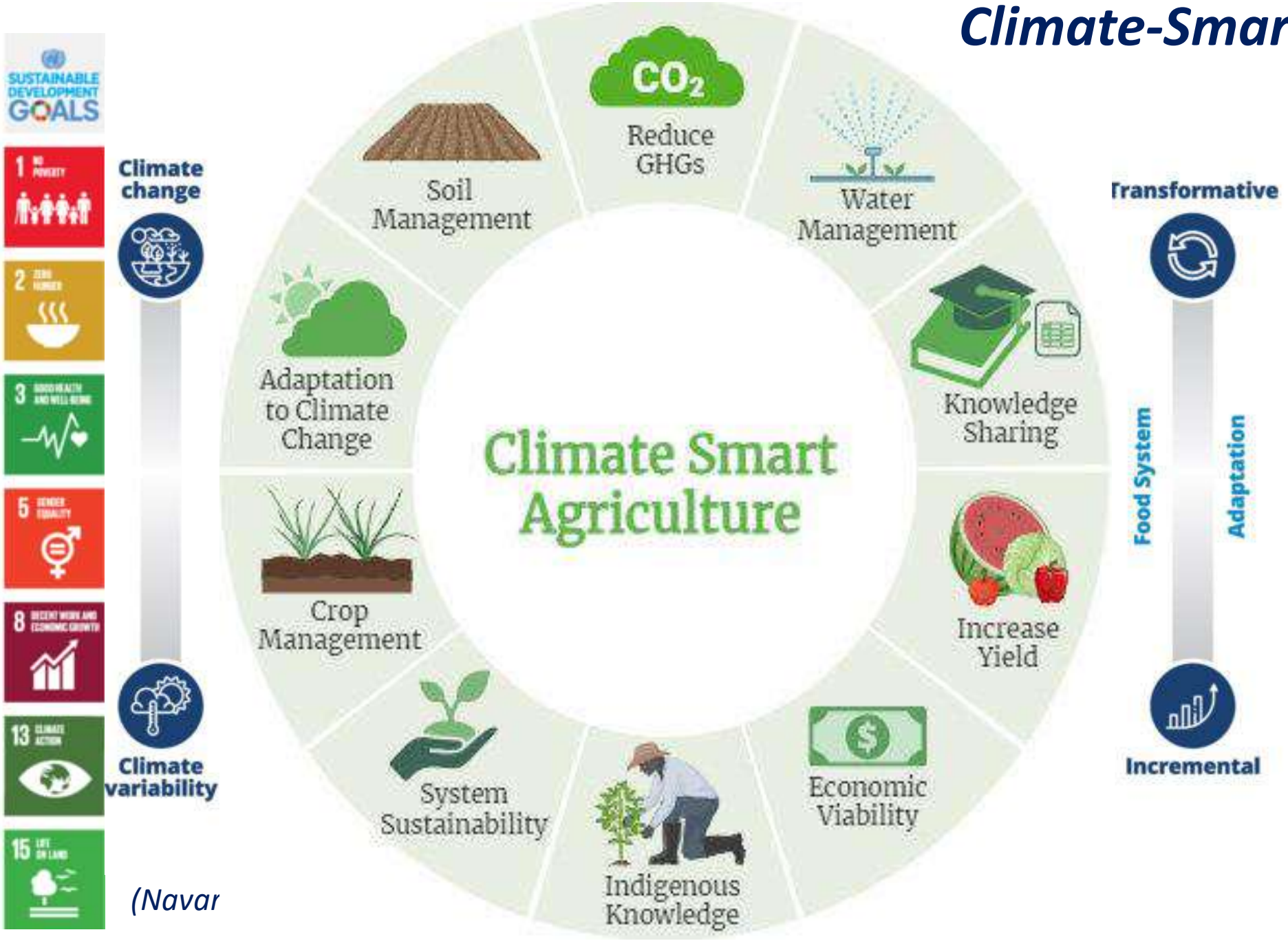
Maize



Projected end-of-century change in **crop yields** resulting from **climate change**, accounting for **adaptation to climate** and **increasing incomes**

(Hultgren et al., 2024)

Climate-Smart Agriculture (CSA)



Climate-Smart Agriculture is a set of **integrative approaches**, not a set of practices, that are used to **increase agricultural productivity** and make **agriculture sustainable**, at the **same time**, with **context-specific**

(Navar

(Epule and Bryant, 2016)

CLIMATE SMART AGRICULTURE (CSA)

CSA = Sustainable Agriculture + Climate Resilience - Emissions

Specific **M**easurable **A**ttainable **R**elevant **T**ime Bound

CLIMATE CHANGE

INTEGRATED APPROACH
Context Specific

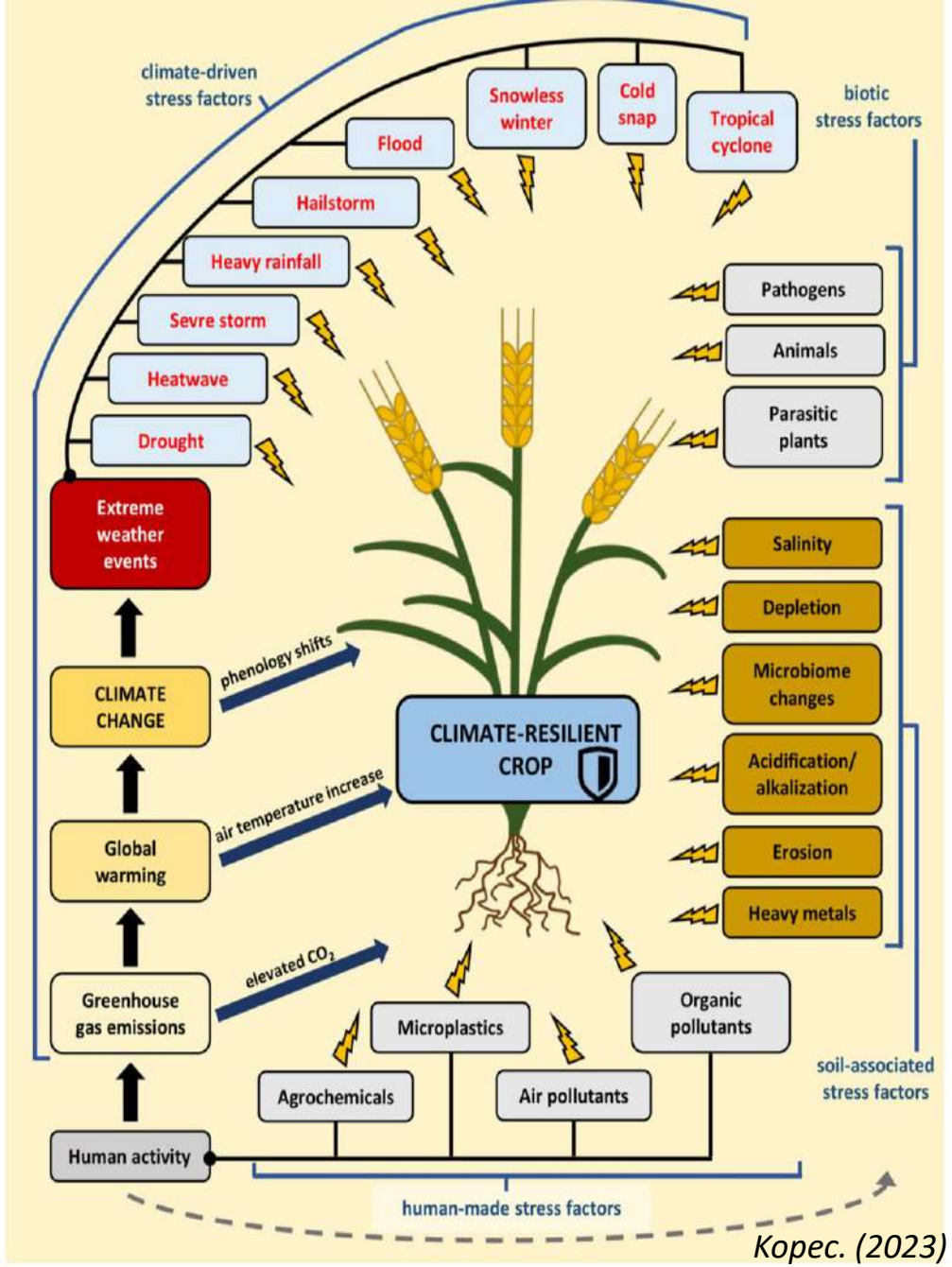
FOOD SECURITY

Objectives of CSA

1. *Increase food production and farm incomes sustainably*
2. *Build resilience to climate and land use change*
3. *Reduce greenhouse gases and carbon stored in farmland*

TRIPLE WIN OF CSA

Modified from Epule and Bryant (2016)



Kopec. (2023)

Resilience to **multiple stress factors (biotic and abiotic)**

Smart Agriculture ®

SMART AGRICULTURE RESEARCH CENTER

DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING
FACULTY OF AGRICULTURAL TECHNOLOGY
UNIVERSITAS GADJAH MADA
INDONESIA

DEPARTEMEN TEKNIK PERTANIAN DAN BIOSISTEM
FAKULTAS TEKNOLOGI PERTANIAN

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Research Supervisor

Prof. Dr. Ir. Lilik Sutiarso, M.Eng., IPU., ASEAN Eng.

Interest: Dynamic System Analysis, Control System Engineering

Research Member

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Interest: Agronomist, Agroecologist, Precision Agriculture

Research Member

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Research Member

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Research Assistant

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Interest: Open Field Technology

Research Assistant

Hafidz Ebril, S.T.P.

