**Title :**

# Innovative Approaches to Urban Food Security: Leveraging Nanobubble Technology, IoT, and Water-Efficient Aerobic Rice Cultivation in Climate-Smart Rice-Fish Systems


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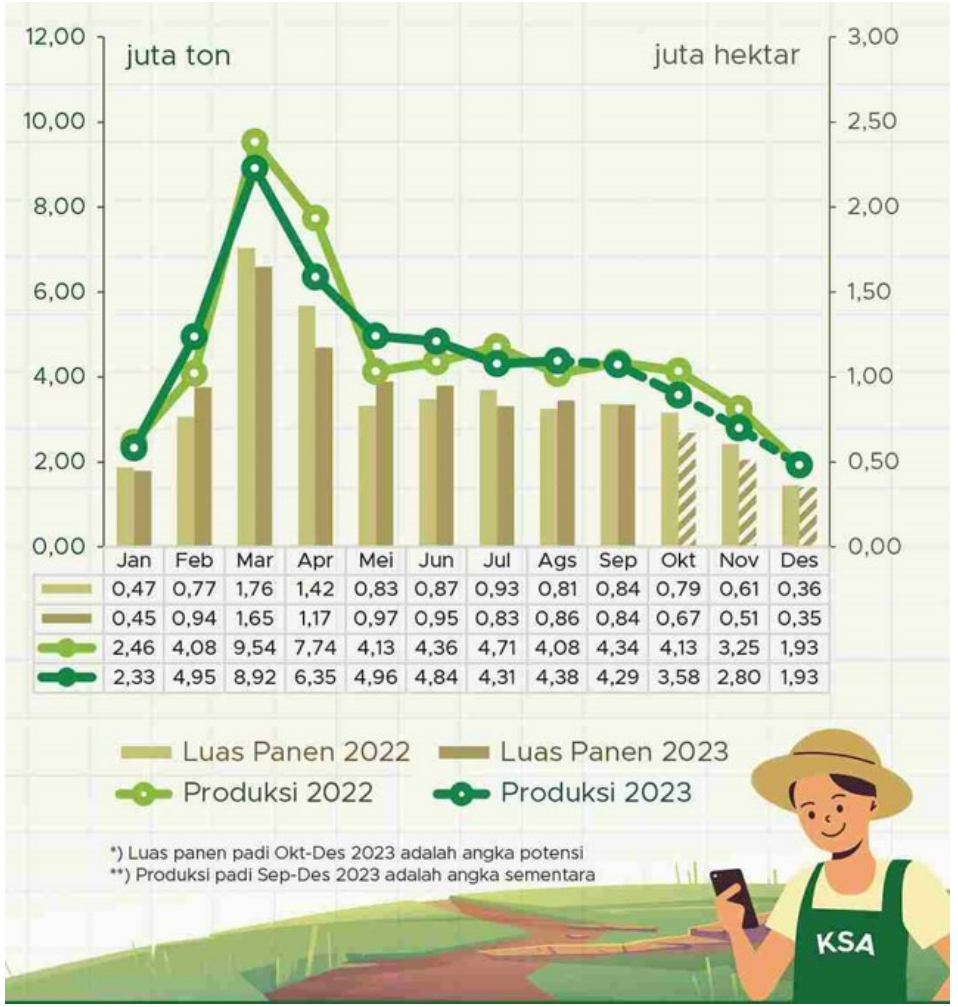
## Background :

- **Problem Context**: Urban food security is an increasing challenge in ASEAN, particularly in Indonesia, where rapid urbanization, population growth, and limited agricultural land have intensified food dependency. Indonesia's population growth of 1.25% annually has led to a per capita rice demand of around 100 kg, necessitating around 31.10 million tons of rice currently, with a projected increase to 40 million tons by 2034.
- **Current Situation:** Food imports are on the rise, with rice imports in 2024 totaling 3.5 million tons and expected to reach 10 million tons by 2034. As rural production stagnates due to land conversion and climate challenges, innovative urban farming solutions become essential.
- **Objective**: Develop a sustainable urban farming model that can supply local food needs, reduce dependency on imports, and improve resource efficiency, particularly through climate-smart practices.




| | Jan | Feb | Mar | Apr | Mei | Jun | Jul | Ags | Sep | Okt | Nov | Des |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Luas Panen 2022 | 0,47 | 0,77 | 1,76 | 1,42 | 0,83 | 0,87 | 0,93 | 0,81 | 0,84 | 0,79 | 0,61 | 0,36 |
| Luas Panen 2023 | 0,45 | 0,94 | 1,65 | 1,17 | 0,97 | 0,95 | 0,83 | 0,86 | 0,84 | 0,67 | 0,51 | 0,35 |
| Produksi 2022 | 2,46 | 4,08 | 9,54 | 7,74 | 4,13 | 4,36 | 4,71 | 4,08 | 4,34 | 4,13 | 3,25 | 1,93 |
| Produksi 2023 | 2,33 | 4,95 | 8,92 | 6,35 | 4,96 | 4,84 | 4,31 | 4,38 | 4,29 | 3,58 | 2,80 | 1,93 |

https://www.bps.go.id/id/pressrelease/2023/10/16/2037/luas-panen-dan-produksi-padi-di-indonesia-2023--angka-sementara-html

## Targets:

- **Primary Goal:** To reduce Indonesia's food import dependency by enhancing local food production through climate-smart urban farming that integrates IoT, nanotechnology, and water-efficient cultivation.
- **Specific Targets**:
  - **Production**: Increase urban rice production to meet local needs through efficient land use.
  - **Resource Efficiency**: Improve water and nutrient management with nanobubble technology, reducing water consumption by up to 30% compared to conventional practices.
  - **Technology Adoption**: Promote the use of IoT-based smart farming tools for environmental monitoring, ensuring adaptable and responsive farming systems.