Interest: Plant Factory Technology

Research Assistant

Zuhrotul Maulidah, S.T.P.

Interest: Plant Physiology

Research Assistant

Saifuddin Afif, S.T.P.

Interest: Plant Electrophysiology

Application of Smart Agriculture

1

Open-field Horticulture Production

Outdoor horticulture production, optimizing the benefit of natural resources in Tropics

3

Oil Palm Plantation Management

Implementation of Technology for improving the plantation management

2

Paddy Rice Field Cultivation

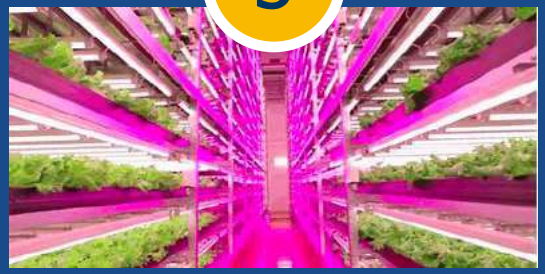
Improving the water utilization for paddy rice by introducing the Irrigation & Agriculture Modernization

4

Greenhouse & Smart Greenhouse Technology

Application of the SmartAgri technology in Greenhouse and Smart Greenouse

5



Plant Factories Technology

Applied Technology in PF, Growing plants inside the fully controlled environment

INDOOR
FARMING

1 **Open-field Horticulture Production**

Development of **Multispectral Drone-Based** Agricultural Mapping System for Precision **Plant Health Evaluation**

TerraDrone

QUANTUM SYSTEMS

VTOL Trinity Pro

Micasense Rededge P

Data Collection

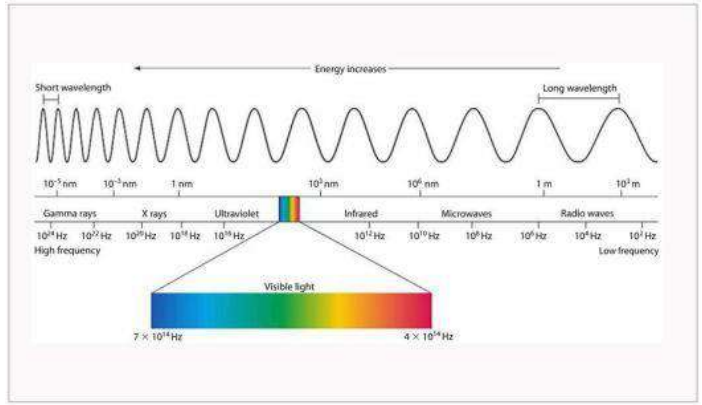
Cloud SmartAgri.id

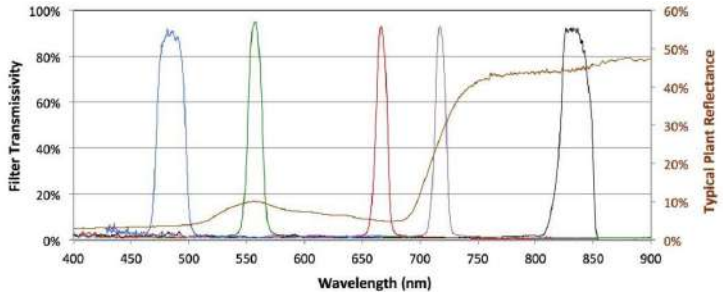
Dashboard DSS SmartAgri.id

The data is further processed for fertilizer application purposes

Results

1. Evaluasi Kesehatan Tanaman
2. NDVI
3. Crop Density And Height Map
4. Yield Estimation





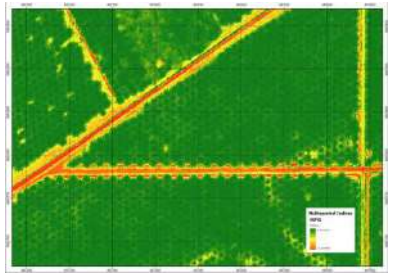
Lahan padi sawah

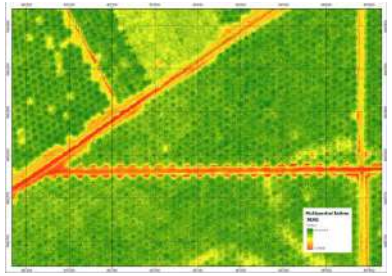
Data Collection

Smart Fertify

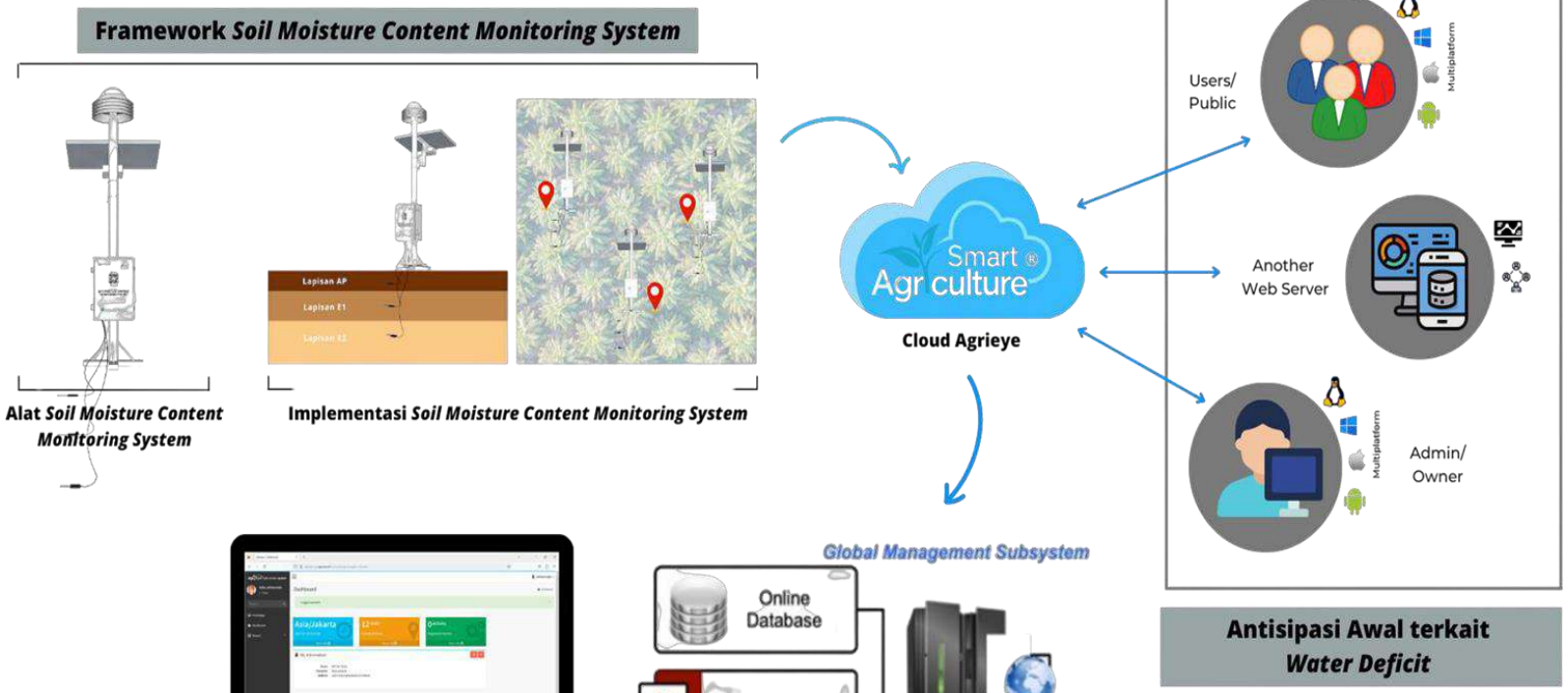
Manajemen lahan pertanian

Recommendation



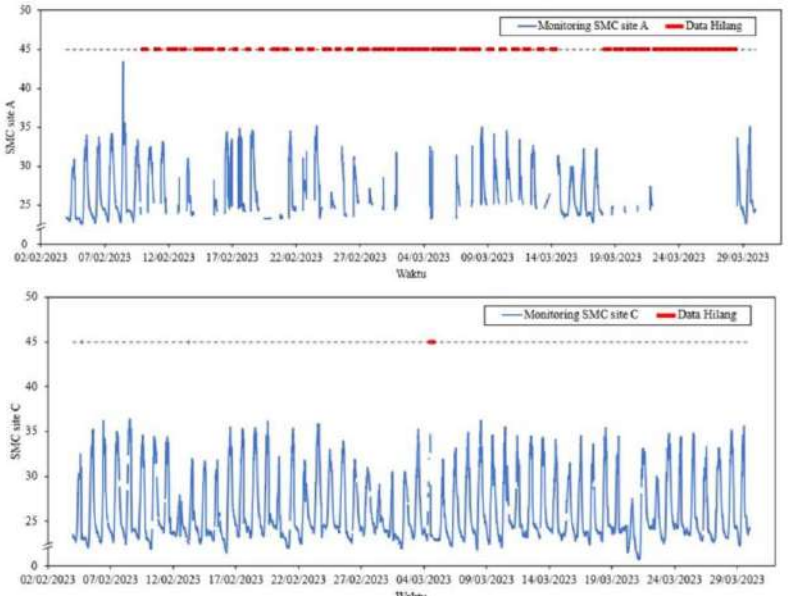


Development of **Soil Moisture Content Monitoring System (SMC)** for monitoring the dynamical properties of sub-optimal soil for estate management