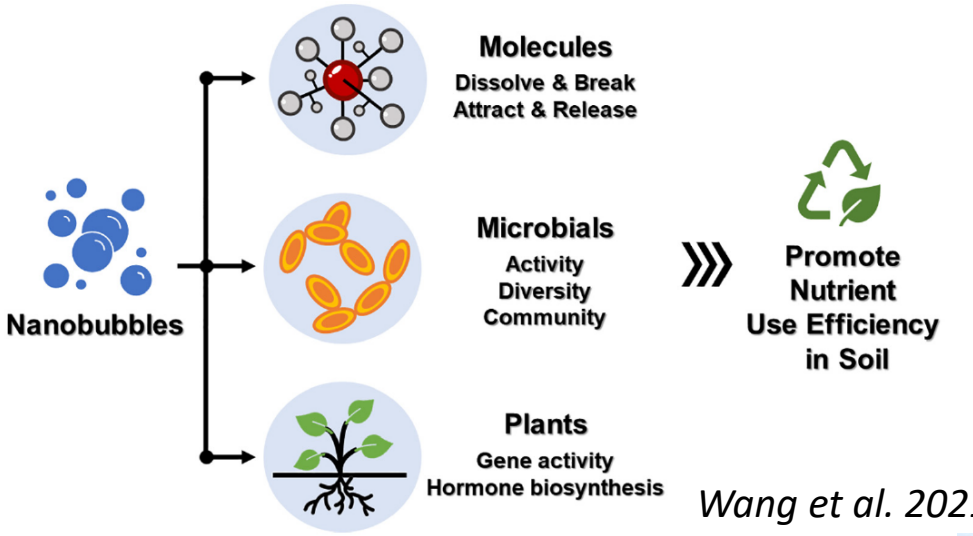
Aerobic Rice-Fish Systems

IoT-Based Monitoring System Dashboard

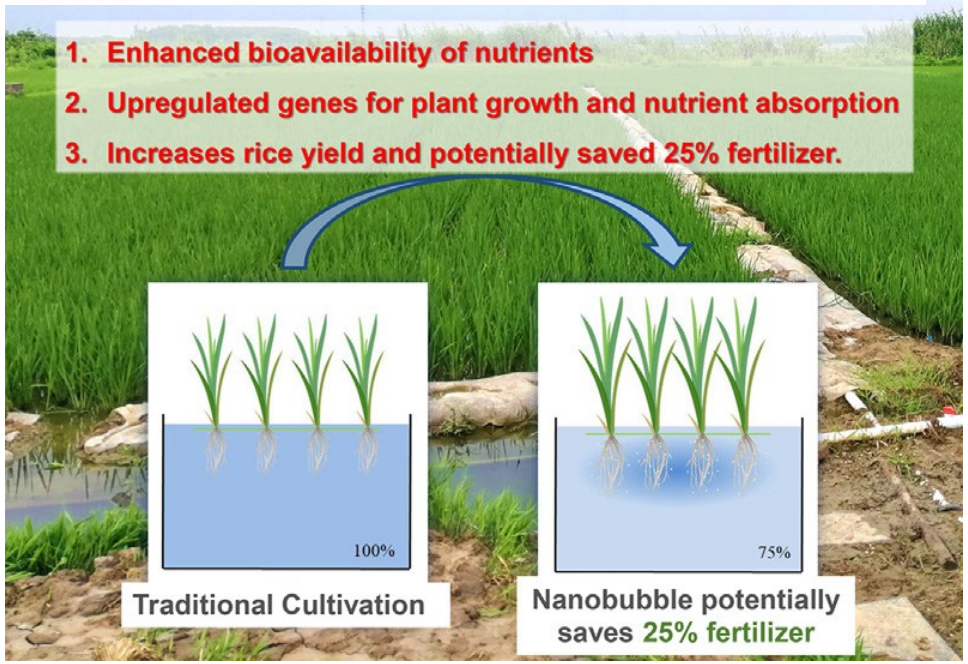
# Proposed Method: Scientific and Technological

- **Innovation:** This approach integrates nanobubble technology to improve water quality and nutrient absorption, coupled with IoT for continuous real-time environmental monitoring. Nanobubble technology elevates dissolved oxygen levels in water, promoting optimal nutrient uptake and enhancing the health of both plants and fish.

- **Technological Tools:** IoT sensors continuously track soil moisture, temperature, and water levels, delivering real-time data to maximize resource efficiency, prevent water waste, and maintain ideal growth conditions. This system is especially advantageous in urban environments where water conservation is crucial.



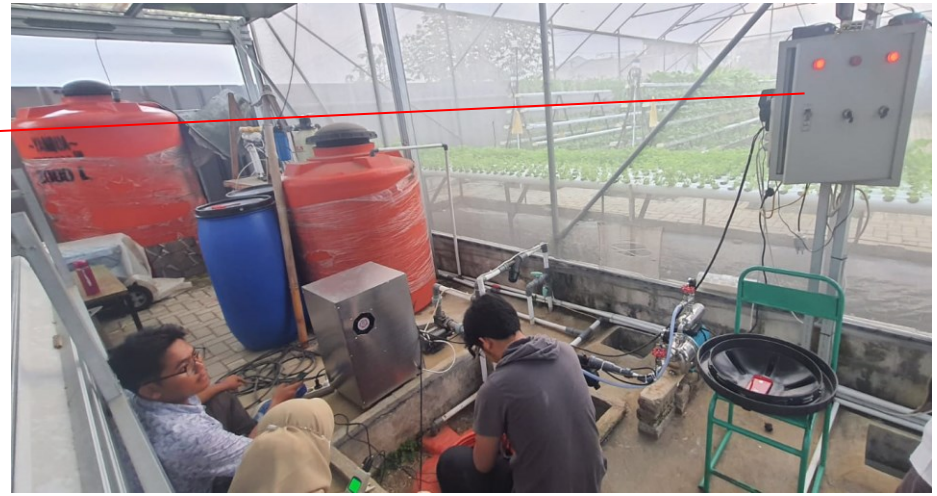

*Wang et al. 2021*



# Proposed Method: Implementation

- **System Design:** Pilot projects will use urban land, such as rooftops and home gardens, to implement aerobic rice-fish farming. Nanobubble-enriched water will maintain soil moisture, while IoT sensors manage water use and nutrient applications.
- **Methodology**: Apply nanobubble-enriched nutrients based on soil moisture data, optimizing irrigation and nutrient cycles.
- **Controlled Variables**: Water table depth (10-15 cm below soil surface) and nanobubble concentrations will be monitored to keep soil at 70% field capacity, improving plant health and reducing the need for frequent irrigation.