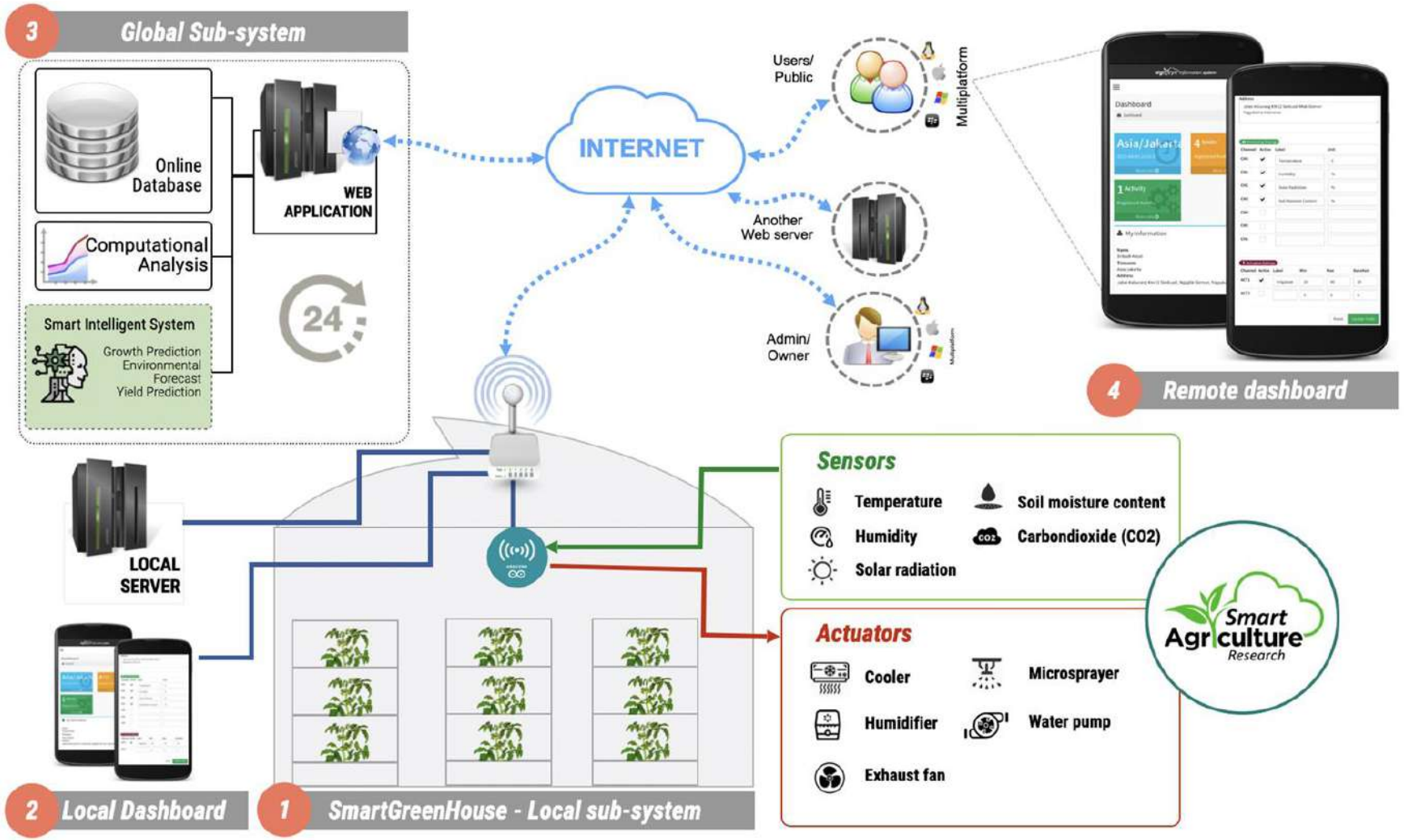
Field Installation of SMC

Real time Monitoring Data

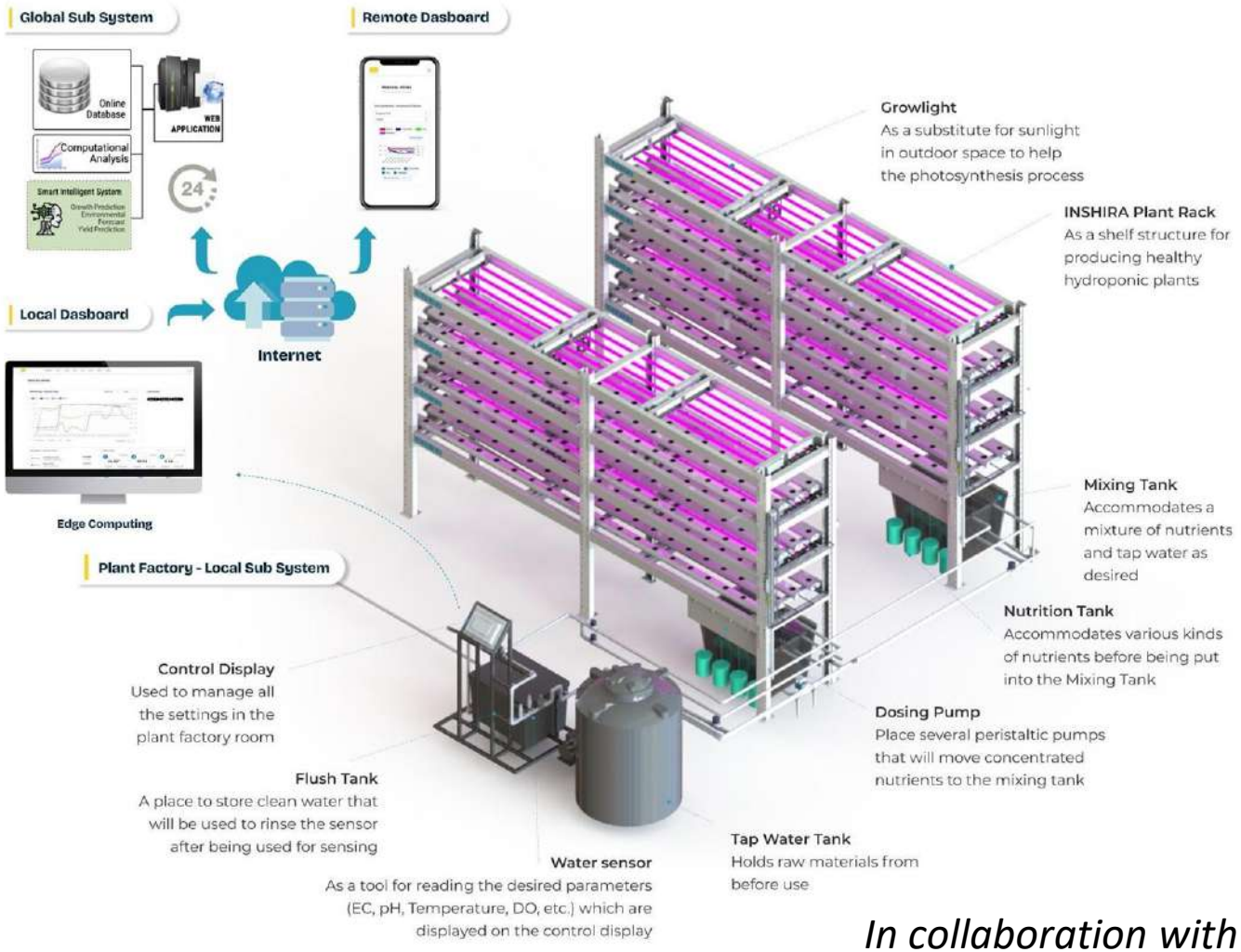


wilmar

Development of **Smart Greenhouse Technology** for supporting horticulture production in tropics - System and Device Development

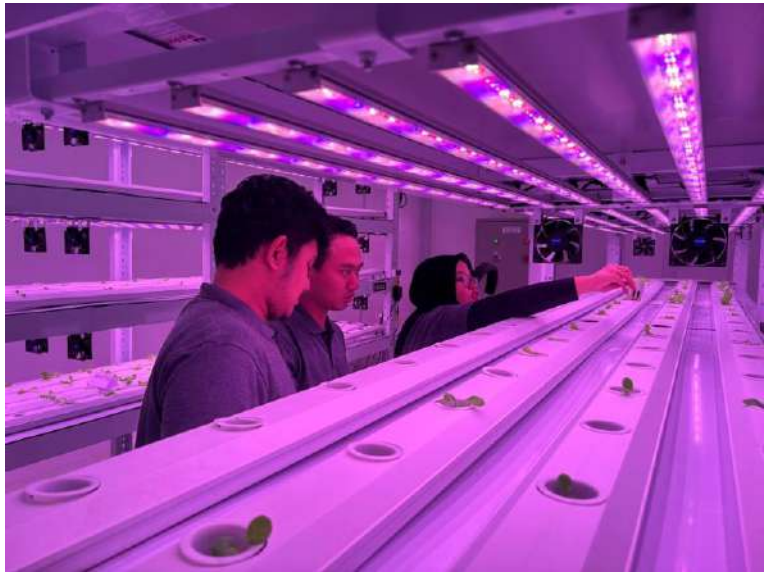


Pilot Research Plant Factory for supporting food sustainability in urban and city areas through climate resilience – PF of the Department of Agricultural and Biosystems Engineering UGM



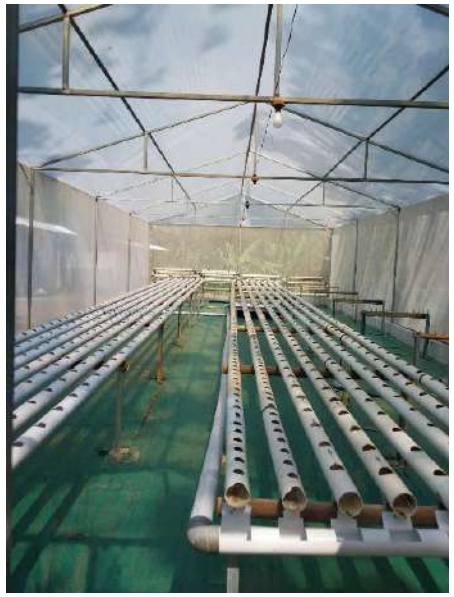
In collaboration with INASTEK


RACK 2



Precision Agriculture-Based Hydroponic Control in a **Low-cost Smart Greenhouse (LCGH)** to Support Horticultural Production in Taruna Tani, Sriharjo, Yogyakarta

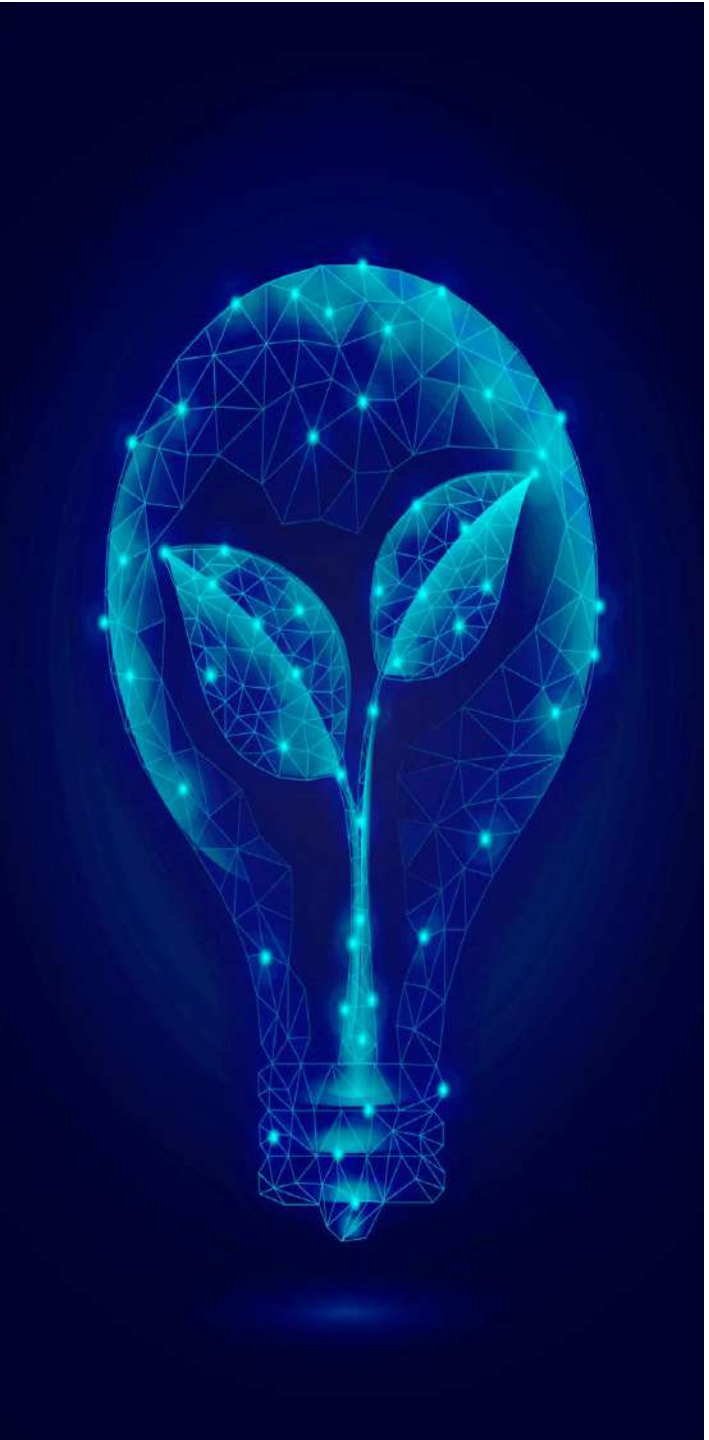
Taruna Tani
Hijaunya Cinta



Development of Smart Greenhouse Technology for Supporting Horticulture Production in Tropical Area





CASE STUDIES (CS)

CS 1:

Implementation Project In Indonesia (3 Pilot Sites in Yogyakarta)

(***Collaboration*** of CSAM UN ESCAP – UGM – ICAMEST)

Phase 1 (2022 – 2023):

*Enabling **sustainable and climate-smart agriculture in Indonesia** through mechanization solutions for integrated management of straw residue*

Phase 2 (to be ongoing):

*Strengthening mechanization-based solutions for **climate-smart crop residue management** in Indonesia*

CS 2 :

Climate-Smart Agrotourism-based Net Zero Waste and Bio-Circular Green Economy of Sambak Village, Magelang Regency, Central Java, Indonesia

(***Collaboration*** *of* Yanmar Environmental Sustainability Support Association/YESSA – UGM – Local Govt -***MULTIYEARS***)

Lessons Learnt from Comparative Studies:

- Building Resilience Through Climate-Smart Technologies, Cluster Farming, and Agriculture Learning Center **in Thailand**
- Integrated Straw Residue Management and Strengthening Mechanization-based Solutions for Sustainable and Climate-Smart Agriculture **in China**

Enabling Sustainable and Climate-Smart Agriculture in Indonesia through Mechanization Solutions for Integrated Management of Straw Residue (2022 – 2023)

Collaboration: Centre of Sustainable Agriculture Mechanization (CSAM) UN ESCAP, UGM, ICAMEST, Local Government & Community

Donor: China – ESCAP Cooperation Programme (CECP)

GAP ANALYSIS

Prior Sub-Optimal Conditions of Straw Residue Management in Three Pilot Sites in Indonesia

(Gamparan, Kwasen, Japuhan Hamlets, Yogyakarta)

- **Sub-optimal training and knowledge of the farmers and women farmers** in their participation for straw management
- **Lack of awareness and training** for implementing straw management (fermented feedstock, composting, organic fertilizer, etc)
- **Low participation** from the farmers in the implementation of straw management, especially targeting to millenial young farmers's participation
- **Lack of agricultural machineries and technology** to support implementation of straw management
- **Sub-optimal condition and agricultural machinery supports** for the implementation of straw management

OPTIMAL CONDITION: Integrated Management of Straw Residue through Agricultural Mechanization Solutions

Agricultural Mechanization-based Implementation Based on Specific Stages and Needs (CONTEXT-SPECIFIC)