***IoT monitoring & control system***

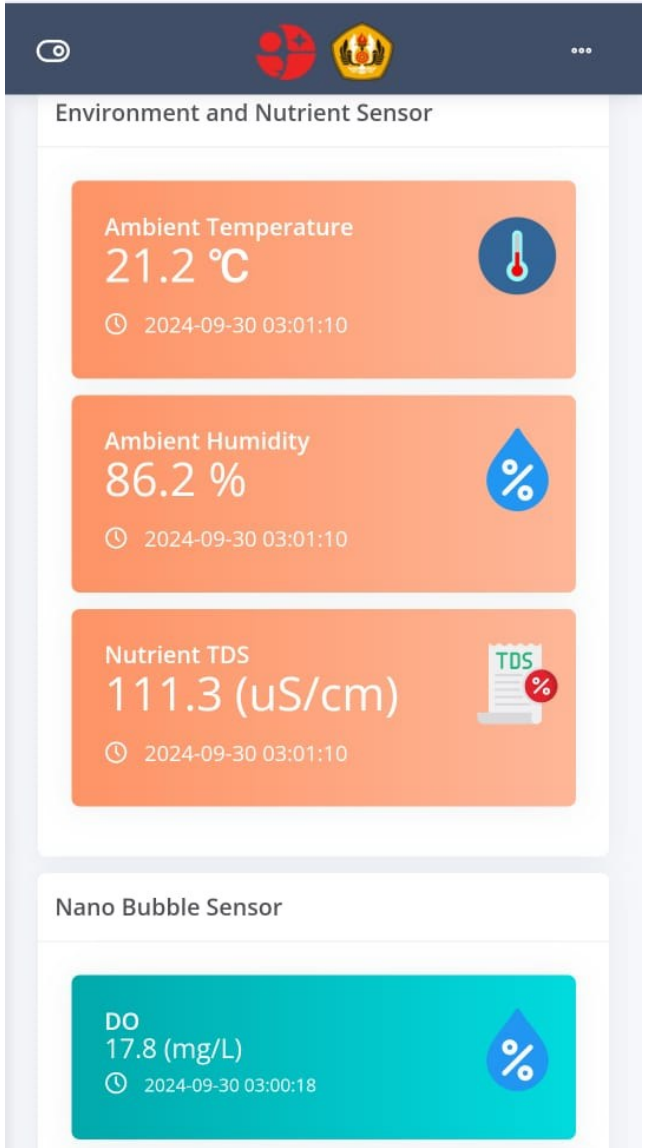


# Proposed Method: Experiments

- **Field Testing Design**: Test both traditional and smart farming systems in urban settings, focusing on water usage, crop yield, and nutrient efficiency.
- **Data Collection**: Parameters such as oxygen levels, water clarity, and nutrient levels will be recorded. Comparisons will focus on water-efficient aerobic rice versus traditional flooded systems, with results informing future urban farming policies.


# Impact: Scientific and Technological Impact

- **Advances in Urban Agriculture Techniques:**
  - Integrates nanobubble technology and IoT for sustainable, urban farming.
  - Enhances dissolved oxygen and nutrient availability, creating resilient crops.
  - Sets a potential standard for high-density, resource-efficient farming suitable for urban environments.
- **Enhanced Precision in Agricultural Monitoring:**
  - IoT sensors provide real-time data on soil moisture, temperature, and nutrients.
  - Enables data-driven adjustments, optimizing crop health and yield.
  - Supports the development of smart, automated systems for urban food production.
- **Contribution to Climate-Smart Agriculture:**
  - Reduces water use and nutrient runoff, addressing key sustainability issues.
  - Promotes water-efficient aerobic rice cultivation, conserving resources.
  - Adaptable for regions with limited water or high climate change vulnerability.