Mechanization-based Interventions Implemented at The Pilot Sites

ON FARM

POST HARVEST

HARVEST

STORAGE / STRAW UTILIZATION

- *Composting*
- *Fermented feed making*
- *Pressed straw storage*

Field Trials, Training, Demonstration, and Awareness of Straw Residue Management





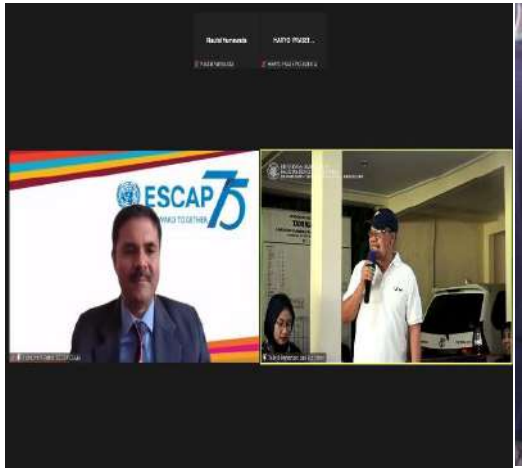








ESCAP CSAM
SERAH TERIMA ALSINTAN, DISEMINASI
CSAM - UGM
2022 - 2023


ESCAP 75

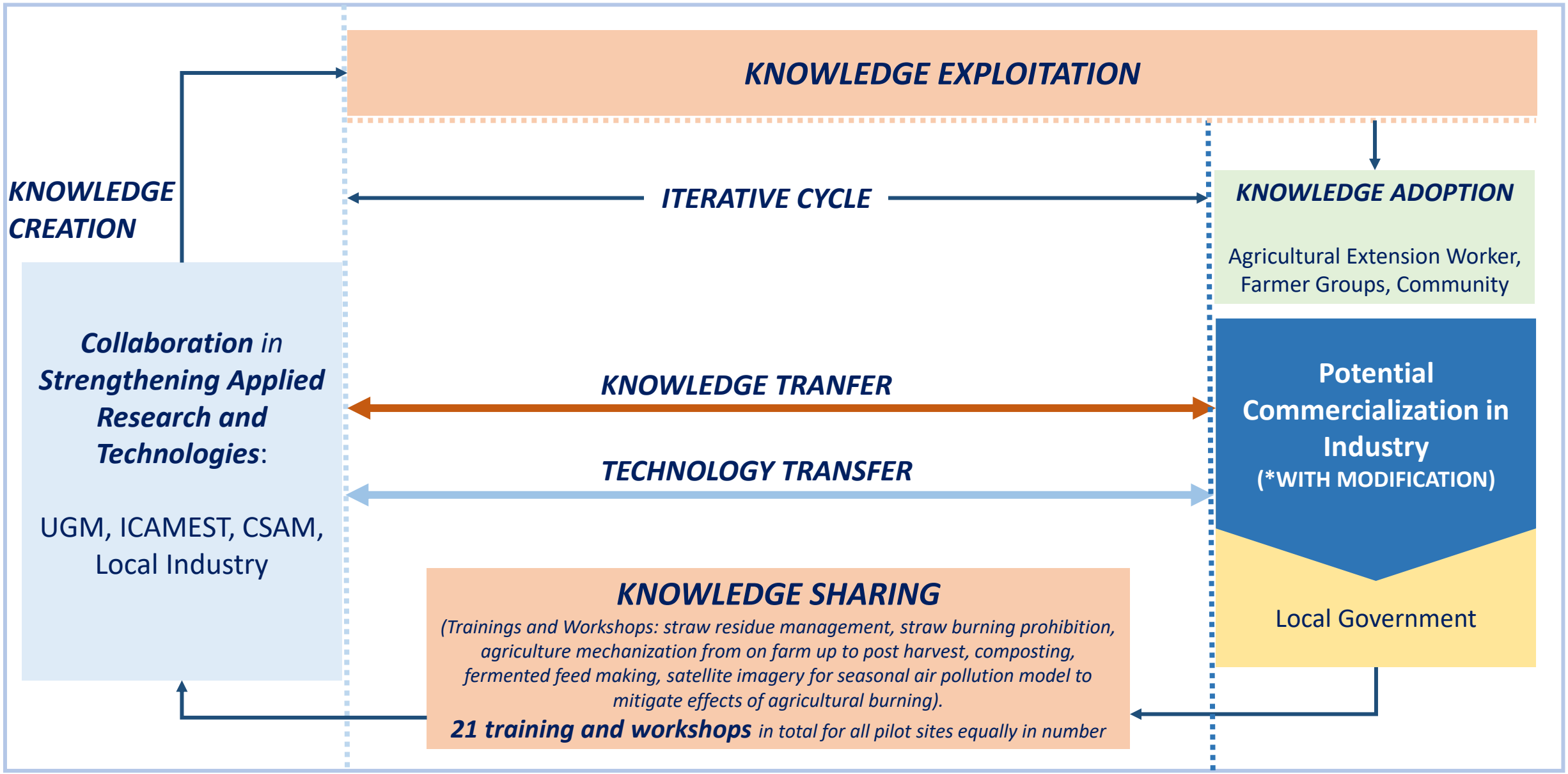

AL FIRDAUS


POSYANDU


ESCAP CSAM

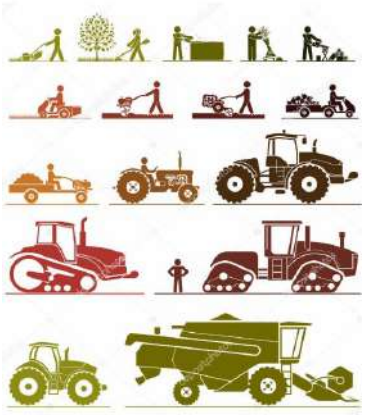

SERAH TERIMA ALSINTAN, DISEMINASI
HASIL, DAN MONITORING
CSAM

TECHNOLOGY TRANSFER MECHANISM: KNOWLEDGE BASE



Modification from Lockett et al. (2009)

KEY ACHIEVEMENTS OF THE PROJECT AND LINKAGE TO CSA



1. **The mechanization index** at the three pilot sites **increased**, ranging from 1.32 to 2.8 HP/ha, compared to the prior condition (0 – 0.39 HP/ha).
2. **Improved Condition of Straw Residue Management**: **25 – 35%** of the straw was utilized by mechanization, and implemented straw residue management, and **60 – 75%** was utilized for direct feedstock or short-term storage, which initiated the straw residue business
3. **Improved Human Resource Capacity** of trained farmers and women farmer groups, and **increased awareness of straw residue management toward sustainable and CSA agriculture**, based on training, field trials, workshops, and feedback surveys.

The Project Objective : **improved crop residue management** and air pollution monitoring for sustainable and climate-smart agriculture

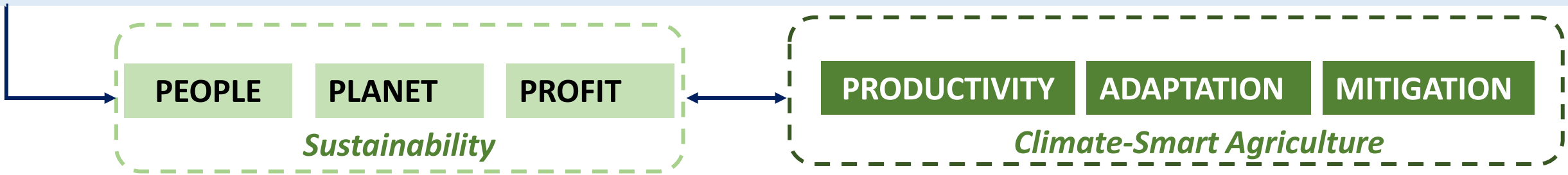
The Project Outcome : Farming community and change agents **implement** improved technologies and practices, and evidence-based decision-making supported by innovative air pollution monitoring approaches for integrated straw residue management

The Project Indikator : By end of the project, **at least 50%** increase in the amount of straw sustainably utilized through improved technologies and practices and evidence-based decision-making

Output 1.1 indicator : Three pilot sites have been established and equipped

Output 1.2 indicator : Field trials of all machinery and modifications have been documented

Output 1.3 indicator **:** Demonstration sessions have reached 105 farming group members (55 male farmers, 50 female farmers, and 30 local government and extension workers), and most respondents in the feedback surveys stated that they have improved capacities and knowledge.



PROJECT PHASE 2

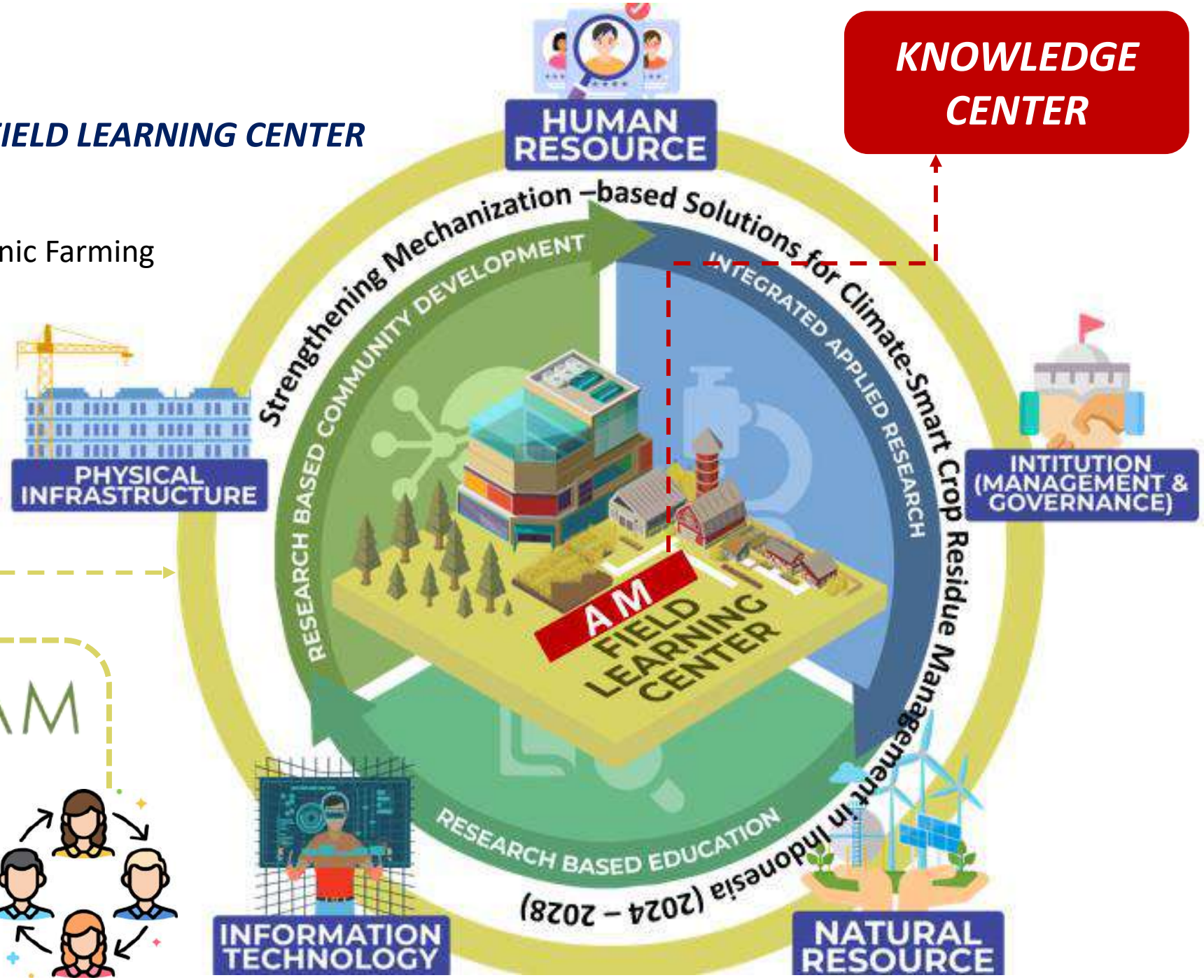
Follow Up:
AGRICULTURAL MECHANIZATION FIELD LEARNING CENTER

- ***December 2024:***

Training of Knowledge Center for Organic Farming and Sustainable Agriculture

- ***As per July 2025:***

Formulation of Country Brief



UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific
CSAM

Open For *Collaboration*

Climate-Smart Agrotourism-based Net Zero Waste and Bio-Circular Green Economy of Sambak Village, Magelang Regency, Central Java, Indonesia (2022 – 2026)

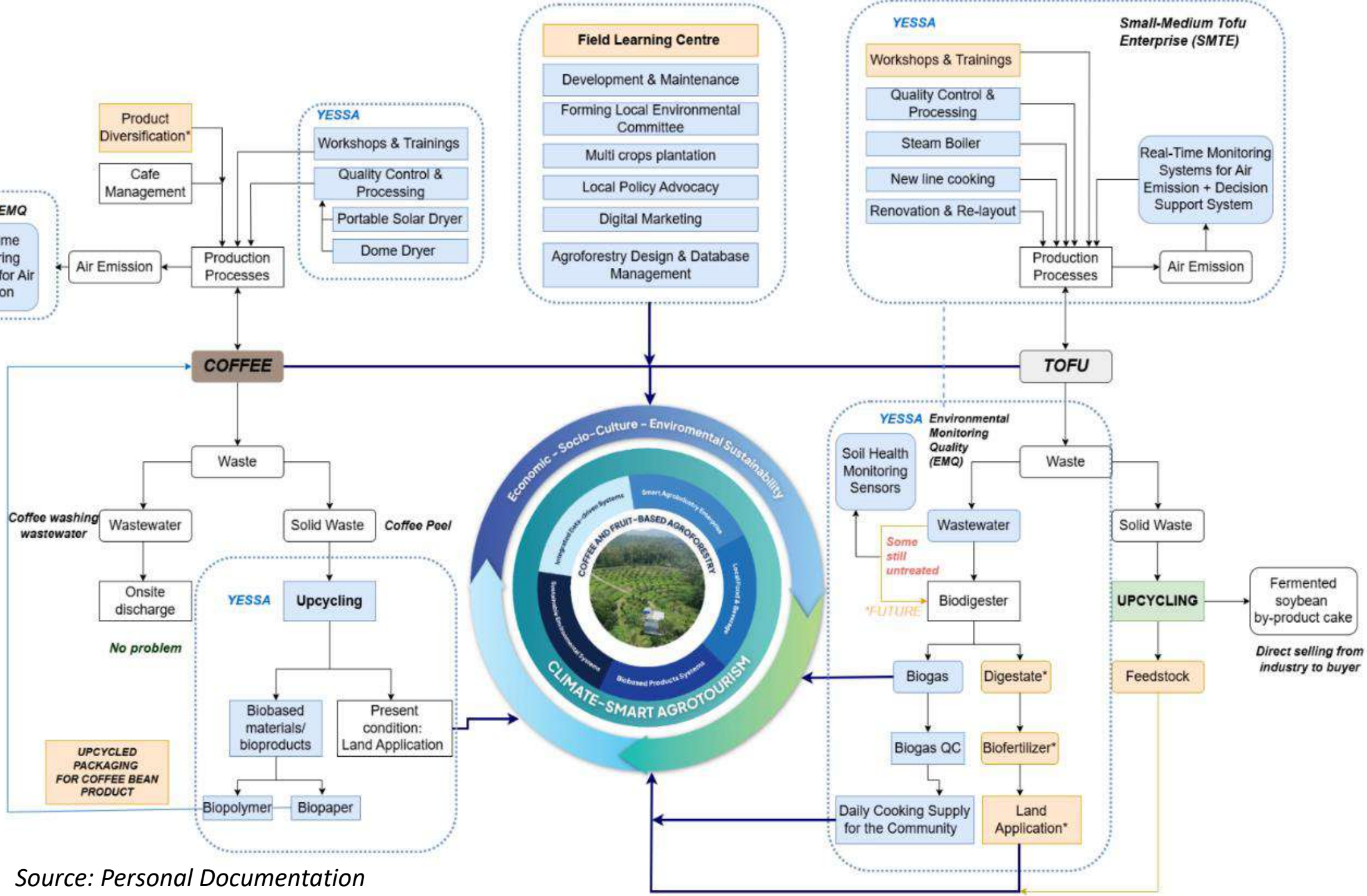
Collaboration and Donor: YESSA – UGM – Local Govt & Community

Brief Description of Sambak Village

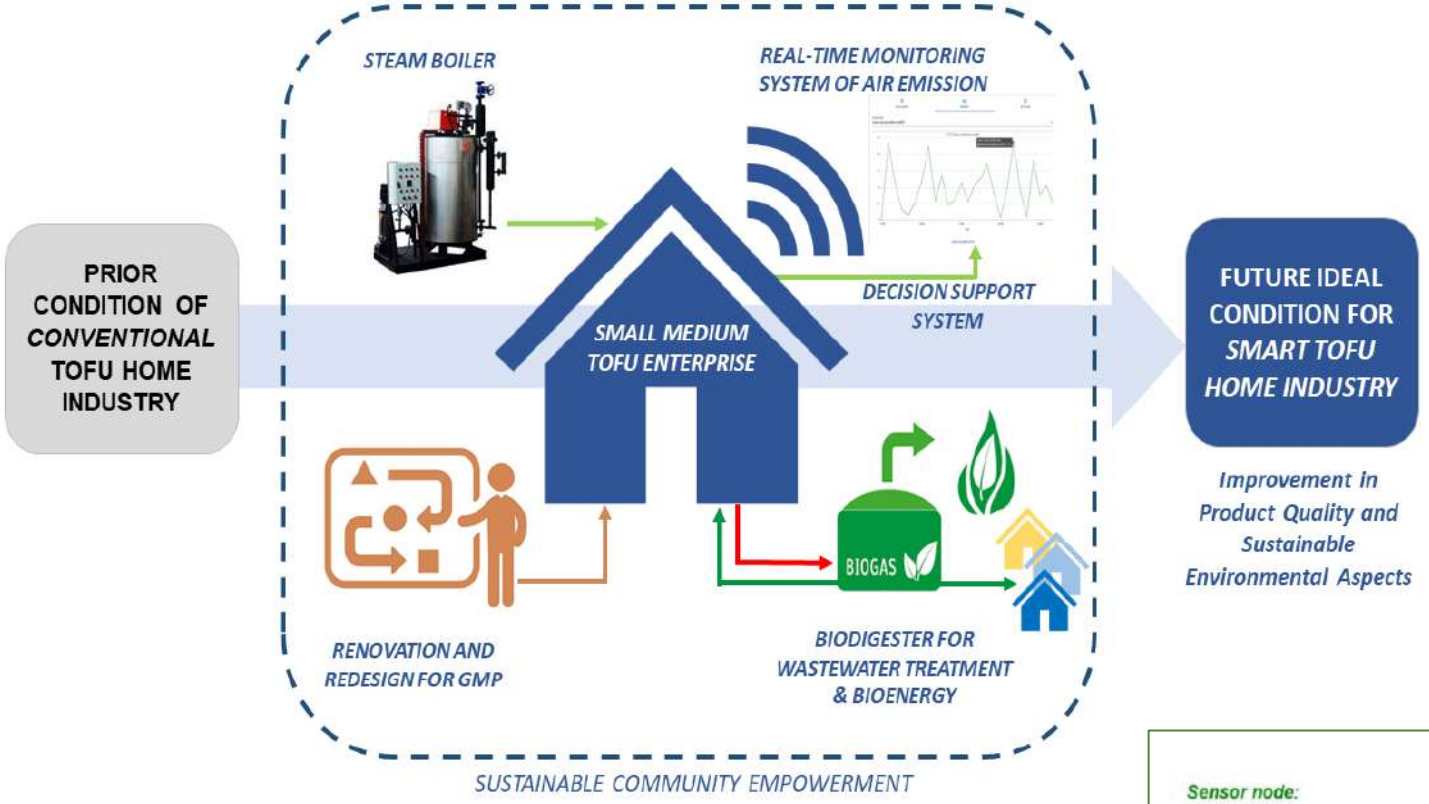
- Located on **transition zones** (tertiary and quaternary volcanic)
- **Climate change** increases **the risk of hydrometeorological disasters** (droughts, landslides) and affects agricultural productivity in this area
- Since 2005, **coffee-based agroforestry** and a supported home coffee industry (processing and selling) have been established
- Since 2015, **14 tofu home industries** (daily capacity of 150 – 400 kg of soybean), have treated their **wastewater using biodigester** and **produced biogas** for **daily usage in the community**
- In 2017, the Sambak was **awarded** as **Pro Climate Village** by **the National Government** for active participation in climate change adaptation and mitigation through **coffee-based agroforestry and biogas for the community**