**IoT-Based Monitoring System Dashboard**

# Impact: Societal Impact

- **Food Security**
  - **Increased Resilience:** Reduces reliance on food imports, ensuring stable local food supply.
  - **Community Empowerment:** Enables urban communities to meet part of their food needs locally, enhancing self-sufficiency.
- **Economic Impact**
  - **Cost Efficiency:** Lowers production costs through resource-efficient nanobubble and IoT technology.
  - **Job Creation**: Opens new job opportunities in urban agriculture, from farm management to tech maintenance.
  - **Support for Local Markets**: Supplies urban markets with locally grown produce, stimulating local economies and reducing demand for imports.

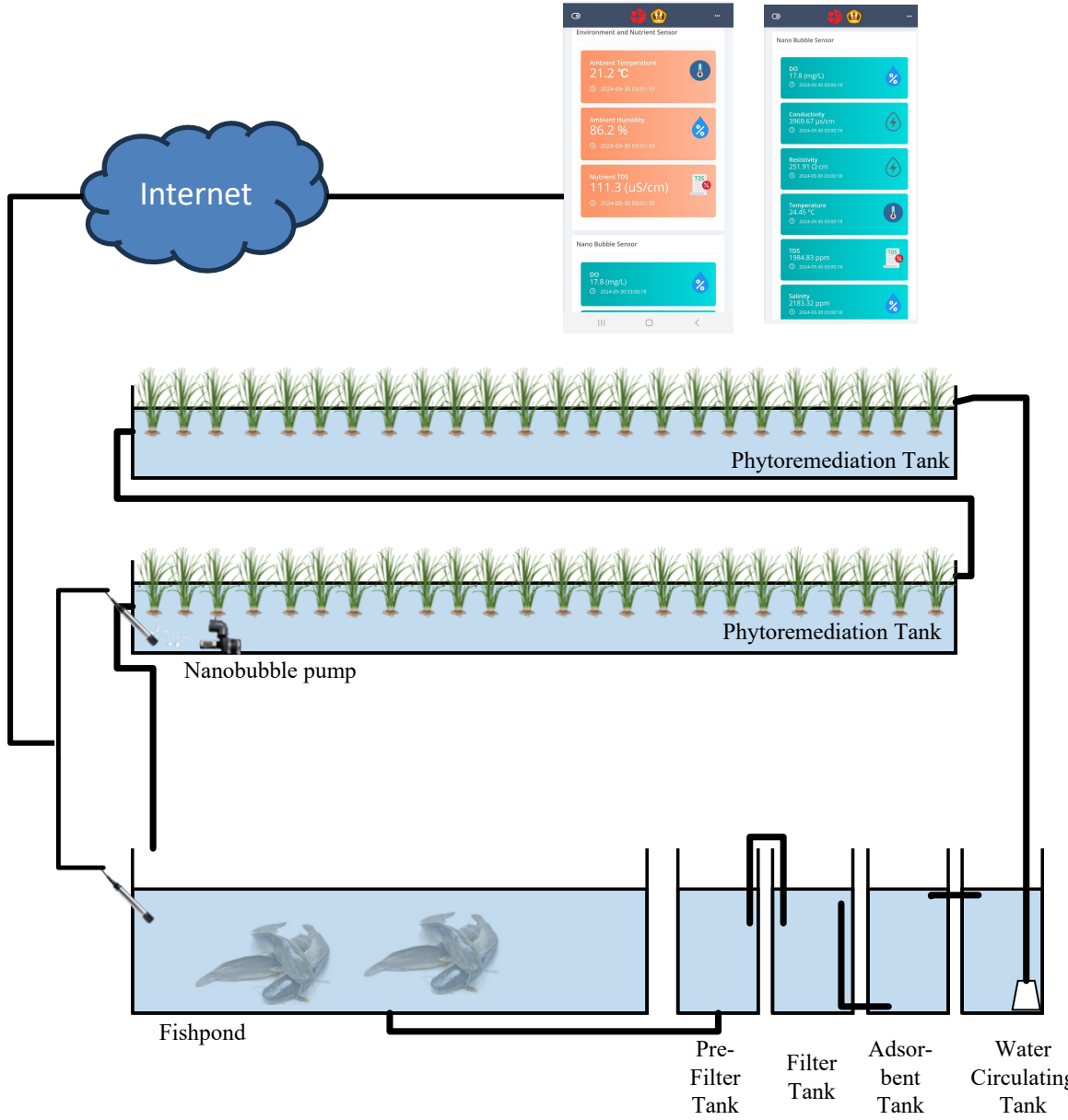

https://www.bps.go.id/id/pressrelease/2023/10/16/2037/luas-panen-dan-produksi-padi-di-indonesia-2023--angka-sementara-html