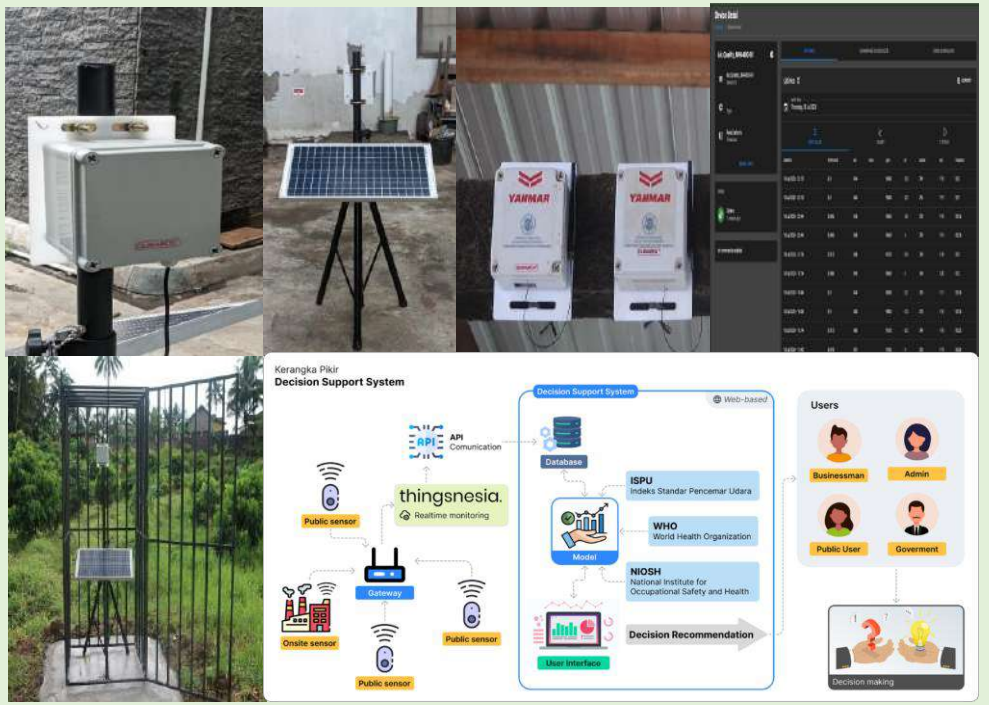
In 2022, **develop an agroforestry fruit plantation for agrotourism** in 25 ha of village ground

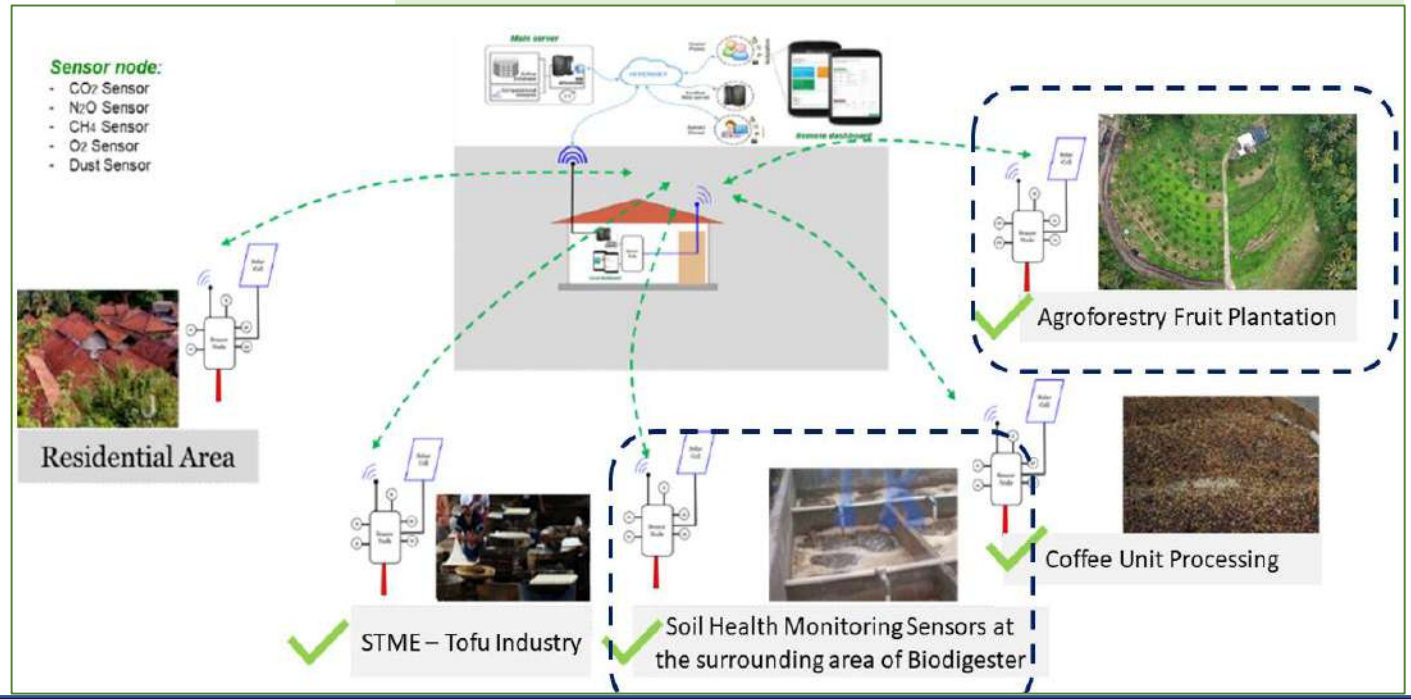
Integrated Approach of Zero Waste-based Agrotourism toward Climate-Smart Agrotourism and Its **Sustainability Assurance** at Sambak Village



Source: Personal Documentation



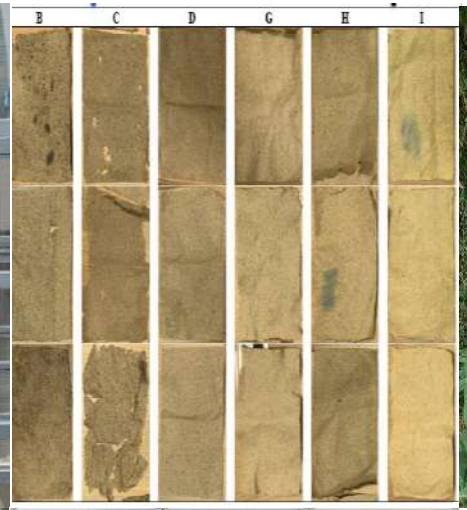




Source: Personal Documentation

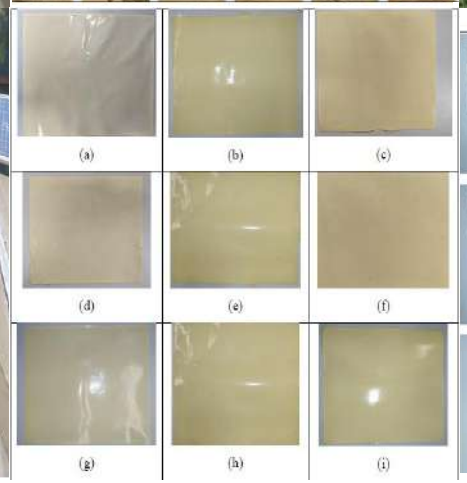
APPLIED TECHNOLOGIES AND INOVATIONS AT SAMBAK VILLAGE TO IMPROVE PRODUCTIVITY & SUSTAINABILITY *(CONTEXT SPECIFIC)*

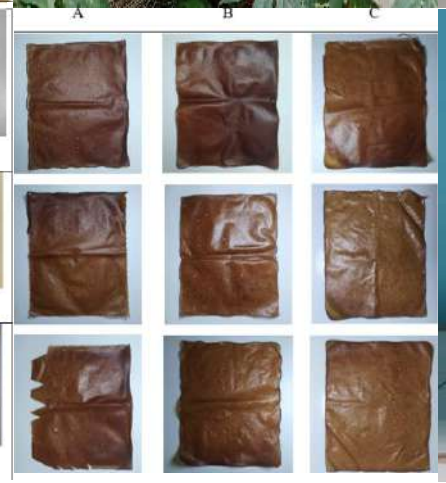








December 2024

RCE AWARDS 2024

This certificate is presented to

RCE Yogyakarta

Integrating Digital Technological Innovations and Local Excellence: Enhancing Smart Field Learning Centre to Drive Pro Climate Agricultural - Educational (Agro-Edu) Tourism

Acknowledged Flagship Project

UNU IAS

RCE

Certified by:

Jonghwi Park
Head of Innovation and Education Programme
United Nations University
Institute for the Advanced Study of Sustainability
1 December 2024

https://pengabdian.ugm.ac.id/2024/12/18/rce-yogyakarta-receives-three-prestigious-awards-for-sustainable-development-initiatives/

"THE ACKNOWLEDGED FLAGSHIP PROJECT"

SDG 4 : Quality Education
SDG 12 : Responsible Consumption and Production
SDG 13: Climate Action

INTELLECTUAL PROPERTY ASSETS

CASE STUDY 1

- Local Context Specific Needs
- Agricultural Mechanization-based Solutions
- Integrated Approach of Collaborators
- **Appropriate Technologies**
- Active Participation and Awareness (Socio-Culture)

CASE STUDY 2

- Local Context Specific Needs
- Local Excellences (Coffee, Tofu, Natural Geography)-based Solutions
- Integrated Approach of Collaborators
- **Appropriate Technologies**
- Active Participation and Awareness (Socio-Culture)

Climate–Resilience Smart Technology

Integrated Local and Future Technologies

APPLIED TECHNOLOGIES

Source of Knowledge

Existing Regulations and Policies in Indonesia relevant to CSA

Up to Related Local Regulations

National Legal Framework for Mitigation and Adaptation

1. Presidential Decree No. 71/2011: Implementation of the National Greenhouse Gas Inventory
2. Presidential Decree No. 98/2021: Implementation of Carbon Economic Value to Achieve Nationally Set Contribution Targets and Control of GHG Emissions in National Development
3. Indonesia Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) 2050

Law and Regulations Support Farmer Adaptation

1. National Law No. 18/2012: Food Security, including the impact to GHG emissions
2. Regulation No. 19/2023: Farmer protection and empowerment, including risk of crop failure due to climate change
3. Regulation of Minister of Agriculture No. 39/2018: Early warning system, and management of climate change impacts in the agricultural sector

Regulations of Sustainable Agriculture

1. National Law No. 22/2019: Sustainable Agriculture Cultivation Systems
2. National Law No. 41/2009: Protection of Agricultural Land for Sustainable Food Production

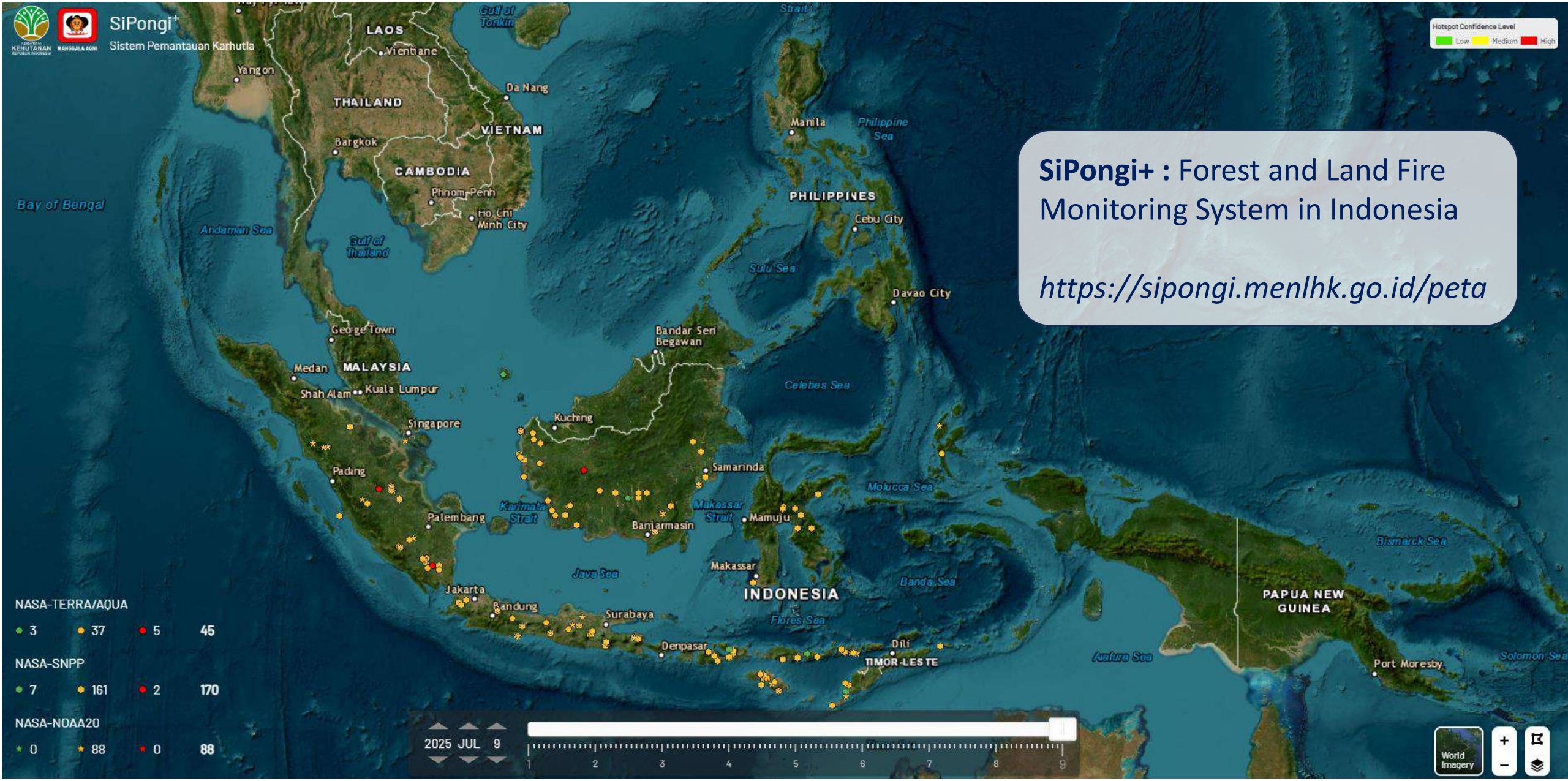
Environmental and Natural Resources

1. Regulation of Minister of Environment and Forestry No. 10/2023: Official Document, including GHG inventory
2. National Law No. 17/2019: Water Resources
3. National Law No. 32/2009: Environmental Protection and Management

Addressing Crop Residue Burning and Integrated Straw Management

1. Regulation of the Minister of Environment and Forestry No. 8/2018: introduces a procedure for checking forest fire and/or burning hotspots
2. Presidential Decree No. 61/2011: National Action Plan to reduce GHG emissions
3. Regulation of the Minister of Agriculture No. 40/2007: Promotes use of rice straw as fertilizer

Existing Environmental Monitoring System for Supporting CSA and SRW in Indonesia



SiPongi+ : Forest and Land Fire Monitoring System in Indonesia

https://sipongi.menlhk.go.id/peta

Lesson Learned

BUILDING RESILIENCE THROUGH CLIMATE-SMART TECHNOLOGIES, CLUSTER FARMING, AND AGRICULTURE LEARNING CENTER IN THAILAND

Thai – Rice NAMA,

a joint project with the **Thai Government** and **local smallholder farmers** as an encouragement to implement **low-emission rice farming,** and **mitigation services and technologies** accessible to farmers

SUSTAINABLE AND LOW-EMISSION RICE FARMING

Agriculture Learning Centre in Thailand applies a holistic approach regarding modern agricultural mechanization, cluster farming, farmers' knowledge capacity, boosting productivity, and exhibiting a strong collaboration and support between national - local governments and farmer groups in one place (***POTENTIAL REFERENCE***)

Source: Personal Documentation and Inclusive Businessnet (2021)

- The Thai Ministry of Agriculture and Cooperatives introduced the “Agriculture 4.0 concepts for 20-year strategic development plan (2017 – 2036).

- This aims to provide farmers with modern technologies, knowledge, financial support, and encourage the formation of “**Clusterfarms**” to enhance productivity, reduce costs, and secure markets

- **Cluster Farming** or “large plots”, as the concept of combining adjacent small plots of land from different farmers into a larger area to ***collectively cultivate a main crop*** using modern technologies

- **Straw Residue Enterprise (*POTENTIAL REFERENCE*)**
  Tackling climate change, environmental pollution while encouraging economic advantages and social welfare

- Technology for On-ground Measurement, Reporting, and Verification for Rice GHG Emissions (Thai Gov and GIZ)

- **Embracing new technology** and convincing the farmers through **economics** and **socio-environmental benefits**, demonstration, initial investment, and revolving fund

Source:
Inclusive Businessnet (2021)
German–Thai Agricultural Cooperation (GETHAC)

GETHAC
German-Thai Agricultural Cooperation

Integrated Straw Residue Management and Strengthening Mechanization-Based Solutions for Sustainable and Climate-Smart Agriculture in China

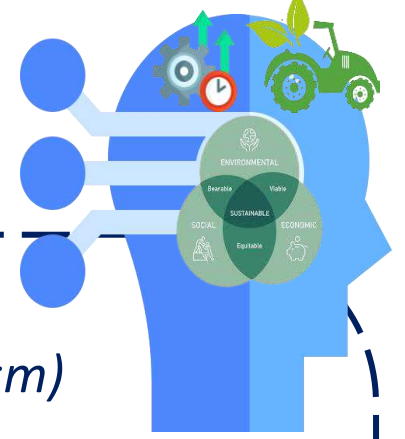
- CSAM Pilot Project in Laixi, Shandong
- Shandong Exotic Fungi Biotech Factory
- 10 agricultural machinery manufacturers

Lesson Learned

Lesson Learned in China

- Institute of Environment and Sustainable Development in Agriculture – Chinese Academy of Agricultural Sciences
  Green and Low-Carbon Agriculture
- Shandong Exotic Fungi Biotech Factory

Key Strategies and Follow-Up Actions



1. **Promote Sustainable and Integrated Agriculture Practices based on Local Excellences**
   (*Agriculture – Multi Crops – Livestock – Fishery (e.g. Mina Padi), Agroforestry, Agrotourism)*
2. **Enhance Climate Resilience and Mitigation**
   (*Waste Valorization and Upcycling of Agriculture Crop Residue to Mitigate Crop Burning, Carbon Storage, Risk Management, Land Conservation)*
3. **Adapting Smart Agriculture Technologies and Modernized Mechanization** toward "the applied stage" in the broader and accessible for the community
   (*Low-cost Smart Green House, Urban Farming, etc)*
4. **Mitigating Greenhouse Gas Emissions through CSA Practices**
   (*Organic Farming, Use Organic Fertilizer, Precision Agriculture, Conservation Tillage or No-Tillage Farming, Fertilizer Efficiency Management*, *Livestock Management*)
5. **Foster Collaboration and Enhance Institutional – Policy Framework - Infrastructure – Funding Support**
   (Knowledge Sharing and Capacity Building, Financial Mechanisms, Policy and Institutional Framework)
6. **Adapting Sustainability Assurance** Toward Economic, Social, Cultural, Environmental Sector

Integrated Applied Technologies and Local Wisdom for CSA Triple Win

THANK YOU

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