# Impact: Collaborative Impact

- **ASEAN Collaboration**
  **Regional Knowledge Exchange**: Facilitates sharing of knowledge, technologies, and best practices across ASEAN to address urban food security.
- **Community Engagement**
  - **Public Awareness Campaigns**: Educates local communities on urban farming benefits, enhancing support for sustainable agriculture.
  - **Promoting Sustainability**: Encourages community involvement in urban agriculture, fostering resilient, sustainable local food systems.
- **International Academic Collaboration**
  - **Partnership with Universiti Teknologi Brunei & Universiti Teknologi Malaysia**: Leverages expertise in agricultural technology and sustainable systems to enrich research outcomes.
  - **Joint Research Initiatives**: Enables data sharing, joint experiments, and field trials adaptable to various ASEAN urban settings.
  - **Educational Development**: Offers training in IoT, nanobubble tech, and sustainable farming, preparing skilled professionals for ASEAN's sustainable agriculture future.

# Output/Outcome: Scientific Impact

- **Technological Developments:**
  - **IoT for Urban Farming:** Advanced IoT applications for precise monitoring of soil, water, and nutrients, optimizing crop health in space-limited urban settings.
  - **Nanobubble Technology Improvement:** Enhanced nutrient delivery and oxygenation, boosting plant and fish resilience and promoting efficient nutrient absorption.
- **Data Contributions:**
  - **Public Datasets on Water-Efficient Farming**: Comprehensive data on water usage, growth metrics, and environmental factors for rice-fish farming in urban settings, supporting further research.
  - **Policy and Research Support**: Provides critical insights for policymakers and researchers, aiding in the development of sustainable urban farming policies.



# Output/Outcome: Societal and Collaborative Impact

- **Societal Impact**
  - **Technology Transfer:** Potential to transfer IoT and nanobubble technologies to urban agriculture startups and community farms, enhancing productivity in small spaces.
  - **Support for Urban Food Policies**: Contributes insights for policies that promote local food production, resource conservation, and urban self-sufficiency.
- **Collaborative Impact**
  - **Partnerships with Regional Agricultural Agencies:** Facilitates knowledge sharing across ASEAN, adapting findings to regional urban farming needs.
  - **Collaboration with Research Institutions:** Partnerships with Universiti Teknologi Brunei and Universiti Teknologi Malaysia provide advanced expertise, enabling joint studies, workshops, and field trials to expand impact.

# Conclusion

- **Summary of Targets**
  - **Reduce Import Dependency**: Enhance local food production to decrease reliance on imported food.
  - **Strengthen Food Security**: Develop resilient urban food systems using innovative farming practices.
- **Method Recap**
  - **IoT and Nanotechnology Integration**: Use IoT for real-time monitoring and nanobubbles for enhanced nutrient delivery.
  - **Resource Efficiency**: Create a scalable, water-efficient farming model tailored for urban environments.
- **Impact Review**
  - **Scientific Contributions**: Advances IoT and nanobubble applications in urban agriculture, supporting future research in sustainable food production.
  - **Societal Impact**: Improves food security, creates job opportunities, and supports local startups and community farms.
  - **ASEAN Collaboration**: Builds partnerships with ASEAN institutions, facilitating knowledge sharing and setting the groundwork for wider regional adoption of climate-smart agriculture.
  - **Environmental Sustainability Impact**: Promotes resource-efficient practices by reducing water consumption and nutrient runoff, supporting climate resilience. The project's low-impact, urban farming model minimizes land use and pollution, making it adaptable for densely populated cities and contributing to broader environmental conservation efforts.